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## A64 -- Base Instructions (alphabetic order)

[ADC](#): Add with Carry.

[ADCS](#): Add with Carry, setting flags.

[ADD \(extended register\)](#): Add (extended register).

[ADD \(immediate\)](#): Add (immediate).

[ADD \(shifted register\)](#): Add (shifted register).

[ADDG](#): Add with Tag.

[ADDS \(extended register\)](#): Add (extended register), setting flags.

[ADDS \(immediate\)](#): Add (immediate), setting flags.

[ADDS \(shifted register\)](#): Add (shifted register), setting flags.

[ADR](#): Form PC-relative address.

[ADRP](#): Form PC-relative address to 4KB page.

[AND \(immediate\)](#): Bitwise AND (immediate).

[AND \(shifted register\)](#): Bitwise AND (shifted register).

[ANDS \(immediate\)](#): Bitwise AND (immediate), setting flags.

[ANDS \(shifted register\)](#): Bitwise AND (shifted register), setting flags.

[ASR \(immediate\)](#): Arithmetic Shift Right (immediate): an alias of SBFM.

[ASR \(register\)](#): Arithmetic Shift Right (register): an alias of ASRV.

[ASRV](#): Arithmetic Shift Right Variable.

[AT](#): Address Translate: an alias of SYS.

[AUTDA, AUTDZA](#): Authenticate Data address, using key A.

[AUTDB, AUTDZB](#): Authenticate Data address, using key B.

[AUTIA, AUTIA1716, AUTIASP, AUTIAZ, AUTIZA](#): Authenticate Instruction address, using key A.

[AUTIB, AUTIB1716, AUTIBSP, AUTIBZ, AUTIZB](#): Authenticate Instruction address, using key B.

[AXFLAG](#): Convert floating-point condition flags from Arm to external format.

[B](#): Branch.

[B.cond](#): Branch conditionally.

[BFC](#): Bitfield Clear: an alias of BFM.

[BFI](#): Bitfield Insert: an alias of BFM.

[BFM](#): Bitfield Move.

[BFXIL](#): Bitfield extract and insert at low end: an alias of BFM.

[BIC \(shifted register\)](#): Bitwise Bit Clear (shifted register).

[BICS \(shifted register\)](#): Bitwise Bit Clear (shifted register), setting flags.

[BL](#): Branch with Link.

[BLR](#): Branch with Link to Register.

[BLRAA](#), [BLRAAZ](#), [BLRAB](#), [BLRABZ](#): Branch with Link to Register, with pointer authentication.

[BR](#): Branch to Register.

[BRAA](#), [BRAAZ](#), [BRAB](#), [BRABZ](#): Branch to Register, with pointer authentication.

[BRK](#): Breakpoint instruction.

[BTI](#): Branch Target Identification.

[CAS](#), [CASA](#), [CASAL](#), [CASL](#): Compare and Swap word or doubleword in memory.

[CASB](#), [CASAB](#), [CASALB](#), [CASLB](#): Compare and Swap byte in memory.

[CASH](#), [CASAHL](#), [CASALH](#), [CASLH](#): Compare and Swap halfword in memory.

[CASP](#), [CASPA](#), [CASPAL](#), [CASPL](#): Compare and Swap Pair of words or doublewords in memory.

[CBNZ](#): Compare and Branch on Nonzero.

[CBZ](#): Compare and Branch on Zero.

[CCMN \(immediate\)](#): Conditional Compare Negative (immediate).

[CCMN \(register\)](#): Conditional Compare Negative (register).

[CCMP \(immediate\)](#): Conditional Compare (immediate).

[CCMP \(register\)](#): Conditional Compare (register).

[CFINV](#): Invert Carry Flag.

[CFP](#): Control Flow Prediction Restriction by Context: an alias of SYS.

[CINC](#): Conditional Increment: an alias of CSINC.

[CINV](#): Conditional Invert: an alias of CSINV.

[CLREX](#): Clear Exclusive.

[CLS](#): Count Leading Sign bits.

[CLZ](#): Count Leading Zeros.

[CMN \(extended register\)](#): Compare Negative (extended register): an alias of ADDS (extended register).

[CMN \(immediate\)](#): Compare Negative (immediate): an alias of ADDS (immediate).

[CMN \(shifted register\)](#): Compare Negative (shifted register): an alias of ADDS (shifted register).

[CMP \(extended register\)](#): Compare (extended register): an alias of SUBS (extended register).

[CMP \(immediate\)](#): Compare (immediate): an alias of SUBS (immediate).

[CMP \(shifted register\)](#): Compare (shifted register): an alias of SUBS (shifted register).

[CMPP](#): Compare with Tag: an alias of SUBPS.

[CNEG](#): Conditional Negate: an alias of CSNEG.

[CPP](#): Cache Prefetch Prediction Restriction by Context: an alias of SYS.

[CRC32B](#), [CRC32H](#), [CRC32W](#), [CRC32X](#): CRC32 checksum.

[CRC32CB](#), [CRC32CH](#), [CRC32CW](#), [CRC32CX](#): CRC32C checksum.

[CSDB](#): Consumption of Speculative Data Barrier.

[CSEL](#): Conditional Select.

[CSET](#): Conditional Set: an alias of CSINC.

[CSETM](#): Conditional Set Mask: an alias of CSINV.

[CSINC](#): Conditional Select Increment.

[CSINV](#): Conditional Select Invert.

[CSNEG](#): Conditional Select Negation.

[DC](#): Data Cache operation: an alias of SYS.

[DCPS1](#): Debug Change PE State to EL1..

[DCPS2](#): Debug Change PE State to EL2..

[DCPS3](#): Debug Change PE State to EL3.

[DGH](#): Data Gathering Hint.

[DMB](#): Data Memory Barrier.

[DRPS](#): Debug restore process state.

[DSB](#): Data Synchronization Barrier.

[DVP](#): Data Value Prediction Restriction by Context: an alias of SYS.

[EON \(shifted register\)](#): Bitwise Exclusive OR NOT (shifted register).

[EOR \(immediate\)](#): Bitwise Exclusive OR (immediate).

[EOR \(shifted register\)](#): Bitwise Exclusive OR (shifted register).

[ERET](#): Exception Return.

[ERETAA](#), [ERETAB](#): Exception Return, with pointer authentication.

[ESB](#): Error Synchronization Barrier.

[EXTR](#): Extract register.

[GMI](#): Tag Mask Insert.

[HINT](#): Hint instruction.

[HLT](#): Halt instruction.

[HVC](#): Hypervisor Call.

[IC](#): Instruction Cache operation: an alias of SYS.

[IRG](#): Insert Random Tag.

[ISB](#): Instruction Synchronization Barrier.

[LDADD](#), [LDADDA](#), [LDADDAL](#), [LDADDL](#): Atomic add on word or doubleword in memory.

[LDADDB](#), [LDADDAB](#), [LDADDALB](#), [LDADDLB](#): Atomic add on byte in memory.

[LDADDH](#), [LDADDAH](#), [LDADDALH](#), [LDADDLH](#): Atomic add on halfword in memory.

[LDAPR](#): Load-Acquire RCpc Register.

[LDAPRB](#): Load-Acquire RCpc Register Byte.

[LDAPRH](#): Load-Acquire RCpc Register Halfword.

[LDAPUR](#): Load-Acquire RCpc Register (unscaled).

[LDAPURB](#): Load-Acquire RCpc Register Byte (unscaled).

[LDAPURH](#): Load-Acquire RCpc Register Halfword (unscaled).



[LDAPURSB](#): Load-Acquire RCpc Register Signed Byte (unscaled).

[LDAPURSH](#): Load-Acquire RCpc Register Signed Halfword (unscaled).

[LDAPURSW](#): Load-Acquire RCpc Register Signed Word (unscaled).

[LDAR](#): Load-Acquire Register.

[LDARB](#): Load-Acquire Register Byte.

[LDARH](#): Load-Acquire Register Halfword.

[LDAXP](#): Load-Acquire Exclusive Pair of Registers.

[LDAXR](#): Load-Acquire Exclusive Register.

[LDAXRB](#): Load-Acquire Exclusive Register Byte.

[LDAXRH](#): Load-Acquire Exclusive Register Halfword.

[LDCLR](#), [LDCLRA](#), [LDCLRAL](#), [LDCLRL](#): Atomic bit clear on word or doubleword in memory.

[LDCLRB](#), [LDCLRAB](#), [LDCLRALB](#), [LDCLRLB](#): Atomic bit clear on byte in memory.

[LDCLRH](#), [LDCLRAH](#), [LDCLRALH](#), [LDCLRLH](#): Atomic bit clear on halfword in memory.

[LDEOR](#), [LDEORA](#), [LDEORAL](#), [LDEORL](#): Atomic exclusive OR on word or doubleword in memory.

[LDEORB](#), [LDEORAB](#), [LDEORALB](#), [LDEORLB](#): Atomic exclusive OR on byte in memory.

[LDEORH](#), [LDEORAH](#), [LDEORALH](#), [LDEORLH](#): Atomic exclusive OR on halfword in memory.

[LDG](#): Load Allocation Tag.

[LDGM](#): Load Tag Multiple.

[LDLAR](#): Load LOAcquire Register.

[LDLARB](#): Load LOAcquire Register Byte.

[LDLARH](#): Load LOAcquire Register Halfword.

[LDNP](#): Load Pair of Registers, with non-temporal hint.

[LDP](#): Load Pair of Registers.

[LDPSW](#): Load Pair of Registers Signed Word.

[LDR \(immediate\)](#): Load Register (immediate).

[LDR \(literal\)](#): Load Register (literal).

[LDR \(register\)](#): Load Register (register).

[LDRAA](#), [LDRAB](#): Load Register, with pointer authentication.

[LDRB \(immediate\)](#): Load Register Byte (immediate).

[LDRB \(register\)](#): Load Register Byte (register).

[LDRH \(immediate\)](#): Load Register Halfword (immediate).

[LDRH \(register\)](#): Load Register Halfword (register).

[LDRSB \(immediate\)](#): Load Register Signed Byte (immediate).

[LDRSB \(register\)](#): Load Register Signed Byte (register).

[LDRSH \(immediate\)](#): Load Register Signed Halfword (immediate).

[LDRSH \(register\)](#): Load Register Signed Halfword (register).

[LDRSW \(immediate\)](#): Load Register Signed Word (immediate).

[LDRSW \(literal\)](#): Load Register Signed Word (literal).

[LDRSW \(register\)](#): Load Register Signed Word (register).

[LDSET](#), [LDSETA](#), [LDSETAL](#), [LDSETL](#): Atomic bit set on word or doubleword in memory.

[LDSETB](#), [LDSETAB](#), [LDSETALB](#), [LDSETLB](#): Atomic bit set on byte in memory.

[LDSETH](#), [LDSETAH](#), [LDSETALH](#), [LDSETLH](#): Atomic bit set on halfword in memory.

[LDSMAX](#), [LDSMAXA](#), [LDSMAXAL](#), [LDSMAXL](#): Atomic signed maximum on word or doubleword in memory.

[LDSMAXB](#), [LDSMAXAB](#), [LDSMAXALB](#), [LDSMAXLB](#): Atomic signed maximum on byte in memory.

[LDSMAXH](#), [LDSMAXAH](#), [LDSMAXALH](#), [LDSMAXLH](#): Atomic signed maximum on halfword in memory.

[LDSMIN](#), [LDSMINA](#), [LDSMINAL](#), [LDSMINL](#): Atomic signed minimum on word or doubleword in memory.

[LDSMINB](#), [LDSMINAB](#), [LDSMINALB](#), [LDSMINLB](#): Atomic signed minimum on byte in memory.

[LDSMINH](#), [LDSMINAH](#), [LDSMINALH](#), [LDSMINLH](#): Atomic signed minimum on halfword in memory.

[LDTR](#): Load Register (unprivileged).

[LDTRB](#): Load Register Byte (unprivileged).

[LDTRH](#): Load Register Halfword (unprivileged).

[LDTRSB](#): Load Register Signed Byte (unprivileged).

[LDTRSH](#): Load Register Signed Halfword (unprivileged).

[LDTRSW](#): Load Register Signed Word (unprivileged).

[LDUMAX](#), [LDUMAXA](#), [LDUMAXAL](#), [LDUMAXL](#): Atomic unsigned maximum on word or doubleword in memory.

[LDUMAXB](#), [LDUMAXAB](#), [LDUMAXALB](#), [LDUMAXLB](#): Atomic unsigned maximum on byte in memory.

[LDUMAXH](#), [LDUMAXAH](#), [LDUMAXALH](#), [LDUMAXLH](#): Atomic unsigned maximum on halfword in memory.

[LDUMIN](#), [LDUMINA](#), [LDUMINAL](#), [LDUMINL](#): Atomic unsigned minimum on word or doubleword in memory.

[LDUMINB](#), [LDUMINAB](#), [LDUMINALB](#), [LDUMINLB](#): Atomic unsigned minimum on byte in memory.

[LDUMINH](#), [LDUMINAH](#), [LDUMINALH](#), [LDUMINLH](#): Atomic unsigned minimum on halfword in memory.

[LDUR](#): Load Register (unscaled).

[LDURB](#): Load Register Byte (unscaled).

[LDURH](#): Load Register Halfword (unscaled).

[LDURSB](#): Load Register Signed Byte (unscaled).

[LDURSH](#): Load Register Signed Halfword (unscaled).

[LDURSW](#): Load Register Signed Word (unscaled).

[LDXP](#): Load Exclusive Pair of Registers.

[LDXR](#): Load Exclusive Register.

[LDXRB](#): Load Exclusive Register Byte.

[LDXRH](#): Load Exclusive Register Halfword.

[LSL \(immediate\)](#): Logical Shift Left (immediate): an alias of UBFM.

[LSL \(register\)](#): Logical Shift Left (register): an alias of LSLV.

[LSLV](#): Logical Shift Left Variable.

[LSR \(immediate\)](#): Logical Shift Right (immediate): an alias of UBFM.

[LSR \(register\)](#): Logical Shift Right (register): an alias of LSRV.

[LSRV](#): Logical Shift Right Variable.

[MADD](#): Multiply-Add.

[MNEG](#): Multiply-Negate: an alias of MSUB.

[MOV \(bitmask immediate\)](#): Move (bitmask immediate): an alias of ORR (immediate).

[MOV \(inverted wide immediate\)](#): Move (inverted wide immediate): an alias of MOVN.

[MOV \(register\)](#): Move (register): an alias of ORR (shifted register).

[MOV \(to/from SP\)](#): Move between register and stack pointer: an alias of ADD (immediate).

[MOV \(wide immediate\)](#): Move (wide immediate): an alias of MOVZ.

[MOVK](#): Move wide with keep.

[MOVN](#): Move wide with NOT.

[MOVZ](#): Move wide with zero.

[MRS](#): Move System Register.

[MSR \(immediate\)](#): Move immediate value to Special Register.

[MSR \(register\)](#): Move general-purpose register to System Register.

[MSUB](#): Multiply-Subtract.

[MUL](#): Multiply: an alias of MADD.

[MVN](#): Bitwise NOT: an alias of ORN (shifted register).

[NEG \(shifted register\)](#): Negate (shifted register): an alias of SUB (shifted register).

[NEGS](#): Negate, setting flags: an alias of SUBS (shifted register).

[NGC](#): Negate with Carry: an alias of SBC.

[NGCS](#): Negate with Carry, setting flags: an alias of SBCS.

[NOP](#): No Operation.

[ORN \(shifted register\)](#): Bitwise OR NOT (shifted register).

[ORR \(immediate\)](#): Bitwise OR (immediate).

[ORR \(shifted register\)](#): Bitwise OR (shifted register).

[PACDA, PACDZA](#): Pointer Authentication Code for Data address, using key A.

[PACDB, PACDZB](#): Pointer Authentication Code for Data address, using key B.

[PACGA](#): Pointer Authentication Code, using Generic key.

[PACIA, PACIA1716, PACIASP, PACIAZ, PACIZA](#): Pointer Authentication Code for Instruction address, using key A.

[PACIB, PACIB1716, PACIBSP, PACIBZ, PACIZB](#): Pointer Authentication Code for Instruction address, using key B.

[PRFM \(immediate\)](#): Prefetch Memory (immediate).

[PRFM \(literal\)](#): Prefetch Memory (literal).

[PRFM \(register\)](#): Prefetch Memory (register).

[PRFUM](#): Prefetch Memory (unscaled offset).

[PSB CSYNC](#): Profiling Synchronization Barrier.

[PSSBB](#): Physical Speculative Store Bypass Barrier.

[RBIT](#): Reverse Bits.

[RET](#): Return from subroutine.

[RETAA](#), [RETAB](#): Return from subroutine, with pointer authentication.

[REV](#): Reverse Bytes.

[REV16](#): Reverse bytes in 16-bit halfwords.

[REV32](#): Reverse bytes in 32-bit words.

[REV64](#): Reverse Bytes: an alias of REV.

[RMIF](#): Rotate, Mask Insert Flags.

[ROR \(immediate\)](#): Rotate right (immediate): an alias of EXTR.

[ROR \(register\)](#): Rotate Right (register): an alias of RORV.

[RORV](#): Rotate Right Variable.

[SB](#): Speculation Barrier.

[SBC](#): Subtract with Carry.

[SBCS](#): Subtract with Carry, setting flags.

[SBFIZ](#): Signed Bitfield Insert in Zero: an alias of SBFM.

[SBFM](#): Signed Bitfield Move.

[SBFX](#): Signed Bitfield Extract: an alias of SBFM.

[SDIV](#): Signed Divide.

[SETF8](#), [SETF16](#): Evaluation of 8 or 16 bit flag values.

[SEV](#): Send Event.

[SEVL](#): Send Event Local.

[SMADDL](#): Signed Multiply-Add Long.

[SMC](#): Secure Monitor Call.

[SMNEGL](#): Signed Multiply-Negate Long: an alias of SMSUBL.

[SMSUBL](#): Signed Multiply-Subtract Long.

[SMULH](#): Signed Multiply High.

[SMULL](#): Signed Multiply Long: an alias of SMADDL.

[SSBB](#): Speculative Store Bypass Barrier.

[ST2G](#): Store Allocation Tags.

[STADD](#), [STADDL](#): Atomic add on word or doubleword in memory, without return: an alias of LDADD, LDADDA, LDADDAL, LDADDL.

[STADDB](#), [STADDLB](#): Atomic add on byte in memory, without return: an alias of LDADDB, LDADDAB, LDADDALB, LDADDLB.

[STADDH](#), [STADDLH](#): Atomic add on halfword in memory, without return: an alias of LDADDH, LDADDAH, LDADDALH, LDADDLH.

[STCLR, STCLRL](#): Atomic bit clear on word or doubleword in memory, without return: an alias of LDCLR, LDCLRA, LDCLRAL, LDCLRL.

[STCLRB, STCLRLB](#): Atomic bit clear on byte in memory, without return: an alias of LDCLRB, LDCLRAB, LDCLRALB, LDCLRLB.

[STCLRH, STCLRLH](#): Atomic bit clear on halfword in memory, without return: an alias of LDCLRH, LDCLRAH, LDCLRALH, LDCLRLH.

[STEOR, STEORL](#): Atomic exclusive OR on word or doubleword in memory, without return: an alias of LDEOR, LDEORA, LDEORAL, LDEORL.

[STEORB, STEORLB](#): Atomic exclusive OR on byte in memory, without return: an alias of LDEORB, LDEORAB, LDEORALB, LDEORLB.

[STEORH, STEORLH](#): Atomic exclusive OR on halfword in memory, without return: an alias of LDEORH, LDEORAH, LDEORALH, LDEORLH.

[STG](#): Store Allocation Tag.

[STGM](#): Store Tag Multiple.

[STGP](#): Store Allocation Tag and Pair of registers.

[STLLR](#): Store LORelease Register.

[STLLRB](#): Store LORelease Register Byte.

[STLLRH](#): Store LORelease Register Halfword.

[STLR](#): Store-Release Register.

[STLRB](#): Store-Release Register Byte.

[STLRH](#): Store-Release Register Halfword.

[STLUR](#): Store-Release Register (unscaled).

[STLURB](#): Store-Release Register Byte (unscaled).

[STLURH](#): Store-Release Register Halfword (unscaled).

[STLXP](#): Store-Release Exclusive Pair of registers.

[STLXR](#): Store-Release Exclusive Register.

[STLXRB](#): Store-Release Exclusive Register Byte.

[STLXRH](#): Store-Release Exclusive Register Halfword.

[STNP](#): Store Pair of Registers, with non-temporal hint.

[STP](#): Store Pair of Registers.

[STR \(immediate\)](#): Store Register (immediate).

[STR \(register\)](#): Store Register (register).

[STRB \(immediate\)](#): Store Register Byte (immediate).

[STRB \(register\)](#): Store Register Byte (register).

[STRH \(immediate\)](#): Store Register Halfword (immediate).

[STRH \(register\)](#): Store Register Halfword (register).

[STSET, STSETL](#): Atomic bit set on word or doubleword in memory, without return: an alias of LDSET, LDSETA, LDSETAL, LDSETL.

[STSETB, STSETLB](#): Atomic bit set on byte in memory, without return: an alias of LDSETB, LDSETAB, LDSETALB, LDSETLB.

[STSETH, STSETLH](#): Atomic bit set on halfword in memory, without return: an alias of LDSETH, LDSETAH, LDSETALH, LDSETLH.

[STSMAX, STSMAXL](#): Atomic signed maximum on word or doubleword in memory, without return: an alias of LDSMAX, LDSMAXA, LDSMAXAL, LDSMAXL.

[STSMAXB, STSMAXLB](#): Atomic signed maximum on byte in memory, without return: an alias of LDSMAXB, LDSMAXAB, LDSMAXALB, LDSMAXLB.

[STSMAXH, STSMAXLH](#): Atomic signed maximum on halfword in memory, without return: an alias of LDSMAXH, LDSMAXAH, LDSMAXALH, LDSMAXLH.

[STSMIN, STSMINL](#): Atomic signed minimum on word or doubleword in memory, without return: an alias of LDSMIN, LDSMINA, LDSMINAL, LDSMINL.

[STSMINB, STSMINLB](#): Atomic signed minimum on byte in memory, without return: an alias of LDSMINB, LDSMINAB, LDSMINALB, LDSMINLB.

[STSMINH, STSMINLH](#): Atomic signed minimum on halfword in memory, without return: an alias of LDSMINH, LDSMINAH, LDSMINALH, LDSMINLH.

[STTR](#): Store Register (unprivileged).

[STTRB](#): Store Register Byte (unprivileged).

[STTRH](#): Store Register Halfword (unprivileged).

[STUMAX, STUMAXL](#): Atomic unsigned maximum on word or doubleword in memory, without return: an alias of LDUMAX, LDUMAXA, LDUMAXAL, LDUMAXL.

[STUMAXB, STUMAXLB](#): Atomic unsigned maximum on byte in memory, without return: an alias of LDUMAXB, LDUMAXAB, LDUMAXALB, LDUMAXLB.

[STUMAXH, STUMAXLH](#): Atomic unsigned maximum on halfword in memory, without return: an alias of LDUMAXH, LDUMAXAH, LDUMAXALH, LDUMAXLH.

[STUMIN, STUMINL](#): Atomic unsigned minimum on word or doubleword in memory, without return: an alias of LDUMIN, LDUMINA, LDUMINAL, LDUMINL.

[STUMINB, STUMINLB](#): Atomic unsigned minimum on byte in memory, without return: an alias of LDUMINB, LDUMINAB, LDUMINALB, LDUMINLB.

[STUMINH, STUMINLH](#): Atomic unsigned minimum on halfword in memory, without return: an alias of LDUMINH, LDUMINAH, LDUMINALH, LDUMINLH.

[STUR](#): Store Register (unscaled).

[STURB](#): Store Register Byte (unscaled).

[STURH](#): Store Register Halfword (unscaled).

[STXP](#): Store Exclusive Pair of registers.

[STXR](#): Store Exclusive Register.

[STXRB](#): Store Exclusive Register Byte.

[STXRH](#): Store Exclusive Register Halfword.

[STZ2G](#): Store Allocation Tags, Zeroing.

[STZG](#): Store Allocation Tag, Zeroing.

[STZGM](#): Store Tag and Zero Multiple.

[SUB \(extended register\)](#): Subtract (extended register).

[SUB \(immediate\)](#): Subtract (immediate).

[SUB \(shifted register\)](#): Subtract (shifted register).

[SUBG](#): Subtract with Tag.

[SUBP](#): Subtract Pointer.

[SUBPS](#): Subtract Pointer, setting Flags.

[SUBS \(extended register\)](#): Subtract (extended register), setting flags.

[SUBS \(immediate\)](#): Subtract (immediate), setting flags.

[SUBS \(shifted register\)](#): Subtract (shifted register), setting flags.

[SVC](#): Supervisor Call.

[SWP, SWPA, SWPAL, SWPL](#): Swap word or doubleword in memory.

[SWPB, SWPAB, SWPALB, SWPLB](#): Swap byte in memory.

[SWPH, SWPAH, SWPALH, SWPLH](#): Swap halfword in memory.

[SXTB](#): Signed Extend Byte: an alias of SBFM.

[SXTH](#): Sign Extend Halfword: an alias of SBFM.

[SXTW](#): Sign Extend Word: an alias of SBFM.

[SYS](#): System instruction.

[SYSL](#): System instruction with result.

[TBNZ](#): Test bit and Branch if Nonzero.

[TBZ](#): Test bit and Branch if Zero.

[TCANCEL](#): Cancel current transaction.

[TCOMMIT](#): Commit current transaction.

[TLBI](#): TLB Invalidate operation: an alias of SYS.

[TSB CSYNC](#): Trace Synchronization Barrier.

[TST \(immediate\)](#): Test bits (immediate): an alias of ANDS (immediate).

[TST \(shifted register\)](#): Test (shifted register): an alias of ANDS (shifted register).

[TSTART](#): Start transaction.

[TTEST](#): Test transaction state.

[UBFIZ](#): Unsigned Bitfield Insert in Zero: an alias of UBFM.

[UBFM](#): Unsigned Bitfield Move.

[UBFX](#): Unsigned Bitfield Extract: an alias of UBFM.

[UDE](#): Permanently Undefined.

[UDIV](#): Unsigned Divide.

[UMADDL](#): Unsigned Multiply-Add Long.

[UMNEGL](#): Unsigned Multiply-Negate Long: an alias of UMSUBL.

[UMSUBL](#): Unsigned Multiply-Subtract Long.

[UMULH](#): Unsigned Multiply High.

[UMULL](#): Unsigned Multiply Long: an alias of UMADDL.

[UXTB](#): Unsigned Extend Byte: an alias of UBFM.

[UXTH](#): Unsigned Extend Halfword: an alias of UBFM.

[WFE](#): Wait For Event.

[WFI](#): Wait For Interrupt.

[XAFLAG](#): Convert floating-point condition flags from external format to Arm format.

[XPACD](#), [XPACL](#), [XPACLR](#): Strip Pointer Authentication Code.

[YIELD](#): YIELD.

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## ADC

Add with Carry adds two register values and the Carry flag value, and writes the result to the destination register.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	0	1	1	0	1	0	0	0	0	Rm					0	0	0	0	0	0	Rn					Rd				
op S																															

### 32-bit (sf == 0)

ADC <Wd>, <Wn>, <Wm>

### 64-bit (sf == 1)

ADC <Xd>, <Xn>, <Xm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
```

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Wm>	Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.

## Operation

```
bits(datasize) result;
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = X[m];

(result, -) = AddWithCarry(operand1, operand2, PSTATE.C);

X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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## ADCS

Add with Carry, setting flags, adds two register values and the Carry flag value, and writes the result to the destination register. It updates the condition flags based on the result.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	1	1	1	0	1	0	0	0	0	Rm					0	0	0	0	0	0	Rn					Rd				
op S																															

### 32-bit (sf == 0)

ADCS <Wd>, <Wn>, <Wm>

### 64-bit (sf == 1)

ADCS <Xd>, <Xn>, <Xm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
```

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Wm>	Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.

## Operation

```
bits(datasize) result;
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = X[m];
bits(4) nzcvc;

(result, nzcvc) = AddWithCarry(operand1, operand2, PSTATE.C);

PSTATE.<N,Z,C,V> = nzcvc;

X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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## ADD (extended register)

Add (extended register) adds a register value and a sign or zero-extended register value, followed by an optional left shift amount, and writes the result to the destination register. The argument that is extended from the <Rm> register can be a byte, halfword, word, or doubleword.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	0	0	1	0	1	1	0	0	1	Rm				option			imm3			Rn				Rd						
op										S																					

### 32-bit (sf == 0)

ADD <Wd|WSP>, <Wn|WSP>, <Wm>{, <extend> {#<amount>}}

### 64-bit (sf == 1)

ADD <Xd|SP>, <Xn|SP>, <R><m>{, <extend> {#<amount>}}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasetize = if sf == '1' then 64 else 32;
ExtendType extend_type = DecodeRegExtend(option);
integer shift = UInt(imm3);
if shift > 4 then UNDEFINED;
```

## Assembler Symbols

- <Wd|WSP> Is the 32-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Wn|WSP> Is the 32-bit name of the first source general-purpose register or stack pointer, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd|SP> Is the 64-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Xn|SP> Is the 64-bit name of the first source general-purpose register or stack pointer, encoded in the "Rn" field.
- <R> Is a width specifier, encoded in "option":

option	<R>
00x	W
010	W
x11	X
10x	W
110	W

- <m> Is the number [0-30] of the second general-purpose source register or the name ZR (31), encoded in the "Rm" field.
- <extend> For the 32-bit variant: is the extension to be applied to the second source operand, encoded in "option":

option	<extend>
000	UXTB
001	UXTH
010	LSL UXTW
011	UXTX
100	SXTB
101	SXTH
110	SXTW
111	SXTX

If "Rd" or "Rn" is '11111' (WSP) and "option" is '010' then LSL is preferred, but may be omitted when "imm3" is '000'. In all other cases <extend> is required and must be UXTW when "option" is '010'.

For the 64-bit variant: is the extension to be applied to the second source operand, encoded in “option”:

option	<extend>
000	UXTB
001	UXTH
010	UXTW
011	LSL UXTX
100	SXTB
101	SXTH
110	SXTW
111	SXTX

If "Rd" or "Rn" is '11111' (SP) and "option" is '011' then LSL is preferred, but may be omitted when "imm3" is '000'. In all other cases <extend> is required and must be UXTX when "option" is '011'.

<amount> Is the left shift amount to be applied after extension in the range 0 to 4, defaulting to 0, encoded in the "imm3" field. It must be absent when <extend> is absent, is required when <extend> is LSL, and is optional when <extend> is present but not LSL.

## Operation

```
bits(datasize) result;
bits(datasize) operand1 = if n == 31 then SP[] else X[n];
bits(datasize) operand2 = ExtendReg(m, extend_type, shift);

(result, -) = AddWithCarry(operand1, operand2, '0');

if d == 31 then
    SP[] = result;
else
    X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

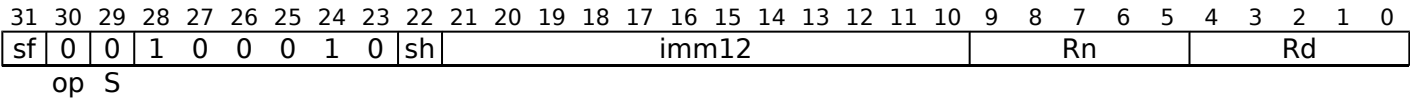
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# ADD (immediate)

Add (immediate) adds a register value and an optionally-shifted immediate value, and writes the result to the destination register.

This instruction is used by the alias [MOV \(to/from SP\)](#).



## 32-bit (sf == 0)

ADD <Wd|WSP>, <Wn|WSP>, #<imm>{, <shift>}

## 64-bit (sf == 1)

ADD <Xd|SP>, <Xn|SP>, #<imm>{, <shift>}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer datasize = if sf == '1' then 64 else 32;
bits(datasize) imm;

case sh of
  when '0' imm = ZeroExtend(imm12, datasize);
  when '1' imm = ZeroExtend(imm12:Zeros(12), datasize);
```

## Assembler Symbols

- <Wd|WSP> Is the 32-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Wn|WSP> Is the 32-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.
- <Xd|SP> Is the 64-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Xn|SP> Is the 64-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.
- <imm> Is an unsigned immediate, in the range 0 to 4095, encoded in the "imm12" field.
- <shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #12

## Alias Conditions

Alias	Is preferred when
<a href="#">MOV (to/from SP)</a>	sh == '0' && imm12 == '000000000000' && (Rd == '11111'    Rn == '11111')

## Operation

```
bits(datasize) result;  
bits(datasize) operand1 = if n == 31 then SP[] else X[n];  
  
(result, -) = AddWithCarry(operand1, imm, '0');  
  
if d == 31 then  
    SP[] = result;  
else  
    X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

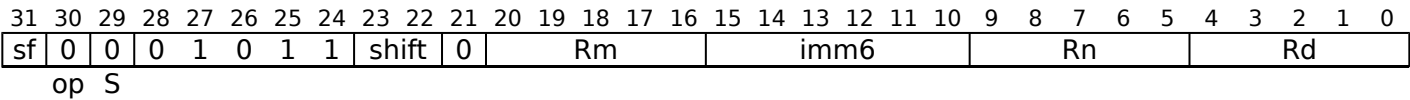
- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# ADD (shifted register)

Add (shifted register) adds a register value and an optionally-shifted register value, and writes the result to the destination register.



## 32-bit (sf == 0)

ADD <Wd>, <Wn>, <Wm>{, <shift> #<amount>}

## 64-bit (sf == 1)

ADD <Xd>, <Xn>, <Xm>{, <shift> #<amount>}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;

if shift == '11' then UNDEFINED;
if sf == '0' && imm6<5> == '1' then UNDEFINED;

ShiftType shift_type = DecodeShift(shift);
integer shift_amount = UInt(imm6);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <shift> Is the optional shift type to be applied to the second source operand, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	RESERVED

- <amount> For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.  
For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field.

## Operation

```
bits(datasize) result;
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = ShiftReg(m, shift_type, shift_amount);

(result, -) = AddWithCarry(operand1, operand2, '0');

X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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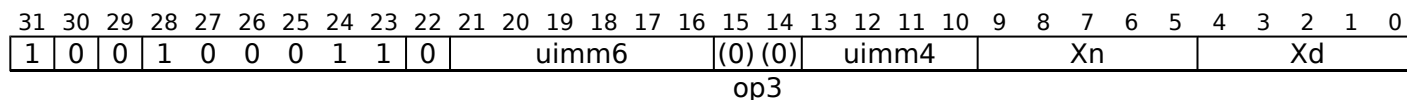
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## ADDG

Add with Tag adds an immediate value scaled by the Tag granule to the address in the source register, modifies the Logical Address Tag of the address using an immediate value, and writes the result to the destination register. Tags specified in GCR\_EL1.Exclude are excluded from the possible outputs when modifying the Logical Address Tag.

### Integer (Armv8.5)



### Integer

ADDG <Xd|SP>, <Xn|SP>, #<uimm6>, #<uimm4>

```
if !HaveMTEExt() then UNDEFINED;
integer d = UInt(Xd);
integer n = UInt(Xn);
bits(64) offset = LSL(ZeroExtend(uimm6, 64), LOG2_TAG_GRANULE);
```

### Assembler Symbols

- <Xd|SP> Is the 64-bit name of the destination general-purpose register or stack pointer, encoded in the "Xd" field.
- <Xn|SP> Is the 64-bit name of the source general-purpose register or stack pointer, encoded in the "Xn" field.
- <uimm6> Is an unsigned immediate, a multiple of 16 in the range 0 to 1008, encoded in the "uimm6" field.
- <uimm4> Is an unsigned immediate, in the range 0 to 15, encoded in the "uimm4" field.

### Operation

```
bits(64) operand1 = if n == 31 then SP[] else X[n];
bits(4) start_tag = AArch64.AllocationTagFromAddress(operand1);
bits(16) exclude = GCR_EL1.Exclude;
bits(64) result;
bits(4) rtag;

if AArch64.AllocationTagAccessIsEnabled(AccType_NORMAL) then
    rtag = AArch64.ChooseNonExcludedTag(start_tag, uimm4, exclude);
else
    rtag = '0000';

(result, -) = AddWithCarry(operand1, offset, '0');
result = AArch64.AddressWithAllocationTag(result, AccType_NORMAL, rtag);

if d == 31 then
    SP[] = result;
else
    X[d] = result;
```

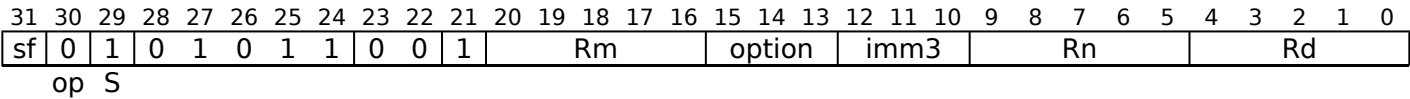
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# ADDS (extended register)

Add (extended register), setting flags, adds a register value and a sign or zero-extended register value, followed by an optional left shift amount, and writes the result to the destination register. The argument that is extended from the <Rm> register can be a byte, halfword, word, or doubleword. It updates the condition flags based on the result.

This instruction is used by the alias [CMN \(extended register\)](#).



## 32-bit (sf == 0)

ADDS <Wd>, <Wn|WSP>, <Wm>{, <extend> {#<amount>}}

## 64-bit (sf == 1)

ADDS <Xd>, <Xn|SP>, <R><m>{, <extend> {#<amount>}}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
ExtendType extend_type = DecodeRegExtend(option);
integer shift = UInt(imm3);
if shift > 4 then UNDEFINED;
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn|WSP> Is the 32-bit name of the first source general-purpose register or stack pointer, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn|SP> Is the 64-bit name of the first source general-purpose register or stack pointer, encoded in the "Rn" field.
- <R> Is a width specifier, encoded in "option":

option	<R>
00x	W
010	W
x11	X
10x	W
110	W

- <m> Is the number [0-30] of the second general-purpose source register or the name ZR (31), encoded in the "Rm" field.
- <extend> For the 32-bit variant: is the extension to be applied to the second source operand, encoded in "option":

option	<extend>
000	UXTB
001	UXTH
010	LSL UXTW
011	UXTX
100	SXTB
101	SXTH
110	SXTW
111	SXTX

If "Rn" is '11111' (WSP) and "option" is '010' then LSL is preferred, but may be omitted when "imm3" is '000'. In all other cases <extend> is required and must be UXTW when "option" is '010'.

For the 64-bit variant: is the extension to be applied to the second source operand, encoded in "option":

option	<extend>
000	UXTB
001	UXTH
010	UXTW
011	LSL UXTX
100	SXTB
101	SXTH
110	SXTW
111	SXTX

If "Rn" is '1111' (SP) and "option" is '011' then LSL is preferred, but may be omitted when "imm3" is '000'. In all other cases <extend> is required and must be UXTX when "option" is '011'.

<amount> Is the left shift amount to be applied after extension in the range 0 to 4, defaulting to 0, encoded in the "imm3" field. It must be absent when <extend> is absent, is required when <extend> is LSL, and is optional when <extend> is present but not LSL.

## Alias Conditions

Alias	Is preferred when
<a href="#">CMN (extended register)</a>	Rd == '11111'

## Operation

```
bits(datasize) result;
bits(datasize) operand1 = if n == 31 then SP[] else X[n];
bits(datasize) operand2 = ExtendReg(m, extend_type, shift);
bits(4) nzcvc;

(result, nzcvc) = AddWithCarry(operand1, operand2, '0');

PSTATE.<N,Z,C,V> = nzcvc;

X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

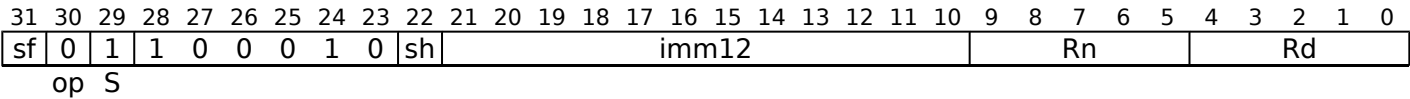
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# ADDS (immediate)

Add (immediate), setting flags, adds a register value and an optionally-shifted immediate value, and writes the result to the destination register. It updates the condition flags based on the result.

This instruction is used by the alias [CMN \(immediate\)](#).



## 32-bit (sf == 0)

ADDS <Wd>, <Wn|WSP>, #<imm>{, <shift>}

## 64-bit (sf == 1)

ADDS <Xd>, <Xn|SP>, #<imm>{, <shift>}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer datasize = if sf == '1' then 64 else 32;
bits(datasize) imm;

case sh of
  when '0' imm = ZeroExtend(imm12, datasize);
  when '1' imm = ZeroExtend(imm12:Zeros(12), datasize);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn|WSP> Is the 32-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn|SP> Is the 64-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.
- <imm> Is an unsigned immediate, in the range 0 to 4095, encoded in the "imm12" field.
- <shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #12

## Alias Conditions

Alias	Is preferred when
<a href="#">CMN (immediate)</a>	Rd == '11111'

## Operation

```
bits(datasize) result;
bits(datasize) operand1 = if n == 31 then SP[] else X[n];
bits(4) nzcvc;

(result, nzcvc) = AddWithCarry(operand1, imm, '0');

PSTATE.<N,Z,C,V> = nzcvc;

X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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## ADDS (shifted register)

Add (shifted register), setting flags, adds a register value and an optionally-shifted register value, and writes the result to the destination register. It updates the condition flags based on the result.

This instruction is used by the alias [CMN \(shifted register\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	1	0	1	0	1	1	shift	0	Rm						imm6						Rn						Rd			
op S																															

### 32-bit (sf == 0)

ADDS <Wd>, <Wn>, <Wm>{, <shift> #<amount>}

### 64-bit (sf == 1)

ADDS <Xd>, <Xn>, <Xm>{, <shift> #<amount>}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;

if shift == '11' then UNDEFINED;
if sf == '0' && imm6<5> == '1' then UNDEFINED;

ShiftType shift_type = DecodeShift(shift);
integer shift_amount = UInt(imm6);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <shift> Is the optional shift type to be applied to the second source operand, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	RESERVED

- <amount> For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.
- For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">CMN (shifted register)</a>	Rd == '11111'

## Operation

```
bits(datasize) result;  
bits(datasize) operand1 = X[n];  
bits(datasize) operand2 = ShiftReg(m, shift_type, shift_amount);  
bits(4) nzcvc;  
  
(result, nzcvc) = AddWithCarry(operand1, operand2, '0');  
  
PSTATE.<N,Z,C,V> = nzcvc;  
  
X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

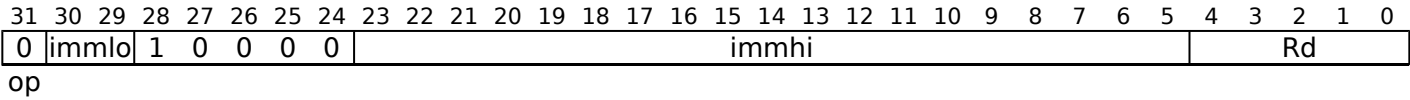
- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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ADR

Form PC-relative address adds an immediate value to the PC value to form a PC-relative address, and writes the result to the destination register.



Literal

```
ADR <Xd>, <label>

integer d = UInt(Rd);
bits(64) imm;

imm = SignExtend(immhi:immlo, 64);
```

Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <label> Is the program label whose address is to be calculated. Its offset from the address of this instruction, in the range +/-1MB, is encoded in "immhi:immlo".

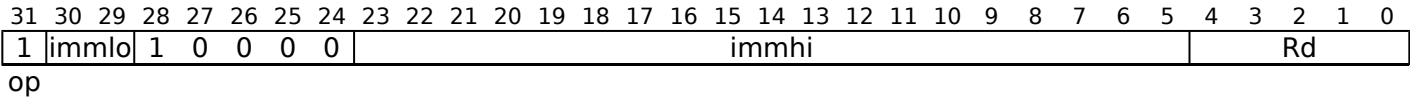
Operation

```
bits(64) base = PC[];
X[d] = base + imm;
```



ADRP

Form PC-relative address to 4KB page adds an immediate value that is shifted left by 12 bits, to the PC value to form a PC-relative address, with the bottom 12 bits masked out, and writes the result to the destination register.



Literal

```
ADRP <Xd>, <label>

integer d = UInt(Rd);
bits(64) imm;

imm = SignExtend(immhi:immlo:Zeros(12), 64);
```

Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <label> Is the program label whose 4KB page address is to be calculated. Its offset from the page address of this instruction, in the range +/-4GB, is encoded as "immhi:immlo" times 4096.

Operation

```
bits(64) base = PC[];

base<11:0> = Zeros(12);

X[d] = base + imm;
```

## AND (immediate)

Bitwise AND (immediate) performs a bitwise AND of a register value and an immediate value, and writes the result to the destination register.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	0	1	0	0	1	0	0	N	immr						imms						Rn						Rd			
opc																															

### 32-bit (sf == 0 && N == 0)

AND <Wd|WSP>, <Wn>, #<imm>

### 64-bit (sf == 1)

AND <Xd|SP>, <Xn>, #<imm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer datasize = if sf == '1' then 64 else 32;
bits(datasize) imm;
if sf == '0' && N != '0' then UNDEFINED;
(imm, -) = DecodeBitMasks(N, imms, immr, TRUE);
```

## Assembler Symbols

- <Wd|WSP> Is the 32-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
- <Xd|SP> Is the 64-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
- <imm> For the 32-bit variant: is the bitmask immediate, encoded in "imms:immr".  
For the 64-bit variant: is the bitmask immediate, encoded in "N:imms:immr".

## Operation

```
bits(datasize) result;
bits(datasize) operand1 = X[n];

result = operand1 AND imm;
if d == 31 then
    SP[] = result;
else
    X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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## AND (shifted register)

Bitwise AND (shifted register) performs a bitwise AND of a register value and an optionally-shifted register value, and writes the result to the destination register.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0						
sf	0	0	0	1	0	1	0	shift	0	Rm						imm6						Rn						Rd									
opc										N																											

### 32-bit (sf == 0)

AND <Wd>, <Wn>, <Wm>{, <shift> #<amount>}

### 64-bit (sf == 1)

AND <Xd>, <Xn>, <Xm>{, <shift> #<amount>}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
if sf == '0' && imm6<5> == '1' then UNDEFINED;

ShiftType shift_type = DecodeShift(shift);
integer shift_amount = UInt(imm6);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <shift> Is the optional shift to be applied to the final source, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	ROR

- <amount> For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.  
For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field,

## Operation

```
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = ShiftReg(m, shift_type, shift_amount);

result = operand1 AND operand2;
X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
  - The execution time of this instruction is independent of:

- The values of the data supplied in any of its registers.
- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

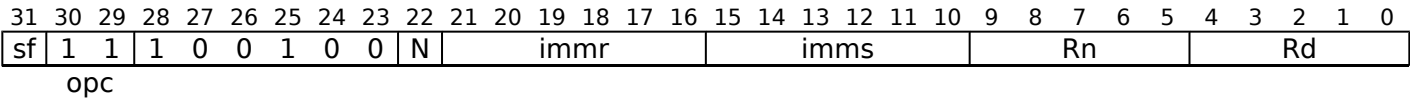
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# ANDS (immediate)

Bitwise AND (immediate), setting flags, performs a bitwise AND of a register value and an immediate value, and writes the result to the destination register. It updates the condition flags based on the result.

This instruction is used by the alias [TST \(immediate\)](#).



## 32-bit (sf == 0 && N == 0)

ANDS <Wd>, <Wn>, #<imm>

## 64-bit (sf == 1)

ANDS <Xd>, <Xn>, #<imm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer datasize = if sf == '1' then 64 else 32;

bits(datasize) imm;
if sf == '0' && N != '0' then UNDEFINED;
(imm, -) = DecodeBitMasks(N, imms, immr, TRUE);
```

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
<imm>	For the 32-bit variant: is the bitmask immediate, encoded in "imms:immr". For the 64-bit variant: is the bitmask immediate, encoded in "N:imms:immr".

## Alias Conditions

Alias	Is preferred when
<a href="#">TST (immediate)</a>	Rd == '11111'

## Operation

```
bits(datasize) result;
bits(datasize) operand1 = X[n];

result = operand1 AND imm;
PSTATE.<N,Z,C,V> = result<datasize-1>:IsZeroBit(result):'00';

X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:

- The values of the data supplied in any of its registers.
- The values of the NZCV flags.

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## ANDS (shifted register)

Bitwise AND (shifted register), setting flags, performs a bitwise AND of a register value and an optionally-shifted register value, and writes the result to the destination register. It updates the condition flags based on the result.

This instruction is used by the alias [TST \(shifted register\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	1	1	0	1	0	1	0	shift	0	Rm						imm6						Rn						Rd			
opc								N																							

### 32-bit (sf == 0)

ANDS <Wd>, <Wn>, <Wm>{, <shift> #<amount>}

### 64-bit (sf == 1)

ANDS <Xd>, <Xn>, <Xm>{, <shift> #<amount>}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;

if sf == '0' && imm6<5> == '1' then UNDEFINED;

ShiftType shift_type = DecodeShift(shift);
integer shift_amount = UInt(imm6);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <shift> Is the optional shift to be applied to the final source, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	ROR

- <amount> For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.  
For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field,

## Alias Conditions

Alias	Is preferred when
<a href="#">TST (shifted register)</a>	Rd == '11111'

## Operation

```
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = ShiftReg(m, shift_type, shift_amount);

result = operand1 AND operand2;
PSTATE.<N,Z,C,V> = result<datasize-1>:IsZeroBit(result):'00';

X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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## ASR (register)

Arithmetic Shift Right (register) shifts a register value right by a variable number of bits, shifting in copies of its sign bit, and writes the result to the destination register. The remainder obtained by dividing the second source register by the data size defines the number of bits by which the first source register is right-shifted.

This is an alias of [ASRV](#). This means:

- The encodings in this description are named to match the encodings of [ASRV](#).
- The description of [ASRV](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0						
sf	0	0	1	1	0	1	0	1	1	0	Rm					0	0	1	0	1	0	Rn					Rd										
																					op2																

### 32-bit (sf == 0)

ASR <Wd>, <Wn>, <Wm>

is equivalent to

[ASRV](#) <Wd>, <Wn>, <Wm>

and is always the preferred disassembly.

### 64-bit (sf == 1)

ASR <Xd>, <Xn>, <Xm>

is equivalent to

[ASRV](#) <Xd>, <Xn>, <Xm>

and is always the preferred disassembly.

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Wm>	Is the 32-bit name of the second general-purpose source register holding a shift amount from 0 to 31 in its bottom 5 bits, encoded in the "Rm" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the second general-purpose source register holding a shift amount from 0 to 63 in its bottom 6 bits, encoded in the "Rm" field.

## Operation

The description of [ASRV](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.



## ASR (immediate)

Arithmetic Shift Right (immediate) shifts a register value right by an immediate number of bits, shifting in copies of the sign bit in the upper bits and zeros in the lower bits, and writes the result to the destination register.

This is an alias of [SBFM](#). This means:

- The encodings in this description are named to match the encodings of [SBFM](#).
- The description of [SBFM](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
sf	0	0	1	0	0	1	1	0	N	immr						x	1	1	1	1	1	Rn						Rd					
opc										imms																							

### 32-bit (sf == 0 && N == 0 && imms == 011111)

ASR <Wd>, <Wn>, #<shift>

is equivalent to

[SBFM](#) <Wd>, <Wn>, #<shift>, #31

and is always the preferred disassembly.

### 64-bit (sf == 1 && N == 1 && imms == 111111)

ASR <Xd>, <Xn>, #<shift>

is equivalent to

[SBFM](#) <Xd>, <Xn>, #<shift>, #63

and is always the preferred disassembly.

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
<shift>	For the 32-bit variant: is the shift amount, in the range 0 to 31, encoded in the "immr" field. For the 64-bit variant: is the shift amount, in the range 0 to 63, encoded in the "immr" field.

## Operation

The description of [SBFM](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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## ASRV

Arithmetic Shift Right Variable shifts a register value right by a variable number of bits, shifting in copies of its sign bit, and writes the result to the destination register. The remainder obtained by dividing the second source register by the data size defines the number of bits by which the first source register is right-shifted.

This instruction is used by the alias [ASRV \(register\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	0	1	1	0	1	0	1	1	0	Rm					0	0	1	0	1	0	Rn					Rd				
																										op2					

### 32-bit (sf == 0)

ASRV <Wd>, <Wn>, <Wm>

### 64-bit (sf == 1)

ASRV <Xd>, <Xn>, <Xm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
ShiftType shift_type = DecodeShift(op2);
```

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Wm>	Is the 32-bit name of the second general-purpose source register holding a shift amount from 0 to 31 in its bottom 5 bits, encoded in the "Rm" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the second general-purpose source register holding a shift amount from 0 to 63 in its bottom 6 bits, encoded in the "Rm" field.

## Operation

```
bits(datasize) result;
bits(datasize) operand2 = X[m];

result = ShiftReg(n, shift_type, UInt(operand2) MOD datasize);
X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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AT

Address Translate. For more information, see *op0==0b01, cache maintenance, TLB maintenance, and address translation instructions*.

This is an alias of [SYS](#). This means:

- The encodings in this description are named to match the encodings of [SYS](#).
- The description of [SYS](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	1	op1			0	1	1	1	1	0	0	x	op2			Rt				
L											CRn				CRm																

System

AT [<at\\_op>](#), [<Xt>](#)

is equivalent to

[SYS](#) [#<op1>](#), C7, [<Cm>](#), [#<op2>](#), [<Xt>](#)

and is the preferred disassembly when `SysOp(op1, '0111', CRm, op2) == Sys_AT`.

Assembler Symbols

[<at\\_op>](#) Is an AT instruction name, as listed for the AT system instruction group, encoded in "op1:CRm<0>:op2":

op1	CRm<0>	op2	<at_op>	Architectural Feature
000	0	000	S1E1R	-
000	0	001	S1E1W	-
000	0	010	S1E0R	-
000	0	011	S1E0W	-
000	1	000	S1E1RP	ARMv8.2-ATS1E1
000	1	001	S1E1WP	ARMv8.2-ATS1E1
100	0	000	S1E2R	-
100	0	001	S1E2W	-
100	0	100	S12E1R	-
100	0	101	S12E1W	-
100	0	110	S12E0R	-
100	0	111	S12E0W	-
110	0	000	S1E3R	-
110	0	001	S1E3W	-

[<op1>](#) Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the "op1" field.

[<Cm>](#) Is a name 'Cm', with 'm' in the range 0 to 15, encoded in the "CRm" field.

[<op2>](#) Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the "op2" field.

[<Xt>](#) Is the 64-bit name of the general-purpose source register, encoded in the "Rt" field.

Operation

The description of [SYS](#) gives the operational pseudocode for this instruction.

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# AUTDA, AUTDZA

Authenticate Data address, using key A. This instruction authenticates a data address, using a modifier and key A. The address is in the general-purpose register that is specified by <Xd>. The modifier is:

- In the general-purpose register or stack pointer that is specified by <Xn|SP> for AUTDA.
- The value zero, for AUTDZA.

If the authentication passes, the upper bits of the address are restored to enable subsequent use of the address. If the authentication fails, the upper bits are corrupted and any subsequent use of the address results in a Translation fault.

## Integer (Armv8.3)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	1	0	1	1	0	0	0	0	1	0	0	Z	1	1	0	Rn						Rd				

### AUTDA (Z == 0)

AUTDA <Xd>, <Xn|SP>

### AUTDZA (Z == 1 && Rn == 11111)

AUTDZA <Xd>

```
boolean source_is_sp = FALSE;
integer d = UInt(Rd);
integer n = UInt(Rn);

if !HavePACExt() then
    UNDEFINED;

if Z == '0' then // AUTDA
    if n == 31 then source_is_sp = TRUE;
else // AUTDZA
    if n != 31 then UNDEFINED;
```

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn|SP> Is the 64-bit name of the general-purpose source register or stack pointer, encoded in the "Rn" field.

## Operation

```
if HavePACExt() then
    if source_is_sp then
        X[d] = AuthDA(X[d], SP[], FALSE);
    else
        X[d] = AuthDA(X[d], X[n], FALSE);
```

# AUTDB, AUTDZB

Authenticate Data address, using key B. This instruction authenticates a data address, using a modifier and key B. The address is in the general-purpose register that is specified by <Xd>. The modifier is:

- In the general-purpose register or stack pointer that is specified by <Xn|SP> for AUTDB.
- The value zero, for AUTDZB.

If the authentication passes, the upper bits of the address are restored to enable subsequent use of the address. If the authentication fails, the upper bits are corrupted and any subsequent use of the address results in a Translation fault.

## Integer (Armv8.3)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	1	0	1	1	0	0	0	0	1	0	0	Z	1	1	1	Rn						Rd				

### AUTDB (Z == 0)

AUTDB <Xd>, <Xn|SP>

### AUTDZB (Z == 1 && Rn == 11111)

AUTDZB <Xd>

```
boolean source_is_sp = FALSE;
integer d = UInt(Rd);
integer n = UInt(Rn);

if !HavePACExt() then
    UNDEFINED;

if Z == '0' then // AUTDB
    if n == 31 then source_is_sp = TRUE;
else // AUTDZB
    if n != 31 then UNDEFINED;
```

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn|SP> Is the 64-bit name of the general-purpose source register or stack pointer, encoded in the "Rn" field.

## Operation

```
if HavePACExt() then
    if source_is_sp then
        X[d] = AuthDB(X[d], SP[], FALSE);
    else
        X[d] = AuthDB(X[d], X[n], FALSE);
```

# AUTIA, AUTIA1716, AUTIASP, AUTIAZ, AUTIZA

Authenticate Instruction address, using key A. This instruction authenticates an instruction address, using a modifier and key A.

The address is:

- In the general-purpose register that is specified by <Xd> for AUTIA and AUTIZA.
- In X17, for AUTIA1716.
- In X30, for AUTIASP and AUTIAZ.

The modifier is:

- In the general-purpose register or stack pointer that is specified by <Xn|SP> for AUTIA.
- The value zero, for AUTIZA and AUTIAZ.
- In X16, for AUTIA1716.
- In SP, for AUTIASP.

If the authentication passes, the upper bits of the address are restored to enable subsequent use of the address. If the authentication fails, the upper bits are corrupted and any subsequent use of the address results in a Translation fault.

It has encodings from 2 classes: [Integer](#) and [System](#)

## Integer (Armv8.3)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	1	0	1	1	0	0	0	0	0	1	0	0	Z	1	0	0	Rn				Rd					

### AUTIA (Z == 0)

AUTIA <Xd>, <Xn|SP>

### AUTIZA (Z == 1 && Rn == 11111)

AUTIZA <Xd>

```
boolean source_is_sp = FALSE;
integer d = UInt(Rd);
integer n = UInt(Rn);

if !HavePACExt() then
    UNDEFINED;

if Z == '0' then // AUTIA
    if n == 31 then source_is_sp = TRUE;
else // AUTIZA
    if n != 31 then UNDEFINED;
```

## System (Armv8.3)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	x	1	1	0	x	1	1	1	1	1
												CRm				op2															



## AUTIA1716 (CRm == 0001 && op2 == 100)

AUTIA1716

## AUTIASP (CRm == 0011 && op2 == 101)

AUTIASP

## AUTIAZ (CRm == 0011 && op2 == 100)

AUTIAZ

```
integer d;  
integer n;  
boolean source_is_sp = FALSE;  
  
case CRm:op2 of  
  when '0011 100'    // AUTIAZ  
    d = 30;  
    n = 31;  
  when '0011 101'    // AUTIASP  
    d = 30;  
    source_is_sp = TRUE;  
  when '0001 100'    // AUTIA1716  
    d = 17;  
    n = 16;  
  when '0001 000' SEE "PACIA";  
  when '0001 010' SEE "PACIB";  
  when '0001 110' SEE "AUTIB";  
  when '0011 00x' SEE "PACIA";  
  when '0011 01x' SEE "PACIB";  
  when '0011 11x' SEE "AUTIB";  
  when '0000 111' SEE "XPACLRI";  
  otherwise SEE "HINT";
```

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn|SP> Is the 64-bit name of the general-purpose source register or stack pointer, encoded in the "Rn" field.

## Operation

```
if HavePACExt() then  
  if source_is_sp then  
    X[d] = AuthIA(X[d], SP[], FALSE);  
  else  
    X[d] = AuthIA(X[d], X[n], FALSE);
```

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# AUTIB, AUTIB1716, AUTIBSP, AUTIBZ, AUTIZB

Authenticate Instruction address, using key B. This instruction authenticates an instruction address, using a modifier and key B.

The address is:

- In the general-purpose register that is specified by <Xd> for AUTIB and AUTIZB.
- In X17, for AUTIB1716.
- In X30, for AUTIBSP and AUTIBZ.

The modifier is:

- In the general-purpose register or stack pointer that is specified by <Xn|SP> for AUTIB.
- The value zero, for AUTIZB and AUTIBZ.
- In X16, for AUTIB1716.
- In SP, for AUTIBSP.

If the authentication passes, the upper bits of the address are restored to enable subsequent use of the address. If the authentication fails, the upper bits are corrupted and any subsequent use of the address results in a Translation fault.

It has encodings from 2 classes: [Integer](#) and [System](#)

## Integer (Armv8.3)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	1	0	1	1	0	0	0	0	0	1	0	0	Z	1	0	1	Rn				Rd					

### AUTIB (Z == 0)

AUTIB <Xd>, <Xn|SP>

### AUTIZB (Z == 1 && Rn == 11111)

AUTIZB <Xd>

```
boolean source_is_sp = FALSE;
integer d = UInt(Rd);
integer n = UInt(Rn);

if !HavePACExt() then
    UNDEFINED;

if Z == '0' then // AUTIB
    if n == 31 then source_is_sp = TRUE;
else // AUTIZB
    if n != 31 then UNDEFINED;
```

## System (Armv8.3)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	x	1	1	1	x	1	1	1	1	1
												CRm				op2															

## AUTIB1716 (CRm == 0001 && op2 == 110)

AUTIB1716

## AUTIBSP (CRm == 0011 && op2 == 111)

AUTIBSP

## AUTIBZ (CRm == 0011 && op2 == 110)

AUTIBZ

```
integer d;  
integer n;  
boolean source_is_sp = FALSE;  
  
case CRm:op2 of  
  when '0011 110'    // AUTIBZ  
    d = 30;  
    n = 31;  
  when '0011 111'    // AUTIBSP  
    d = 30;  
    source_is_sp = TRUE;  
  when '0001 110'    // AUTIB1716  
    d = 17;  
    n = 16;  
  when '0001 000' SEE "PACIA";  
  when '0001 010' SEE "PACIB";  
  when '0001 100' SEE "AUTIA";  
  when '0011 00x' SEE "PACIA";  
  when '0011 01x' SEE "PACIB";  
  when '0011 10x' SEE "AUTIA";  
  when '0000 111' SEE "XPACLRI";  
  otherwise SEE "HINT";
```

## Assembler Symbols

<Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.

<Xn|SP> Is the 64-bit name of the general-purpose source register or stack pointer, encoded in the "Rn" field.

## Operation

```
if HavePACExt() then  
  if source_is_sp then  
    X[d] = AuthIB(X[d], SP[], FALSE);  
  else  
    X[d] = AuthIB(X[d], X[n], FALSE);
```

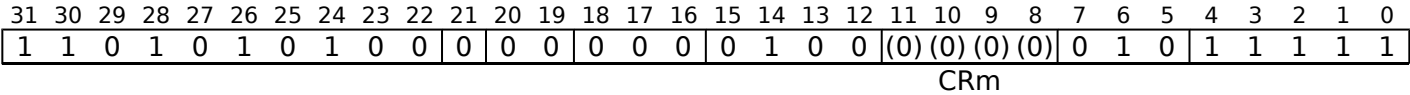
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AXFLAG

Convert floating-point condition flags from Arm to external format. This instruction converts the state of the PSTATE.{N,Z,C,V} flags from a form representing the result of an Arm floating-point scalar compare instruction to an alternative representation required by some software.

System  
(Armv8.5)



System

AXFLAG

```
if !HaveFlagFormatExt() then UNDEFINED;
```

Operation

```
bit Z = PSTATE.Z OR PSTATE.V;
bit C = PSTATE.C AND NOT(PSTATE.V);

PSTATE.N = '0';
PSTATE.Z = Z;
PSTATE.C = C;
PSTATE.V = '0';
```

# B.cond

Branch conditionally to a label at a PC-relative offset, with a hint that this is not a subroutine call or return.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	0	1	0	0	imm19											0	cond											

## 19-bit signed PC-relative branch offset

```
B.<cond> <label>

bits(64) offset = SignExtend(imm19:'00', 64);
```

## Assembler Symbols

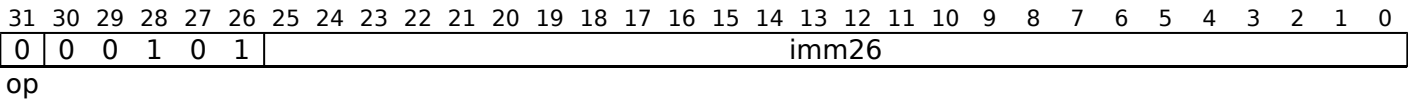
- <cond> Is one of the standard conditions, encoded in the "cond" field in the standard way.
- <label> Is the program label to be conditionally branched to. Its offset from the address of this instruction, in the range +/-1MB, is encoded as "imm19" times 4.

## Operation

```
if ConditionHolds(cond) then
    BranchTo(PC[] + offset, BranchType_DIR);
```

B

Branch causes an unconditional branch to a label at a PC-relative offset, with a hint that this is not a subroutine call or return.



26-bit signed PC-relative branch offset

```
B <label>  
  
bits(64) offset = SignExtend(imm26:'00', 64);
```

Assembler Symbols

<label> Is the program label to be unconditionally branched to. Its offset from the address of this instruction, in the range +/-128MB, is encoded as "imm26" times 4.

Operation

```
BranchTo(PC[] + offset, BranchType_DIR);
```

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# BFC

Bitfield Clear sets a bitfield of <width> bits at bit position <lsb> of the destination register to zero, leaving the other destination bits unchanged.

This is an alias of [BFM](#). This means:

- The encodings in this description are named to match the encodings of [BFM](#).
- The description of [BFM](#) gives the operational pseudocode for this instruction.

## Leaving other bits unchanged (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
sf	0	1	1	0	0	1	1	0	N	immr						imms						1	1	1	1	1	Rd					
opc										Rn																						

### 32-bit (sf == 0 && N == 0)

BFC <Wd>, #<lsb>, #<width>

is equivalent to

[BFM](#) <Wd>, WZR, #(-<lsb> MOD 32), #(<width>-1)

and is the preferred disassembly when `UInt(imms) < UInt(immr)`.

### 64-bit (sf == 1 && N == 1)

BFC <Xd>, #<lsb>, #<width>

is equivalent to

[BFM](#) <Xd>, XZR, #(-<lsb> MOD 64), #(<width>-1)

and is the preferred disassembly when `UInt(imms) < UInt(immr)`.

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <lsb> For the 32-bit variant: is the bit number of the lsb of the destination bitfield, in the range 0 to 31.  
For the 64-bit variant: is the bit number of the lsb of the destination bitfield, in the range 0 to 63.
- <width> For the 32-bit variant: is the width of the bitfield, in the range 1 to 32-<lsb>.  
For the 64-bit variant: is the width of the bitfield, in the range 1 to 64-<lsb>.

## Operation

The description of [BFM](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.





## BFI

Bitfield Insert copies a bitfield of <width> bits from the least significant bits of the source register to bit position <lsb> of the destination register, leaving the other destination bits unchanged.

This is an alias of [BFM](#). This means:

- The encodings in this description are named to match the encodings of [BFM](#).
- The description of [BFM](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	1	1	0	0	1	1	0	N	immr						imms						!= 1111				Rd					
opc										Rn																					

### 32-bit (sf == 0 && N == 0)

BFI <Wd>, <Wn>, #<lsb>, #<width>

is equivalent to

BFM <Wd>, <Wn>, #(-<lsb> MOD 32), #(<width>-1)

and is the preferred disassembly when `UInt(imms) < UInt(immr)`.

### 64-bit (sf == 1 && N == 1)

BFI <Xd>, <Xn>, #<lsb>, #<width>

is equivalent to

BFM <Xd>, <Xn>, #(-<lsb> MOD 64), #(<width>-1)

and is the preferred disassembly when `UInt(imms) < UInt(immr)`.

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
<lsb>	For the 32-bit variant: is the bit number of the lsb of the destination bitfield, in the range 0 to 31. For the 64-bit variant: is the bit number of the lsb of the destination bitfield, in the range 0 to 63.
<width>	For the 32-bit variant: is the width of the bitfield, in the range 1 to 32-<lsb>. For the 64-bit variant: is the width of the bitfield, in the range 1 to 64-<lsb>.

## Operation

The description of [BFM](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.



BFM

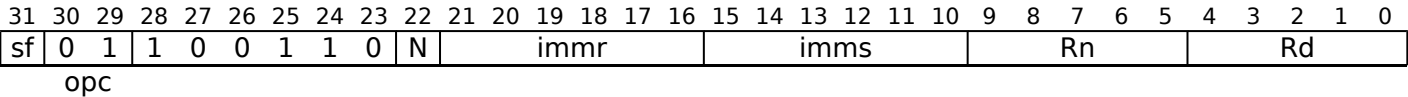
Bitfield Move is usually accessed via one of its aliases, which are always preferred for disassembly.

If `<imms>` is greater than or equal to `<immr>`, this copies a bitfield of (`<imms>-<immr>+1`) bits starting from bit position `<immr>` in the source register to the least significant bits of the destination register.

If `<imms>` is less than `<immr>`, this copies a bitfield of (`<imms>+1`) bits from the least significant bits of the source register to bit position (`regsize-<immr>`) of the destination register, where `regsize` is the destination register size of 32 or 64 bits.

In both cases the other bits of the destination register remain unchanged.

This instruction is used by the aliases [BFC](#), [BFI](#), and [BFXIL](#).



32-bit (sf == 0 && N == 0)

BFM `<Wd>`, `<Wn>`, `#<immr>`, `#<imms>`

64-bit (sf == 1 && N == 1)

BFM `<Xd>`, `<Xn>`, `#<immr>`, `#<imms>`

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer datasize = if sf == '1' then 64 else 32;

integer R;
bits(datasize) wmask;
bits(datasize) tmask;

if sf == '1' && N != '1' then UNDEFINED;
if sf == '0' && (N != '0' || immr<5> != '0' || imms<5> != '0') then UNDEFINED;

R = UInt(immr);
(wmask, tmask) = DecodeBitMasks(N, imms, immr, FALSE);
```

Assembler Symbols

- `<Wd>` Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- `<Wn>` Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
- `<Xd>` Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- `<Xn>` Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
- `<immr>` For the 32-bit variant: is the right rotate amount, in the range 0 to 31, encoded in the "immr" field.  
For the 64-bit variant: is the right rotate amount, in the range 0 to 63, encoded in the "immr" field.
- `<imms>` For the 32-bit variant: is the leftmost bit number to be moved from the source, in the range 0 to 31, encoded in the "imms" field.  
For the 64-bit variant: is the leftmost bit number to be moved from the source, in the range 0 to 63, encoded in the "imms" field.

Alias Conditions

Alias	Is preferred when
<a href="#">BFC</a>	<code>Rn == '11111' &amp;&amp; UInt(imms) &lt; UInt(immr)</code>
<a href="#">BFI</a>	<code>Rn != '11111' &amp;&amp; UInt(imms) &lt; UInt(immr)</code>
<a href="#">BFXIL</a>	<code>UInt(imms) &gt;= UInt(immr)</code>

## Operation

```
bits(datasize) dst = X[d];
bits(datasize) src = X[n];

// perform bitfield move on low bits
bits(datasize) bot = (dst AND NOT(wmask)) OR (ROR(src, R) AND wmask);

// combine extension bits and result bits
X[d] = (dst AND NOT(tmask)) OR (bot AND tmask);
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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## BFXIL

Bitfield Extract and Insert Low copies a bitfield of <width> bits starting from bit position <lsb> in the source register to the least significant bits of the destination register, leaving the other destination bits unchanged.

This is an alias of [BFM](#). This means:

- The encodings in this description are named to match the encodings of [BFM](#).
- The description of [BFM](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	1	1	0	0	1	1	0	N	immr						imms						Rn						Rd			
opc																															

### 32-bit (sf == 0 && N == 0)

BFXIL <Wd>, <Wn>, #<lsb>, #<width>

is equivalent to

BFM <Wd>, <Wn>, #<lsb>, #(<lsb>+<width>-1)

and is the preferred disassembly when `UInt(imms) >= UInt(immr)`.

### 64-bit (sf == 1 && N == 1)

BFXIL <Xd>, <Xn>, #<lsb>, #<width>

is equivalent to

BFM <Xd>, <Xn>, #<lsb>, #(<lsb>+<width>-1)

and is the preferred disassembly when `UInt(imms) >= UInt(immr)`.

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
<lsb>	For the 32-bit variant: is the bit number of the lsb of the source bitfield, in the range 0 to 31. For the 64-bit variant: is the bit number of the lsb of the source bitfield, in the range 0 to 63.
<width>	For the 32-bit variant: is the width of the bitfield, in the range 1 to 32-<lsb>. For the 64-bit variant: is the width of the bitfield, in the range 1 to 64-<lsb>.

## Operation

The description of [BFM](#) gives the operational pseudocode for this instruction.

## Operational information

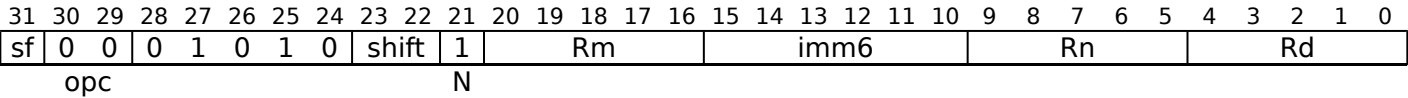
If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.



## BIC (shifted register)

Bitwise Bit Clear (shifted register) performs a bitwise AND of a register value and the complement of an optionally-shifted register value, and writes the result to the destination register.



### 32-bit (sf == 0)

```
BIC <Wd>, <Wn>, <Wm>{, <shift> #<amount>}
```

### 64-bit (sf == 1)

```
BIC <Xd>, <Xn>, <Xm>{, <shift> #<amount>}
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
if sf == '0' && imm6<5> == '1' then UNDEFINED;

ShiftType shift_type = DecodeShift(shift);
integer shift_amount = UInt(imm6);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <shift> Is the optional shift to be applied to the final source, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	ROR

- <amount> For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.  
For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field,

## Operation

```
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = ShiftReg(m, shift_type, shift_amount);

operand2 = NOT(operand2);

result = operand1 AND operand2;
X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

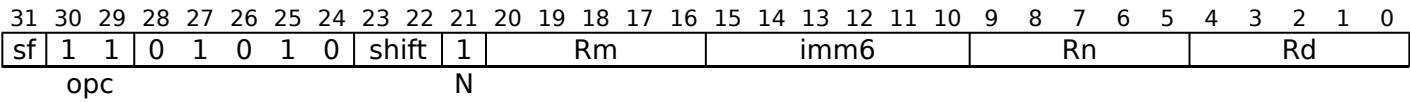
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## BICS (shifted register)

Bitwise Bit Clear (shifted register), setting flags, performs a bitwise AND of a register value and the complement of an optionally-shifted register value, and writes the result to the destination register. It updates the condition flags based on the result.



### 32-bit (sf == 0)

```
BICS <Wd>, <Wn>, <Wm>{, <shift> #<amount>}
```

### 64-bit (sf == 1)

```
BICS <Xd>, <Xn>, <Xm>{, <shift> #<amount>}
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;

if sf == '0' && imm6<5> == '1' then UNDEFINED;

ShiftType shift_type = DecodeShift(shift);
integer shift_amount = UInt(imm6);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <shift> Is the optional shift to be applied to the final source, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	ROR

- <amount> For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.  
For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field,

## Operation

```
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = ShiftReg(m, shift_type, shift_amount);

operand2 = NOT(operand2);

result = operand1 AND operand2;
PSTATE.<N,Z,C,V> = result<datasize-1>:IsZeroBit(result):'00';

X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

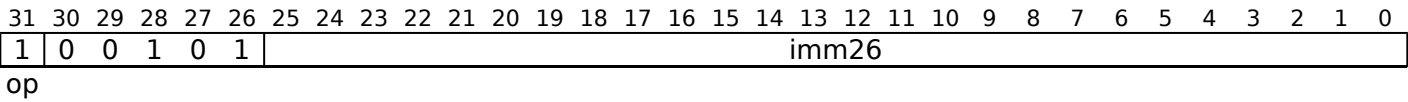
- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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BL

Branch with Link branches to a PC-relative offset, setting the register X30 to PC+4. It provides a hint that this is a subroutine call.



26-bit signed PC-relative branch offset

```
BL <label>

bits(64) offset = SignExtend(imm26:'00', 64);
```

Assembler Symbols

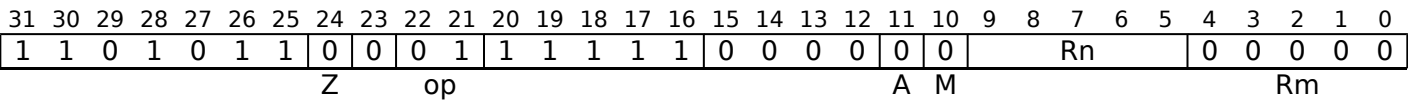
<label> Is the program label to be unconditionally branched to. Its offset from the address of this instruction, in the range +/-128MB, is encoded as "imm26" times 4.

Operation

```
X[30] = PC[] + 4;
BranchTo(PC[] + offset, BranchType_DIRCALL);
```

# BLR

Branch with Link to Register calls a subroutine at an address in a register, setting register X30 to PC+4.



## Integer

BLR <Xn>

```
integer n = UInt(Rn);
```

## Assembler Symbols

<Xn> Is the 64-bit name of the general-purpose register holding the address to be branched to, encoded in the "Rn" field.

## Operation

```
bits(64) target = X[n];
X[30] = PC[] + 4;
BranchTo(target, BranchType_INDCALL);
```

# BLRAA, BLRAAZ, BLRAB, BLRABZ

Branch with Link to Register, with pointer authentication. This instruction authenticates the address in the general-purpose register that is specified by <Xn>, using a modifier and the specified key, and calls a subroutine at the authenticated address, setting register X30 to PC+4.

The modifier is:

- In the general-purpose register or stack pointer that is specified by <Xm|SP> for BLRAA and BLRAB.
- The value zero, for BLRAAZ and BLRABZ.

Key A is used for BLRAA and BLRAAZ, and key B is used for BLRAB and BLRABZ.

If the authentication passes, the PE continues execution at the target of the branch. If the authentication fails, a Translation fault is generated.

The authenticated address is not written back to the general-purpose register.

## Integer (Armv8.3)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	1	Z	0	0	1	1	1	1	1	0	0	0	0	1	M	Rn				Rm						
op																A															

Key A, zero modifier (Z == 0 && M == 0 && Rm == 11111)

BLRAAZ <Xn>

Key A, register modifier (Z == 1 && M == 0)

BLRAA <Xn>, <Xm|SP>

Key B, zero modifier (Z == 0 && M == 1 && Rm == 11111)

BLRABZ <Xn>

Key B, register modifier (Z == 1 && M == 1)

BLRAB <Xn>, <Xm|SP>

```
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean use_key_a = (M == '0');
boolean source_is_sp = ((Z == '1') && (m == 31));

if !HavePACExt() then
    UNDEFINED;

if Z == '0' && m != 31 then
    UNDEFINED;
```

## Assembler Symbols

- <Xn>
- Is the 64-bit name of the general-purpose register holding the address to be branched to, encoded in the "Rn" field.
- <Xm|SP>
- Is the 64-bit name of the general-purpose source register or stack pointer holding the modifier, encoded in the "Rm" field.

## Operation

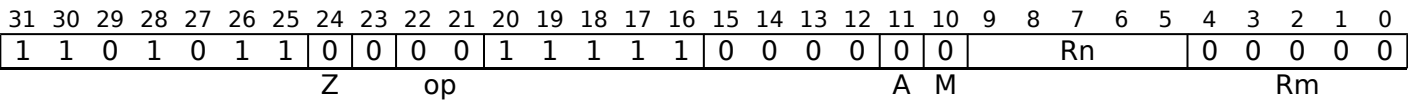
```
bits(64) target = X[n];  
bits(64) modifier = if source_is_sp then SP[] else X[m];  
if use_key_a then  
    target = AuthIA(target, modifier, TRUE);  
else  
    target = AuthIB(target, modifier, TRUE);  
X[30] = PC[] + 4;  
BranchTo(target, BranchType_INDCALL);
```

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# BR

Branch to Register branches unconditionally to an address in a register, with a hint that this is not a subroutine return.



## Integer

```
BR <Xn>

integer n = UInt(Rn);
```

## Assembler Symbols

<Xn> Is the 64-bit name of the general-purpose register holding the address to be branched to, encoded in the "Rn" field.

## Operation

```
bits(64) target = X[n];
BranchTo(target, BranchType_INDIR);
```

# BRAA, BRAAZ, BRAB, BRABZ

Branch to Register, with pointer authentication. This instruction authenticates the address in the general-purpose register that is specified by <Xn>, using a modifier and the specified key, and branches to the authenticated address. The modifier is:

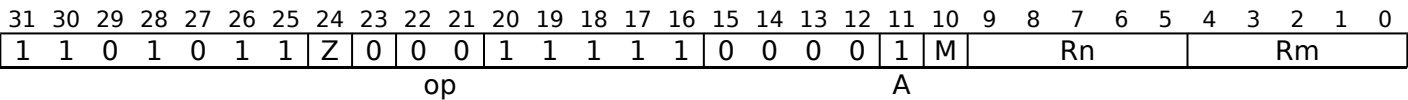
- In the general-purpose register or stack pointer that is specified by <Xm|SP> for BRAA and BRAB.
- The value zero, for BRAAZ and BRABZ.

Key A is used for BRAA and BRAAZ, and key B is used for BRAB and BRABZ.

If the authentication passes, the PE continues execution at the target of the branch. If the authentication fails, a Translation fault is generated.

The authenticated address is not written back to the general-purpose register.

## Integer (Armv8.3)



Key A, zero modifier (Z == 0 && M == 0 && Rm == 11111)

BRAAZ <Xn>

Key A, register modifier (Z == 1 && M == 0)

BRAA <Xn>, <Xm|SP>

Key B, zero modifier (Z == 0 && M == 1 && Rm == 11111)

BRABZ <Xn>

Key B, register modifier (Z == 1 && M == 1)

BRAB <Xn>, <Xm|SP>

```
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean use_key_a = (M == '0');
boolean source_is_sp = ((Z == '1') && (m == 31));

if !HavePACExt() then
    UNDEFINED;

if Z == '0' && m != 31 then
    UNDEFINED;
```

## Assembler Symbols

- <Xn> Is the 64-bit name of the general-purpose register holding the address to be branched to, encoded in the "Rn" field.
- <Xm|SP> Is the 64-bit name of the general-purpose source register or stack pointer holding the modifier, encoded in the "Rm" field.



## Operation

```
bits(64) target = X[n];  
bits(64) modifier = if source_is_sp then SP[] else X[m];  
if use_key_a then  
    target = AuthIA(target, modifier, TRUE);  
else  
    target = AuthIB(target, modifier, TRUE);  
BranchTo(target, BranchType_INDIR);
```

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# BRK

Breakpoint instruction. A BRK instruction generates a Breakpoint Instruction exception. The PE records the exception in *ESR\_ELx*, using the EC value 0x3c, and captures the value of the immediate argument in *ESR\_ELx*.ISS.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	0	0	0	1	imm16																0	0	0	0	0

## System

```
BRK #<imm>

if HaveBTIExt() then
    SetBTypeCompatible(TRUE);
```

## Assembler Symbols

<imm> Is a 16-bit unsigned immediate, in the range 0 to 65535, encoded in the "imm16" field.

## Operation

```
AArch64.SoftwareBreakpoint(imm16);
```

BTI

Branch Target Identification. A BTI instruction is used to guard against the execution of instructions which are not the intended target of a branch.

Outside of a guarded memory region, a BTI instruction executes as a NOP. Within a guarded memory region while *PSTATE*.BTTYPE != 0b00, a BTI instruction compatible with the current value of *PSTATE*.BTTYPE will not generate a Branch Target Exception and will allow execution of subsequent instructions within the memory region.

The operand <targets> passed to a BTI instruction determines the values of *PSTATE*.BTTYPE which the BTI instruction is compatible with.

Within a guarded memory region, while *PSTATE*.BTTYPE != 0b00, all instructions will generate a Branch Target Exception, other than BRK, BTI, HLT, PACIASP, and PACIBSP, which may not. See the individual instructions for details.

System (Armv8.5)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	1	0	0	x	x	0	1	1	1	1	1				
																					CRm				op2										

System

```
BTI {<targets>}

SystemHintOp op;

if CRm:op2 == '0100 xx0' then
    op = SystemHintOp_BTI;
    // Check branch target compatibility between BTI instruction and PSTATE.BTTYPE
    SetBTypeCompatible(BTypeCompatible_BTI(op2<2:1>));
else
    EndOfInstruction();
```

Assembler Symbols

<targets> Is the type of indirection, encoded in “op2<2:1>”:

op2<2:1>	<targets>
00	(omitted)
01	c
10	j
11	jc



```

case op of
when SystemHintOp\_YIELD
    Hint\_Yield\(\);

when SystemHintOp\_DGH
    Hint\_DGH\(\);

when SystemHintOp\_WFE
    if IsEventRegisterSet\(\) then
        ClearEventRegister\(\);
    else
        trap = FALSE;
        if PSTATE.EL == EL0 then
            // Check for traps described by the OS which may be EL1 or EL2.
            if HaveTWEDEExt\(\) then
                - = SCTLR\[\];
                trap = sctlr.nTWE == '0';
                target_el = EL1;
            else
                AArch64.CheckForWfxTrap\(EL1, TRUE\);

        if !trap && PSTATE.EL IN {EL0, EL1} && EL2Enabled\(\) && !IsInHost\(\) then
            // Check for traps described by the Hypervisor.
            if HaveTWEDEExt\(\) then
                trap = HCR_EL2.TWE == '1';
                target_el = EL2;
            else
                AArch64.CheckForWfxTrap\(EL2, TRUE\);

        if !trap && HaveEL\(EL3\) && PSTATE.EL != EL3 then
            // Check for traps described by the Secure Monitor.
            if HaveTWEDEExt\(\) then
                trap = SCR_EL3.TWE == '1';
                target_el = EL3;
            else
                AArch64.CheckForWfxTrap\(EL3, TRUE\);

        if HaveTWEDEExt\(\) && trap && PSTATE.EL != EL3 then
            (delay_enabled, delay) = WFETrapDelay\(target\_el\); // (If trap delay is enabled, Delay
            if !AArch64.WaitForEventUntilDelay\(delay\_enabled, delay\) then
                // Event did not arrive until delay expired
                AArch64.WFxTrap\(target\_el, TRUE\); // Trap WFE
        else
            WaitForEvent\(\);

when SystemHintOp\_WFI
    if !InterruptPending\(\) then
        if PSTATE.EL == EL0 then
            // Check for traps described by the OS which may be EL1 or EL2.
            AArch64.CheckForWfxTrap\(EL1, FALSE\);
        if PSTATE.EL IN {EL0, EL1} && EL2Enabled\(\) && !IsInHost\(\) then
            // Check for traps described by the Hypervisor.
            AArch64.CheckForWfxTrap\(EL2, FALSE\);
        if HaveEL\(EL3\) && PSTATE.EL != EL3 then
            // Check for traps described by the Secure Monitor.
            AArch64.CheckForWfxTrap\(EL3, FALSE\);
        WaitForInterrupt\(\);

when SystemHintOp\_SEV
    SendEvent\(\);

when SystemHintOp\_SEVL
    SendEventLocal\(\);

when SystemHintOp\_ESB
    if HaveTME\(\) && TSTATE.depth > 0 then
        FailTransaction\(TMFailure\_ERR, FALSE\);
        SynchronizeErrors\(\);
        AArch64.ESB0operation\(\);
    if PSTATE.EL IN {EL0, EL1} && EL2Enabled\(\) then AArch64.vESB0operation\(\);

```

```

    TakeUnmaskedSErrorInterrupts();

when SystemHintOp_PSB
    ProfilingSynchronizationBarrier();

when SystemHintOp_TSB
    TraceSynchronizationBarrier();

when SystemHintOp_CSDB
    ConsumptionOfSpeculativeDataBarrier();

when SystemHintOp_BTI
    SetBTypeNext('00');

otherwise    // do nothing

```

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CAS, CASA, CASAL, CASL

Compare and Swap word or doubleword in memory reads a 32-bit word or 64-bit doubleword from memory, and compares it against the value held in a first register. If the comparison is equal, the value in a second register is written to memory. If the write is performed, the read and write occur atomically such that no other modification of the memory location can take place between the read and write.

- CASA and CASAL load from memory with acquire semantics.
- CASL and CASAL store to memory with release semantics.
- CAS has neither acquire nor release semantics.

For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

The architecture permits that the data read clears any exclusive monitors associated with that location, even if the compare subsequently fails.

If the instruction generates a synchronous Data Abort, the register which is compared and loaded, that is <Ws>, or <Xs>, is restored to the value held in the register before the instruction was executed.

No offset  
(Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	0	0	1	0	0	0	1	L	1	Rs				o0	1	1	1	1	1	Rn				Rt						
size																															

### 32-bit CAS (size == 10 && L == 0 && o0 == 0)

CAS <Ws>, <Wt>, [<Xn|SP>{,#0}]

### 32-bit CASA (size == 10 && L == 1 && o0 == 0)

CASA <Ws>, <Wt>, [<Xn|SP>{,#0}]

### 32-bit CASAL (size == 10 && L == 1 && o0 == 1)

CASAL <Ws>, <Wt>, [<Xn|SP>{,#0}]

### 32-bit CASL (size == 10 && L == 0 && o0 == 1)

CASL <Ws>, <Wt>, [<Xn|SP>{,#0}]

### 64-bit CAS (size == 11 && L == 0 && o0 == 0)

CAS <Xs>, <Xt>, [<Xn|SP>{,#0}]

### 64-bit CASA (size == 11 && L == 1 && o0 == 0)

CASA <Xs>, <Xt>, [<Xn|SP>{,#0}]

### 64-bit CASAL (size == 11 && L == 1 && o0 == 1)

CASAL <Xs>, <Xt>, [<Xn|SP>{,#0}]

### 64-bit CASL (size == 11 && L == 0 && o0 == 1)

CASL <Xs>, <Xt>, [<Xn|SP>{,#0}]

```
if !HaveAtomicExt() then UNDEFINED;

integer n = UInt(Rn);
integer t = UInt(Rt);
integer s = UInt(Rs);

integer datasize = 8 << UInt(size);
integer regsize = if datasize == 64 then 64 else 32;
AccType ldacctype = if L == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if o0 == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

<Ws>	Is the 32-bit name of the general-purpose register to be compared and loaded, encoded in the "Rs" field.
<Wt>	Is the 32-bit name of the general-purpose register to be conditionally stored, encoded in the "Rt" field.
<Xs>	Is the 64-bit name of the general-purpose register to be compared and loaded, encoded in the "Rs" field.
<Xt>	Is the 64-bit name of the general-purpose register to be conditionally stored, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.



## Operation

```
bits(64) address;
bits(datasize) comparevalue;
bits(datasize) newvalue;
bits(datasize) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

comparevalue = X[s];
newvalue = X[t];

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomicCompareAndSwap(address, comparevalue, newvalue, ldacctype, stacctype);
X[s] = ZeroExtend(data, regsize);
```

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# CASB, CASAB, CASALB, CASLB

Compare and Swap byte in memory reads an 8-bit byte from memory, and compares it against the value held in a first register. If the comparison is equal, the value in a second register is written to memory. If the write is performed, the read and write occur atomically such that no other modification of the memory location can take place between the read and write.

- CASAB and CASALB load from memory with acquire semantics.
- CASLB and CASALB store to memory with release semantics.
- CASB has neither acquire nor release semantics.

For more information about memory ordering semantics see [Load-Acquire, Store-Release](#).

For information about memory accesses see [Load/Store addressing modes](#).

The architecture permits that the data read clears any exclusive monitors associated with that location, even if the compare subsequently fails.

If the instruction generates a synchronous Data Abort, the register which is compared and loaded, that is <Ws>, is restored to the values held in the register before the instruction was executed.

## No offset (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	1	0	0	0	1	L	1	Rs				o0	1	1	1	1	1	Rn				Rt						
size																															

### CASAB (L == 1 && o0 == 0)

CASAB <Ws>, <Wt>, [<Xn|SP>{, #0}]

### CASALB (L == 1 && o0 == 1)

CASALB <Ws>, <Wt>, [<Xn|SP>{, #0}]

### CASB (L == 0 && o0 == 0)

CASB <Ws>, <Wt>, [<Xn|SP>{, #0}]

### CASLB (L == 0 && o0 == 1)

CASLB <Ws>, <Wt>, [<Xn|SP>{, #0}]

```
if !HaveAtomicExt() then UNDEFINED;

integer n = UInt(Rn);
integer t = UInt(Rt);
integer s = UInt(Rs);

AccType ldacctype = if L == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if o0 == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register to be compared and loaded, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be conditionally stored, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(8) comparevalue;
bits(8) newvalue;
bits(8) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

comparevalue = X[s];
newvalue = X[t];

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomicCompareAndSwap(address, comparevalue, newvalue, ldacctype, stacctype);
X[s] = ZeroExtend(data, 32);
```

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# CASH, CASA, CASALH, CASLH

Compare and Swap halfword in memory reads a 16-bit halfword from memory, and compares it against the value held in a first register. If the comparison is equal, the value in a second register is written to memory. If the write is performed, the read and write occur atomically such that no other modification of the memory location can take place between the read and write.

- CASA and CASALH load from memory with acquire semantics.
- CASLH and CASALH store to memory with release semantics.
- CAS has neither acquire nor release semantics.

For more information about memory ordering semantics see [Load-Acquire, Store-Release](#).

For information about memory accesses see [Load/Store addressing modes](#).

The architecture permits that the data read clears any exclusive monitors associated with that location, even if the compare subsequently fails.

If the instruction generates a synchronous Data Abort, the register which is compared and loaded, that is <Ws>, is restored to the values held in the register before the instruction was executed.

## No offset (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	1	0	0	0	1	L	1	Rs				o0	1	1	1	1	1	Rn				Rt						
size																															

### CASAH (L == 1 && o0 == 0)

CASAH <Ws>, <Wt>, [<Xn|SP>{, #0}]

### CASALH (L == 1 && o0 == 1)

CASALH <Ws>, <Wt>, [<Xn|SP>{, #0}]

### CASH (L == 0 && o0 == 0)

CASH <Ws>, <Wt>, [<Xn|SP>{, #0}]

### CASLH (L == 0 && o0 == 1)

CASLH <Ws>, <Wt>, [<Xn|SP>{, #0}]

```
if !HaveAtomicExt() then UNDEFINED;

integer n = UInt(Rn);
integer t = UInt(Rt);
integer s = UInt(Rs);

AccType ldacctype = if L == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if o0 == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register to be compared and loaded, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be conditionally stored, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(16) comparevalue;
bits(16) newvalue;
bits(16) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

comparevalue = X[s];
newvalue = X[t];

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomicCompareAndSwap(address, comparevalue, newvalue, ldacctype, stacctype);
X[s] = ZeroExtend(data, 32);
```

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# CASP, CASPA, CASPAL, CASPL

Compare and Swap Pair of words or doublewords in memory reads a pair of 32-bit words or 64-bit doublewords from memory, and compares them against the values held in the first pair of registers. If the comparison is equal, the values in the second pair of registers are written to memory. If the writes are performed, the reads and writes occur atomically such that no other modification of the memory location can take place between the reads and writes.

- CASPA and CASPAL load from memory with acquire semantics.
- CASPL and CASPAL store to memory with release semantics.
- CAS has neither acquire nor release semantics.

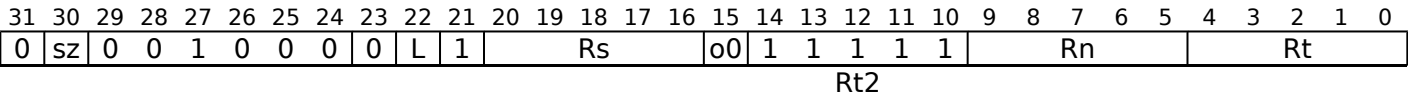
For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

The architecture permits that the data read clears any exclusive monitors associated with that location, even if the compare subsequently fails.

If the instruction generates a synchronous Data Abort, the registers which are compared and loaded, that is <Ws> and <W(s+1)>, or <Xs> and <X(s+1)>, are restored to the values held in the registers before the instruction was executed.

## No offset (Armv8.1)



### 32-bit CASP (sz == 0 && L == 0 && o0 == 0)

CASP <Ws>, <W(s+1)>, <Wt>, <W(t+1)>, [<Xn|SP>{, #0}]

### 32-bit CASPA (sz == 0 && L == 1 && o0 == 0)

CASPA <Ws>, <W(s+1)>, <Wt>, <W(t+1)>, [<Xn|SP>{, #0}]

### 32-bit CASPAL (sz == 0 && L == 1 && o0 == 1)

CASPAL <Ws>, <W(s+1)>, <Wt>, <W(t+1)>, [<Xn|SP>{, #0}]

### 32-bit CASPL (sz == 0 && L == 0 && o0 == 1)

CASPL <Ws>, <W(s+1)>, <Wt>, <W(t+1)>, [<Xn|SP>{, #0}]

### 64-bit CASP (sz == 1 && L == 0 && o0 == 0)

CASP <Xs>, <X(s+1)>, <Xt>, <X(t+1)>, [<Xn|SP>{, #0}]

### 64-bit CASPA (sz == 1 && L == 1 && o0 == 0)

CASPA <Xs>, <X(s+1)>, <Xt>, <X(t+1)>, [<Xn|SP>{, #0}]

### 64-bit CASPAL (sz == 1 && L == 1 && o0 == 1)

CASPAL <Xs>, <X(s+1)>, <Xt>, <X(t+1)>, [<Xn|SP>{, #0}]

### 64-bit CASPL (sz == 1 && L == 0 && o0 == 1)

CASPL <Xs>, <X(s+1)>, <Xt>, <X(t+1)>, [<Xn|SP>{, #0}]

```

if !HaveAtomicExt() then UNDEFINED;
if Rs<0> == '1' then UNDEFINED;
if Rt<0> == '1' then UNDEFINED;

integer n = UInt(Rn);
integer t = UInt(Rt);
integer s = UInt(Rs);

integer datasize = 32 << UInt(sz);
AccType ldacctype = if L == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if o0 == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;

```

## Assembler Symbols

<Ws>	Is the 32-bit name of the first general-purpose register to be compared and loaded, encoded in the "Rs" field. <Ws> must be an even-numbered register.
<W(s+1)>	Is the 32-bit name of the second general-purpose register to be compared and loaded.
<Wt>	Is the 32-bit name of the first general-purpose register to be conditionally stored, encoded in the "Rt" field. <Wt> must be an even-numbered register.
<W(t+1)>	Is the 32-bit name of the second general-purpose register to be conditionally stored.
<Xs>	Is the 64-bit name of the first general-purpose register to be compared and loaded, encoded in the "Rs" field. <Xs> must be an even-numbered register.
<X(s+1)>	Is the 64-bit name of the second general-purpose register to be compared and loaded.
<Xt>	Is the 64-bit name of the first general-purpose register to be conditionally stored, encoded in the "Rt" field. <Xt> must be an even-numbered register.

- <X(t+1)> Is the 64-bit name of the second general-purpose register to be conditionally stored.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```

bits(64) address;
bits(2*datasize) comparevalue;
bits(2*datasize) newvalue;
bits(2*datasize) data;

bits(datasize) s1 = X[s];
bits(datasize) s2 = X[s+1];
bits(datasize) t1 = X[t];
bits(datasize) t2 = X[t+1];
comparevalue = if BigEndian() then s1:s2 else s2:s1;
newvalue = if BigEndian() then t1:t2 else t2:t1;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomicCompareAndSwap(address, comparevalue, newvalue, ldacctype, stacctype);

if BigEndian() then
    X[s] = ZeroExtend(data<2*datasize-1:datasize>, datasize);
    X[s+1] = ZeroExtend(data<datasize-1:0>, datasize);
else
    X[s] = ZeroExtend(data<datasize-1:0>, datasize);
    X[s+1] = ZeroExtend(data<2*datasize-1:datasize>, datasize);

```

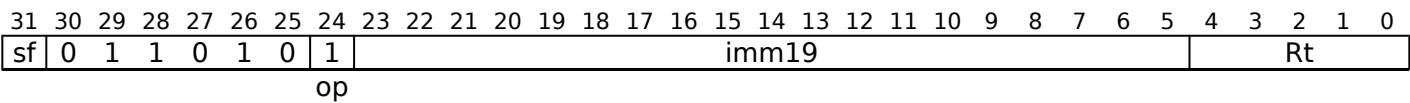
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# CBNZ

Compare and Branch on Nonzero compares the value in a register with zero, and conditionally branches to a label at a PC-relative offset if the comparison is not equal. It provides a hint that this is not a subroutine call or return. This instruction does not affect the condition flags.



## 32-bit (sf == 0)

CBNZ <Wt>, <label>

## 64-bit (sf == 1)

CBNZ <Xt>, <label>

```
integer t = UInt(Rt);
integer datasize = if sf == '1' then 64 else 32;
bits(64) offset = SignExtend(imm19:'00', 64);
```

## Assembler Symbols

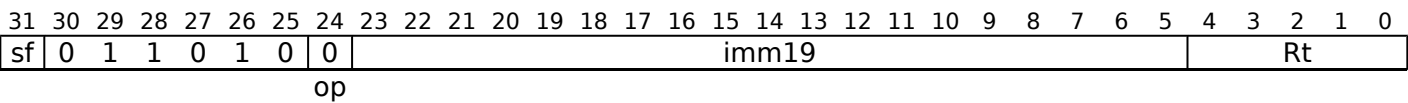
- <Wt> Is the 32-bit name of the general-purpose register to be tested, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be tested, encoded in the "Rt" field.
- <label> Is the program label to be conditionally branched to. Its offset from the address of this instruction, in the range +/-1MB, is encoded as "imm19" times 4.

## Operation

```
bits(datasize) operand1 = X[t];
if IsZero(operand1) == FALSE then
    BranchTo(PC[] + offset, BranchType_DIR);
```

# CBZ

Compare and Branch on Zero compares the value in a register with zero, and conditionally branches to a label at a PC-relative offset if the comparison is equal. It provides a hint that this is not a subroutine call or return. This instruction does not affect condition flags.



## 32-bit (sf == 0)

```
CBZ <Wt>, <label>
```

## 64-bit (sf == 1)

```
CBZ <Xt>, <label>
```

```
integer t = UInt(Rt);
integer datasize = if sf == '1' then 64 else 32;
bits(64) offset = SignExtend(imm19:'00', 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be tested, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be tested, encoded in the "Rt" field.
- <label> Is the program label to be conditionally branched to. Its offset from the address of this instruction, in the range +/-1MB, is encoded as "imm19" times 4.

## Operation

```
bits(datasize) operand1 = X[t];
if IsZero(operand1) == TRUE then
    BranchTo(PC[] + offset, BranchType_DIR);
```

## CCMN (immediate)

Conditional Compare Negative (immediate) sets the value of the condition flags to the result of the comparison of a register value and a negated immediate value if the condition is TRUE, and an immediate value otherwise.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
sf	0	1	1	1	0	1	0	0	1	0	imm5					cond					1	0	Rn					0	nzcv			
op																																

### 32-bit (sf == 0)

CCMN <Wn>, #<imm>, #<nzcv>, <cond>

### 64-bit (sf == 1)

CCMN <Xn>, #<imm>, #<nzcv>, <cond>

```
integer n = UInt(Rn);
integer datasize = if sf == '1' then 64 else 32;
bits(4) flags = nzcv;
bits(datasize) imm = ZeroExtend(imm5, datasize);
```

## Assembler Symbols

- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <imm> Is a five bit unsigned (positive) immediate encoded in the "imm5" field.
- <nzcv> Is the flag bit specifier, an immediate in the range 0 to 15, giving the alternative state for the 4-bit NZCV condition flags, encoded in the "nzcv" field.
- <cond> Is one of the standard conditions, encoded in the "cond" field in the standard way.

## Operation

```
bits(datasize) operand1 = X[n];
if ConditionHolds(cond) then
    (-, flags) = AddWithCarry(operand1, imm, '0');
PSTATE.<N,Z,C,V> = flags;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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## CCMN (register)

Conditional Compare Negative (register) sets the value of the condition flags to the result of the comparison of a register value and the inverse of another register value if the condition is TRUE, and an immediate value otherwise.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	1	1	1	0	1	0	0	1	0	Rm				cond				0	0	Rn				0	nzcw					
op																															

### 32-bit (sf == 0)

CCMN <Wn>, <Wm>, #<nzcw>, <cond>

### 64-bit (sf == 1)

CCMN <Xn>, <Xm>, #<nzcw>, <cond>

```
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
bits(4) flags = nzcw;
```

## Assembler Symbols

<Wn>	Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Wm>	Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
<Xn>	Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
<nzcw>	Is the flag bit specifier, an immediate in the range 0 to 15, giving the alternative state for the 4-bit NZCV condition flags, encoded in the "nzcw" field.
<cond>	Is one of the standard conditions, encoded in the "cond" field in the standard way.

## Operation

```
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = X[m];

if ConditionHolds(cond) then
    (-, flags) = AddWithCarry(operand1, operand2, '0');
PSTATE.<N,Z,C,V> = flags;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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## CCMP (immediate)

Conditional Compare (immediate) sets the value of the condition flags to the result of the comparison of a register value and an immediate value if the condition is TRUE, and an immediate value otherwise.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	1	1	1	1	0	1	0	0	1	0	imm5					cond				1	0	Rn				0	nzcw				
op																															

### 32-bit (sf == 0)

CCMP <Wn>, #<imm>, #<nzcw>, <cond>

### 64-bit (sf == 1)

CCMP <Xn>, #<imm>, #<nzcw>, <cond>

```
integer n = UInt(Rn);
integer datasize = if sf == '1' then 64 else 32;
bits(4) flags = nzcw;
bits(datasize) imm = ZeroExtend(imm5, datasize);
```

## Assembler Symbols

- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <imm> Is a five bit unsigned (positive) immediate encoded in the "imm5" field.
- <nzcw> Is the flag bit specifier, an immediate in the range 0 to 15, giving the alternative state for the 4-bit NZCV condition flags, encoded in the "nzcw" field.
- <cond> Is one of the standard conditions, encoded in the "cond" field in the standard way.

## Operation

```
bits(datasize) operand1 = X[n];
bits(datasize) operand2;

if ConditionHolds(cond) then
    operand2 = NOT(imm);
    (-, flags) = AddWithCarry(operand1, operand2, '1');
PSTATE.<N,Z,C,V> = flags;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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## CCMP (register)

Conditional Compare (register) sets the value of the condition flags to the result of the comparison of two registers if the condition is TRUE, and an immediate value otherwise.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	1	1	1	1	0	1	0	0	1	0	Rm				cond				0	0	Rn				0	nzcw					
op																															

### 32-bit (sf == 0)

CCMP <Wn>, <Wm>, #<nzcw>, <cond>

### 64-bit (sf == 1)

CCMP <Xn>, <Xm>, #<nzcw>, <cond>

```
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
bits(4) flags = nzcw;
```

## Assembler Symbols

- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <nzcw> Is the flag bit specifier, an immediate in the range 0 to 15, giving the alternative state for the 4-bit NZCW condition flags, encoded in the "nzcw" field.
- <cond> Is one of the standard conditions, encoded in the "cond" field in the standard way.

## Operation

```
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = X[m];

if ConditionHolds(cond) then
    operand2 = NOT(operand2);
    (-, flags) = AddWithCarry(operand1, operand2, '1');
PSTATE.<N,Z,C,V> = flags;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCW flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCW flags.

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CFINV

Invert Carry Flag. This instruction inverts the value of the PSTATE.C flag.

System  
(Armv8.4)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	(0)	(0)	(0)	(0)	0	0	0	1	1	1	1	1

CRm

System

CFINV

```
if !HaveFlagManipulateExt() then UNDEFINED;
```

Operation

```
PSTATE.C = NOT(PSTATE.C);
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

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CFP

Control Flow Prediction Restriction by Context prevents control flow predictions that predict execution addresses, based on information gathered from earlier execution within a particular execution context, from allowing later speculative execution within that context to be observable through side-channels.

For more information, see *CFP RCTX, Control Flow Prediction Restriction by Context*.

This is an alias of [SYS](#). This means:

- The encodings in this description are named to match the encodings of [SYS](#).
- The description of [SYS](#) gives the operational pseudocode for this instruction.

System  
(Armv8.5)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	1	0	1	1	0	1	1	1	0	0	1	1	1	0	0	Rt				
L										op1				CRn				CRm				op2									

System

CFP RCTX, [<Xt>](#)  
is equivalent to  
[SYS](#) #3, C7, C3, #4, [<Xt>](#)  
and is always the preferred disassembly.

Assembler Symbols

[<Xt>](#) Is the 64-bit name of the general-purpose source register, encoded in the "Rt" field.

Operation

The description of [SYS](#) gives the operational pseudocode for this instruction.

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# CINC

Conditional Increment returns, in the destination register, the value of the source register incremented by 1 if the condition is TRUE, and otherwise returns the value of the source register.

This is an alias of [CSINC](#). This means:

- The encodings in this description are named to match the encodings of [CSINC](#).
- The description of [CSINC](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	0	1	1	0	1	0	1	0	0	!= 11111				!= 111x				0	1	!= 11111				Rd						
op			Rm								cond				o2		Rn														

## 32-bit (sf == 0)

CINC <Wd>, <Wn>, <cond>

is equivalent to

[CSINC](#) <Wd>, <Wn>, <Wn>, invert(<cond>)

and is the preferred disassembly when Rn == Rm.

## 64-bit (sf == 1)

CINC <Xd>, <Xn>, <cond>

is equivalent to

[CSINC](#) <Xd>, <Xn>, <Xn>, invert(<cond>)

and is the preferred disassembly when Rn == Rm.

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" and "Rm" fields.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" and "Rm" fields.
<cond>	Is one of the standard conditions, excluding AL and NV, encoded in the "cond" field with its least significant bit inverted.

## Operation

The description of [CSINC](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

# CINV

Conditional Invert returns, in the destination register, the bitwise inversion of the value of the source register if the condition is TRUE, and otherwise returns the value of the source register.

This is an alias of [CSINV](#). This means:

- The encodings in this description are named to match the encodings of [CSINV](#).
- The description of [CSINV](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
sf	1	0	1	1	0	1	0	1	0	0	!= 11111					!= 111x					0	0	!= 11111					Rd				
op											Rm					cond					o2		Rn									

## 32-bit (sf == 0)

CINV <Wd>, <Wn>, <cond>

is equivalent to

[CSINV](#) <Wd>, <Wn>, <Wn>, invert(<cond>)

and is the preferred disassembly when Rn == Rm.

## 64-bit (sf == 1)

CINV <Xd>, <Xn>, <cond>

is equivalent to

[CSINV](#) <Xd>, <Xn>, <Xn>, invert(<cond>)

and is the preferred disassembly when Rn == Rm.

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" and "Rm" fields.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" and "Rm" fields.
<cond>	Is one of the standard conditions, excluding AL and NV, encoded in the "cond" field with its least significant bit inverted.

## Operation

The description of [CSINV](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

# CLREX

Clear Exclusive clears the local monitor of the executing PE.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	1	CRm			0	1	0	1	1	1	1	1	1

## System

CLREX {#<imm>}

// CRm field is ignored

## Assembler Symbols

<imm> Is an optional 4-bit unsigned immediate, in the range 0 to 15, defaulting to 15 and encoded in the "CRm" field.

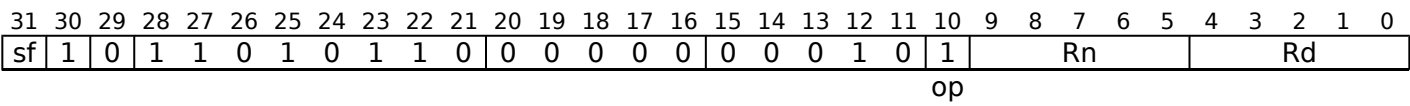
## Operation

[ClearExclusiveLocal](#)([ProcessorID](#)() );

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# CLS

Count Leading Sign bits counts the number of leading bits of the source register that have the same value as the most significant bit of the register, and writes the result to the destination register. This count does not include the most significant bit of the source register.



## 32-bit (sf == 0)

CLS <Wd>, <Wn>

## 64-bit (sf == 1)

CLS <Xd>, <Xn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer datasize = if sf == '1' then 64 else 32;
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.

## Operation

```
integer result;
bits(datasize) operand1 = X[n];

result = CountLeadingSignBits(operand1);

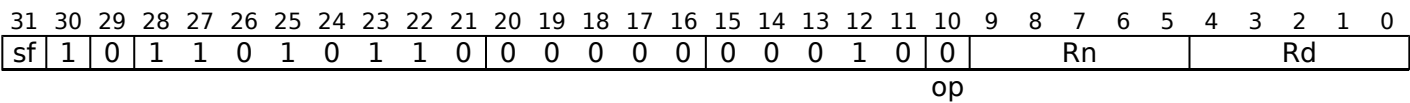
X[d] = result<datasize-1:0>;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# CLZ

Count Leading Zeros counts the number of binary zero bits before the first binary one bit in the value of the source register, and writes the result to the destination register.



## 32-bit (sf == 0)

CLZ <Wd>, <Wn>

## 64-bit (sf == 1)

CLZ <Xd>, <Xn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer datasize = if sf == '1' then 64 else 32;
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.

## Operation

```
integer result;
bits(datasize) operand1 = X[n];

result = CountLeadingZeroBits(operand1);
X[d] = result<datasize-1:0>;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

## CMN (extended register)

Compare Negative (extended register) adds a register value and a sign or zero-extended register value, followed by an optional left shift amount. The argument that is extended from the <Rm> register can be a byte, halfword, word, or doubleword. It updates the condition flags based on the result, and discards the result.

This is an alias of [ADDS \(extended register\)](#). This means:

- The encodings in this description are named to match the encodings of [ADDS \(extended register\)](#).
- The description of [ADDS \(extended register\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	1	0	1	0	1	1	0	0	1	Rm				option			imm3			Rn				1	1	1	1	1		
op S											Rd																				

### 32-bit (sf == 0)

CMN <Wn|WSP>, <Wm>{, <extend> {#<amount>}}

is equivalent to

ADDS WZR, <Wn|WSP>, <Wm>{, <extend> {#<amount>}}

and is always the preferred disassembly.

### 64-bit (sf == 1)

CMN <Xn|SP>, <R><m>{, <extend> {#<amount>}}

is equivalent to

ADDS XZR, <Xn|SP>, <R><m>{, <extend> {#<amount>}}

and is always the preferred disassembly.

## Assembler Symbols

<Wn|WSP> Is the 32-bit name of the first source general-purpose register or stack pointer, encoded in the "Rn" field.

<Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.

<Xn|SP> Is the 64-bit name of the first source general-purpose register or stack pointer, encoded in the "Rn" field.

<R> Is a width specifier, encoded in "option":

option	<R>
00x	W
010	W
x11	X
10x	W
110	W

<m> Is the number [0-30] of the second general-purpose source register or the name ZR (31), encoded in the "Rm" field.

<extend> For the 32-bit variant: is the extension to be applied to the second source operand, encoded in "option":

option	<extend>
000	UXTB
001	UXTH
010	LSL UXTW
011	UXTX
100	SXTB
101	SXTH
110	SXTW
111	SXTX

If "Rn" is '11111' (WSP) and "option" is '010' then LSL is preferred, but may be omitted when "imm3" is '000'. In all other cases <extend> is required and must be UXTW when "option" is '010'.

For the 64-bit variant: is the extension to be applied to the second source operand, encoded in "option":

option	<extend>
000	UXTB
001	UXTH
010	UXTW
011	LSL UXTX
100	SXTB
101	SXTH
110	SXTW
111	SXTX

If "Rn" is '11111' (SP) and "option" is '011' then LSL is preferred, but may be omitted when "imm3" is '000'. In all other cases <extend> is required and must be UXTX when "option" is '011'.

<amount> Is the left shift amount to be applied after extension in the range 0 to 4, defaulting to 0, encoded in the "imm3" field. It must be absent when <extend> is absent, is required when <extend> is LSL, and is optional when <extend> is present but not LSL.

## Operation

The description of [ADDS \(extended register\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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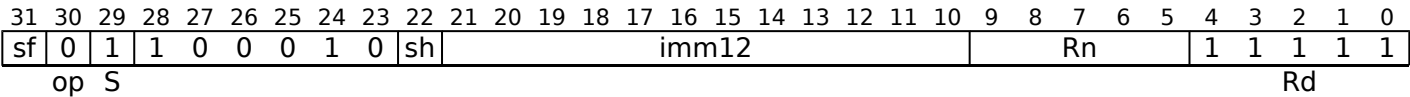
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# CMN (immediate)

Compare Negative (immediate) adds a register value and an optionally-shifted immediate value. It updates the condition flags based on the result, and discards the result.

This is an alias of [ADDS \(immediate\)](#). This means:

- The encodings in this description are named to match the encodings of [ADDS \(immediate\)](#).
- The description of [ADDS \(immediate\)](#) gives the operational pseudocode for this instruction.



## 32-bit (sf == 0)

CMN <Wn|WSP>, #<imm>{, <shift>}

is equivalent to

ADDS WZR, <Wn|WSP>, #<imm> {, <shift>}

and is always the preferred disassembly.

## 64-bit (sf == 1)

CMN <Xn|SP>, #<imm>{, <shift>}

is equivalent to

ADDS XZR, <Xn|SP>, #<imm> {, <shift>}

and is always the preferred disassembly.

## Assembler Symbols

- <Wn|WSP> Is the 32-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.
- <Xn|SP> Is the 64-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.
- <imm> Is an unsigned immediate, in the range 0 to 4095, encoded in the "imm12" field.
- <shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #12

## Operation

The description of [ADDS \(immediate\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.



# CMN (shifted register)

Compare Negative (shifted register) adds a register value and an optionally-shifted register value. It updates the condition flags based on the result, and discards the result.

This is an alias of [ADDS \(shifted register\)](#). This means:

- The encodings in this description are named to match the encodings of [ADDS \(shifted register\)](#).
- The description of [ADDS \(shifted register\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
sf	0	1	0	1	0	1	1	shift	0	Rm						imm6						Rn						1	1	1	1	1
op S										Rd																						

## 32-bit (sf == 0)

CMN <Wn>, <Wm>{, <shift> #<amount>}

is equivalent to

ADDS WZR, <Wn>, <Wm> {, <shift> #<amount>}

and is always the preferred disassembly.

## 64-bit (sf == 1)

CMN <Xn>, <Xm>{, <shift> #<amount>}

is equivalent to

ADDS XZR, <Xn>, <Xm> {, <shift> #<amount>}

and is always the preferred disassembly.

## Assembler Symbols

- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <shift> Is the optional shift type to be applied to the second source operand, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	RESERVED

- <amount> For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.
- For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field.

## Operation

The description of [ADDS \(shifted register\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# CMP (extended register)

Compare (extended register) subtracts a sign or zero-extended register value, followed by an optional left shift amount, from a register value. The argument that is extended from the <Rm> register can be a byte, halfword, word, or doubleword. It updates the condition flags based on the result, and discards the result.

This is an alias of [SUBS \(extended register\)](#). This means:

- The encodings in this description are named to match the encodings of [SUBS \(extended register\)](#).
  - The description of [SUBS \(extended register\)](#) gives the operational pseudocode for this instruction.
- |      |    |    |    |    |    |    |    |    |    |    |    |    |    |    |        |    |    |      |    |    |    |   |   |   |           |   |    |   |   |   |   |
|------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|--------|----|----|------|----|----|----|---|---|---|-----------|---|----|---|---|---|---|
| 31   | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16     | 15 | 14 | 13   | 12 | 11 | 10 | 9 | 8 | 7 | 6         | 5 | 4  | 3 | 2 | 1 | 0 |
| sf   | 1  | 1  | 0  | 1  | 0  | 1  | 1  | 0  | 0  | 1  | Rm |    |    |    | option |    |    | imm3 |    |    | Rn |   |   |   | 1 1 1 1 1 |   |    |   |   |   |   |
| op S |    |    |    |    |    |    |    |    |    |    |    |    |    |    |        |    |    |      |    |    |    |   |   |   |           |   | Rd |   |   |   |   |

## 32-bit (sf == 0)

CMP <Wn|WSP>, <Wm>{, <extend> {#<amount>}}

is equivalent to

SUBS WZR, <Wn|WSP>, <Wm>{, <extend> {#<amount>}}

and is always the preferred disassembly.

## 64-bit (sf == 1)

CMP <Xn|SP>, <R><m>{, <extend> {#<amount>}}

is equivalent to

SUBS XZR, <Xn|SP>, <R><m>{, <extend> {#<amount>}}

and is always the preferred disassembly.

## Assembler Symbols

- <Wn|WSP> Is the 32-bit name of the first source general-purpose register or stack pointer, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xn|SP> Is the 64-bit name of the first source general-purpose register or stack pointer, encoded in the "Rn" field.
- <R> Is a width specifier, encoded in "option":
- | option | <R> |
|--------|-----|
| 00x    | W   |
| 010    | W   |
| x11    | X   |
| 10x    | W   |
| 110    | W   |
- <m> Is the number [0-30] of the second general-purpose source register or the name ZR (31), encoded in the "Rm" field.
- <extend> For the 32-bit variant: is the extension to be applied to the second source operand, encoded in "option":

option	<extend>
000	UXTB
001	UXTH
010	LSL UXTW
011	UXTX
100	SXTB
101	SXTH
110	SXTW
111	SXTX

If "Rn" is '11111' (WSP) and "option" is '010' then LSL is preferred, but may be omitted when "imm3" is '000'. In all other cases <extend> is required and must be UXTW when "option" is '010'.

For the 64-bit variant: is the extension to be applied to the second source operand, encoded in "option":

option	<extend>
000	UXTB
001	UXTH
010	UXTW
011	LSL UXTX
100	SXTB
101	SXTH
110	SXTW
111	SXTX

If "Rn" is '11111' (SP) and "option" is '011' then LSL is preferred, but may be omitted when "imm3" is '000'. In all other cases <extend> is required and must be UXTX when "option" is '011'.

<amount> Is the left shift amount to be applied after extension in the range 0 to 4, defaulting to 0, encoded in the "imm3" field. It must be absent when <extend> is absent, is required when <extend> is LSL, and is optional when <extend> is present but not LSL.

## Operation

The description of [SUBS \(extended register\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# CMP (immediate)

Compare (immediate) subtracts an optionally-shifted immediate value from a register value. It updates the condition flags based on the result, and discards the result.

This is an alias of [SUBS \(immediate\)](#). This means:

- The encodings in this description are named to match the encodings of [SUBS \(immediate\)](#).
  - The description of [SUBS \(immediate\)](#) gives the operational pseudocode for this instruction.
- |      |    |    |    |    |    |    |    |    |    |       |    |    |    |    |    |    |    |    |    |    |    |    |   |   |           |   |   |    |   |   |   |  |
|------|----|----|----|----|----|----|----|----|----|-------|----|----|----|----|----|----|----|----|----|----|----|----|---|---|-----------|---|---|----|---|---|---|--|
| 31   | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21    | 20 | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9  | 8 | 7 | 6         | 5 | 4 | 3  | 2 | 1 | 0 |  |
| sf   | 1  | 1  | 1  | 0  | 0  | 0  | 1  | 0  | sh | imm12 |    |    |    |    |    |    |    |    |    |    |    | Rn |   |   | 1 1 1 1 1 |   |   |    |   |   |   |  |
| op S |    |    |    |    |    |    |    |    |    |       |    |    |    |    |    |    |    |    |    |    |    |    |   |   |           |   |   | Rd |   |   |   |  |

## 32-bit (sf == 0)

CMP <Wn|WSP>, #<imm>{, <shift>}

is equivalent to

SUBS WZR, <Wn|WSP>, #<imm> {, <shift>}

and is always the preferred disassembly.

## 64-bit (sf == 1)

CMP <Xn|SP>, #<imm>{, <shift>}

is equivalent to

SUBS XZR, <Xn|SP>, #<imm> {, <shift>}

and is always the preferred disassembly.

## Assembler Symbols

- <Wn|WSP> Is the 32-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.
- <Xn|SP> Is the 64-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.
- <imm> Is an unsigned immediate, in the range 0 to 4095, encoded in the "imm12" field.
- <shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":
- | sh | <shift> |
|----|---------|
| 0  | LSL #0  |
| 1  | LSL #12 |

## Operation

The description of [SUBS \(immediate\)](#) gives the operational pseudocode for this instruction.

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

## CMP (shifted register)

Compare (shifted register) subtracts an optionally-shifted register value from a register value. It updates the condition flags based on the result, and discards the result.

This is an alias of [SUBS \(shifted register\)](#). This means:

- The encodings in this description are named to match the encodings of [SUBS \(shifted register\)](#).
- The description of [SUBS \(shifted register\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
sf	1	1	0	1	0	1	1	shift	0	Rm						imm6						Rn						1	1	1	1	1	
op S																												Rd					

### 32-bit (sf == 0)

CMP <Wn>, <Wm>{, <shift> #<amount>}

is equivalent to

SUBS WZR, <Wn>, <Wm> {, <shift> #<amount>}

and is always the preferred disassembly.

### 64-bit (sf == 1)

CMP <Xn>, <Xm>{, <shift> #<amount>}

is equivalent to

SUBS XZR, <Xn>, <Xm> {, <shift> #<amount>}

and is always the preferred disassembly.

## Assembler Symbols

<Wn>	Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Wm>	Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
<Xn>	Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
<shift>	Is the optional shift type to be applied to the second source operand, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	RESERVED

<amount>	For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.
	For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field.

## Operation

The description of [SUBS \(shifted register\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# CMPP

Compare with Tag subtracts the 56-bit address held in the second source register from the 56-bit address held in the first source register, updates the condition flags based on the result of the subtraction, and discards the result.

This is an alias of [SUBPS](#). This means:

- The encodings in this description are named to match the encodings of [SUBPS](#).
- The description of [SUBPS](#) gives the operational pseudocode for this instruction.

## Integer (Armv8.5)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	1	1	0	1	0	1	1	0	Xm					0	0	0	0	0	0	Xn					1	1	1	1	1
																												Xd			

## Integer

CMPP [<Xn|SP>](#), [<Xm|SP>](#)

is equivalent to

[SUBPS](#) XZR, [<Xn|SP>](#), [<Xm|SP>](#)

and is always the preferred disassembly.

## Assembler Symbols

- <Xn|SP>

Is the 64-bit name of the first source general-purpose register or stack pointer, encoded in the "Xn" field.
- <Xm|SP>

Is the 64-bit name of the second general-purpose source register or stack pointer, encoded in the "Xm" field.

## Operation

The description of [SUBPS](#) gives the operational pseudocode for this instruction.



# CNEG

Conditional Negate returns, in the destination register, the negated value of the source register if the condition is TRUE, and otherwise returns the value of the source register.

This is an alias of [CSNEG](#). This means:

- The encodings in this description are named to match the encodings of [CSNEG](#).
- The description of [CSNEG](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	1	0	1	1	0	1	0	1	0	0	Rm					!= 111x			0	1	Rn					Rd					
op											cond					o2															

## 32-bit (sf == 0)

CNEG <Wd>, <Wn>, <cond>

is equivalent to

[CSNEG](#) <Wd>, <Wn>, <Wn>, invert(<cond>)

and is the preferred disassembly when Rn == Rm.

## 64-bit (sf == 1)

CNEG <Xd>, <Xn>, <cond>

is equivalent to

[CSNEG](#) <Xd>, <Xn>, <Xn>, invert(<cond>)

and is the preferred disassembly when Rn == Rm.

## Assembler Symbols

<Wd>

Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.

<Wn>

Is the 32-bit name of the general-purpose source register, encoded in the "Rn" and "Rm" fields.

<Xd>

Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.

<Xn>

Is the 64-bit name of the general-purpose source register, encoded in the "Rn" and "Rm" fields.

<cond>

Is one of the standard conditions, excluding AL and NV, encoded in the "cond" field with its least significant bit inverted.

## Operation

The description of [CSNEG](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

CPP

Cache Prefetch Prediction Restriction by Context prevents cache allocation predictions, based on information gathered from earlier execution within a particular execution context, from allowing later speculative execution within that context to be observable through side-channels.

For more information, see *CPP RCTX, Cache Prefetch Prediction Restriction by Context*.

This is an alias of [SYS](#). This means:

- The encodings in this description are named to match the encodings of [SYS](#).
- The description of [SYS](#) gives the operational pseudocode for this instruction.

System  
(Armv8.5)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	1	0	1	1	0	1	1	1	0	0	1	1	1	1	1	1	Rt			
L										op1				CRn				CRm				op2									

System

CPP RCTX, [<Xt>](#)

is equivalent to

[SYS](#) #3, C7, C3, #7, [<Xt>](#)

and is always the preferred disassembly.

Assembler Symbols

[<Xt>](#) Is the 64-bit name of the general-purpose source register, encoded in the "Rt" field.

Operation

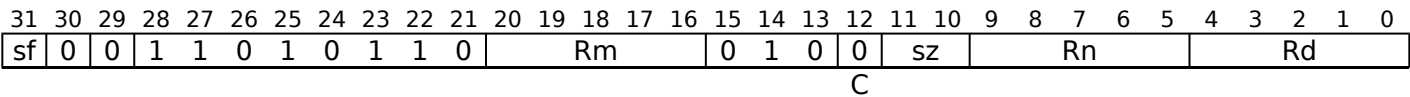
The description of [SYS](#) gives the operational pseudocode for this instruction.

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# CRC32B, CRC32H, CRC32W, CRC32X

CRC32 checksum performs a cyclic redundancy check (CRC) calculation on a value held in a general-purpose register. It takes an input CRC value in the first source operand, performs a CRC on the input value in the second source operand, and returns the output CRC value. The second source operand can be 8, 16, 32, or 64 bits. To align with common usage, the bit order of the values is reversed as part of the operation, and the polynomial 0x04C11DB7 is used for the CRC calculation.

In Armv8-A, this is an OPTIONAL instruction, and in Armv8.1 it is mandatory for all implementations to implement it. [ID\\_AA64ISAR0\\_EL1](#).CRC32 indicates whether this instruction is supported.



## CRC32B (sf == 0 && sz == 00)

CRC32B <Wd>, <Wn>, <Wm>

## CRC32H (sf == 0 && sz == 01)

CRC32H <Wd>, <Wn>, <Wm>

## CRC32W (sf == 0 && sz == 10)

CRC32W <Wd>, <Wn>, <Wm>

## CRC32X (sf == 1 && sz == 11)

CRC32X <Wd>, <Wn>, <Xm>

```
if !HaveCRCExt() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sf == '1' && sz != '11' then UNDEFINED;
if sf == '0' && sz == '11' then UNDEFINED;
integer size = 8 << UInt(sz);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose accumulator output register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the general-purpose accumulator input register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose data source register, encoded in the "Rm" field.
- <Wm> Is the 32-bit name of the general-purpose data source register, encoded in the "Rm" field.

## Operation

```
bits(32) acc = X[n]; // accumulator
bits(size) val = X[m]; // input value
bits(32) poly = 0x04C11DB7<31:0>;

bits(32+size) tempacc = BitReverse(acc):Zeros(size);
bits(size+32) tempval = BitReverse(val):Zeros(32);

// Poly32Mod2 on a bitstring does a polynomial Modulus over {0,1} operation
X[d] = BitReverse(Poly32Mod2(tempacc EOR tempval, poly));
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

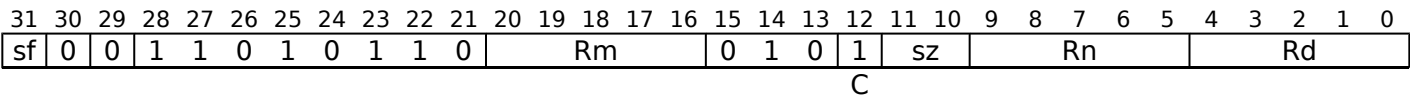
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# CRC32CB, CRC32CH, CRC32CW, CRC32CX

CRC32 checksum performs a cyclic redundancy check (CRC) calculation on a value held in a general-purpose register. It takes an input CRC value in the first source operand, performs a CRC on the input value in the second source operand, and returns the output CRC value. The second source operand can be 8, 16, 32, or 64 bits. To align with common usage, the bit order of the values is reversed as part of the operation, and the polynomial 0x1EDC6F41 is used for the CRC calculation.

In Armv8-A, this is an OPTIONAL instruction, and in Armv8.1 it is mandatory for all implementations to implement it. [ID\\_AA64ISAR0\\_EL1.CRC32](#) indicates whether this instruction is supported.



## CRC32CB (sf == 0 && sz == 00)

CRC32CB <Wd>, <Wn>, <Wm>

## CRC32CH (sf == 0 && sz == 01)

CRC32CH <Wd>, <Wn>, <Wm>

## CRC32CW (sf == 0 && sz == 10)

CRC32CW <Wd>, <Wn>, <Wm>

## CRC32CX (sf == 1 && sz == 11)

CRC32CX <Wd>, <Wn>, <Xm>

```
if !HaveCRCExt() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sf == '1' && sz != '11' then UNDEFINED;
if sf == '0' && sz == '11' then UNDEFINED;
integer size = 8 << UInt(sz);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose accumulator output register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the general-purpose accumulator input register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose data source register, encoded in the "Rm" field.
- <Wm> Is the 32-bit name of the general-purpose data source register, encoded in the "Rm" field.

## Operation

```
bits(32) acc = X[n]; // accumulator
bits(size) val = X[m]; // input value
bits(32) poly = 0x1EDC6F41<31:0>;

bits(32+size) tempacc = BitReverse(acc):Zeros(size);
bits(size+32) tempval = BitReverse(val):Zeros(32);

// Poly32Mod2 on a bitstring does a polynomial Modulus over {0,1} operation
X[d] = BitReverse(Poly32Mod2(tempacc EOR tempval, poly));
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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CSDB

Consumption of Speculative Data Barrier is a memory barrier that controls speculative execution and data value prediction.

No instruction other than branch instructions appearing in program order after the CSDB can be speculatively executed using the results of any:

- Data value predictions of any instructions.
- PSTATE.{N,Z,C,V} predictions of any instructions other than conditional branch instructions appearing in program order before the CSDB that have not been architecturally resolved.
- Predictions of SVE predication state for any SVE instructions.

For purposes of the definition of CSDB, PSTATE.{N,Z,C,V} is not considered a data value. This definition permits:

- Control flow speculation before and after the CSDB.
- Speculative execution of conditional data processing instructions after the CSDB, unless they use the results of data value or PSTATE.{N,Z,C,V} predictions of instructions appearing in program order before the CSDB that have not been architecturally resolved.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	1	0	1	0	0	1	1	1	1	1
																CRm				op2											

System

CSDB

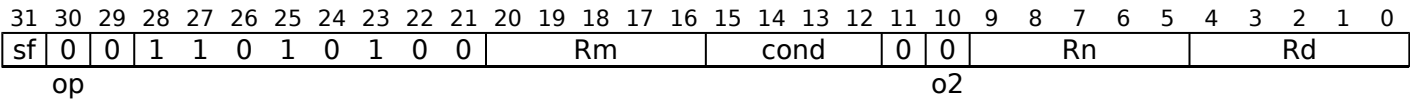
```
// Empty.
```

Operation

```
ConsumptionOfSpeculativeDataBarrier();
```

CSEL

Conditional Select returns, in the destination register, the value of the first source register if the condition is TRUE, and otherwise returns the value of the second source register.



32-bit (sf == 0)

CSEL <Wd>, <Wn>, <Wm>, <cond>

64-bit (sf == 1)

CSEL <Xd>, <Xn>, <Xm>, <cond>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
```

Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <cond> Is one of the standard conditions, encoded in the "cond" field in the standard way.

Operation

```
bits(datasize) result;
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = X[m];

if ConditionHolds(cond) then
    result = operand1;
else
    result = operand2;

X[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

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## CSET

Conditional Set sets the destination register to 1 if the condition is TRUE, and otherwise sets it to 0.

This is an alias of [CSINC](#). This means:

- The encodings in this description are named to match the encodings of [CSINC](#).
- The description of [CSINC](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
sf		0	0	1	1	0	1	0	1	0	0	1	1	1	1	1	!= 111x			0	1	1	1	1	1	1	Rd						
op											Rm					cond			o2		Rn												

### 32-bit (sf == 0)

CSET <Wd>, <cond>

is equivalent to

[CSINC](#) <Wd>, WZR, WZR, invert(<cond>)

and is always the preferred disassembly.

### 64-bit (sf == 1)

CSET <Xd>, <cond>

is equivalent to

[CSINC](#) <Xd>, XZR, XZR, invert(<cond>)

and is always the preferred disassembly.

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<cond>	Is one of the standard conditions, excluding AL and NV, encoded in the "cond" field with its least significant bit inverted.

## Operation

The description of [CSINC](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# CSETM

Conditional Set Mask sets all bits of the destination register to 1 if the condition is TRUE, and otherwise sets all bits to 0.

This is an alias of [CSINV](#). This means:

- The encodings in this description are named to match the encodings of [CSINV](#).
- The description of [CSINV](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	1	0	1	1	0	1	0	1	0	0	1	1	1	1	1	!= 111x	0	0	1	1	1	1	1								
op			Rm						cond			o2		Rn																	

## 32-bit (sf == 0)

CSETM <Wd>, <cond>

is equivalent to

[CSINV](#) <Wd>, WZR, WZR, invert(<cond>)

and is always the preferred disassembly.

## 64-bit (sf == 1)

CSETM <Xd>, <cond>

is equivalent to

[CSINV](#) <Xd>, XZR, XZR, invert(<cond>)

and is always the preferred disassembly.

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<cond>	Is one of the standard conditions, excluding AL and NV, encoded in the "cond" field with its least significant bit inverted.

## Operation

The description of [CSINV](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

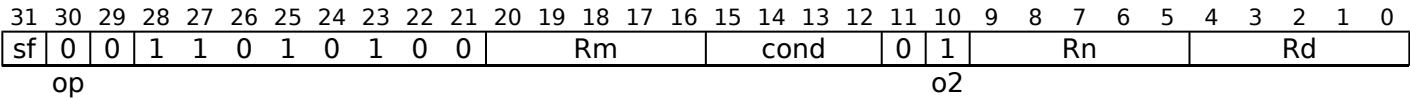
Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# CSINC

Conditional Select Increment returns, in the destination register, the value of the first source register if the condition is TRUE, and otherwise returns the value of the second source register incremented by 1.

This instruction is used by the aliases [CINC](#), and [CSET](#).



## 32-bit (sf == 0)

CSINC <Wd>, <Wn>, <Wm>, <cond>

## 64-bit (sf == 1)

CSINC <Xd>, <Xn>, <Xm>, <cond>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
```

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Wm>	Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
<cond>	Is one of the standard conditions, encoded in the "cond" field in the standard way.

## Alias Conditions

Alias	Is preferred when
<a href="#">CINC</a>	Rm != '11111' && cond != '111x' && Rn != '11111' && Rn == Rm
<a href="#">CSET</a>	Rm == '11111' && cond != '111x' && Rn == '11111'

## Operation

```
bits(datasize) result;
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = X[m];

if ConditionHolds(cond) then
    result = operand1;
else
    result = operand2 + 1;

X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:

- The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

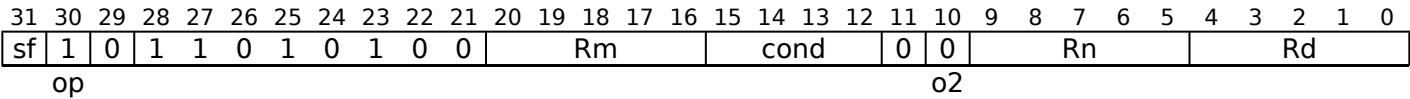
Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# CSINV

Conditional Select Invert returns, in the destination register, the value of the first source register if the condition is TRUE, and otherwise returns the bitwise inversion value of the second source register.

This instruction is used by the aliases [CINV](#), and [CSETM](#).



## 32-bit (sf == 0)

CSINV <Wd>, <Wn>, <Wm>, <cond>

## 64-bit (sf == 1)

CSINV <Xd>, <Xn>, <Xm>, <cond>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
```

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Wm>	Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
<cond>	Is one of the standard conditions, encoded in the "cond" field in the standard way.

## Alias Conditions

Alias	Is preferred when
<a href="#">CINV</a>	Rm != '11111' && cond != '111x' && Rn != '11111' && Rn == Rm
<a href="#">CSETM</a>	Rm == '11111' && cond != '111x' && Rn == '11111'

## Operation

```
bits(datasize) result;
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = X[m];

if ConditionHolds(cond) then
    result = operand1;
else
    result = NOT(operand2);

X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:

- The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

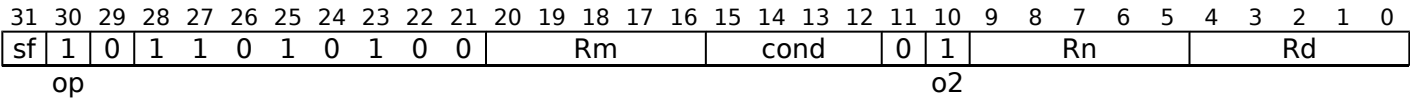
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# CSNEG

Conditional Select Negation returns, in the destination register, the value of the first source register if the condition is TRUE, and otherwise returns the negated value of the second source register.

This instruction is used by the alias [CNEG](#).



## 32-bit (sf == 0)

CSNEG <Wd>, <Wn>, <Wm>, <cond>

## 64-bit (sf == 1)

CSNEG <Xd>, <Xn>, <Xm>, <cond>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
```

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Wm>	Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
<cond>	Is one of the standard conditions, encoded in the "cond" field in the standard way.

## Alias Conditions

Alias	Is preferred when
<a href="#">CNEG</a>	cond != '111x' && Rn == Rm

## Operation

```
bits(datasize) result;
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = X[m];

if ConditionHolds(cond) then
    result = operand1;
else
    result = NOT(operand2);
    result = result + 1;

X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.

- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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DC

Data Cache operation. For more information, see *op0==0b01, cache maintenance, TLB maintenance, and address translation instructions*.

This is an alias of [SYS](#). This means:

- The encodings in this description are named to match the encodings of [SYS](#).
- The description of [SYS](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	1	op1			0	1	1	1	CRm			op2			Rt					
L											CRn																				

System

DC [<dc\\_op>](#), [<Xt>](#)

is equivalent to

[SYS](#) [#<op1>](#), C7, [<Cm>](#), [#<op2>](#), [<Xt>](#)

and is the preferred disassembly when `SysOp(op1, '0111', CRm, op2) == Sys_DC`.

Assembler Symbols

[<dc\\_op>](#) Is a DC instruction name, as listed for the DC system instruction group, encoded in “op1:CRm:op2”:

op1	CRm	op2	<dc_op>	Architectural Feature
000	0110	001	IVAC	-
000	0110	010	ISW	-
000	0110	011	IGVAC	ARMv8.5-MemTag
000	0110	100	IGSW	ARMv8.5-MemTag
000	0110	101	IGDVAC	ARMv8.5-MemTag
000	0110	110	IGDSW	ARMv8.5-MemTag
000	1010	010	CSW	-
000	1010	100	CGSW	ARMv8.5-MemTag
000	1010	110	CGDSW	ARMv8.5-MemTag
000	1110	010	CISW	-
000	1110	100	CIGSW	ARMv8.5-MemTag
000	1110	110	CIGDSW	ARMv8.5-MemTag
011	0100	001	ZVA	-
011	0100	011	GVA	ARMv8.5-MemTag
011	0100	100	GZVA	ARMv8.5-MemTag
011	1010	001	CVAC	-
011	1010	011	CGVAC	ARMv8.5-MemTag
011	1010	101	CGDVAC	ARMv8.5-MemTag
011	1011	001	CVAU	-
011	1100	001	CVAP	ARMv8.2-DCPoP
011	1100	011	CGVAP	ARMv8.5-MemTag
011	1100	101	CGDVAP	ARMv8.5-MemTag
011	1101	001	CVADP	ARMv8.2-DCCVADP
011	1101	011	CGVADP	ARMv8.5-MemTag
011	1101	101	CGDVADP	ARMv8.5-MemTag
011	1110	001	CIVAC	-
011	1110	011	CIGVAC	ARMv8.5-MemTag
011	1110	101	CIGDVAC	ARMv8.5-MemTag

- [<op1>](#) Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the "op1" field.
- [<Cm>](#) Is a name 'Cm', with 'm' in the range 0 to 15, encoded in the "CRm" field.
- [<op2>](#) Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the "op2" field.
- [<Xt>](#) Is the 64-bit name of the general-purpose source register, encoded in the "Rt" field.

## Operation

The description of [SYS](#) gives the operational pseudocode for this instruction.

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# DCPS1

- Debug Change PE State to EL1, when executed in Debug state:
- If executed at EL0 changes the current Exception level and SP to EL1 using SP\_EL1.
  - Otherwise, if executed at ELx, selects SP\_ELx.

- The target exception level of a DCPS1 instruction is:
- EL1 if the instruction is executed at EL0.
  - Otherwise, the Exception level at which the instruction is executed.

- When the target Exception level of a DCPS1 instruction is ELx, on executing this instruction:
- *ELR\_ELx* becomes UNKNOWN.
  - *SPSR\_ELx* becomes UNKNOWN.
  - *ESR\_ELx* becomes UNKNOWN.
  - *DLR\_EL0* and *DSPSR\_EL0* become UNKNOWN.
  - The endianness is set according to *SCTLR\_ELx*.EE.

This instruction is UNDEFINED at EL0 in Non-secure state if EL2 is implemented and *HCR\_EL2*.TGE == 1.  
This instruction is always UNDEFINED in Non-debug state.  
For more information on the operation of the DCPSn instructions, see *DCPS*.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	0	1	0	1	imm16															0	0	0	0	1	
LL																															

## System

```
DCPS1 {#<imm>}  
if !Halted() then UNDEFINED;
```

## Assembler Symbols

<imm> Is an optional 16-bit unsigned immediate, in the range 0 to 65535, defaulting to 0 and encoded in the "imm16" field.

## Operation

```
DCPSInstruction(LL);
```

DCPS2

- Debug Change PE State to EL2, when executed in Debug state:
- If executed at EL0 or EL1 changes the current Exception level and SP to EL2 using SP\_EL2.
  - Otherwise, if executed at ELx, selects SP\_ELx.

- The target exception level of a DCPS2 instruction is:
- EL2 if the instruction is executed at an exception level that is not EL3.
  - EL3 if the instruction is executed at EL3.

- When the target Exception level of a DCPS2 instruction is ELx, on executing this instruction:
- *ELR\_ELx* becomes UNKNOWN.
  - *SPSR\_ELx* becomes UNKNOWN.
  - *ESR\_ELx* becomes UNKNOWN.
  - *DLR\_EL0* and *DSPSR\_EL0* become UNKNOWN.
  - The endianness is set according to *SCTLR\_ELx*.EE.

- This instruction is UNDEFINED at the following exception levels:
- All exception levels if EL2 is not implemented.
  - At EL0 and EL1 if EL2 is disabled in the current Security state.

This instruction is always UNDEFINED in Non-debug state.  
For more information on the operation of the DCPSn instructions, see *DCPS*.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	0	1	0	1	imm16														0	0	0	1	0		
LL																															

System

```
DCPS2 {#<imm>}  
  
if !Halted() then UNDEFINED;
```

Assembler Symbols

<imm> Is an optional 16-bit unsigned immediate, in the range 0 to 65535, defaulting to 0 and encoded in the "imm16" field.

Operation

```
DCPSInstruction(LL);
```

# DCPS3

- Debug Change PE State to EL3, when executed in Debug state:
- If executed at EL3 selects SP\_EL3.
  - Otherwise, changes the current Exception level and SP to EL3 using SP\_EL3.

The target exception level of a DCPS3 instruction is EL3.

- On executing a DCPS3 instruction:
- *ELR\_EL3* becomes UNKNOWN.
  - *SPSR\_EL3* becomes UNKNOWN.
  - *ESR\_EL3* becomes UNKNOWN.
  - *DLR\_EL0* and *DSPSR\_EL0* become UNKNOWN.
  - The endianness is set according to *SCTLR\_EL3*.EE.

This instruction is UNDEFINED at all exception levels if either:

- *EDSCR*.SDD == 1.
- EL3 is not implemented.

This instruction is always UNDEFINED in Non-debug state.

For more information on the operation of the DCPSn instructions, see *DCPS*.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	0	1	0	1	imm16																0	0	0	1	1
LL																															

## System

```
DCPS3 {#<imm>}
if !Halted() then UNDEFINED;
```

## Assembler Symbols

<imm> Is an optional 16-bit unsigned immediate, in the range 0 to 65535, defaulting to 0 and encoded in the "imm16" field.

## Operation

```
DCPSInstruction(LL);
```

# DGH

DGH is a hint instruction. A DGH instruction is not expected to be performance optimal to merge memory accesses with Normal Non-cacheable or Device-GRE attributes appearing in program order before the hint instruction with any memory accesses appearing after the hint instruction into a single memory transaction on an interconnect.

## System (Armv8.6)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	1	1	0	1	1	1	1	1
												CRm				op2															

## System

DGH

```
if !HaveDGHExt() then EndOfInstruction();
```

## Operation

```
Hint_DGH();
```

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## DMB

Data Memory Barrier is a memory barrier that ensures the ordering of observations of memory accesses, see [Data Memory Barrier](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	1	CRm			1	0	1	1	1	1	1	1	1
<div>opc</div>																															

## System

DMB <option>|<imm>

```
case CRm<3:2> of
  when '00' domain = MBReqDomain_OuterShareable;
  when '01' domain = MBReqDomain_Nonshareable;
  when '10' domain = MBReqDomain_InnerShareable;
  when '11' domain = MBReqDomain_FullSystem;
case CRm<1:0> of
  when '00' types = MBReqTypes_All; domain = MBReqDomain_FullSystem;
  when '01' types = MBReqTypes_Reads;
  when '10' types = MBReqTypes_Writes;
  when '11' types = MBReqTypes_All;
```

## Assembler Symbols

<option> Specifies the limitation on the barrier operation. Values are:

### SY

Full system is the required shareability domain, reads and writes are the required access types, both before and after the barrier instruction. This option is referred to as the full system barrier. Encoded as CRm = 0b1111.

### ST

Full system is the required shareability domain, writes are the required access type, both before and after the barrier instruction. Encoded as CRm = 0b1110.

### LD

Full system is the required shareability domain, reads are the required access type before the barrier instruction, and reads and writes are the required access types after the barrier instruction. Encoded as CRm = 0b1101.

### ISH

Inner Shareable is the required shareability domain, reads and writes are the required access types, both before and after the barrier instruction. Encoded as CRm = 0b1011.

### ISHST

Inner Shareable is the required shareability domain, writes are the required access type, both before and after the barrier instruction. Encoded as CRm = 0b1010.

### ISHLD

Inner Shareable is the required shareability domain, reads are the required access type before the barrier instruction, and reads and writes are the required access types after the barrier instruction. Encoded as CRm = 0b1001.

### NSH

Non-shareable is the required shareability domain, reads and writes are the required access, both before and after the barrier instruction. Encoded as CRm = 0b0111.

### NSHST

Non-shareable is the required shareability domain, writes are the required access type, both before and after the barrier instruction. Encoded as CRm = 0b0110.

### NSHLD

Non-shareable is the required shareability domain, reads are the required access type before the barrier instruction, and reads and writes are the required access types after the barrier instruction. Encoded as CRm = 0b0101.

**OSH**

Outer Shareable is the required shareability domain, reads and writes are the required access types, both before and after the barrier instruction. Encoded as CRm = 0b0011.

**OSHST**

Outer Shareable is the required shareability domain, writes are the required access type, both before and after the barrier instruction. Encoded as CRm = 0b0010.

**OSHL**

Outer Shareable is the required shareability domain, reads are the required access type before the barrier instruction, and reads and writes are the required access types after the barrier instruction. Encoded as CRm = 0b0001.

All other encodings of CRm that are not listed above are reserved, and can be encoded using the #<imm> syntax. All unsupported and reserved options must execute as a full system barrier operation, but software must not rely on this behavior. For more information on whether an access is before or after a barrier instruction, see *Data Memory Barrier (DMB)* or see *Data Synchronization Barrier (DSB)*.

<imm> Is a 4-bit unsigned immediate, in the range 0 to 15, encoded in the "CRm" field.

**Operation**

```
DataMemoryBarrier(domain, types);
```

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DRPS

Debug restore process state.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	1	0	1	0	1	1	1	1	1	1	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0

System

DRPS

```
if !Halted() || PSTATE.EL == EL0 then UNDEFINED;
```

Operation

```
DRPSInstruction();
```

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## DSB

Data Synchronization Barrier is a memory barrier that ensures the completion of memory accesses, see [Data Synchronization Barrier](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	1	!= 0x00			1	0	0	1	1	1	1	1	1
																				CRm			opc								

## System

DSB <option>|<imm>

```
case CRm<3:2> of
  when '00' domain = MBReqDomain_OuterShareable;
  when '01' domain = MBReqDomain_Nonshareable;
  when '10' domain = MBReqDomain_InnerShareable;
  when '11' domain = MBReqDomain_FullSystem;
case CRm<1:0> of
  when '00' types = MBReqTypes_All; domain = MBReqDomain_FullSystem;
  when '01' types = MBReqTypes_Reads;
  when '10' types = MBReqTypes_Writes;
  when '11' types = MBReqTypes_All;
```

## Assembler Symbols

<option> Specifies the limitation on the barrier operation. Values are:

### SY

Full system is the required shareability domain, reads and writes are the required access types, both before and after the barrier instruction. This option is referred to as the full system barrier. Encoded as CRm = 0b1111.

### ST

Full system is the required shareability domain, writes are the required access type, both before and after the barrier instruction. Encoded as CRm = 0b1110.

### LD

Full system is the required shareability domain, reads are the required access type before the barrier instruction, and reads and writes are the required access types after the barrier instruction. Encoded as CRm = 0b1101.

### ISH

Inner Shareable is the required shareability domain, reads and writes are the required access types, both before and after the barrier instruction. Encoded as CRm = 0b1011.

### ISHST

Inner Shareable is the required shareability domain, writes are the required access type, both before and after the barrier instruction. Encoded as CRm = 0b1010.

### ISHLD

Inner Shareable is the required shareability domain, reads are the required access type before the barrier instruction, and reads and writes are the required access types after the barrier instruction. Encoded as CRm = 0b1001.

### NSH

Non-shareable is the required shareability domain, reads and writes are the required access, both before and after the barrier instruction. Encoded as CRm = 0b0111.

### NSHST

Non-shareable is the required shareability domain, writes are the required access type, both before and after the barrier instruction. Encoded as CRm = 0b0110.

### NSHLD

Non-shareable is the required shareability domain, reads are the required access type before the barrier instruction, and reads and writes are the required access types after the barrier instruction. Encoded as CRm = 0b0101.

**OSH**

Outer Shareable is the required shareability domain, reads and writes are the required access types, both before and after the barrier instruction. Encoded as CRm = 0b0011.

**OSHST**

Outer Shareable is the required shareability domain, writes are the required access type, both before and after the barrier instruction. Encoded as CRm = 0b0010.

**OSHL**

Outer Shareable is the required shareability domain, reads are the required access type before the barrier instruction, and reads and writes are the required access types after the barrier instruction. Encoded as CRm = 0b0001.

All other encodings of CRm, other than the values 0b0000 and 0b0100, that are not listed above are reserved, and can be encoded using the #<imm> syntax. All unsupported and reserved options must execute as a full system barrier operation, but software must not rely on this behavior. For more information on whether an access is before or after a barrier instruction, see [Data Memory Barrier \(DMB\)](#) or see [Data Synchronization Barrier \(DSB\)](#).

The value 0b0000 is used to encode SSBB and the value 0b0100 is used to encode PSSBB.

<imm> Is a 4-bit unsigned immediate, in the range 0 to 15, encoded in the "CRm" field.

**Operation**

```
if HaveTME() && TSTATE.depth > 0 then
    FailTransaction(TMFailure_ERR, FALSE);
    DataSynchronizationBarrier(domain, types);
```

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# DVP

Data Value Prediction Restriction by Context prevents data value predictions, based on information gathered from earlier execution within an particular execution context, from allowing later speculative execution within that context to be observable through side-channels.

For more information, see *DVP RCTX, Data Value Prediction Restriction by Context*.

This is an alias of [SYS](#). This means:

- The encodings in this description are named to match the encodings of [SYS](#).
- The description of [SYS](#) gives the operational pseudocode for this instruction.

## System (Armv8.5)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	1	0	1	1	0	1	1	1	0	0	1	1	1	0	1					Rt
L										op1				CRn				CRm				op2									

## System

DVP RCTX, [<Xt>](#)

is equivalent to

[SYS](#) #3, C7, C3, #5, [<Xt>](#)

and is always the preferred disassembly.

## Assembler Symbols

[<Xt>](#) Is the 64-bit name of the general-purpose source register, encoded in the "Rt" field.

## Operation

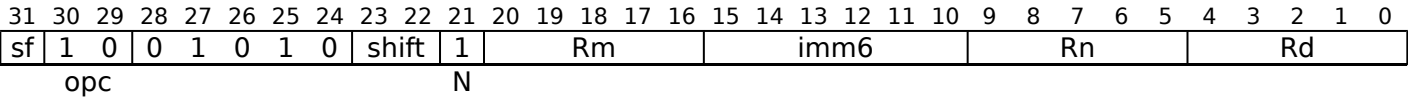
The description of [SYS](#) gives the operational pseudocode for this instruction.

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## EON (shifted register)

Bitwise Exclusive OR NOT (shifted register) performs a bitwise Exclusive OR NOT of a register value and an optionally-shifted register value, and writes the result to the destination register.



### 32-bit (sf == 0)

EON <Wd>, <Wn>, <Wm>{, <shift> #<amount>}

### 64-bit (sf == 1)

EON <Xd>, <Xn>, <Xm>{, <shift> #<amount>}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
if sf == '0' && imm6<5> == '1' then UNDEFINED;

ShiftType shift_type = DecodeShift(shift);
integer shift_amount = UInt(imm6);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <shift> Is the optional shift to be applied to the final source, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	ROR

- <amount> For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.  
For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field,

## Operation

```
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = ShiftReg(m, shift_type, shift_amount);

operand2 = NOT(operand2);

result = operand1 EOR operand2;

X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

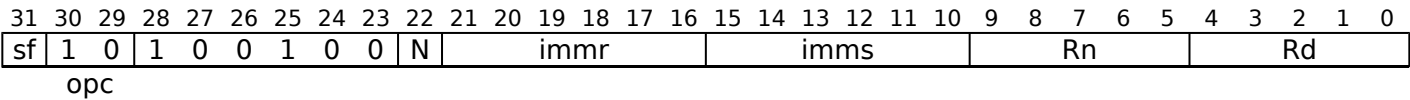
- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# EOR (immediate)

Bitwise Exclusive OR (immediate) performs a bitwise Exclusive OR of a register value and an immediate value, and writes the result to the destination register.



## 32-bit (sf == 0 && N == 0)

```
EOR <Wd|WSP>, <Wn>, #<imm>
```

## 64-bit (sf == 1)

```
EOR <Xd|SP>, <Xn>, #<imm>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer datasize = if sf == '1' then 64 else 32;
bits(datasize) imm;
if sf == '0' && N != '0' then UNDEFINED;
(imm, -) = DecodeBitMasks(N, imms, immr, TRUE);
```

## Assembler Symbols

- <Wd|WSP> Is the 32-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
- <Xd|SP> Is the 64-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
- <imm> For the 32-bit variant: is the bitmask immediate, encoded in "imms:immr".  
For the 64-bit variant: is the bitmask immediate, encoded in "N:imms:immr".

## Operation

```
bits(datasize) result;
bits(datasize) operand1 = X[n];

result = operand1 EOR imm;

if d == 31 then
    SP[] = result;
else
    X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

## EOR (shifted register)

Bitwise Exclusive OR (shifted register) performs a bitwise Exclusive OR of a register value and an optionally-shifted register value, and writes the result to the destination register.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	1	0	0	1	0	1	0	shift	0	Rm						imm6						Rn						Rd			
opc								N																							

### 32-bit (sf == 0)

EOR <Wd>, <Wn>, <Wm>{, <shift> #<amount>}

### 64-bit (sf == 1)

EOR <Xd>, <Xn>, <Xm>{, <shift> #<amount>}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
if sf == '0' && imm6<5> == '1' then UNDEFINED;

ShiftType shift_type = DecodeShift(shift);
integer shift_amount = UInt(imm6);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <shift> Is the optional shift to be applied to the final source, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	ROR

- <amount> For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.  
For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field,

## Operation

```
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = ShiftReg(m, shift_type, shift_amount);

result = operand1 EOR operand2;

X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:



- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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ERET

Exception Return using the ELR and SPSR for the current Exception level. When executed, the PE restores *PSTATE* from the SPSR, and branches to the address held in the ELR.

The PE checks the SPSR for the current Exception level for an illegal return event. See *Illegal return events from AArch64 state*.

ERET is UNDEFINED at EL0.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0								
1	1	0	1	0	1	1	0	1	0	0	1	1	1	1	1	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0								
																					A		M									Rn				op4			

System

ERET

```
if PSTATE.EL == EL0 then UNDEFINED;
```

Operation

```
AArch64.CheckForERetTrap(FALSE, TRUE);
bits(64) target = ELR[];

AArch64.ExceptionReturn(target, SPSR[]);
```

ERETAA, ERETAB

Exception Return, with pointer authentication. This instruction authenticates the address in ELR, using SP as the modifier and the specified key, the PE restores *PSTATE* from the SPSR for the current Exception level, and branches to the authenticated address.

Key A is used for ERETAA, and key B is used for ERETAB.

If the authentication passes, the PE continues execution at the target of the branch. If the authentication fails, a Translation fault is generated.

The authenticated address is not written back to ELR.

The PE checks the SPSR for the current Exception level for an illegal return event. See *Illegal return events from AArch64 state*.

ERETAA and ERETAB are UNDEFINED at EL0.

Integer  
(Armv8.3)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
1	1	0	1	0	1	1	0	1	0	0	1	1	1	1	1	0	0	0	0	1	M	1	1	1	1	1	1	1	1	1	1	
A																					Rn						op4					

ERETAA (M == 0)

ERETAA

ERETAB (M == 1)

ERETAB

```
if PSTATE.EL == EL0 then UNDEFINED;
boolean use_key_a = (M == '0');

if !HavePACExt() then
    UNDEFINED;
```

Operation

```
AArch64.CheckForERetTrap(TRUE, use_key_a);
bits(64) target;

if use_key_a then
    target = AuthIA(ELR[], SP[], TRUE);
else
    target = AuthIB(ELR[], SP[], TRUE);

AArch64.ExceptionReturn(target, SPSR[]);
```

ESB

Error Synchronization Barrier is an error synchronization event that might also update DISR\_EL1 and VDISR\_EL2. This instruction can be used at all Exception levels and in Debug state.

In Debug state, this instruction behaves as if SError interrupts are masked at all Exception levels. See Error Synchronization Barrier in the Arm(R) Reliability, Availability, and Serviceability (RAS) Specification, Armv8, for Armv8-A architecture profile.

If the RAS Extension is not implemented, this instruction executes as a NOP.

System  
(Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	1	0	0	0	0	1	1	1	1	1
																CRm				op2											

System

```
ESB

if !HaveRASExt() then EndOfInstruction();
```

Operation

```
if HaveTME() && TSTATE.depth > 0 then
    FailTransaction(TMFailure_ERR, FALSE);
SynchronizeErrors();
AArch64.ESB0operation();
if PSTATE.EL IN {EL0, EL1} && EL2Enabled() then AArch64.vESB0operation();
TakeUnmaskedSErrorInterrupts();
```

EXTR

Extract register extracts a register from a pair of registers.

This instruction is used by the alias [ROR \(immediate\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	0	1	0	0	1	1	1	N	0	Rm					imms					Rn					Rd					

32-bit (sf == 0 && N == 0 && imms == 0xxxxx)

EXTR <Wd>, <Wn>, <Wm>, #<lsb>

64-bit (sf == 1 && N == 1)

EXTR <Xd>, <Xn>, <Xm>, #<lsb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
integer lsb;

if N != sf then UNDEFINED;
if sf == '0' && imms<5> == '1' then UNDEFINED;
lsb = UInt(imms);
```

Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <lsb> For the 32-bit variant: is the least significant bit position from which to extract, in the range 0 to 31, encoded in the "imms" field.  
For the 64-bit variant: is the least significant bit position from which to extract, in the range 0 to 63, encoded in the "imms" field.

Alias Conditions

Alias	Is preferred when
<a href="#">ROR (immediate)</a>	Rn == Rm

Operation

```
bits(datasize) result;
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = X[m];
bits(2*datasize) concat = operand1:operand2;

result = concat<lsb+datasize-1:lsb>;

X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

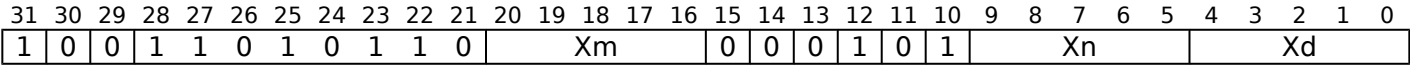
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GMI

Tag Mask Insert inserts the tag in the first source register into the excluded set specified in the second source register, writing the new excluded set to the destination register.

Integer  
(Armv8.5)



Integer

```
GMI <Xd>, <Xn|SP>, <Xm>

if !HaveMTEExt() then UNDEFINED;
integer d = UInt(Xd);
integer n = UInt(Xn);
integer m = UInt(Xm);
```

Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Xd" field.
- <Xn|SP> Is the 64-bit name of the first source general-purpose register or stack pointer, encoded in the "Xn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Xm" field.

Operation

```
bits(64) address = if n == 31 then SP[] else X[n];
bits(64) mask = X[m];
bits(4) tag = AArch64.AllocationTagFromAddress(address);

mask<UInt(tag)> = '1';
X[d] = mask;
```

# HINT

Hint instruction is for the instruction set space that is reserved for architectural hint instructions. Some encodings described here are not allocated in this revision of the architecture, and behave as NOPs. These encodings might be allocated to other hint functionality in future revisions of the architecture and therefore must not be used by software.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	CRm			op2			1	1	1	1	1	1

## System

```
HINT #<imm>

SystemHintOp op;

case CRm:op2 of
    when '0000 000' op = SystemHintOp_NOP;
    when '0000 001' op = SystemHintOp_YIELD;
    when '0000 010' op = SystemHintOp_WFE;
    when '0000 011' op = SystemHintOp_WFI;
    when '0000 100' op = SystemHintOp_SEV;
    when '0000 101' op = SystemHintOp_SEVL;
    when '0000 110'
        if !HaveDGHExt() then EndOfInstruction(); // Instruction executes as NOP
        op = SystemHintOp_DGH;
    when '0000 111' SEE "XPACLRI";
    when '0001 xxx'
        case op2 of
            when '000' SEE "PACIA1716";
            when '010' SEE "PACIB1716";
            when '100' SEE "AUTIA1716";
            when '110' SEE "AUTIB1716";
            otherwise EndOfInstruction();
    when '0010 000'
        if !HaveRASExt() then EndOfInstruction(); // Instruction executes as NOP
        op = SystemHintOp_ESB;
    when '0010 001'
        if !HaveStatisticalProfiling() then EndOfInstruction(); // Instruction executes as NOP
        op = SystemHintOp_PSB;
    when '0010 010'
        if !HaveSelfHostedTrace() then EndOfInstruction(); // Instruction executes as NOP
        op = SystemHintOp_TSB;
    when '0010 100'
        op = SystemHintOp_CSDB;
    when '0011 xxx'
        case op2 of
            when '000' SEE "PACIAZ";
            when '001' SEE "PACIASP";
            when '010' SEE "PACIBZ";
            when '011' SEE "PACIBSP";
            when '100' SEE "AUTIAZ";
            when '101' SEE "AUTHASP";
            when '110' SEE "AUTIBZ";
            when '111' SEE "AUTIBSP";
    when '0100 xx0'
        op = SystemHintOp_BTI;
        // Check branch target compatibility between BTI instruction and PSTATE.BTYPE
        SetBTypeCompatible(BTypeCompatible_BTI(op2<2:1>));
    otherwise EndOfInstruction();
```

## Assembler Symbols

<imm> Is a 7-bit unsigned immediate, in the range 0 to 127 encoded in the "CRm:op2" field.



The encodings that are allocated to architectural hint functionality are described in the "Hints" table in the "Index by Encoding".

For allocated encodings of "CRm:op2":

- A disassembler will disassemble the allocated instruction, rather than the HINT instruction.
- An assembler may support assembly of allocated encodings using HINT with the corresponding <imm> value, but it is not required to do so.



```

case op of
when SystemHintOp\_YIELD
    Hint\_Yield\(\);

when SystemHintOp\_DGH
    Hint\_DGH\(\);

when SystemHintOp\_WFE
    if IsEventRegisterSet\(\) then
        ClearEventRegister\(\);
    else
        trap = FALSE;
        if PSTATE.EL == EL0 then
            // Check for traps described by the OS which may be EL1 or EL2.
            if HaveTWEDEExt\(\) then
                - = SCTLR\[\];
                trap = sctlr.nTWE == '0';
                target_el = EL1;
            else
                AArch64.CheckForWfxTrap\(EL1, TRUE\);

        if !trap && PSTATE.EL IN {EL0, EL1} && EL2Enabled\(\) && !IsInHost\(\) then
            // Check for traps described by the Hypervisor.
            if HaveTWEDEExt\(\) then
                trap = HCR_EL2.TWE == '1';
                target_el = EL2;
            else
                AArch64.CheckForWfxTrap\(EL2, TRUE\);

        if !trap && HaveEL\(EL3\) && PSTATE.EL != EL3 then
            // Check for traps described by the Secure Monitor.
            if HaveTWEDEExt\(\) then
                trap = SCR_EL3.TWE == '1';
                target_el = EL3;
            else
                AArch64.CheckForWfxTrap\(EL3, TRUE\);

        if HaveTWEDEExt\(\) && trap && PSTATE.EL != EL3 then
            (delay_enabled, delay) = WFETrapDelay\(target\_el\);    // (If trap delay is enabled, Delay
            if !AArch64.WaitForEventUntilDelay\(delay\_enabled, delay\) then
                // Event did not arrive until delay expired
                AArch64.WFxTrap\(target\_el, TRUE\);    // Trap WFE
        else
            WaitForEvent\(\);

when SystemHintOp\_WFI
    if !InterruptPending\(\) then
        if PSTATE.EL == EL0 then
            // Check for traps described by the OS which may be EL1 or EL2.
            AArch64.CheckForWfxTrap\(EL1, FALSE\);
        if PSTATE.EL IN {EL0, EL1} && EL2Enabled\(\) && !IsInHost\(\) then
            // Check for traps described by the Hypervisor.
            AArch64.CheckForWfxTrap\(EL2, FALSE\);
        if HaveEL\(EL3\) && PSTATE.EL != EL3 then
            // Check for traps described by the Secure Monitor.
            AArch64.CheckForWfxTrap\(EL3, FALSE\);
        WaitForInterrupt\(\);

when SystemHintOp\_SEV
    SendEvent\(\);

when SystemHintOp\_SEVL
    SendEventLocal\(\);

when SystemHintOp\_ESB
    if HaveTME\(\) && TSTATE.depth > 0 then
        FailTransaction\(TMFailure\_ERR, FALSE\);
        SynchronizeErrors\(\);
        AArch64.ESB0peration\(\);
    if PSTATE.EL IN {EL0, EL1} && EL2Enabled\(\) then AArch64.vESB0peration\(\);

```

```

    TakeUnmaskedSErrorInterrupts();

when SystemHintOp_PSB
    ProfilingSynchronizationBarrier();

when SystemHintOp_TSB
    TraceSynchronizationBarrier();

when SystemHintOp_CSDB
    ConsumptionOfSpeculativeDataBarrier();

when SystemHintOp_BTI
    SetBTypeNext('00');

otherwise    // do nothing

```

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# HLT

Halt instruction. A HLTinstruction can generate a Halt Instruction debug event, which causes entry into Debug state.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	0	0	1	0	imm16																0	0	0	0	0

## System

```
HLT #<imm>

if EDSCR.HDE == '0' || !HaltingAllowed() then UNDEFINED;
if HaveBTIExt() then
    SetBTypeCompatible(TRUE);
```

## Assembler Symbols

<imm> Is a 16-bit unsigned immediate, in the range 0 to 65535, encoded in the "imm16" field.

## Operation

```
Halt(DebugHalt_HaltInstruction);
```

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# HVC

Hypervisor Call causes an exception to EL2. Non-secure software executing at EL1 can use this instruction to call the hypervisor to request a service.

The HVC instruction is UNDEFINED:

- At EL0.
- At EL1 if EL2 is not enabled in the current Security state.
- When [SCR\\_EL3.HCE](#) is set to 0.

On executing an HVC instruction, the PE records the exception as a Hypervisor Call exception in [ESR\\_ELx](#), using the EC value 0x16, and the value of the immediate argument.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	0	0	0	0	imm16																0	0	0	1	0

## System

```
HVC #<imm>
// Empty.
```

## Assembler Symbols

<imm> Is a 16-bit unsigned immediate, in the range 0 to 65535, encoded in the "imm16" field.

## Operation

```
if !HaveEL(EL2) || PSTATE.EL == EL0 || (PSTATE.EL == EL1 && (!IsSecureEL2Enabled() && IsSecure())) then
    UNDEFINED;

hvc_enable = if HaveEL(EL3) then SCR_EL3.HCE else NOT(HCR_EL2.HCD);

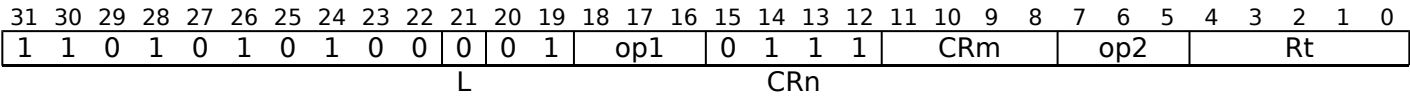
if hvc_enable == '0' then
    UNDEFINED;
else
    AArch64.CallHypervisor(imm16);
```

IC

Instruction Cache operation. For more information, see *op0==0b01, cache maintenance, TLB maintenance, and address translation instructions*.

This is an alias of [SYS](#). This means:

- The encodings in this description are named to match the encodings of [SYS](#).
- The description of [SYS](#) gives the operational pseudocode for this instruction.



System

IC <ic\_op>{, <Xt>}

is equivalent to

[SYS](#) #<op1>, C7, <Cm>, #<op2>{, <Xt>}

and is the preferred disassembly when `SysOp(op1, '0111', CRm, op2) == Sys_IC`.

Assembler Symbols

<ic\_op> Is an IC instruction name, as listed for the IC system instruction pages, encoded in “op1:CRm:op2”:

op1	CRm	op2	<ic_op>
000	0001	000	IALLUIS
000	0101	000	IALLU
011	0101	001	IVAU

- <op1> Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the "op1" field.
- <Cm> Is a name 'Cm', with 'm' in the range 0 to 15, encoded in the "CRm" field.
- <op2> Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the "op2" field.
- <Xt> Is the 64-bit name of the optional general-purpose source register, defaulting to '11111', encoded in the "Rt" field.

Operation

The description of [SYS](#) gives the operational pseudocode for this instruction.

## IRG

Insert Random Tag inserts a random Logical Address Tag into the address in the first source register, and writes the result to the destination register. Any tags specified in the optional second source register or in GCR\_EL1.Exclude are excluded from the selection of the random Logical Address Tag.

### Integer (Armv8.5)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	1	0	1	0	1	1	0	Xm				0	0	0	1	0	0	Xn				Xd						

### Integer

IRG <Xd|SP>, <Xn|SP>{, <Xm>}

```
if !HaveMTEExt() then UNDEFINED;
integer d = UInt(Xd);
integer n = UInt(Xn);
integer m = UInt(Xm);
```

### Assembler Symbols

- <Xd|SP> Is the 64-bit name of the destination general-purpose register or stack pointer, encoded in the "Xd" field.
- <Xn|SP> Is the 64-bit name of the first source general-purpose register or stack pointer, encoded in the "Xn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Xm" field. Defaults to XZR if absent.

### Operation

```
bits(64) operand = if n == 31 then SP[] else X[n];
bits(64) exclude_reg = X[m];
bits(16) exclude = exclude_reg<15:0> OR GCR_EL1.Exclude;

if AArch64.AllocationTagAccessIsEnabled(AccType_NORMAL) then
    if GCR_EL1.RRND == '1' then
        rtag = _ChooseRandomNonExcludedTag(exclude);
    else
        bits(4) start = RGSR_EL1.TAG;
        bits(4) offset = AArch64.RandomTag();

        rtag = AArch64.ChooseNonExcludedTag(start, offset, exclude);

        RGSR_EL1.TAG = rtag;
else
    rtag = '0000';

bits(64) result = AArch64.AddressWithAllocationTag(operand, AccType_NORMAL, rtag);

if d == 31 then
    SP[] = result;
else
    X[d] = result;
```

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# ISB

Instruction Synchronization Barrier flushes the pipeline in the PE and is a context synchronization event. For more information, see [Instruction Synchronization Barrier \(ISB\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	1	CRm			1	1	0	1	1	1	1	1	1
opc																															

## System

```
ISB {<option>|<imm>}  
  
// No additional decoding required
```

## Assembler Symbols

- <option>

Specifies an optional limitation on the barrier operation. Values are:

**SY** Full system barrier operation, encoded as CRm = 0b1111. Can be omitted.

All other encodings of CRm are reserved. The corresponding instructions execute as full system barrier operations, but must not be relied upon by software.
- <imm>

Is an optional 4-bit unsigned immediate, in the range 0 to 15, defaulting to 15 and encoded in the "CRm" field.

## Operation

```
InstructionSynchronizationBarrier();
```

# LDADD, LDADDA, LDADDAL, LDADDL

Atomic add on word or doubleword in memory atomically loads a 32-bit word or 64-bit doubleword from memory, adds the value held in a register to it, and stores the result back to memory. The value initially loaded from memory is returned in the destination register.

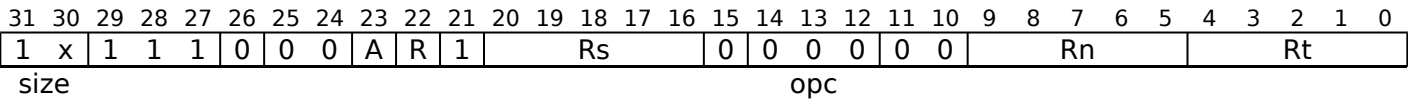
- If the destination register is not one of WZR or XZR, LDADDA and LDADDAL load from memory with acquire semantics.
- LDADDL and LDADDAL store to memory with release semantics.
- LDADD has neither acquire nor release semantics.

For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This instruction is used by the alias *STADD, STADDL*.

## Integer (Armv8.1)



32-bit LDADD (size == 10 && A == 0 && R == 0)

```
LDADD <Ws>, <Wt>, [<Xn|SP>]
```

32-bit LDADDA (size == 10 && A == 1 && R == 0)

```
LDADDA <Ws>, <Wt>, [<Xn|SP>]
```

32-bit LDADDAL (size == 10 && A == 1 && R == 1)

```
LDADDAL <Ws>, <Wt>, [<Xn|SP>]
```

32-bit LDADDL (size == 10 && A == 0 && R == 1)

```
LDADDL <Ws>, <Wt>, [<Xn|SP>]
```

64-bit LDADD (size == 11 && A == 0 && R == 0)

```
LDADD <Xs>, <Xt>, [<Xn|SP>]
```

64-bit LDADDA (size == 11 && A == 1 && R == 0)

```
LDADDA <Xs>, <Xt>, [<Xn|SP>]
```

64-bit LDADDAL (size == 11 && A == 1 && R == 1)

```
LDADDAL <Xs>, <Xt>, [<Xn|SP>]
```

64-bit LDADDL (size == 11 && A == 0 && R == 1)

```
LDADDL <Xs>, <Xt>, [<Xn|SP>]
```

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

integer datasize = 8 << UInt(size);
integer regsize = if datasize == 64 then 64 else 32;
AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

Assembler Symbols

<Ws>	Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Wt>	Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
<Xs>	Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xt>	Is the 64-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Alias Conditions

Alias	Is preferred when
<a href="#">STADD, STADDL</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(datasize) value;
bits(datasize) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_ADD, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, regsize);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDADDB, LDADDAB, LDADDALB, LDADDLB

Atomic add on byte in memory atomically loads an 8-bit byte from memory, adds the value held in a register to it, and stores the result back to memory. The value initially loaded from memory is returned in the destination register.

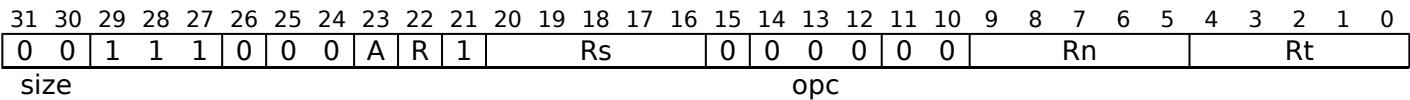
- If the destination register is not WZR, LDADDAB and LDADDALB load from memory with acquire semantics.
- LDADDLB and LDADDALB store to memory with release semantics.
- LDADDB has neither acquire nor release semantics.

For more information about memory ordering semantics see [Load-Acquire, Store-Release](#).

For information about memory accesses see [Load/Store addressing modes](#).

This instruction is used by the alias [STADDB, STADDLB](#).

## Integer (Armv8.1)



### LDADDAB (A == 1 && R == 0)

LDADDAB <Ws>, <Wt>, [<Xn|SP>]

### LDADDALB (A == 1 && R == 1)

LDADDALB <Ws>, <Wt>, [<Xn|SP>]

### LDADDB (A == 0 && R == 0)

LDADDB <Ws>, <Wt>, [<Xn|SP>]

### LDADDLB (A == 0 && R == 1)

LDADDLB <Ws>, <Wt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '1111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">STADDB, STADDLB</a>	A == '0' && Rt == '1111'

## Operation

```
bits(64) address;
bits(8) value;
bits(8) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_ADD, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDADDH, LDADDAH, LDADDALH, LDADDLH

Atomic add on halfword in memory atomically loads a 16-bit halfword from memory, adds the value held in a register to it, and stores the result back to memory. The value initially loaded from memory is returned in the destination register.

- If the destination register is not WZR, LDADDAH and LDADDALH load from memory with acquire semantics.
- LDADDLH and LDADDALH store to memory with release semantics.
- LDADDH has neither acquire nor release semantics.

For more information about memory ordering semantics see [Load-Acquire, Store-Release](#).

For information about memory accesses see [Load/Store addressing modes](#).

This instruction is used by the alias [STADDH, STADDLH](#).

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	A	R	1	Rs				0	0	0	0	0	0	Rn				Rt						
size											opc																				

### LDADDAH (A == 1 && R == 0)

LDADDAH <Ws>, <Wt>, [<Xn|SP>]

### LDADDALH (A == 1 && R == 1)

LDADDALH <Ws>, <Wt>, [<Xn|SP>]

### LDADDH (A == 0 && R == 0)

LDADDH <Ws>, <Wt>, [<Xn|SP>]

### LDADDLH (A == 0 && R == 1)

LDADDLH <Ws>, <Wt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">STADDH, STADDLH</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(16) value;
bits(16) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_ADD, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDAPR

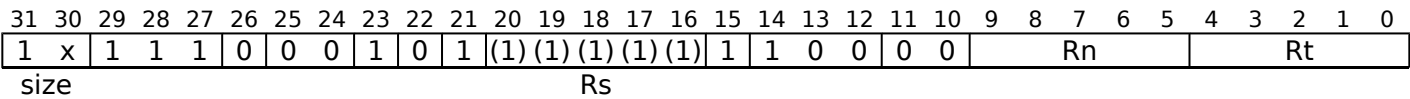
Load-Acquire RCpc Register derives an address from a base register value, loads a 32-bit word or 64-bit doubleword from the derived address in memory, and writes it to a register.

The instruction has memory ordering semantics as described in *Load-Acquire, Load-AcquirePC, and Store-Release*, except that:

- There is no ordering requirement, separate from the requirements of a Load-AcquirePC or a Store-Release, created by having a Store-Release followed by a Load-AcquirePC instruction.
- The reading of a value written by a Store-Release by a Load-AcquirePC instruction by the same observer does not make the write of the Store-Release globally observed.

This difference in memory ordering is not described in the pseudocode.  
For information about memory accesses, see *Load/Store addressing modes*.

## Integer (Armv8.3)



### 32-bit (size == 10)

```
LDAPR <Wt>, [<Xn|SP> {,#0}]
```

### 64-bit (size == 11)

```
LDAPR <Xt>, [<Xn|SP> {,#0}]
```

```
integer n = UInt(Rn);
integer t = UInt(Rt);

integer elsize = 8 << UInt(size);
integer regsize = if elsize == 64 then 64 else 32;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(elsize) data;
constant integer dbytes = elsize DIV 8;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = Mem[address, dbytes, AccType_ORDERED];
X[t] = ZeroExtend(data, regsize);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDAPRB

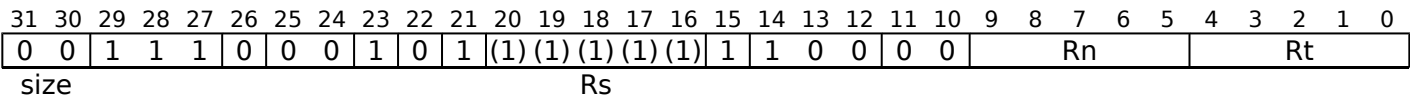
Load-Acquire RCpc Register Byte derives an address from a base register value, loads a byte from the derived address in memory, zero-extends it and writes it to a register.

The instruction has memory ordering semantics as described in *Load-Acquire, Load-AcquirePC, and Store-Release*, except that:

- There is no ordering requirement, separate from the requirements of a Load-AcquirePC or a Store-Release, created by having a Store-Release followed by a Load-AcquirePC instruction.
- The reading of a value written by a Store-Release by a Load-AcquirePC instruction by the same observer does not make the write of the Store-Release globally observed.

This difference in memory ordering is not described in the pseudocode.  
For information about memory accesses, see *Load/Store addressing modes*.

## Integer (Armv8.3)



Integer

```
LDAPRB <Wt>, [<Xn|SP> {,#0}]

integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Wt>
- Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP>
- Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(8) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = Mem[address, 1, AccType_ORDERED];
X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

# LDAPRH

Load-Acquire RCpc Register Halfword derives an address from a base register value, loads a halfword from the derived address in memory, zero-extends it and writes it to a register.

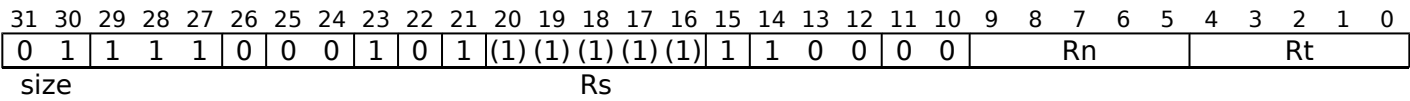
The instruction has memory ordering semantics as described in *Load-Acquire, Load-AcquirePC, and Store-Release*, except that:

- There is no ordering requirement, separate from the requirements of a Load-AcquirePC or a Store-Release, created by having a Store-Release followed by a Load-AcquirePC instruction.
- The reading of a value written by a Store-Release by a Load-AcquirePC instruction by the same observer does not make the write of the Store-Release globally observed.

This difference in memory ordering is not described in the pseudocode.

For information about memory accesses, see *Load/Store addressing modes*.

## Integer (Armv8.3)



Integer

```
LDAPRH <Wt>, [<Xn|SP> {, #0}]
```

```
integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(16) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = Mem[address, 2, AccType_ORDERED];
X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDAPUR

Load-Acquire RCpc Register (unscaled) calculates an address from a base register and an immediate offset, loads a 32-bit word or 64-bit doubleword from memory, zero-extends it, and writes it to a register.

The instruction has memory ordering semantics as described in *Load-Acquire, Load-AcquirePC, and Store-Release*, except that:

- There is no ordering requirement, separate from the requirements of a Load-AcquirePC or a Store-Release, created by having a Store-Release followed by a Load-AcquirePC instruction.
- The reading of a value written by a Store-Release by a Load-AcquirePC instruction by the same observer does not make the write of the Store-Release globally observed.

This difference in memory ordering is not described in the pseudocode.  
For information about memory accesses, see *Load/Store addressing modes*.

## Unscaled offset (Armv8.4)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
1	x	0	1	1	0	0	1	0	1	0	imm9									0	0	Rn				Rt									
size										opc																									

### 32-bit (size == 10)

```
LDAPUR <Wt>, [<Xn|SP>{, #<simm>}]
```

### 64-bit (size == 11)

```
LDAPUR <Xt>, [<Xn|SP>{, #<simm>}]
```

```
integer scale = UInt(size);  
bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <simm> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);  
integer t = UInt(Rt);  
integer regsize;  
  
regsize = if size == '11' then 64 else 32;  
integer datasize = 8 << scale;  
boolean tag_checked = n != 31;
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(datasize) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = Mem[address, datasize DIV 8, AccType_ORDERED];
X[t] = ZeroExtend(data, regsize);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDAPURB

Load-Acquire RCpc Register Byte (unscaled) calculates an address from a base register and an immediate offset, loads a byte from memory, zero-extends it, and writes it to a register.

The instruction has memory ordering semantics as described in *Load-Acquire, Load-AcquirePC, and Store-Release*, except that:

- There is no ordering requirement, separate from the requirements of a Load-AcquirePC or a Store-Release, created by having a Store-Release followed by a Load-AcquirePC instruction.
- The reading of a value written by a Store-Release by a Load-AcquirePC instruction by the same observer does not make the write of the Store-Release globally observed.

This difference in memory ordering is not described in the pseudocode.  
For information about memory accesses, see *Load/Store addressing modes*.

## Unscaled offset (Armv8.4)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1	1	0	0	1	0	1	0	imm9									0	0	Rn				Rt					
size										opc																					

## Unscaled offset

```
LDAPURB <Wt>, [<Xn|SP>{, #<sim>}]  
  
bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);  
integer t = UInt(Rt);  
  
boolean tag_checked = n != 31;
```

## Operation

```
if HaveMTEExt() then  
    SetTagCheckedInstruction(tag_checked);  
  
bits(64) address;  
bits(8) data;  
  
if n == 31 then  
    CheckSPAlignment();  
    address = SP[];  
else  
    address = X[n];  
  
address = address + offset;  
  
data = Mem[address, 1, AccType_ORDERED];  
X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDAPURH

Load-Acquire RCpc Register Halfword (unscaled) calculates an address from a base register and an immediate offset, loads a halfword from memory, zero-extends it, and writes it to a register.

The instruction has memory ordering semantics as described in *Load-Acquire, Load-AcquirePC, and Store-Release*, except that:

- There is no ordering requirement, separate from the requirements of a Load-AcquirePC or a Store-Release, created by having a Store-Release followed by a Load-AcquirePC instruction.
- The reading of a value written by a Store-Release by a Load-AcquirePC instruction by the same observer does not make the write of the Store-Release globally observed.

This difference in memory ordering is not described in the pseudocode.  
For information about memory accesses, see *Load/Store addressing modes*.

## Unscaled offset (Armv8.4)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	1	0	imm9									0	0	Rn				Rt					
size										opc																					

## Unscaled offset

```
LDAPURH <Wt>, [<Xn|SP>{, #<sim>}]  
  
bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);  
integer t = UInt(Rt);  
  
boolean tag_checked = n != 31;
```

## Operation

```
if HaveMTEExt() then  
    SetTagCheckedInstruction(tag_checked);  
  
bits(64) address;  
bits(16) data;  
  
if n == 31 then  
    CheckSPAlignment();  
    address = SP[];  
else  
    address = X[n];  
  
address = address + offset;  
  
data = Mem[address, 2, AccType_ORDERED];  
X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDAPURSB

Load-Acquire RCpc Register Signed Byte (unscaled) calculates an address from a base register and an immediate offset, loads a signed byte from memory, sign-extends it, and writes it to a register.

The instruction has memory ordering semantics as described in *Load-Acquire, Load-AcquirePC, and Store-Release*, except that:

- There is no ordering requirement, separate from the requirements of a Load-AcquirePC or a Store-Release, created by having a Store-Release followed by a Load-AcquirePC instruction.
- The reading of a value written by a Store-Release by a Load-AcquirePC instruction by the same observer does not make the write of the Store-Release globally observed.

This difference in memory ordering is not described in the pseudocode.

For information about memory accesses, see *Load/Store addressing modes*.

## Unscaled offset (Armv8.4)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1	1	0	0	1	1	x	0	imm9									0	0	Rn				Rt					
size										opc																					

### 32-bit (opc == 11)

```
LDAPURSB <Wt>, [<Xn|SP>{, #<sim>}]
```

### 64-bit (opc == 10)

```
LDAPURSB <Xt>, [<Xn|SP>{, #<sim>}]

bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

<Wt>	Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
<Xt>	Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<sim>	Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
MemOp memop;
boolean signed;
integer regsize;

if opc<1> == '0' then
    // store or zero-extending load
    memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;
    regsize = 32;
    signed = FALSE;
else
    // sign-extending load
    memop = MemOp_LOAD;
    regsize = if opc<0> == '1' then 32 else 64;
    signed = TRUE;

boolean tag_checked = memop != MemOp_PREFETCH && (n != 31);
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(8) data;

if n == 31 then
    if memop != MemOp_PREFETCH then CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

case memop of
    when MemOp_STORE
        data = X[t];
        Mem[address, 1, AccType_ORDERED] = data;

    when MemOp_LOAD
        data = Mem[address, 1, AccType_ORDERED];
        if signed then
            X[t] = SignExtend(data, regsize);
        else
            X[t] = ZeroExtend(data, regsize);

    when MemOp_PREFETCH
        Prefetch(address, t<4:0>);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDAPURSH

Load-Acquire RCpc Register Signed Halfword (unscaled) calculates an address from a base register and an immediate offset, loads a signed halfword from memory, sign-extends it, and writes it to a register.

The instruction has memory ordering semantics as described in *Load-Acquire, Load-AcquirePC, and Store-Release*, except that:

- There is no ordering requirement, separate from the requirements of a Load-AcquirePC or a Store-Release, created by having a Store-Release followed by a Load-AcquirePC instruction.
- The reading of a value written by a Store-Release by a Load-AcquirePC instruction by the same observer does not make the write of the Store-Release globally observed.

This difference in memory ordering is not described in the pseudocode.  
For information about memory accesses, see *Load/Store addressing modes*.

## Unscaled offset (Armv8.4)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
0	1	0	1	1	0	0	1	1	x	0	imm9									0	0	Rn				Rt									
size										opc																									

### 32-bit (opc == 11)

```
LDAPURSH <Wt>, [<Xn|SP>{, #<sim>}]
```

### 64-bit (opc == 10)

```
LDAPURSH <Xt>, [<Xn|SP>{, #<sim>}]
```

```
bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
MemOp memop;
boolean signed;
integer regsize;

if opc<1> == '0' then
    // store or zero-extending load
    memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;
    regsize = 32;
    signed = FALSE;
else
    // sign-extending load
    memop = MemOp_LOAD;
    regsize = if opc<0> == '1' then 32 else 64;
    signed = TRUE;

boolean tag_checked = memop != MemOp_PREFETCH && (n != 31);
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(16) data;

if n == 31 then
    if memop != MemOp_PREFETCH then CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

case memop of
    when MemOp_STORE
        data = X[t];
        Mem[address, 2, AccType_ORDERED] = data;

    when MemOp_LOAD
        data = Mem[address, 2, AccType_ORDERED];
        if signed then
            X[t] = SignExtend(data, regsize);
        else
            X[t] = ZeroExtend(data, regsize);

    when MemOp_PREFETCH
        Prefetch(address, t<4:0>);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDAPURSW

Load-Acquire RCpc Register Signed Word (unscaled) calculates an address from a base register and an immediate offset, loads a signed word from memory, sign-extends it, and writes it to a register.

The instruction has memory ordering semantics as described in *Load-Acquire, Load-AcquirePC, and Store-Release*, except that:

- There is no ordering requirement, separate from the requirements of a Load-AcquirePC or a Store-Release, created by having a Store-Release followed by a Load-AcquirePC instruction.
- The reading of a value written by a Store-Release by a Load-AcquirePC instruction by the same observer does not make the write of the Store-Release globally observed.

This difference in memory ordering is not described in the pseudocode.

For information about memory accesses, see *Load/Store addressing modes*.

## Unscaled offset (Armv8.4)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	1	0	0	1	1	0	0	imm9									0	0	Rn				Rt					
size								opc																							

## Unscaled offset

```
LDAPURSW <Xt>, [<Xn|SP>{, #<sim>}]

bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(32) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = Mem[address, 4, AccType_ORDERED];
X[t] = SignExtend(data, 64);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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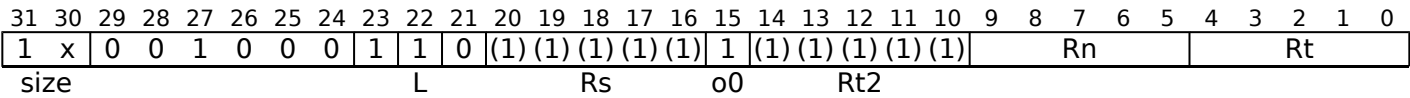
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# LDAR

Load-Acquire Register derives an address from a base register value, loads a 32-bit word or 64-bit doubleword from memory, and writes it to a register. The instruction also has memory ordering semantics as described in *Load-Acquire, Store-Release*. For information about memory accesses, see *Load/Store addressing modes*.

For this instruction, if the destination is WZR/XZR, it is impossible for software to observe the presence of the acquire semantic other than its effect on the arrival at endpoints.



## 32-bit (size == 10)

```
LDAR <Wt>, [<Xn|SP>{, #0}]
```

## 64-bit (size == 11)

```
LDAR <Xt>, [<Xn|SP>{, #0}]
```

```
integer n = UInt(Rn);
integer t = UInt(Rt);

integer elsize = 8 << UInt(size);
integer regsize = if elsize == 64 then 64 else 32;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(elsize) data;
constant integer dbytes = elsize DIV 8;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = Mem[address, dbytes, AccType_ORDERED];
X[t] = ZeroExtend(data, regsize);
```

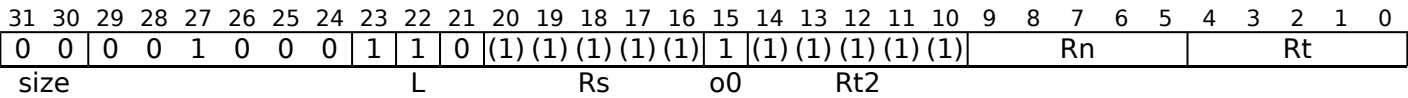
## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

# LDARB

Load-Acquire Register Byte derives an address from a base register value, loads a byte from memory, zero-extends it and writes it to a register. The instruction also has memory ordering semantics as described in [Load-Acquire, Store-Release](#). For information about memory accesses, see [Load/Store addressing modes](#).

For this instruction, if the destination is WZR/XZR, it is impossible for software to observe the presence of the acquire semantic other than its effect on the arrival at endpoints.



## No offset

```
LDARB <Wt>, [<Xn|SP>{, #0}]

integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(8) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = Mem[address, 1, AccType_ORDERED];
X[t] = ZeroExtend(data, 32);
```

## Operational information

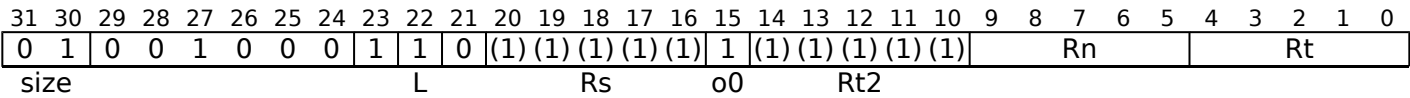
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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LDARH

Load-Acquire Register Halfword derives an address from a base register value, loads a halfword from memory, zero-extends it, and writes it to a register. The instruction also has memory ordering semantics as described in *Load-Acquire, Store-Release*. For information about memory accesses, see *Load/Store addressing modes*.  
For this instruction, if the destination is WZR/XZR, it is impossible for software to observe the presence of the acquire semantic other than its effect on the arrival at endpoints.



No offset

```
LDARH <Wt>, [<Xn|SP>{, #0}]

integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Operation

```
bits(64) address;
bits(16) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = Mem[address, 2, AccType_ORDERED];
X[t] = ZeroExtend(data, 32);
```

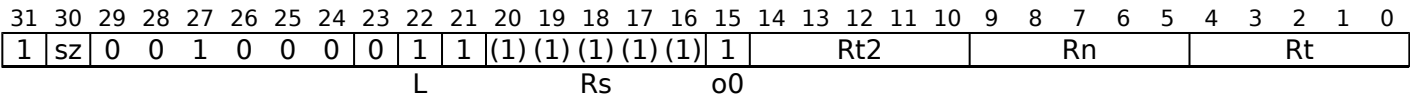
Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDAXP

Load-Acquire Exclusive Pair of Registers derives an address from a base register value, loads two 32-bit words or two 64-bit doublewords from memory, and writes them to two registers. A 32-bit pair requires the address to be doubleword aligned and is single-copy atomic at doubleword granularity. A 64-bit pair requires the address to be quadword aligned and is single-copy atomic for each doubleword at doubleword granularity. The PE marks the physical address being accessed as an exclusive access. This exclusive access mark is checked by Store Exclusive instructions. See *Synchronization and semaphores*. The instruction also has memory ordering semantics as described in *Load-Acquire, Store-Release*. For information about memory accesses see *Load/Store addressing modes*.



## 32-bit (sz == 0)

```
LDAXP <Wt1>, <Wt2>, [<Xn|SP>{, #0}]
```

## 64-bit (sz == 1)

```
LDAXP <Xt1>, <Xt2>, [<Xn|SP>{, #0}]
```

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer t2 = UInt(Rt2);

integer elsize = 32 << UInt(sz);
integer datasize = elsize * 2;
boolean tag_checked = n != 31;
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see *Architectural Constraints on UNPREDICTABLE behaviors*, and particularly *LDAXP*.

## Assembler Symbols

- <Wt1> Is the 32-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
- <Wt2> Is the 32-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
- <Xt1> Is the 64-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt2> Is the 64-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(datasize) data;
constant integer dbytes = datasize DIV 8;
boolean rt_unknown = FALSE;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if t == t2 then
    Constraint c = ConstrainUnpredictable(Unpredictable_LDPOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rt_unknown = TRUE;    // result is UNKNOWN
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

// Tell the Exclusives monitors to record a sequence of one or more atomic
// memory reads from virtual address range [address, address+dbytes-1].
// The Exclusives monitor will only be set if all the reads are from the
// same dbytes-aligned physical address, to allow for the possibility of
// an atomicity break if the translation is changed between reads.
AArch64.SetExclusiveMonitors(address, dbytes);

if rt_unknown then
    // ConstrainedUNPREDICTABLE case
    X[t] = bits(datasize) UNKNOWN;    // In this case t = t2
elsif elsize == 32 then
    // 32-bit load exclusive pair (atomic)
    data = Mem[address, dbytes, AccType_ORDEREDATOMIC];
    if BigEndian() then
        X[t] = data<datasize-1:elsize>;
        X[t2] = data<elsize-1:0>;
    else
        X[t] = data<elsize-1:0>;
        X[t2] = data<datasize-1:elsize>;
else // elsize == 64
    // 64-bit load exclusive pair (not atomic),
    // but must be 128-bit aligned
    if address != Align(address, dbytes) then
        AArch64.Abort(address, AArch64.AlignmentFault(AccType_ORDEREDATOMIC, FALSE, FALSE));
    X[t] = Mem[address, 8, AccType_ORDEREDATOMIC];
    X[t2] = Mem[address+8, 8, AccType_ORDEREDATOMIC];
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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## LDAXR

Load-Acquire Exclusive Register derives an address from a base register value, loads a 32-bit word or 64-bit doubleword from memory, and writes it to a register. The memory access is atomic. The PE marks the physical address being accessed as an exclusive access. This exclusive access mark is checked by Store Exclusive instructions. See [Synchronization and semaphores](#). The instruction also has memory ordering semantics as described in [Load-Acquire, Store-Release](#). For information about memory accesses see [Load/Store addressing modes](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	0	0	1	0	0	0	0	1	0	(1)	(1)	(1)	(1)	(1)	1	(1)	(1)	(1)	(1)	(1)	Rn					Rt				
size								L		Rs					o0		Rt2														

### 32-bit (size == 10)

```
LDAXR <Wt>, [<Xn|SP>{, #0}]
```

### 64-bit (size == 11)

```
LDAXR <Xt>, [<Xn|SP>{, #0}]
```

```
integer n = UInt(Rn);
integer t = UInt(Rt);

integer elsize = 8 << UInt(size);
integer regsize = if elsize == 64 then 64 else 32;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(elsize) data;
constant integer dbytes = elsize DIV 8;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

// Tell the Exclusives monitors to record a sequence of one or more atomic
// memory reads from virtual address range [address, address+dbytes-1].
// The Exclusives monitor will only be set if all the reads are from the
// same dbytes-aligned physical address, to allow for the possibility of
// an atomicity break if the translation is changed between reads.
AArch64.SetExclusiveMonitors(address, dbytes);

data = Mem[address, dbytes, AccType_ORDEREDATOMIC];
X[t] = ZeroExtend(data, regsize);
```

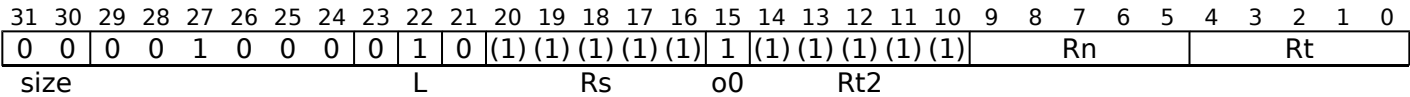
## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.



# LDAXRB

Load-Acquire Exclusive Register Byte derives an address from a base register value, loads a byte from memory, zero-extends it and writes it to a register. The memory access is atomic. The PE marks the physical address being accessed as an exclusive access. This exclusive access mark is checked by Store Exclusive instructions. See [Synchronization and semaphores](#). The instruction also has memory ordering semantics as described in [Load-Acquire, Store-Release](#). For information about memory accesses see [Load/Store addressing modes](#).



## No offset

```
LDAXRB <Wt>, [<Xn|SP>{, #0}]

integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(8) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

// Tell the Exclusives monitors to record a sequence of one or more atomic
// memory reads from virtual address range [address, address+dbytes-1].
// The Exclusives monitor will only be set if all the reads are from the
// same dbytes-aligned physical address, to allow for the possibility of
// an atomicity break if the translation is changed between reads.
AArch64.SetExclusiveMonitors(address, 1);

data = Mem[address, 1, AccType_ORDEREDATOMIC];
X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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## LDAXRH

Load-Acquire Exclusive Register Halfword derives an address from a base register value, loads a halfword from memory, zero-extends it and writes it to a register. The memory access is atomic. The PE marks the physical address being accessed as an exclusive access. This exclusive access mark is checked by Store Exclusive instructions. See [Synchronization and semaphores](#). The instruction also has memory ordering semantics as described in [Load-Acquire, Store-Release](#). For information about memory accesses see [Load/Store addressing modes](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	1	0	0	0	0	1	0	(1)	(1)	(1)	(1)	(1)	1	(1)	(1)	(1)	(1)	(1)	Rn						Rt			
size								L			Rs				o0		Rt2														

### No offset

```
LDAXRH <Wt>, [<Xn|SP>{, #0}]
```

```
integer n = UInt(Rn);
```

```
integer t = UInt(Rt);
```

```
boolean tag_checked = n != 31;
```

### Assembler Symbols

<Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.

<Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

### Operation

```
bits(64) address;
```

```
bits(16) data;
```

```
if HaveMTEExt() then
```

```
    SetTagCheckedInstruction(tag_checked);
```

```
if n == 31 then
```

```
    CheckSPAlignment();
```

```
    address = SP[];
```

```
else
```

```
    address = X[n];
```

```
// Tell the Exclusives monitors to record a sequence of one or more atomic
```

```
// memory reads from virtual address range [address, address+dbytes-1].
```

```
// The Exclusives monitor will only be set if all the reads are from the
```

```
// same dbytes-aligned physical address, to allow for the possibility of
```

```
// an atomicity break if the translation is changed between reads.
```

```
AArch64.SetExclusiveMonitors(address, 2);
```

```
data = Mem[address, 2, AccType_ORDEREDATOMIC];
```

```
X[t] = ZeroExtend(data, 32);
```

### Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDCLR, LDCLRA, LDCLRAL, LDCLRL

Atomic bit clear on word or doubleword in memory atomically loads a 32-bit word or 64-bit doubleword from memory, performs a bitwise AND with the complement of the value held in a register on it, and stores the result back to memory. The value initially loaded from memory is returned in the destination register.

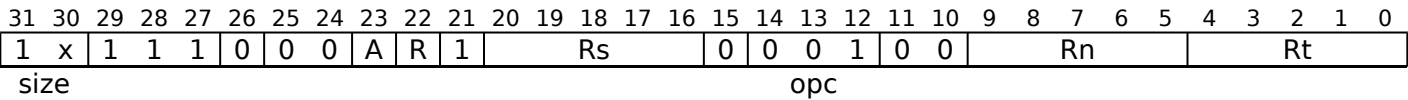
- If the destination register is not one of WZR or XZR, LDCLRA and LDCLRAL load from memory with acquire semantics.
- LDCLRL and LDCLRAL store to memory with release semantics.
- LDCLR has neither acquire nor release semantics.

For more information about memory ordering semantics see [Load-Acquire, Store-Release](#).

For information about memory accesses see [Load/Store addressing modes](#).

This instruction is used by the alias [STCLR, STCLRL](#).

## Integer (Armv8.1)



**32-bit LDCLR (size == 10 && A == 0 && R == 0)**

LDCLR <Ws>, <Wt>, [<Xn|SP>]

**32-bit LDCLRA (size == 10 && A == 1 && R == 0)**

LDCLRA <Ws>, <Wt>, [<Xn|SP>]

**32-bit LDCLRAL (size == 10 && A == 1 && R == 1)**

LDCLRAL <Ws>, <Wt>, [<Xn|SP>]

**32-bit LDCLRL (size == 10 && A == 0 && R == 1)**

LDCLRL <Ws>, <Wt>, [<Xn|SP>]

**64-bit LDCLR (size == 11 && A == 0 && R == 0)**

LDCLR <Xs>, <Xt>, [<Xn|SP>]

**64-bit LDCLRA (size == 11 && A == 1 && R == 0)**

LDCLRA <Xs>, <Xt>, [<Xn|SP>]

**64-bit LDCLRAL (size == 11 && A == 1 && R == 1)**

LDCLRAL <Xs>, <Xt>, [<Xn|SP>]

**64-bit LDCLRL (size == 11 && A == 0 && R == 1)**

LDCLRL <Xs>, <Xt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

integer datasize = 8 << UInt(size);
integer regsize = if datasize == 64 then 64 else 32;
AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

**Assembler Symbols**

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xs> Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xt> Is the 64-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

**Alias Conditions**

Alias	Is preferred when
<a href="#">STCLR</a> , <a href="#">STCLRL</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(datasize) value;
bits(datasize) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_BIC, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, regsize);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDCLRB, LDCLRAB, LDCLRALB, LDCLRLB

Atomic bit clear on byte in memory atomically loads an 8-bit byte from memory, performs a bitwise AND with the complement of the value held in a register on it, and stores the result back to memory. The value initially loaded from memory is returned in the destination register.

- If the destination register is not WZR, LDCLRAB and LDCLRALB load from memory with acquire semantics.
- LDCLRLB and LDCLRALB store to memory with release semantics.
- LDCLRB has neither acquire nor release semantics.

For more information about memory ordering semantics see [Load-Acquire, Store-Release](#).

For information about memory accesses see [Load/Store addressing modes](#).

This instruction is used by the alias [STCLRB, STCLRLB](#).

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	A	R	1	Rs					0	0	0	1	0	0	Rn					Rt				
size											opc																				

### LDCLRAB (A == 1 && R == 0)

LDCLRAB <Ws>, <Wt>, [<Xn|SP>]

### LDCLRALB (A == 1 && R == 1)

LDCLRALB <Ws>, <Wt>, [<Xn|SP>]

### LDCLRB (A == 0 && R == 0)

LDCLRB <Ws>, <Wt>, [<Xn|SP>]

### LDCLRLB (A == 0 && R == 1)

LDCLRLB <Ws>, <Wt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">STCLRB, STCLRLB</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(8) value;
bits(8) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_BIC, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDCLRH, LDCLRAH, LDCLRALH, LDCLRLH

Atomic bit clear on halfword in memory atomically loads a 16-bit halfword from memory, performs a bitwise AND with the complement of the value held in a register on it, and stores the result back to memory. The value initially loaded from memory is returned in the destination register.

- If the destination register is not WZR, LDCLRAH and LDCLRALH load from memory with acquire semantics.
- LDCLRLH and LDCLRALH store to memory with release semantics.
- LDCLRH has neither acquire nor release semantics.

For more information about memory ordering semantics see [Load-Acquire, Store-Release](#).

For information about memory accesses see [Load/Store addressing modes](#).

This instruction is used by the alias [STCLRH, STCLRLH](#).

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	A	R	1	Rs					0	0	0	1	0	0	Rn					Rt				
size											opc																				

### LDCLRAH (A == 1 && R == 0)

LDCLRAH <Ws>, <Wt>, [<Xn|SP>]

### LDCLRALH (A == 1 && R == 1)

LDCLRALH <Ws>, <Wt>, [<Xn|SP>]

### LDCLRH (A == 0 && R == 0)

LDCLRH <Ws>, <Wt>, [<Xn|SP>]

### LDCLRLH (A == 0 && R == 1)

LDCLRLH <Ws>, <Wt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">STCLRH, STCLRLH</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(16) value;
bits(16) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_BIC, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDEOR, LDEORA, LDEORAL, LDEORL

Atomic exclusive OR on word or doubleword in memory atomically loads a 32-bit word or 64-bit doubleword from memory, performs an exclusive OR with the value held in a register on it, and stores the result back to memory. The value initially loaded from memory is returned in the destination register.

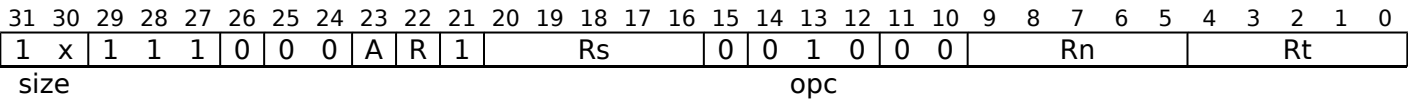
- If the destination register is not one of WZR or XZR, LDEORA and LDEORAL load from memory with acquire semantics.
- LDEORL and LDEORAL store to memory with release semantics.
- LDEOR has neither acquire nor release semantics.

For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This instruction is used by the alias *STEOR, STEORL*.

## Integer (Armv8.1)



**32-bit LDEOR (size == 10 && A == 0 && R == 0)**

```
LDEOR <Ws>, <Wt>, [<Xn|SP>]
```

**32-bit LDEORA (size == 10 && A == 1 && R == 0)**

```
LDEORA <Ws>, <Wt>, [<Xn|SP>]
```

**32-bit LDEORAL (size == 10 && A == 1 && R == 1)**

```
LDEORAL <Ws>, <Wt>, [<Xn|SP>]
```

**32-bit LDEORL (size == 10 && A == 0 && R == 1)**

```
LDEORL <Ws>, <Wt>, [<Xn|SP>]
```

**64-bit LDEOR (size == 11 && A == 0 && R == 0)**

```
LDEOR <Xs>, <Xt>, [<Xn|SP>]
```

**64-bit LDEORA (size == 11 && A == 1 && R == 0)**

```
LDEORA <Xs>, <Xt>, [<Xn|SP>]
```

**64-bit LDEORAL (size == 11 && A == 1 && R == 1)**

```
LDEORAL <Xs>, <Xt>, [<Xn|SP>]
```

**64-bit LDEORL (size == 11 && A == 0 && R == 1)**

```
LDEORL <Xs>, <Xt>, [<Xn|SP>]
```

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

integer datasize = 8 << UInt(size);
integer regsize = if datasize == 64 then 64 else 32;
AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

**Assembler Symbols**

<Ws>	Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Wt>	Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
<Xs>	Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xt>	Is the 64-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

**Alias Conditions**

Alias	Is preferred when
<a href="#">STEOR</a> , <a href="#">STEORL</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(datasize) value;
bits(datasize) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_EOR, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, regsize);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDEORB, LDEORAB, LDEORALB, LDEORLB

Atomic exclusive OR on byte in memory atomically loads an 8-bit byte from memory, performs an exclusive OR with the value held in a register on it, and stores the result back to memory. The value initially loaded from memory is returned in the destination register.

- If the destination register is not WZR, LDEORAB and LDEORALB load from memory with acquire semantics.
- LDEORLB and LDEORALB store to memory with release semantics.
- LDEORB has neither acquire nor release semantics.

For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This instruction is used by the alias [STEORB, STEORLB](#).

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	A	R	1	Rs					0	0	1	0	0	0	Rn					Rt				
size											opc																				

### LDEORAB (A == 1 && R == 0)

LDEORAB <Ws>, <Wt>, [<Xn|SP>]

### LDEORALB (A == 1 && R == 1)

LDEORALB <Ws>, <Wt>, [<Xn|SP>]

### LDEORB (A == 0 && R == 0)

LDEORB <Ws>, <Wt>, [<Xn|SP>]

### LDEORLB (A == 0 && R == 1)

LDEORLB <Ws>, <Wt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">STEORB, STEORLB</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;  
bits(8) value;  
bits(8) data;  
  
if HaveMTEExt() then  
    SetTagCheckedInstruction(tag_checked);  
  
value = X[s];  
if n == 31 then  
    CheckSPAlignment();  
    address = SP[];  
else  
    address = X[n];  
  
data = MemAtomic(address, MemAtomicOp_EOR, value, ldacctype, stacctype);  
  
if t != 31 then  
    X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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LDEORH, LDEORAH, LDEORALH, LDEORLH

Atomic exclusive OR on halfword in memory atomically loads a 16-bit halfword from memory, performs an exclusive OR with the value held in a register on it, and stores the result back to memory. The value initially loaded from memory is returned in the destination register.

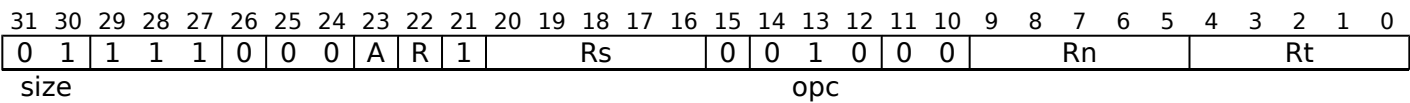
- If the destination register is not WZR, LDEORAH and LDEORALH load from memory with acquire semantics.
- LDEORLH and LDEORALH store to memory with release semantics.
- LDEORH has neither acquire nor release semantics.

For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This instruction is used by the alias [STEORH, STEORLH](#).

Integer
(Armv8.1)



LDEORAH (A == 1 && R == 0)

LDEORAH <Ws>, <Wt>, [<Xn|SP>]

LDEORALH (A == 1 && R == 1)

LDEORALH <Ws>, <Wt>, [<Xn|SP>]

LDEORH (A == 0 && R == 0)

LDEORH <Ws>, <Wt>, [<Xn|SP>]

LDEORLH (A == 0 && R == 1)

LDEORLH <Ws>, <Wt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Alias Conditions

Alias	Is preferred when
<a href="#">STEORH, STEORLH</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(16) value;
bits(16) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_EOR, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

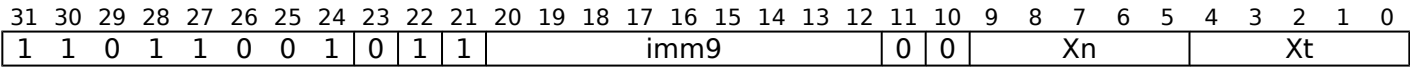
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LDG

Load Allocation Tag loads an Allocation Tag from a memory address, generates a Logical Address Tag from the Allocation Tag and merges it into the destination register. The address used for the load is calculated from the base register and an immediate signed offset scaled by the Tag granule.

Integer  
(Armv8.5)



Integer

```
LDG <Xt>, [<Xn|SP>{, #<simm>}]

if !HaveMTEExt() then UNDEFINED;
integer t = UInt(Xt);
integer n = UInt(Xn);
bits(64) offset = LSL(SignExtend(imm9, 64), LOG2_TAG_GRANULE);
```

Assembler Symbols

- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Xt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Xn" field.
- <simm> Is the optional signed immediate offset, a multiple of 16 in the range -4096 to 4080, defaulting to 0 and encoded in the "imm9" field.

Operation

```
bits(64) address;
bits(4) tag;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;
address = Align(address, TAG_GRANULE);

tag = AArch64.MemTag[address, AccType_NORMAL];
X[t] = AArch64.AddressWithAllocationTag(X[t], AccType_NORMAL, tag);
```



## LDGM

Load Tag Multiple reads a naturally aligned block of N Allocation Tags, where the size of N is identified in GMID\_EL1.BS, and writes the Allocation Tag read from address A to the destination register at  $4*A<7:4>+3:4*A<7:4>$ . Bits of the destination register not written with an Allocation Tag are set to 0.

This instruction is UNDEFINED at EL0.

This instruction generates an Unchecked access.

If [ID\\_AA64PFR1\\_EL1.MTE](#) != 0b0010, this instruction is UNDEFINED.

### Integer (Armv8.5)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	Xn					Xt				

### Integer

LDGM <Xt>, [<Xn|SP>]

```
if !HaveMTEExt() then UNDEFINED;
integer t = UInt(Xt);
integer n = UInt(Xn);
```

### Assembler Symbols

- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Xt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Xn" field.

### Operation

```
if PSTATE.EL == EL0 then
    UNDEFINED;

bits(64) data = Zeros(64);
bits(64) address;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

integer size = 4 * (2 ^ (UInt(GMID_EL1.BS)));
address = Align(address, size);
integer count = size >> LOG2_TAG_GRANULE;
integer index = UInt(address<LOG2_TAG_GRANULE+3:LOG2_TAG_GRANULE>);

for i = 0 to count-1
    bits(4) tag = AArch64.MemTag[address, AccType_NORMAL];
    data<(index*4)+3:index*4> = tag;
    address = address + TAG_GRANULE;
    index = index + 1;

X[t] = data;
```

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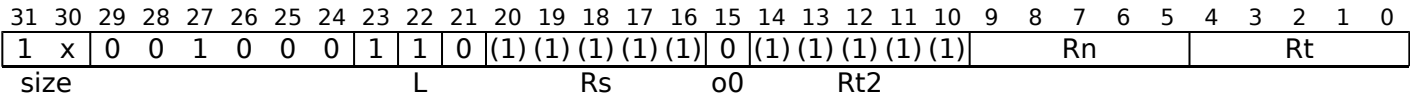
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# LDLAR

Load LOAcquire Register loads a 32-bit word or 64-bit doubleword from memory, and writes it to a register. The instruction also has memory ordering semantics as described in [Load LOAcquire, Store LORelease](#). For information about memory accesses, see [Load/Store addressing modes](#).

For this instruction, if the destination is WZR/XZR, it is impossible for software to observe the presence of the acquire semantic other than its effect on the arrival at endpoints.

## No offset (Armv8.1)



### 32-bit (size == 10)

```
LDLAR <Wt>, [<Xn|SP>{, #0}]
```

### 64-bit (size == 11)

```
LDLAR <Xt>, [<Xn|SP>{, #0}]

integer n = UInt(Rn);
integer t = UInt(Rt);

integer elsize = 8 << UInt(size);
integer regsize = if elsize == 64 then 64 else 32;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(elsize) data;
constant integer dbytes = elsize DIV 8;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = Mem[address, dbytes, AccType_LIMITEDORDERED];
X[t] = ZeroExtend(data, regsize);
```

## Operational information

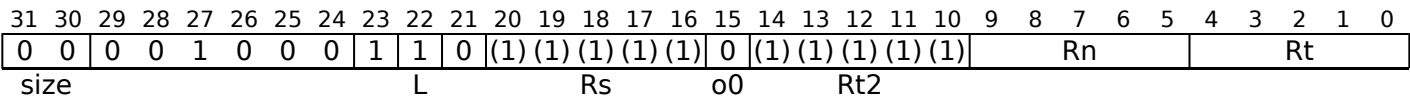
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

# LDLARB

Load LOAcquire Register Byte loads a byte from memory, zero-extends it and writes it to a register. The instruction also has memory ordering semantics as described in *Load LOAcquire, Store LORelease*. For information about memory accesses, see *Load/Store addressing modes*.

For this instruction, if the destination is WZR/XZR, it is impossible for software to observe the presence of the acquire semantic other than its effect on the arrival at endpoints.

## No offset (Armv8.1)



## No offset

```
LDLARB <Wt>, [<Xn|SP>{, #0}]

integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(8) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = Mem[address, 1, AccType_LIMITEDORDERED];
X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

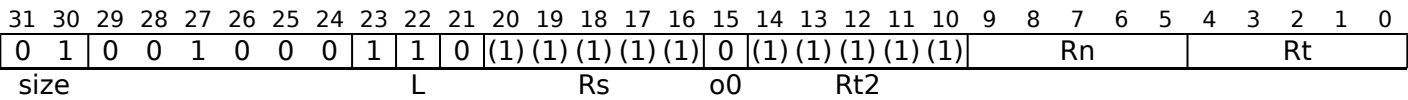
Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44  
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# LDLARH

Load LOAcquire Register Halfword loads a halfword from memory, zero-extends it, and writes it to a register. The instruction also has memory ordering semantics as described in [Load LOAcquire, Store LORelease](#). For information about memory accesses, see [Load/Store addressing modes](#).

For this instruction, if the destination is WZR/XZR, it is impossible for software to observe the presence of the acquire semantic other than its effect on the arrival at endpoints.

## No offset (Armv8.1)



## No offset

```
LDLARH <Wt>, [<Xn|SP>{, #0}]

integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(16) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = Mem[address, 2, AccType_LIMITEDORDERED];
X[t] = ZeroExtend(data, 32);
```

## Operational information

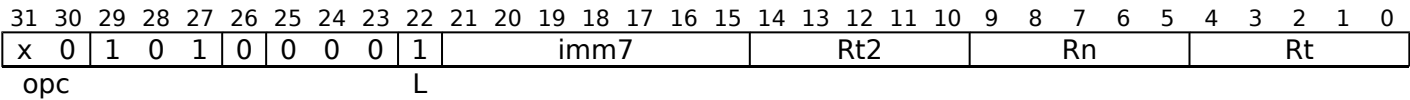
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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LDNP

Load Pair of Registers, with non-temporal hint, calculates an address from a base register value and an immediate offset, loads two 32-bit words or two 64-bit doublewords from memory, and writes them to two registers. For information about memory accesses, see [Load/Store addressing modes](#). For information about Non-temporal pair instructions, see [Load/Store Non-temporal pair](#).



32-bit (opc == 00)

```
LDNP <Wt1>, <Wt2>, [<Xn|SP>{, #<imm>}]
```

64-bit (opc == 10)

```
LDNP <Xt1>, <Xt2>, [<Xn|SP>{, #<imm>}]
```

```
// Empty.
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [LDNP](#).

Assembler Symbols

- <Wt1> Is the 32-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
- <Wt2> Is the 32-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
- <Xt1> Is the 64-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt2> Is the 64-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> For the 32-bit variant: is the optional signed immediate byte offset, a multiple of 4 in the range -256 to 252, defaulting to 0 and encoded in the "imm7" field as <imm>/4.  
For the 64-bit variant: is the optional signed immediate byte offset, a multiple of 8 in the range -512 to 504, defaulting to 0 and encoded in the "imm7" field as <imm>/8.

Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer t2 = UInt(Rt2);
if opc<0> == '1' then UNDEFINED;
integer scale = 2 + UInt(opc<1>);
integer datasize = 8 << scale;
bits(64) offset = LSL(SignExtend(imm7, 64), scale);
boolean tag_checked = n != 31;
```

## Operation

```
bits(64) address;
bits(datasize) data1;
bits(datasize) data2;
constant integer dbytes = datasize DIV 8;
boolean rt_unknown = FALSE;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if t == t2 then
    Constraint c = ConstrainUnpredictable(Unpredictable_LDPOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rt_unknown = TRUE;    // result is UNKNOWN
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data1 = Mem[address, dbytes, AccType_STREAM];
data2 = Mem[address+dbytes, dbytes, AccType_STREAM];
if rt_unknown then
    data1 = bits(datasize) UNKNOWN;
    data2 = bits(datasize) UNKNOWN;
X[t] = data1;
X[t2] = data2;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

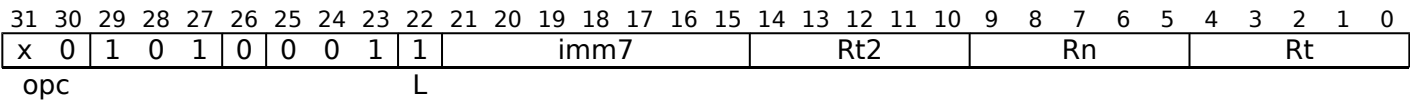
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# LDP

Load Pair of Registers calculates an address from a base register value and an immediate offset, loads two 32-bit words or two 64-bit doublewords from memory, and writes them to two registers. For information about memory accesses, see [Load/Store addressing modes](#).

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Signed offset](#)

## Post-index



### 32-bit (opc == 00)

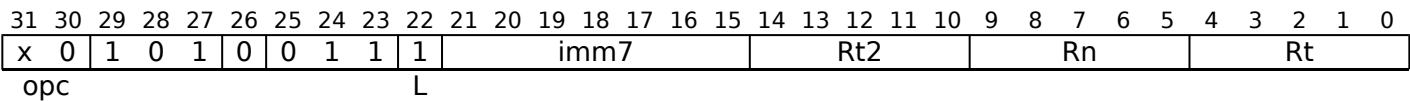
```
LDP <Wt1>, <Wt2>, [<Xn|SP>], #<imm>
```

### 64-bit (opc == 10)

```
LDP <Xt1>, <Xt2>, [<Xn|SP>], #<imm>
```

```
boolean wback = TRUE;
boolean postindex = TRUE;
```

## Pre-index



### 32-bit (opc == 00)

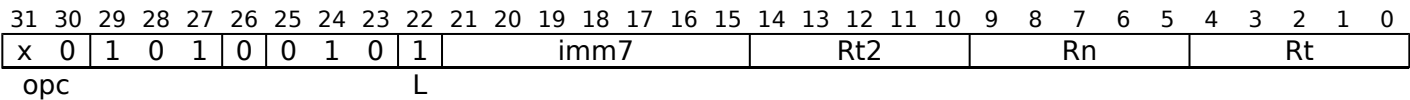
```
LDP <Wt1>, <Wt2>, [<Xn|SP>, #<imm>]!
```

### 64-bit (opc == 10)

```
LDP <Xt1>, <Xt2>, [<Xn|SP>, #<imm>]!
```

```
boolean wback = TRUE;
boolean postindex = FALSE;
```

## Signed offset



### 32-bit (opc == 00)

```
LDP <Wt1>, <Wt2>, [<Xn|SP>{, #<imm>}]
```

### 64-bit (opc == 10)

```
LDP <Xt1>, <Xt2>, [<Xn|SP>{, #<imm>}]
```

```
boolean wback = FALSE;
boolean postindex = FALSE;
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [LDP](#).

## Assembler Symbols

<Wt1>	Is the 32-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
<Wt2>	Is the 32-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
<Xt1>	Is the 64-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
<Xt2>	Is the 64-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<imm>	<p>For the 32-bit post-index and 32-bit pre-index variant: is the signed immediate byte offset, a multiple of 4 in the range -256 to 252, encoded in the "imm7" field as &lt;imm&gt;/4.</p> <p>For the 32-bit signed offset variant: is the optional signed immediate byte offset, a multiple of 4 in the range -256 to 252, defaulting to 0 and encoded in the "imm7" field as &lt;imm&gt;/4.</p> <p>For the 64-bit post-index and 64-bit pre-index variant: is the signed immediate byte offset, a multiple of 8 in the range -512 to 504, encoded in the "imm7" field as &lt;imm&gt;/8.</p> <p>For the 64-bit signed offset variant: is the optional signed immediate byte offset, a multiple of 8 in the range -512 to 504, defaulting to 0 and encoded in the "imm7" field as &lt;imm&gt;/8.</p>

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer t2 = UInt(Rt2);
if L:opc<0> == '01' || opc == '11' then UNDEFINED;
boolean signed = (opc<0> != '0');
integer scale = 2 + UInt(opc<1>);
integer datasize = 8 << scale;
bits(64) offset = LSL(SignExtend(imm7, 64), scale);
boolean tag_checked = wback || n != 31;
```



## Operation

```
bits(64) address;
bits(datasize) data1;
bits(datasize) data2;
constant integer dbytes = datasize DIV 8;
boolean rt_unknown = FALSE;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

boolean wb_unknown = FALSE;

if wback && (t == n || t2 == n) && n != 31 then
    Constraint c = ConstrainUnpredictable(Unpredictable_WBOVERLAPLD);
    assert c IN {Constraint_WBSUPPRESS, Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_WBSUPPRESS wback = FALSE;    // writeback is suppressed
        when Constraint_UNKNOWN    wb_unknown = TRUE; // writeback is UNKNOWN
        when Constraint_UNDEF      UNDEFINED;
        when Constraint_NOP        EndOfInstruction();

if t == t2 then
    Constraint c = ConstrainUnpredictable(Unpredictable_LDPOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rt_unknown = TRUE;    // result is UNKNOWN
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

data1 = Mem[address, dbytes, AccType_NORMAL];
data2 = Mem[address+dbytes, dbytes, AccType_NORMAL];
if rt_unknown then
    data1 = bits(datasize) UNKNOWN;
    data2 = bits(datasize) UNKNOWN;
if signed then
    X[t] = SignExtend(data1, 64);
    X[t2] = SignExtend(data2, 64);
else
    X[t] = data1;
    X[t2] = data2;

if wback then
    if wb_unknown then
        address = bits(64) UNKNOWN;
    elsif postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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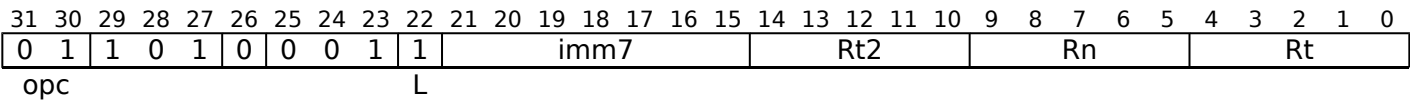
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# LDPSW

Load Pair of Registers Signed Word calculates an address from a base register value and an immediate offset, loads two 32-bit words from memory, sign-extends them, and writes them to two registers. For information about memory accesses, see [Load/Store addressing modes](#).

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Signed offset](#)

## Post-index

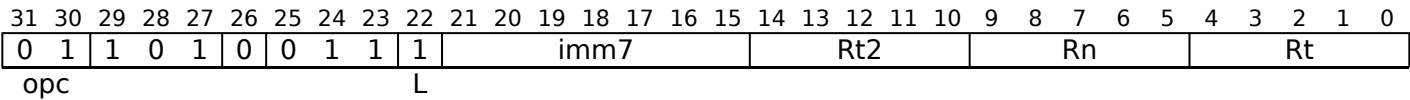


## Post-index

```
LDPSW <Xt1>, <Xt2>, [<Xn|SP>], #<imm>

boolean wback = TRUE;
boolean postindex = TRUE;
```

## Pre-index

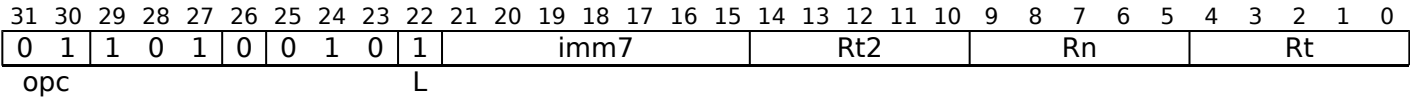


## Pre-index

```
LDPSW <Xt1>, <Xt2>, [<Xn|SP>, #<imm>]!

boolean wback = TRUE;
boolean postindex = FALSE;
```

## Signed offset



## Signed offset

```
LDPSW <Xt1>, <Xt2>, [<Xn|SP>{, #<imm>}]

boolean wback = FALSE;
boolean postindex = FALSE;
```

For information about the **CONSTRAINED UNPREDICTABLE** behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [LDPSW](#).

## Assembler Symbols

- <Xt1> Is the 64-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt2> Is the 64-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> For the post-index and pre-index variant: is the signed immediate byte offset, a multiple of 4 in the range -256 to 252, encoded in the "imm7" field as <imm>/4.

For the signed offset variant: is the optional signed immediate byte offset, a multiple of 4 in the range -256 to 252, defaulting to 0 and encoded in the "imm7" field as <imm>/4.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer t2 = UInt(Rt2);
bits(64) offset = LSL(SignExtend(imm7, 64), 2);
boolean tag_checked = wback || n != 31;
```

## Operation

```
bits(64) address;
bits(32) data1;
bits(32) data2;
boolean rt_unknown = FALSE;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

boolean wb_unknown = FALSE;

if wback && (t == n || t2 == n) && n != 31 then
    Constraint c = ConstrainUnpredictable(Unpredictable_WBOVERLAPLD);
    assert c IN {Constraint_WBSUPPRESS, Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_WBSUPPRESS wback = FALSE;    // writeback is suppressed
        when Constraint_UNKNOWN    wb_unknown = TRUE; // writeback is UNKNOWN
        when Constraint_UNDEF      UNDEFINED;
        when Constraint_NOP        EndOfInstruction();

if t == t2 then
    Constraint c = ConstrainUnpredictable(Unpredictable_LDPOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rt_unknown = TRUE;    // result is UNKNOWN
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

data1 = Mem[address, 4, AccType_NORMAL];
data2 = Mem[address+4, 4, AccType_NORMAL];
if rt_unknown then
    data1 = bits(32) UNKNOWN;
    data2 = bits(32) UNKNOWN;
X[t] = SignExtend(data1, 64);
X[t2] = SignExtend(data2, 64);
if wback then
    if wb_unknown then
        address = bits(64) UNKNOWN;
    elsif postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDR (immediate)

Load Register (immediate) loads a word or doubleword from memory and writes it to a register. The address that is used for the load is calculated from a base register and an immediate offset. For information about memory accesses, see [Load/Store addressing modes](#). The Unsigned offset variant scales the immediate offset value by the size of the value accessed before adding it to the base register value.

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Unsigned offset](#)

## Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	0	0	1	0	imm9									0	1	Rn				Rt					
size										opc																					

### 32-bit (size == 10)

```
LDR <Wt>, [<Xn|SP>], #<sim>
```

### 64-bit (size == 11)

```
LDR <Xt>, [<Xn|SP>], #<sim>
```

```
boolean wback = TRUE;
boolean postindex = TRUE;
integer scale = UInt(size);
bits(64) offset = SignExtend(imm9, 64);
```

## Pre-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	0	0	1	0	imm9									1	1	Rn				Rt					
size										opc																					

### 32-bit (size == 10)

```
LDR <Wt>, [<Xn|SP>, #<sim>]!
```

### 64-bit (size == 11)

```
LDR <Xt>, [<Xn|SP>, #<sim>]!
```

```
boolean wback = TRUE;
boolean postindex = FALSE;
integer scale = UInt(size);
bits(64) offset = SignExtend(imm9, 64);
```

## Unsigned offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	1	0	1	imm12											Rn				Rt						
size										opc																					

### 32-bit (size == 10)

```
LDR <Wt>, [<Xn|SP>{, #<pimm>}]
```

### 64-bit (size == 11)

```
LDR <Xt>, [<Xn|SP>{, #<pimm>}]
```

```
boolean wback = FALSE;
boolean postindex = FALSE;
integer scale = UInt(size);
bits(64) offset = LSL(ZeroExtend(imm12, 64), scale);
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [LDR \(immediate\)](#).

### Assembler Symbols

<Wt>	Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
<Xt>	Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<sim>	Is the signed immediate byte offset, in the range -256 to 255, encoded in the "imm9" field.
<pimm>	For the 32-bit variant: is the optional positive immediate byte offset, a multiple of 4 in the range 0 to 16380, defaulting to 0 and encoded in the "imm12" field as <pimm>/4. For the 64-bit variant: is the optional positive immediate byte offset, a multiple of 8 in the range 0 to 32760, defaulting to 0 and encoded in the "imm12" field as <pimm>/8.

### Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer regsize;

regsize = if size == '11' then 64 else 32;
integer datasize = 8 << scale;
boolean tag_checked = wback || n != 31;
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(datasize) data;

boolean wb_unknown = FALSE;

if wback && n == t && n != 31 then
    c = ConstrainUnpredictable(Unpredictable_WBOVERLAPLD);
    assert c IN {Constraint_WBSUPPRESS, Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_WBSUPPRESS wback = FALSE;    // writeback is suppressed
        when Constraint_UNKNOWN    wb_unknown = TRUE; // writeback is UNKNOWN
        when Constraint_UNDEF      UNDEFINED;
        when Constraint_NOP        EndOfInstruction();

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

data = Mem[address, datasize DIV 8, AccType_NORMAL];
X[t] = ZeroExtend(data, regsize);

if wback then
    if wb_unknown then
        address = bits(64) UNKNOWN;
    elsif postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

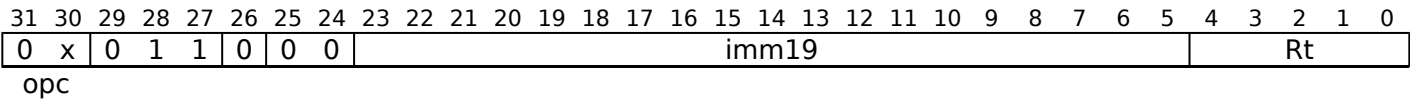
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDR (literal)

Load Register (literal) calculates an address from the PC value and an immediate offset, loads a word from memory, and writes it to a register. For information about memory accesses, see [Load/Store addressing modes](#).



## 32-bit (opc == 00)

```
LDR <Wt>, <label>
```

## 64-bit (opc == 01)

```
LDR <Xt>, <label>
```

```
integer t = UInt(Rt);
MemOp memop = MemOp_LOAD;
boolean signed = FALSE;
integer size;
bits(64) offset;

case opc of
  when '00'
    size = 4;
  when '01'
    size = 8;
  when '10'
    size = 4;
    signed = TRUE;
  when '11'
    memop = MemOp_PREFETCH;

offset = SignExtend(imm19:'00', 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <label> Is the program label from which the data is to be loaded. Its offset from the address of this instruction, in the range +/-1MB, is encoded as "imm19" times 4.

## Operation

```
bits(64) address = PC[] + offset;
bits(size*8) data;

if HaveMTEExt() then
  SetTagCheckedInstruction(FALSE);

case memop of
  when MemOp_LOAD
    data = Mem[address, size, AccType_NORMAL];
    if signed then
      X[t] = SignExtend(data, 64);
    else
      X[t] = data;

  when MemOp_PREFETCH
    Prefetch(address, t<4:0>);
```



## Operational information

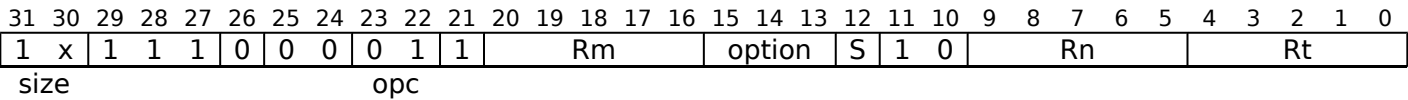
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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LDR (register)

Load Register (register) calculates an address from a base register value and an offset register value, loads a word from memory, and writes it to a register. The offset register value can optionally be shifted and extended. For information about memory accesses, see [Load/Store addressing modes](#).



32-bit (size == 10)

```
LDR <Wt>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]
```

64-bit (size == 11)

```
LDR <Xt>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]
```

```
integer scale = UInt(size);
if option<1> == '0' then UNDEFINED;    // sub-word index
ExtendType extend_type = DecodeRegExtend(option);
integer shift = if S == '1' then scale else 0;
```

Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Wm> When option<0> is set to 0, is the 32-bit name of the general-purpose index register, encoded in the "Rm" field.
- <Xm> When option<0> is set to 1, is the 64-bit name of the general-purpose index register, encoded in the "Rm" field.
- <extend> Is the index extend/shift specifier, defaulting to LSL, and which must be omitted for the LSL option when <amount> is omitted. encoded in "option":

option	<extend>
010	UXTW
011	LSL
110	SXTW
111	SCTX

- <amount> For the 32-bit variant: is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in "S":

S	<amount>
0	#0
1	#2

- For the 64-bit variant: is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in "S":

S	<amount>
0	#0
1	#3

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer m = UInt(Rm);
integer regsize;

regsize = if size == 'l1' then 64 else 32;
integer datasize = 8 << scale;
```

## Operation

```
bits(64) offset = ExtendReg(m, extend_type, shift);
if HaveMTEExt() then
    SetTagCheckedInstruction(TRUE);

bits(64) address;
bits(datasize) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = Mem[address, datasize DIV 8, AccType_NORMAL];
X[t] = ZeroExtend(data, regsize);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDRAA, LDRAB

Load Register, with pointer authentication. This instruction authenticates an address from a base register using a modifier of zero and the specified key, adds an immediate offset to the authenticated address, and loads a 64-bit doubleword from memory at this resulting address into a register.

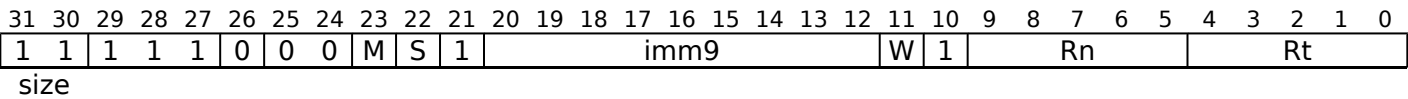
Key A is used for LDRAA, and key B is used for LDRAB.

If the authentication passes, the PE behaves the same as for an LDR instruction. If the authentication fails, a Translation fault is generated.

The authenticated address is not written back to the base register, unless the pre-indexed variant of the instruction is used. In this case, the address that is written back to the base register does not include the pointer authentication code.

For information about memory accesses, see [Load/Store addressing modes](#).

## Unscaled offset (Armv8.3)



### Key A, offset (M == 0 && W == 0)

```
LDRAA <Xt>, [<Xn|SP>{, #<simm>}]
```

### Key A, pre-indexed (M == 0 && W == 1)

```
LDRAA <Xt>, [<Xn|SP>{, #<simm>}]!
```

### Key B, offset (M == 1 && W == 0)

```
LDRAB <Xt>, [<Xn|SP>{, #<simm>}]
```

### Key B, pre-indexed (M == 1 && W == 1)

```
LDRAB <Xt>, [<Xn|SP>{, #<simm>}]!
```

```
if !HavePACExt() then UNDEFINED;
integer t = UInt(Rt);
integer n = UInt(Rn);
boolean wback = (W == '1');
boolean use_key_a = (M == '0');
bits(10) S10 = S:imm9;
bits(64) offset = LSL(SignExtend(S10, 64), 3);
boolean tag_checked = wback || n != 31;
```

## Assembler Symbols

- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <simm> Is the optional signed immediate byte offset, a multiple of 8 in the range -4096 to 4088, defaulting to 0 and encoded in the "S:imm9" field as <simm>/8.

## Operation

```
bits(64) address;
bits(64) data;
boolean wb_unknown = FALSE;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if wback && n == t && n != 31 then
    c = ConstrainUnpredictable(Unpredictable_WBOVERLAPLD);
    assert c IN {Constraint_WBSUPPRESS, Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_WBSUPPRESS wback = FALSE;    // writeback is suppressed
        when Constraint_UNKNOWN    wb_unknown = TRUE; // writeback is UNKNOWN
        when Constraint_UNDEF      UNDEFINED;
        when Constraint_NOP        EndOfInstruction();

if n == 31 then
    address = SP[];
else
    address = X[n];

if use_key_a then
    address = AuthDA(address, X[31], TRUE);
else
    address = AuthDB(address, X[31], TRUE);

if n == 31 then
    CheckSPAlignment();

address = address + offset;
data = Mem[address, 8, AccType_NORMAL];
X[t] = data;

if wback then
    if wb_unknown then
        address = bits(64) UNKNOWN;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDRB (immediate)

Load Register Byte (immediate) loads a byte from memory, zero-extends it, and writes the result to a register. The address that is used for the load is calculated from a base register and an immediate offset. For information about memory accesses, see [Load/Store addressing modes](#).

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Unsigned offset](#)

## Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	0	1	0	imm9									0	1	Rn				Rt					
size										opc																					

## Post-index

```
LDRB <Wt>, [<Xn|SP>], #<simm>

boolean wback = TRUE;
boolean postindex = TRUE;
bits(64) offset = SignExtend(imm9, 64);
```

## Pre-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	0	1	0	imm9									1	1	Rn				Rt					
size										opc																					

## Pre-index

```
LDRB <Wt>, [<Xn|SP>, #<simm>]!

boolean wback = TRUE;
boolean postindex = FALSE;
bits(64) offset = SignExtend(imm9, 64);
```

## Unsigned offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	1	0	1	imm12												Rn				Rt					
size										opc																					

## Unsigned offset

```
LDRB <Wt>, [<Xn|SP>{, #<pimm>}]

boolean wback = FALSE;
boolean postindex = FALSE;
bits(64) offset = LSL(ZeroExtend(imm12, 64), 0);
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [LDRH \(immediate\)](#).

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <simm> Is the signed immediate byte offset, in the range -256 to 255, encoded in the "imm9" field.

<pimm> Is the optional positive immediate byte offset, in the range 0 to 4095, defaulting to 0 and encoded in the "imm12" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = wback || n != 31;
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(8) data;

boolean wb_unknown = FALSE;

if wback && n == t && n != 31 then
    c = ConstrainUnpredictable(Unpredictable_WBOVERLAPLD);
    assert c IN {Constraint_WBSUPPRESS, Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_WBSUPPRESS wback = FALSE;    // writeback is suppressed
        when Constraint_UNKNOWN    wb_unknown = TRUE; // writeback is UNKNOWN
        when Constraint_UNDEF      UNDEFINED;
        when Constraint_NOP        EndOfInstruction();

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

data = Mem[address, 1, AccType_NORMAL];
X[t] = ZeroExtend(data, 32);

if wback then
    if wb_unknown then
        address = bits(64) UNKNOWN;
    elsif postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDRB (register)

Load Register Byte (register) calculates an address from a base register value and an offset register value, loads a byte from memory, zero-extends it, and writes it to a register. For information about memory accesses, see [Load/Store addressing modes](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
0	0	1	1	1	0	0	0	0	1	1	Rm				option			S	1	0	Rn				Rt										
size								opc																											

## Extended register (option != 011)

LDRB <Wt>, [<Xn|SP>, (<Wm>|<Xm>), <extend> {<amount>}]

## Shifted register (option == 011)

LDRB <Wt>, [<Xn|SP>, <Xm>{, LSL <amount>}]

```
if option<1> == '0' then UNDEFINED; // sub-word index
ExtendType extend_type = DecodeRegExtend(option);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Wm> When option<0> is set to 0, is the 32-bit name of the general-purpose index register, encoded in the "Rm" field.
- <Xm> When option<0> is set to 1, is the 64-bit name of the general-purpose index register, encoded in the "Rm" field.
- <extend> Is the index extend specifier, encoded in "option":

option	<extend>
010	UXTW
110	SXTW
111	SCTX

<amount> Is the index shift amount, it must be #0, encoded in "S" as 0 if omitted, or as 1 if present.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer m = UInt(Rm);
```



## Operation

```
bits(64) offset = ExtendReg(m, extend_type, 0);
if HaveMTEExt() then
    SetTagCheckedInstruction(TRUE);

bits(64) address;
bits(8) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = Mem[address, 1, AccType_NORMAL];
X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDRH (immediate)

Load Register Halfword (immediate) loads a halfword from memory, zero-extends it, and writes the result to a register. The address that is used for the load is calculated from a base register and an immediate offset. For information about memory accesses, see [Load/Store addressing modes](#).

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Unsigned offset](#)

## Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
0	1	1	1	1	0	0	0	0	1	0	imm9									0	1	Rn				Rt									
size										opc																									

## Post-index

```
LDRH <Wt>, [<Xn|SP>], #<simm>

boolean wback = TRUE;
boolean postindex = TRUE;
bits(64) offset = SignExtend(imm9, 64);
```

## Pre-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
0	1	1	1	1	0	0	0	0	1	0	imm9									1	1	Rn				Rt									
size										opc																									

## Pre-index

```
LDRH <Wt>, [<Xn|SP>, #<simm>]!

boolean wback = TRUE;
boolean postindex = FALSE;
bits(64) offset = SignExtend(imm9, 64);
```

## Unsigned offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	1	0	1	imm12												Rn				Rt					
size										opc																					

## Unsigned offset

```
LDRH <Wt>, [<Xn|SP>{, #<pimm>}]

boolean wback = FALSE;
boolean postindex = FALSE;
bits(64) offset = LSL(ZeroExtend(imm12, 64), 1);
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [LDRH \(immediate\)](#).

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <simm> Is the signed immediate byte offset, in the range -256 to 255, encoded in the "imm9" field.

<pimm> Is the optional positive immediate byte offset, a multiple of 2 in the range 0 to 8190, defaulting to 0 and encoded in the "imm12" field as <pimm>/2.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = wback || n != 31;
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(16) data;

boolean wb_unknown = FALSE;

if wback && n == t && n != 31 then
    c = ConstrainUnpredictable(Unpredictable_WBOVERLAPLD);
    assert c IN {Constraint_WBSUPPRESS, Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_WBSUPPRESS wback = FALSE;    // writeback is suppressed
        when Constraint_UNKNOWN    wb_unknown = TRUE; // writeback is UNKNOWN
        when Constraint_UNDEF      UNDEFINED;
        when Constraint_NOP        EndOfInstruction();

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

data = Mem[address, 2, AccType_NORMAL];
X[t] = ZeroExtend(data, 32);

if wback then
    if wb_unknown then
        address = bits(64) UNKNOWN;
    elsif postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

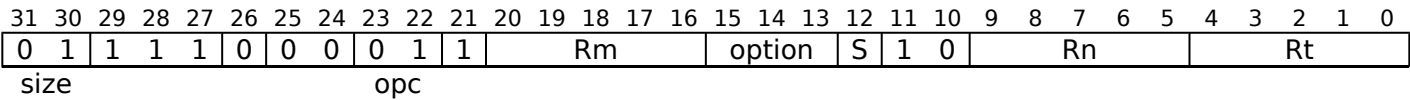
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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## LDRH (register)

Load Register Halfword (register) calculates an address from a base register value and an offset register value, loads a halfword from memory, zero-extends it, and writes it to a register. For information about memory accesses, see [Load/Store addressing modes](#).



### 32-bit

LDRH <Wt>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]

```
if option<1> == '0' then UNDEFINED;    // sub-word index
ExtendType extend_type = DecodeRegExtend(option);
integer shift = if S == '1' then 1 else 0;
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#).

### Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Wm> When option<0> is set to 0, is the 32-bit name of the general-purpose index register, encoded in the "Rm" field.
- <Xm> When option<0> is set to 1, is the 64-bit name of the general-purpose index register, encoded in the "Rm" field.
- <extend> Is the index extend/shift specifier, defaulting to LSL, and which must be omitted for the LSL option when <amount> is omitted. encoded in "option":

option	<extend>
010	UXTW
011	LSL
110	SXTW
111	SCTX

- <amount> Is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in "S":

S	<amount>
0	#0
1	#1

### Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer m = UInt(Rm);
```

## Operation

```
bits(64) offset = ExtendReg(m, extend_type, shift);
if HaveMTEExt() then
    SetTagCheckedInstruction(TRUE);

bits(64) address;
bits(16) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = Mem[address, 2, AccType_NORMAL];
X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDRSB (immediate)

Load Register Signed Byte (immediate) loads a byte from memory, sign-extends it to either 32 bits or 64 bits, and writes the result to a register. The address that is used for the load is calculated from a base register and an immediate offset. For information about memory accesses, see [Load/Store addressing modes](#).

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Unsigned offset](#)

## Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	1	x	0	imm9									0	1	Rn				Rt					
size										opc																					

### 32-bit (opc == 11)

```
LDRSB <Wt>, [<Xn|SP>], #<sim>
```

### 64-bit (opc == 10)

```
LDRSB <Xt>, [<Xn|SP>], #<sim>
```

```
boolean wback = TRUE;
boolean postindex = TRUE;
bits(64) offset = SignExtend(imm9, 64);
```

## Pre-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	1	x	0	imm9									1	1	Rn				Rt					
size										opc																					

### 32-bit (opc == 11)

```
LDRSB <Wt>, [<Xn|SP>, #<sim>]!
```

### 64-bit (opc == 10)

```
LDRSB <Xt>, [<Xn|SP>, #<sim>]!
```

```
boolean wback = TRUE;
boolean postindex = FALSE;
bits(64) offset = SignExtend(imm9, 64);
```

## Unsigned offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	1	1	x	imm12												Rn				Rt					
size										opc																					

### 32-bit (opc == 11)

```
LDRSB <Wt>, [<Xn|SP>{, #<pimm>}]
```

### 64-bit (opc == 10)

```
LDRSB <Xt>, [<Xn|SP>{, #<pimm>}]
```

```
boolean wback = FALSE;  
boolean postindex = FALSE;  
bits(64) offset = LSL(ZeroExtend(imm12, 64), 0);
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [LDRSB \(immediate\)](#).

## Assembler Symbols

<Wt>	Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
<Xt>	Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<sim>	Is the signed immediate byte offset, in the range -256 to 255, encoded in the "imm9" field.
<pimm>	Is the optional positive immediate byte offset, in the range 0 to 4095, defaulting to 0 and encoded in the "imm12" field.

## Shared Decode

```
integer n = UInt(Rn);  
integer t = UInt(Rt);  
MemOp memop;  
boolean signed;  
integer regsize;  
  
if opc<1> == '0' then  
    // store or zero-extending load  
    memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;  
    regsize = 32;  
    signed = FALSE;  
else  
    // sign-extending load  
    memop = MemOp_LOAD;  
    regsize = if opc<0> == '1' then 32 else 64;  
    signed = TRUE;  
  
boolean tag_checked = memop != MemOp_PREFETCH && (wback || n != 31);
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(8) data;

boolean wb_unknown = FALSE;
boolean rt_unknown = FALSE;

if memop == MemOp_LOAD && wback && n == t && n != 31 then
    c = ConstrainUnpredictable(Unpredictable_WBOVERLAPLD);
    assert c IN {Constraint_WBSUPPRESS, Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_WBSUPPRESS wback = FALSE;    // writeback is suppressed
        when Constraint_UNKNOWN    wb_unknown = TRUE; // writeback is UNKNOWN
        when Constraint_UNDEF      UNDEFINED;
        when Constraint_NOP        EndOfInstruction();

if memop == MemOp_STORE && wback && n == t && n != 31 then
    c = ConstrainUnpredictable(Unpredictable_WBOVERLAPST);
    assert c IN {Constraint_NONE, Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_NONE    rt_unknown = FALSE; // value stored is original value
        when Constraint_UNKNOWN rt_unknown = TRUE;  // value stored is UNKNOWN
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();

if n == 31 then
    if memop != MemOp_PREFETCH then CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

case memop of
    when MemOp_STORE
        if rt_unknown then
            data = bits(8) UNKNOWN;
        else
            data = X[t];
            Mem[address, 1, AccType_NORMAL] = data;

    when MemOp_LOAD
        data = Mem[address, 1, AccType_NORMAL];
        if signed then
            X[t] = SignExtend(data, regsize);
        else
            X[t] = ZeroExtend(data, regsize);

    when MemOp_PREFETCH
        Prefetch(address, t<4:0>);

if wback then
    if wb_unknown then
        address = bits(64) UNKNOWN;
    elsif postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

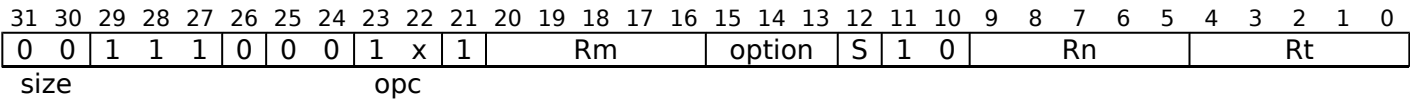
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.





LDRSB (register)

Load Register Signed Byte (register) calculates an address from a base register value and an offset register value, loads a byte from memory, sign-extends it, and writes it to a register. For information about memory accesses, see [Load/Store addressing modes](#).



32-bit with extended register offset (opc == 11 && option != 011)

```
LDRSB <Wt>, [<Xn|SP>, (<Wm>|<Xm>), <extend> {<amount>}]
```

32-bit with shifted register offset (opc == 11 && option == 011)

```
LDRSB <Wt>, [<Xn|SP>, <Xm>{, LSL <amount>}]
```

64-bit with extended register offset (opc == 10 && option != 011)

```
LDRSB <Xt>, [<Xn|SP>, (<Wm>|<Xm>), <extend> {<amount>}]
```

64-bit with shifted register offset (opc == 10 && option == 011)

```
LDRSB <Xt>, [<Xn|SP>, <Xm>{, LSL <amount>}]
```

```
if option<1> == '0' then UNDEFINED; // sub-word index
ExtendType extend_type = DecodeRegExtend(option);
```

Assembler Symbols

- <Wt>

Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt>

Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP>

Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Wm>

When option<0> is set to 0, is the 32-bit name of the general-purpose index register, encoded in the "Rm" field.
- <Xm>

When option<0> is set to 1, is the 64-bit name of the general-purpose index register, encoded in the "Rm" field.
- <extend>

Is the index extend specifier, encoded in "option":

option	<extend>
010	UXTW
110	SXTW
111	SCTX
- <amount>

Is the index shift amount, it must be #0, encoded in "S" as 0 if omitted, or as 1 if present.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer m = UInt(Rm);
MemOp memop;
boolean signed;
integer regsize;

if opc<1> == '0' then
    // store or zero-extending load
    memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;
    regsize = 32;
    signed = FALSE;
else
    // sign-extending load
    memop = MemOp_LOAD;
    regsize = if opc<0> == '1' then 32 else 64;
    signed = TRUE;

boolean tag_checked = memop != MemOp_PREFETCH;
```

## Operation

```
bits(64) offset = ExtendReg(m, extend_type, 0);
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(8) data;

if n == 31 then
    if memop != MemOp_PREFETCH then CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

case memop of
    when MemOp_STORE
        data = X[t];
        Mem[address, 1, AccType_NORMAL] = data;

    when MemOp_LOAD
        data = Mem[address, 1, AccType_NORMAL];
        if signed then
            X[t] = SignExtend(data, regsize);
        else
            X[t] = ZeroExtend(data, regsize);

    when MemOp_PREFETCH
        Prefetch(address, t<4:0>);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDRSH (immediate)

Load Register Signed Halfword (immediate) loads a halfword from memory, sign-extends it to 32 bits or 64 bits, and writes the result to a register. The address that is used for the load is calculated from a base register and an immediate offset. For information about memory accesses, see [Load/Store addressing modes](#).

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Unsigned offset](#)

## Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
0	1	1	1	1	0	0	0	1	x	0	imm9									0	1	Rn				Rt									
size										opc																									

### 32-bit (opc == 11)

```
LDRSH <Wt>, [<Xn|SP>], #<sim>
```

### 64-bit (opc == 10)

```
LDRSH <Xt>, [<Xn|SP>], #<sim>
```

```
boolean wback = TRUE;
boolean postindex = TRUE;
bits(64) offset = SignExtend(imm9, 64);
```

## Pre-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	1	x	0	imm9									1	1	Rn				Rt					
size										opc																					

### 32-bit (opc == 11)

```
LDRSH <Wt>, [<Xn|SP>, #<sim>]!
```

### 64-bit (opc == 10)

```
LDRSH <Xt>, [<Xn|SP>, #<sim>]!
```

```
boolean wback = TRUE;
boolean postindex = FALSE;
bits(64) offset = SignExtend(imm9, 64);
```

## Unsigned offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	1	1	x	imm12												Rn				Rt					
size										opc																					

### 32-bit (opc == 11)

```
LDRSH <Wt>, [<Xn|SP>{, #<pimm>}]
```

### 64-bit (opc == 10)

```
LDRSH <Xt>, [<Xn|SP>{, #<pimm>}]
```

```
boolean wback = FALSE;  
boolean postindex = FALSE;  
bits(64) offset = LSL(ZeroExtend(imm12, 64), 1);
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [LDRSH \(immediate\)](#).

## Assembler Symbols

<Wt>	Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
<Xt>	Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<sim>	Is the signed immediate byte offset, in the range -256 to 255, encoded in the "imm9" field.
<pimm>	Is the optional positive immediate byte offset, a multiple of 2 in the range 0 to 8190, defaulting to 0 and encoded in the "imm12" field as <pimm>/2.

## Shared Decode

```
integer n = UInt(Rn);  
integer t = UInt(Rt);  
MemOp memop;  
boolean signed;  
integer regsize;  
  
if opc<1> == '0' then  
    // store or zero-extending load  
    memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;  
    regsize = 32;  
    signed = FALSE;  
else  
    // sign-extending load  
    memop = MemOp_LOAD;  
    regsize = if opc<0> == '1' then 32 else 64;  
    signed = TRUE;  
  
boolean tag_checked = memop != MemOp_PREFETCH && (wback || n != 31);
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(16) data;

boolean wb_unknown = FALSE;
boolean rt_unknown = FALSE;

if memop == MemOp_LOAD && wback && n == t && n != 31 then
    c = ConstrainUnpredictable(Unpredictable_WBOVERLAPLD);
    assert c IN {Constraint_WBSUPPRESS, Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_WBSUPPRESS wback = FALSE;    // writeback is suppressed
        when Constraint_UNKNOWN    wb_unknown = TRUE; // writeback is UNKNOWN
        when Constraint_UNDEF      UNDEFINED;
        when Constraint_NOP        EndOfInstruction();

if memop == MemOp_STORE && wback && n == t && n != 31 then
    c = ConstrainUnpredictable(Unpredictable_WBOVERLAPST);
    assert c IN {Constraint_NONE, Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_NONE    rt_unknown = FALSE;    // value stored is original value
        when Constraint_UNKNOWN  rt_unknown = TRUE;    // value stored is UNKNOWN
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();

if n == 31 then
    if memop != MemOp_PREFETCH then CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

case memop of
    when MemOp_STORE
        if rt_unknown then
            data = bits(16) UNKNOWN;
        else
            data = X[t];
            Mem[address, 2, AccType_NORMAL] = data;

    when MemOp_LOAD
        data = Mem[address, 2, AccType_NORMAL];
        if signed then
            X[t] = SignExtend(data, regsize);
        else
            X[t] = ZeroExtend(data, regsize);

    when MemOp_PREFETCH
        Prefetch(address, t<4:0>);

if wback then
    if wb_unknown then
        address = bits(64) UNKNOWN;
    elsif postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.



LDRSH (register)

Load Register Signed Halfword (register) calculates an address from a base register value and an offset register value, loads a halfword from memory, sign-extends it, and writes it to a register. For information about memory accesses see [Load/Store addressing modes](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	1	x	1	Rm				option		S	1	0	Rn				Rt							
size								opc																							

32-bit (opc == 11)

```
LDRSH <Wt>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]
```

64-bit (opc == 10)

```
LDRSH <Xt>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]
```

```
if option<1> == '0' then UNDEFINED; // sub-word index
ExtendType extend_type = DecodeRegExtend(option);
integer shift = if S == '1' then 1 else 0;
```

Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Wm> When option<0> is set to 0, is the 32-bit name of the general-purpose index register, encoded in the "Rm" field.
- <Xm> When option<0> is set to 1, is the 64-bit name of the general-purpose index register, encoded in the "Rm" field.
- <extend> Is the index extend/shift specifier, defaulting to LSL, and which must be omitted for the LSL option when <amount> is omitted. encoded in "option":

option	<extend>
010	UXTW
011	LSL
110	SXTW
111	SCTX

- <amount> Is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in "S":

S	<amount>
0	#0
1	#1



## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer m = UInt(Rm);
MemOp memop;
boolean signed;
integer regsize;

if opc<1> == '0' then
    // store or zero-extending load
    memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;
    regsize = 32;
    signed = FALSE;
else
    // sign-extending load
    memop = MemOp_LOAD;
    regsize = if opc<0> == '1' then 32 else 64;
    signed = TRUE;

boolean tag_checked = memop != MemOp_PREFETCH;
```

## Operation

```
bits(64) offset = ExtendReg(m, extend_type, shift);
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(16) data;

if n == 31 then
    if memop != MemOp_PREFETCH then CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

case memop of
    when MemOp_STORE
        data = X[t];
        Mem[address, 2, AccType_NORMAL] = data;

    when MemOp_LOAD
        data = Mem[address, 2, AccType_NORMAL];
        if signed then
            X[t] = SignExtend(data, regsize);
        else
            X[t] = ZeroExtend(data, regsize);

    when MemOp_PREFETCH
        Prefetch(address, t<4:0>);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDRSW (immediate)

Load Register Signed Word (immediate) loads a word from memory, sign-extends it to 64 bits, and writes the result to a register. The address that is used for the load is calculated from a base register and an immediate offset. For information about memory accesses, see [Load/Store addressing modes](#).

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Unsigned offset](#)

## Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
1	0	1	1	1	0	0	0	1	0	0	imm9									0	1	Rn				Rt									
size										opc																									

## Post-index

```
LDRSW <Xt>, [<Xn|SP>], #<simm>

boolean wback = TRUE;
boolean postindex = TRUE;
bits(64) offset = SignExtend(imm9, 64);
```

## Pre-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
1	0	1	1	1	0	0	0	1	0	0	imm9									1	1	Rn				Rt									
size										opc																									

## Pre-index

```
LDRSW <Xt>, [<Xn|SP>, #<simm>]!

boolean wback = TRUE;
boolean postindex = FALSE;
bits(64) offset = SignExtend(imm9, 64);
```

## Unsigned offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	1	1	0	0	1	1	0	imm12												Rn				Rt					
size										opc																					

## Unsigned offset

```
LDRSW <Xt>, [<Xn|SP>{, #<pimm>}]

boolean wback = FALSE;
boolean postindex = FALSE;
bits(64) offset = LSL(ZeroExtend(imm12, 64), 2);
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [LDRSW \(immediate\)](#).

## Assembler Symbols

- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <simm> Is the signed immediate byte offset, in the range -256 to 255, encoded in the "imm9" field.

<pimm> Is the optional positive immediate byte offset, a multiple of 4 in the range 0 to 16380, defaulting to 0 and encoded in the "imm12" field as <pimm>/4.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = wback || n != 31;
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(32) data;

boolean wb_unknown = FALSE;

if wback && n == t && n != 31 then
    c = ConstrainUnpredictable(Unpredictable_WBOVERLAPLD);
    assert c IN {Constraint_WBSUPPRESS, Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_WBSUPPRESS wback = FALSE;    // writeback is suppressed
        when Constraint_UNKNOWN    wb_unknown = TRUE; // writeback is UNKNOWN
        when Constraint_UNDEF      UNDEFINED;
        when Constraint_NOP        EndOfInstruction();

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

data = Mem[address, 4, AccType_NORMAL];
X[t] = SignExtend(data, 64);
if wback then
    if wb_unknown then
        address = bits(64) UNKNOWN;
    elsif postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

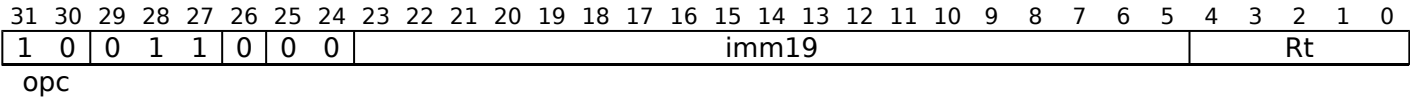
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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## LDRSW (literal)

Load Register Signed Word (literal) calculates an address from the PC value and an immediate offset, loads a word from memory, and writes it to a register. For information about memory accesses, see [Load/Store addressing modes](#).



### Literal

```
LDRSW <Xt>, <label>

integer t = UInt(Rt);
bits(64) offset;

offset = SignExtend(imm19:'00', 64);
```

### Assembler Symbols

- <Xt> Is the 64-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <label> Is the program label from which the data is to be loaded. Its offset from the address of this instruction, in the range +/-1MB, is encoded as "imm19" times 4.

### Operation

```
bits(64) address = PC[] + offset;
bits(32) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(FALSE);

data = Mem[address, 4, AccType_NORMAL];
X[t] = SignExtend(data, 64);
```

### Operational information

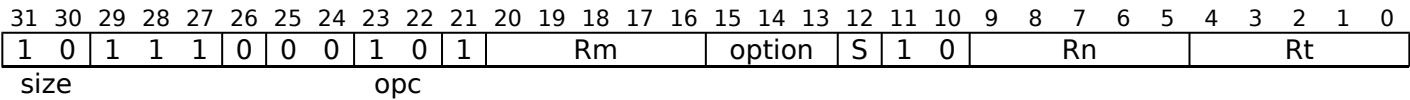
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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LDRSW (register)

Load Register Signed Word (register) calculates an address from a base register value and an offset register value, loads a word from memory, sign-extends it to form a 64-bit value, and writes it to a register. The offset register value can be shifted left by 0 or 2 bits. For information about memory accesses, see [Load/Store addressing modes](#).



64-bit

```
LDRSW <Xt>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]
```

```
if option<1> == '0' then UNDEFINED;    // sub-word index
ExtendType extend_type = DecodeRegExtend(option);
integer shift = if S == '1' then 2 else 0;
```

Assembler Symbols

- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Wm> When option<0> is set to 0, is the 32-bit name of the general-purpose index register, encoded in the "Rm" field.
- <Xm> When option<0> is set to 1, is the 64-bit name of the general-purpose index register, encoded in the "Rm" field.
- <extend> Is the index extend/shift specifier, defaulting to LSL, and which must be omitted for the LSL option when <amount> is omitted. encoded in "option":

option	<extend>
010	UXTW
011	LSL
110	SXTW
111	SCTX
- <amount> Is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in "S":

S	<amount>
0	#0
1	#2

Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer m = UInt(Rm);
```

## Operation

```
bits(64) offset = ExtendReg(m, extend_type, shift);
if HaveMTEExt() then
    SetTagCheckedInstruction(TRUE);

bits(64) address;
bits(32) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = Mem[address, 4, AccType_NORMAL];
X[t] = SignExtend(data, 64);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDSET, LDSETA, LDSETAL, LDSETL

Atomic bit set on word or doubleword in memory atomically loads a 32-bit word or 64-bit doubleword from memory, performs a bitwise OR with the value held in a register on it, and stores the result back to memory. The value initially loaded from memory is returned in the destination register.

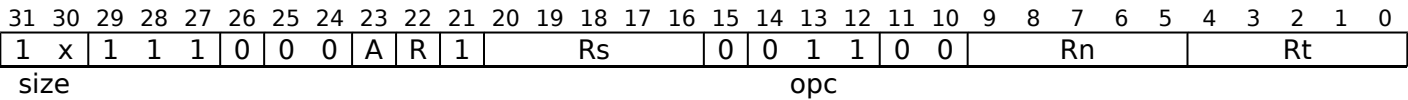
- If the destination register is not one of WZR or XZR, LDSETA and LDSETAL load from memory with acquire semantics.
- LDSETL and LDSETAL store to memory with release semantics.
- LDSET has neither acquire nor release semantics.

For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This instruction is used by the alias *STSET, STSETL*.

## Integer (Armv8.1)



**32-bit LDSET (size == 10 && A == 0 && R == 0)**

LDSET <Ws>, <Wt>, [<Xn|SP>]

**32-bit LDSETA (size == 10 && A == 1 && R == 0)**

LDSETA <Ws>, <Wt>, [<Xn|SP>]

**32-bit LDSETAL (size == 10 && A == 1 && R == 1)**

LDSETAL <Ws>, <Wt>, [<Xn|SP>]

**32-bit LDSETL (size == 10 && A == 0 && R == 1)**

LDSETL <Ws>, <Wt>, [<Xn|SP>]

**64-bit LDSET (size == 11 && A == 0 && R == 0)**

LDSET <Xs>, <Xt>, [<Xn|SP>]

**64-bit LDSETA (size == 11 && A == 1 && R == 0)**

LDSETA <Xs>, <Xt>, [<Xn|SP>]

**64-bit LDSETAL (size == 11 && A == 1 && R == 1)**

LDSETAL <Xs>, <Xt>, [<Xn|SP>]

**64-bit LDSETL (size == 11 && A == 0 && R == 1)**

LDSETL <Xs>, <Xt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

integer datasize = 8 << UInt(size);
integer regsize = if datasize == 64 then 64 else 32;
AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

**Assembler Symbols**

<Ws>	Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Wt>	Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
<Xs>	Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xt>	Is the 64-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

**Alias Conditions**

Alias	Is preferred when
<a href="#">STSET, STSETL</a>	A == '0' && Rt == '11111'



## Operation

```
bits(64) address;
bits(datasize) value;
bits(datasize) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_ORR, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, regsize);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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LDSETB, LDSETAB, LDSETALB, LDSETLB

Atomic bit set on byte in memory atomically loads an 8-bit byte from memory, performs a bitwise OR with the value held in a register on it, and stores the result back to memory. The value initially loaded from memory is returned in the destination register.

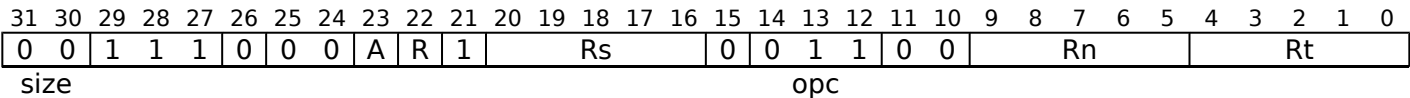
- If the destination register is not WZR, LDSETAB and LDSETALB load from memory with acquire semantics.
- LDSETLB and LDSETALB store to memory with release semantics.
- LDSETB has neither acquire nor release semantics.

For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This instruction is used by the alias *STSETB, STSETLB*.

Integer
(Armv8.1)



LDSETAB (A == 1 && R == 0)

```
LDSETAB <Ws>, <Wt>, [<Xn|SP>]
```

LDSETALB (A == 1 && R == 1)

```
LDSETALB <Ws>, <Wt>, [<Xn|SP>]
```

LDSETB (A == 0 && R == 0)

```
LDSETB <Ws>, <Wt>, [<Xn|SP>]
```

LDSETLB (A == 0 && R == 1)

```
LDSETLB <Ws>, <Wt>, [<Xn|SP>]
```

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Alias Conditions

Alias	Is preferred when
STSETB, STSETLB	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(8) value;
bits(8) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_ORR, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDSETH, LDSETAH, LDSETALH, LDSETLH

Atomic bit set on halfword in memory atomically loads a 16-bit halfword from memory, performs a bitwise OR with the value held in a register on it, and stores the result back to memory. The value initially loaded from memory is returned in the destination register.

- If the destination register is not WZR, LDSETAH and LDSETALH load from memory with acquire semantics.
- LDSETLH and LDSETALH store to memory with release semantics.
- LDSETH has neither acquire nor release semantics.

For more information about memory ordering semantics see [Load-Acquire, Store-Release](#).

For information about memory accesses see [Load/Store addressing modes](#).

This instruction is used by the alias [STSETH, STSETLH](#).

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	A	R	1	Rs					0	0	1	1	0	0	Rn					Rt				
size											opc																				

### LDSETAH (A == 1 && R == 0)

LDSETAH <Ws>, <Wt>, [<Xn|SP>]

### LDSETALH (A == 1 && R == 1)

LDSETALH <Ws>, <Wt>, [<Xn|SP>]

### LDSETH (A == 0 && R == 0)

LDSETH <Ws>, <Wt>, [<Xn|SP>]

### LDSETLH (A == 0 && R == 1)

LDSETLH <Ws>, <Wt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">STSETH, STSETLH</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(16) value;
bits(16) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_ORR, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDSMAX, LDSMAXA, LDSMAXAL, LDSMAXL

Atomic signed maximum on word or doubleword in memory atomically loads a 32-bit word or 64-bit doubleword from memory, compares it against the value held in a register, and stores the larger value back to memory, treating the values as signed numbers. The value initially loaded from memory is returned in the destination register.

- If the destination register is not one of WZR or XZR, LDSMAXA and LDSMAXAL load from memory with acquire semantics.
- LDSMAXL and LDSMAXAL store to memory with release semantics.
- LDSMAX has neither acquire nor release semantics.

For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This instruction is used by the alias *STSMAX, STSMAXL*.

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	0	A	R	1	Rs				0	1	0	0	0	0	Rn				Rt						
size												opc																			

32-bit LDSMAX (size == 10 && A == 0 && R == 0)

```
LDSMAX <Ws>, <Wt>, [<Xn|SP>]
```

32-bit LDSMAXA (size == 10 && A == 1 && R == 0)

```
LDSMAXA <Ws>, <Wt>, [<Xn|SP>]
```

32-bit LDSMAXAL (size == 10 && A == 1 && R == 1)

```
LDSMAXAL <Ws>, <Wt>, [<Xn|SP>]
```

32-bit LDSMAXL (size == 10 && A == 0 && R == 1)

```
LDSMAXL <Ws>, <Wt>, [<Xn|SP>]
```

64-bit LDSMAX (size == 11 && A == 0 && R == 0)

```
LDSMAX <Xs>, <Xt>, [<Xn|SP>]
```

64-bit LDSMAXA (size == 11 && A == 1 && R == 0)

```
LDSMAXA <Xs>, <Xt>, [<Xn|SP>]
```

64-bit LDSMAXAL (size == 11 && A == 1 && R == 1)

```
LDSMAXAL <Xs>, <Xt>, [<Xn|SP>]
```

64-bit LDSMAXL (size == 11 && A == 0 && R == 1)

```
LDSMAXL <Xs>, <Xt>, [<Xn|SP>]
```

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

integer datasize = 8 << UInt(size);
integer regsize = if datasize == 64 then 64 else 32;
AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

Assembler Symbols

<Ws>	Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Wt>	Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
<Xs>	Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xt>	Is the 64-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Alias Conditions

Alias	Is preferred when
<a href="#">STSMAX</a> , <a href="#">STSMAXL</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(datasize) value;
bits(datasize) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_SMAX, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, regsize);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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LDSMAXB, LDSMAXAB, LDSMAXALB, LDSMAXLB

Atomic signed maximum on byte in memory atomically loads an 8-bit byte from memory, compares it against the value held in a register, and stores the larger value back to memory, treating the values as signed numbers. The value initially loaded from memory is returned in the destination register.

- If the destination register is not WZR, LDSMAXAB and LDSMAXALB load from memory with acquire semantics.
- LDSMAXLB and LDSMAXALB store to memory with release semantics.
- LDSMAXB has neither acquire nor release semantics.

For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This instruction is used by the alias [STSMAXB, STSMAXLB](#).

Integer  
(Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	A	R	1	Rs					0	1	0	0	0	0	Rn					Rt				
size											opc																				

LDSMAXAB (A == 1 && R == 0)

LDSMAXAB <Ws>, <Wt>, [[<Xn|SP>](#)]

LDSMAXALB (A == 1 && R == 1)

LDSMAXALB <Ws>, <Wt>, [[<Xn|SP>](#)]

LDSMAXB (A == 0 && R == 0)

LDSMAXB <Ws>, <Wt>, [[<Xn|SP>](#)]

LDSMAXLB (A == 0 && R == 1)

LDSMAXLB <Ws>, <Wt>, [[<Xn|SP>](#)]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Alias Conditions

Alias	Is preferred when
<a href="#">STSMAXB, STSMAXLB</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(8) value;
bits(8) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_SMAX, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDSMAXH, LDSMAXAH, LDSMAXALH, LDSMAXLH

Atomic signed maximum on halfword in memory atomically loads a 16-bit halfword from memory, compares it against the value held in a register, and stores the larger value back to memory, treating the values as signed numbers. The value initially loaded from memory is returned in the destination register.

- If the destination register is not WZR, LDSMAXAH and LDSMAXALH load from memory with acquire semantics.
- LDSMAXLH and LDSMAXALH store to memory with release semantics.
- LDSMAXH has neither acquire nor release semantics.

For more information about memory ordering semantics see [Load-Acquire, Store-Release](#).

For information about memory accesses see [Load/Store addressing modes](#).

This instruction is used by the alias [STSMAXH, STSMAXLH](#).

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	A	R	1	Rs					0	1	0	0	0	0	Rn					Rt				
size											opc																				

### LDSMAXAH (A == 1 && R == 0)

LDSMAXAH <Ws>, <Wt>, [<Xn|SP>]

### LDSMAXALH (A == 1 && R == 1)

LDSMAXALH <Ws>, <Wt>, [<Xn|SP>]

### LDSMAXH (A == 0 && R == 0)

LDSMAXH <Ws>, <Wt>, [<Xn|SP>]

### LDSMAXLH (A == 0 && R == 1)

LDSMAXLH <Ws>, <Wt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">STSMAXH, STSMAXLH</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(16) value;
bits(16) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_SMAX, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDSMIN, LDSMINA, LDSMINAL, LDSMINL

Atomic signed minimum on word or doubleword in memory atomically loads a 32-bit word or 64-bit doubleword from memory, compares it against the value held in a register, and stores the smaller value back to memory, treating the values as signed numbers. The value initially loaded from memory is returned in the destination register.

- If the destination register is not one of WZR or XZR, LDSMINA and LDSMINAL load from memory with acquire semantics.
- LDSMINL and LDSMINAL store to memory with release semantics.
- LDSMIN has neither acquire nor release semantics.

For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This instruction is used by the alias *STSMIN, STSMINL*.

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	0	A	R	1	Rs				0	1	0	1	0	0	Rn				Rt						
size										opc																					

32-bit LDSMIN (size == 10 && A == 0 && R == 0)

LDSMIN <Ws>, <Wt>, [<Xn|SP>]

32-bit LDSMINA (size == 10 && A == 1 && R == 0)

LDSMINA <Ws>, <Wt>, [<Xn|SP>]

32-bit LDSMINAL (size == 10 && A == 1 && R == 1)

LDSMINAL <Ws>, <Wt>, [<Xn|SP>]

32-bit LDSMINL (size == 10 && A == 0 && R == 1)

LDSMINL <Ws>, <Wt>, [<Xn|SP>]

64-bit LDSMIN (size == 11 && A == 0 && R == 0)

LDSMIN <Xs>, <Xt>, [<Xn|SP>]

64-bit LDSMINA (size == 11 && A == 1 && R == 0)

LDSMINA <Xs>, <Xt>, [<Xn|SP>]

64-bit LDSMINAL (size == 11 && A == 1 && R == 1)

LDSMINAL <Xs>, <Xt>, [<Xn|SP>]

64-bit LDSMINL (size == 11 && A == 0 && R == 1)

LDSMINL <Xs>, <Xt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

integer datasize = 8 << UInt(size);
integer regsize = if datasize == 64 then 64 else 32;
AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xs> Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xt> Is the 64-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Alias Conditions

Alias	Is preferred when
<a href="#">STSMIN</a> , <a href="#">STSMINL</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(datasize) value;
bits(datasize) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_SMIN, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, regsize);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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LDSMINB, LDSMINAB, LDSMINALB, LDSMINLB

Atomic signed minimum on byte in memory atomically loads an 8-bit byte from memory, compares it against the value held in a register, and stores the smaller value back to memory, treating the values as signed numbers. The value initially loaded from memory is returned in the destination register.

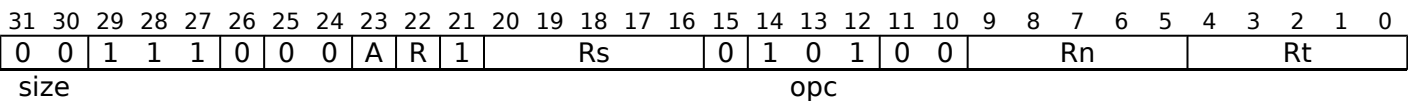
- If the destination register is not WZR, LDSMINAB and LDSMINALB load from memory with acquire semantics.
- LDSMINLB and LDSMINALB store to memory with release semantics.
- LDSMINB has neither acquire nor release semantics.

For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This instruction is used by the alias [STSMINB, STSMINLB](#).

Integer  
(Armv8.1)



LDSMINAB (A == 1 && R == 0)

```
LDSMINAB <Ws>, <Wt>, [<Xn|SP>]
```

LDSMINALB (A == 1 && R == 1)

```
LDSMINALB <Ws>, <Wt>, [<Xn|SP>]
```

LDSMINB (A == 0 && R == 0)

```
LDSMINB <Ws>, <Wt>, [<Xn|SP>]
```

LDSMINLB (A == 0 && R == 1)

```
LDSMINLB <Ws>, <Wt>, [<Xn|SP>]
```

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Alias Conditions

Alias	Is preferred when
<a href="#">STSMINB, STSMINLB</a>	A == '0' && Rt == '11111'



## Operation

```
bits(64) address;
bits(8) value;
bits(8) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_SMIN, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDSMINH, LDSMINAH, LDSMINALH, LDSMINLH

Atomic signed minimum on halfword in memory atomically loads a 16-bit halfword from memory, compares it against the value held in a register, and stores the smaller value back to memory, treating the values as signed numbers. The value initially loaded from memory is returned in the destination register.

- If the destination register is not WZR, LDSMINAH and LDSMINALH load from memory with acquire semantics.
- LDSMINLH and LDSMINALH store to memory with release semantics.
- LDSMINH has neither acquire nor release semantics.

For more information about memory ordering semantics see [Load-Acquire, Store-Release](#).

For information about memory accesses see [Load/Store addressing modes](#).

This instruction is used by the alias [STSMINH, STSMINLH](#).

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	A	R	1	Rs					0	1	0	1	0	0	Rn					Rt				
size											opc																				

### LDSMINAH (A == 1 && R == 0)

LDSMINAH <Ws>, <Wt>, [[<Xn|SP>](#)]

### LDSMINALH (A == 1 && R == 1)

LDSMINALH <Ws>, <Wt>, [[<Xn|SP>](#)]

### LDSMINH (A == 0 && R == 0)

LDSMINH <Ws>, <Wt>, [[<Xn|SP>](#)]

### LDSMINLH (A == 0 && R == 1)

LDSMINLH <Ws>, <Wt>, [[<Xn|SP>](#)]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType\_ORDEREDATOMICRW else AccType\_ATOMICRW;
AccType stacctype = if R == '1' then AccType\_ORDEREDATOMICRW else AccType\_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">STSMINH, STSMINLH</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(16) value;
bits(16) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_SMIN, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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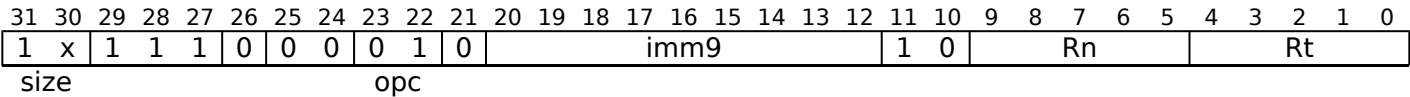
LDTR

Load Register (unprivileged) loads a word or doubleword from memory, and writes it to a register. The address that is used for the load is calculated from a base register and an immediate offset.

Memory accesses made by the instruction behave as if the instruction was executed at EL0 if the *Effective value* of PSTATE.UAO is 0 and either:

- The instruction is executed at EL1.
- The instruction is executed at EL2 when the *Effective value* of HCR\_EL2.{E2H, TGE} is {1, 1}.

Otherwise, the memory access operates with the restrictions determined by the Exception level at which the instruction is executed. For information about memory accesses, see *Load/Store addressing modes*.



32-bit (size == 10)

```
LDTR <Wt>, [<Xn|SP>{, #<sim>}]
```

64-bit (size == 11)

```
LDTR <Xt>, [<Xn|SP>{, #<sim>}]
```

```
integer scale = UInt(size);
bits(64) offset = SignExtend(imm9, 64);
```

Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

unpriv_at_el1 = PSTATE.EL == EL1 && !(EL2Enabled() && HaveNVExt() && HCR_EL2.<NV,NV1> == '11');
unpriv_at_el2 = PSTATE.EL == EL2 && HaveVirtHostExt() && HCR_EL2.<E2H,TGE> == '11';

user_access_override = HaveUA0Ext() && PSTATE.UAO == '1';
if !user_access_override && (unpriv_at_el1 || unpriv_at_el2) then
    acctype = AccType_UNPRIV;
else
    acctype = AccType_NORMAL;

integer regsize;

regsize = if size == '11' then 64 else 32;
integer datasize = 8 << scale;
boolean tag_checked = n != 31;
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(datasize) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = Mem[address, datasize DIV 8, acctype];
X[t] = ZeroExtend(data, regsize);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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## LDTRB

Load Register Byte (unprivileged) loads a byte from memory, zero-extends it, and writes the result to a register. The address that is used for the load is calculated from a base register and an immediate offset.

Memory accesses made by the instruction behave as if the instruction was executed at EL0 if the *Effective value* of PSTATE.UAO is 0 and either:

- The instruction is executed at EL1.
- The instruction is executed at EL2 when the *Effective value* of *HCR\_EL2*.{E2H, TGE} is {1, 1}.

Otherwise, the memory access operates with the restrictions determined by the Exception level at which the instruction is executed. For information about memory accesses, see *Load/Store addressing modes*.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0											
0		0		1		1		1		0		0		0		0		1		0		imm9									1		0		Rn				Rt			
size										opc																																

### Unscaled offset

```
LDTRB <Wt>, [<Xn|SP>{, #<sim>}]
```

```
bits(64) offset = SignExtend(imm9, 64);
```

### Assembler Symbols

<Wt>	Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<sim>	Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

### Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

unpriv_at_el1 = PSTATE.EL == EL1 && !(EL2Enabled() && HaveNVExt() && HCR_EL2.<NV,NV1> == '11');
unpriv_at_el2 = PSTATE.EL == EL2 && HaveVirtHostExt() && HCR_EL2.<E2H,TGE> == '11';

user_access_override = HaveUA0Ext() && PSTATE.UAO == '1';
if !user_access_override && (unpriv_at_el1 || unpriv_at_el2) then
    acctype = AccType_UNPRIV;
else
    acctype = AccType_NORMAL;

boolean tag_checked = n != 31;
```

### Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(8) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = Mem[address, 1, acctype];
X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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## LDTRH

Load Register Halfword (unprivileged) loads a halfword from memory, zero-extends it, and writes the result to a register. The address that is used for the load is calculated from a base register and an immediate offset.

Memory accesses made by the instruction behave as if the instruction was executed at EL0 if the *Effective value* of PSTATE.UAO is 0 and either:

- The instruction is executed at EL1.
- The instruction is executed at EL2 when the *Effective value* of HCR\_EL2.{E2H, TGE} is {1, 1}.

Otherwise, the memory access operates with the restrictions determined by the Exception level at which the instruction is executed. For information about memory accesses, see *Load/Store addressing modes*.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
0	1	1	1	1	0	0	0	0	1	0	imm9									1	0	Rn				Rt									
size										opc																									

### Unscaled offset

LDTRH <Wt>, [<Xn|SP>{, #<sim>}]

```
bits(64) offset = SignExtend(imm9, 64);
```

### Assembler Symbols

<Wt>	Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<sim>	Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

### Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

unpriv_at_el1 = PSTATE.EL == EL1 && !(EL2Enabled() && HaveNVExt() && HCR_EL2.<NV,NV1> == '11');
unpriv_at_el2 = PSTATE.EL == EL2 && HaveVirtHostExt() && HCR_EL2.<E2H,TGE> == '11';

user_access_override = HaveUA0Ext() && PSTATE.UAO == '1';
if !user_access_override && (unpriv_at_el1 || unpriv_at_el2) then
    acctype = AccType_UNPRIV;
else
    acctype = AccType_NORMAL;

boolean tag_checked = n != 31;
```

### Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(16) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = Mem[address, 2, acctype];
X[t] = ZeroExtend(data, 32);
```



## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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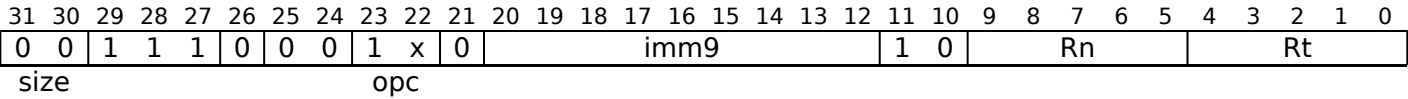
# LDTRSB

Load Register Signed Byte (unprivileged) loads a byte from memory, sign-extends it to 32 bits or 64 bits, and writes the result to a register. The address that is used for the load is calculated from a base register and an immediate offset.

Memory accesses made by the instruction behave as if the instruction was executed at EL0 if the *Effective value* of PSTATE.UAO is 0 and either:

- The instruction is executed at EL1.
- The instruction is executed at EL2 when the *Effective value* of *HCR\_EL2*.{E2H, TGE} is {1, 1}.

Otherwise, the memory access operates with the restrictions determined by the Exception level at which the instruction is executed. For information about memory accesses, see *Load/Store addressing modes*.



## 32-bit (opc == 11)

LDTRSB <Wt>, [<Xn|SP>{, #<simm>}]

## 64-bit (opc == 10)

LDTRSB <Xt>, [<Xn|SP>{, #<simm>}]

bits(64) offset = [SignExtend](#)(imm9, 64);

## Assembler Symbols

- |         |  |
|---------|--|
| <Wt>    | Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.                         |
| <Xt>    | Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.                         |
| <Xn SP> | Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.                     |
| <simm>  | Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field. |

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

unpriv_at_el1 = PSTATE.EL == EL1 && !(EL2Enabled() && HaveNVExt() && HCR_EL2.<NV,NV1> == '11');
unpriv_at_el2 = PSTATE.EL == EL2 && HaveVirtHostExt() && HCR_EL2.<E2H,TGE> == '11';

user_access_override = HaveUA0Ext() && PSTATE.UAO == '1';
if !user_access_override && (unpriv_at_el1 || unpriv_at_el2) then
    acctype = AccType_UNPRIV;
else
    acctype = AccType_NORMAL;

MemOp memop;
boolean signed;
integer regsize;

if opc<1> == '0' then
    // store or zero-extending load
    memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;
    regsize = 32;
    signed = FALSE;
else
    // sign-extending load
    memop = MemOp_LOAD;
    regsize = if opc<0> == '1' then 32 else 64;
    signed = TRUE;

boolean tag_checked = memop != MemOp_PREFETCH && (n != 31);
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(8) data;

if n == 31 then
    if memop != MemOp_PREFETCH then CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

case memop of
    when MemOp_STORE
        data = X[t];
        Mem[address, 1, acctype] = data;

    when MemOp_LOAD
        data = Mem[address, 1, acctype];
        if signed then
            X[t] = SignExtend(data, regsize);
        else
            X[t] = ZeroExtend(data, regsize);

    when MemOp_PREFETCH
        Prefetch(address, t<4:0>);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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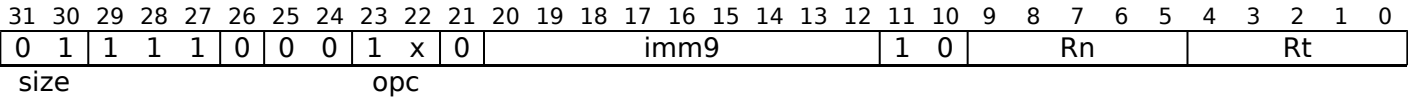
# LDTRSH

Load Register Signed Halfword (unprivileged) loads a halfword from memory, sign-extends it to 32 bits or 64 bits, and writes the result to a register. The address that is used for the load is calculated from a base register and an immediate offset.

Memory accesses made by the instruction behave as if the instruction was executed at EL0 if the *Effective value* of PSTATE.UAO is 0 and either:

- The instruction is executed at EL1.
- The instruction is executed at EL2 when the *Effective value* of HCR\_EL2.{E2H, TGE} is {1, 1}.

Otherwise, the memory access operates with the restrictions determined by the Exception level at which the instruction is executed. For information about memory accesses, see *Load/Store addressing modes*.



## 32-bit (opc == 11)

```
LDTRSH <Wt>, [<Xn|SP>{, #<sim>}]
```

## 64-bit (opc == 10)

```
LDTRSH <Xt>, [<Xn|SP>{, #<sim>}]
```

```
bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

unpriv_at_el1 = PSTATE.EL == EL1 && !(EL2Enabled() && HaveNVExt() && HCR_EL2.<NV,NV1> == '11');
unpriv_at_el2 = PSTATE.EL == EL2 && HaveVirtHostExt() && HCR_EL2.<E2H,TGE> == '11';

user_access_override = HaveUA0Ext() && PSTATE.UAO == '1';
if !user_access_override && (unpriv_at_el1 || unpriv_at_el2) then
    acctype = AccType_UNPRIV;
else
    acctype = AccType_NORMAL;

MemOp memop;
boolean signed;
integer regsize;

if opc<1> == '0' then
    // store or zero-extending load
    memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;
    regsize = 32;
    signed = FALSE;
else
    // sign-extending load
    memop = MemOp_LOAD;
    regsize = if opc<0> == '1' then 32 else 64;
    signed = TRUE;

boolean tag_checked = memop != MemOp_PREFETCH && (n != 31);
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(16) data;

if n == 31 then
    if memop != MemOp_PREFETCH then CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

case memop of
    when MemOp_STORE
        data = X[t];
        Mem[address, 2, acctype] = data;

    when MemOp_LOAD
        data = Mem[address, 2, acctype];
        if signed then
            X[t] = SignExtend(data, regsize);
        else
            X[t] = ZeroExtend(data, regsize);

    when MemOp_PREFETCH
        Prefetch(address, t<4:0>);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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## LDTRSW

Load Register Signed Word (unprivileged) loads a word from memory, sign-extends it to 64 bits, and writes the result to a register. The address that is used for the load is calculated from a base register and an immediate offset.

Memory accesses made by the instruction behave as if the instruction was executed at EL0 if the *Effective value* of PSTATE.UAO is 0 and either:

- The instruction is executed at EL1.
- The instruction is executed at EL2 when the *Effective value* of *HCR\_EL2*.{E2H, TGE} is {1, 1}.

Otherwise, the memory access operates with the restrictions determined by the Exception level at which the instruction is executed. For information about memory accesses, see *Load/Store addressing modes*.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
1	0	1	1	1	0	0	0	1	0	0	imm9									1	0	Rn				Rt									
size								opc																											

### Unscaled offset

LDTRSW <Xt>, [<Xn|SP>{, #<sim>}]

```
bits(64) offset = SignExtend(imm9, 64);
```

### Assembler Symbols

<Xt>	Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<sim>	Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

### Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

unpriv_at_el1 = PSTATE.EL == EL1 && !(EL2Enabled() && HaveNVExt() && HCR_EL2.<NV,NV1> == '11');
unpriv_at_el2 = PSTATE.EL == EL2 && HaveVirtHostExt() && HCR_EL2.<E2H,TGE> == '11';

user_access_override = HaveUA0Ext() && PSTATE.UAO == '1';
if !user_access_override && (unpriv_at_el1 || unpriv_at_el2) then
    acctype = AccType_UNPRIV;
else
    acctype = AccType_NORMAL;

boolean tag_checked = n != 31;
```

### Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(32) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = Mem[address, 4, acctype];
X[t] = SignExtend(data, 64);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDUMAX, LDUMAXA, LDUMAXAL, LDUMAXL

Atomic unsigned maximum on word or doubleword in memory atomically loads a 32-bit word or 64-bit doubleword from memory, compares it against the value held in a register, and stores the larger value back to memory, treating the values as unsigned numbers. The value initially loaded from memory is returned in the destination register.

- If the destination register is not one of WZR or XZR, LDUMAXA and LDUMAXAL load from memory with acquire semantics.
- LDUMAXL and LDUMAXAL store to memory with release semantics.
- LDUMAX has neither acquire nor release semantics.

For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This instruction is used by the alias *STUMAX, STUMAXL*.

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	0	A	R	1	Rs				0	1	1	0	0	0	Rn				Rt						
size												opc																			



32-bit LDUMAX (size == 10 && A == 0 && R == 0)

```
LDUMAX <Ws>, <Wt>, [<Xn|SP>]
```

32-bit LDUMAXA (size == 10 && A == 1 && R == 0)

```
LDUMAXA <Ws>, <Wt>, [<Xn|SP>]
```

32-bit LDUMAXAL (size == 10 && A == 1 && R == 1)

```
LDUMAXAL <Ws>, <Wt>, [<Xn|SP>]
```

32-bit LDUMAXL (size == 10 && A == 0 && R == 1)

```
LDUMAXL <Ws>, <Wt>, [<Xn|SP>]
```

64-bit LDUMAX (size == 11 && A == 0 && R == 0)

```
LDUMAX <Xs>, <Xt>, [<Xn|SP>]
```

64-bit LDUMAXA (size == 11 && A == 1 && R == 0)

```
LDUMAXA <Xs>, <Xt>, [<Xn|SP>]
```

64-bit LDUMAXAL (size == 11 && A == 1 && R == 1)

```
LDUMAXAL <Xs>, <Xt>, [<Xn|SP>]
```

64-bit LDUMAXL (size == 11 && A == 0 && R == 1)

```
LDUMAXL <Xs>, <Xt>, [<Xn|SP>]
```

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

integer datasize = 8 << UInt(size);
integer regsize = if datasize == 64 then 64 else 32;
AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

Assembler Symbols

<Ws>	Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Wt>	Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
<Xs>	Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xt>	Is the 64-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Alias Conditions

Alias	Is preferred when
<a href="#">STUMAX, STUMAXL</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(datasize) value;
bits(datasize) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_UMAX, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, regsize);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDUMAXB, LDUMAXAB, LDUMAXALB, LDUMAXLB

Atomic unsigned maximum on byte in memory atomically loads an 8-bit byte from memory, compares it against the value held in a register, and stores the larger value back to memory, treating the values as unsigned numbers. The value initially loaded from memory is returned in the destination register.

- If the destination register is not WZR, LDUMAXAB and LDUMAXALB load from memory with acquire semantics.
- LDUMAXLB and LDUMAXALB store to memory with release semantics.
- LDUMAXB has neither acquire nor release semantics.

For more information about memory ordering semantics see [Load-Acquire, Store-Release](#).

For information about memory accesses see [Load/Store addressing modes](#).

This instruction is used by the alias [STUMAXB, STUMAXLB](#).

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	A	R	1	Rs					0	1	1	0	0	0	Rn					Rt				
size											opc																				

### LDUMAXAB (A == 1 && R == 0)

LDUMAXAB <Ws>, <Wt>, [<Xn|SP>]

### LDUMAXALB (A == 1 && R == 1)

LDUMAXALB <Ws>, <Wt>, [<Xn|SP>]

### LDUMAXB (A == 0 && R == 0)

LDUMAXB <Ws>, <Wt>, [<Xn|SP>]

### LDUMAXLB (A == 0 && R == 1)

LDUMAXLB <Ws>, <Wt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">STUMAXB, STUMAXLB</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(8) value;
bits(8) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_UMAX, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDUMAXH, LDUMAXAH, LDUMAXALH, LDUMAXLH

Atomic unsigned maximum on halfword in memory atomically loads a 16-bit halfword from memory, compares it against the value held in a register, and stores the larger value back to memory, treating the values as unsigned numbers. The value initially loaded from memory is returned in the destination register.

- If the destination register is not WZR, LDUMAXAH and LDUMAXALH load from memory with acquire semantics.
- LDUMAXLH and LDUMAXALH store to memory with release semantics.
- LDUMAXH has neither acquire nor release semantics.

For more information about memory ordering semantics see [Load-Acquire, Store-Release](#).

For information about memory accesses see [Load/Store addressing modes](#).

This instruction is used by the alias [STUMAXH, STUMAXLH](#).

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	A	R	1	Rs					0	1	1	0	0	0	Rn					Rt				
size											opc																				

### LDUMAXAH (A == 1 && R == 0)

LDUMAXAH <Ws>, <Wt>, [<Xn|SP>]

### LDUMAXALH (A == 1 && R == 1)

LDUMAXALH <Ws>, <Wt>, [<Xn|SP>]

### LDUMAXH (A == 0 && R == 0)

LDUMAXH <Ws>, <Wt>, [<Xn|SP>]

### LDUMAXLH (A == 0 && R == 1)

LDUMAXLH <Ws>, <Wt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">STUMAXH, STUMAXLH</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(16) value;
bits(16) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_UMAX, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDUMIN, LDUMINA, LDUMINAL, LDUMINL

Atomic unsigned minimum on word or doubleword in memory atomically loads a 32-bit word or 64-bit doubleword from memory, compares it against the value held in a register, and stores the smaller value back to memory, treating the values as unsigned numbers. The value initially loaded from memory is returned in the destination register.

- If the destination register is not one of WZR or XZR, LDUMINA and LDUMINAL load from memory with acquire semantics.
- LDUMINL and LDUMINAL store to memory with release semantics.
- LDUMIN has neither acquire nor release semantics.

For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This instruction is used by the alias *STUMIN, STUMINL*.

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	0	A	R	1	Rs				0	1	1	1	0	0	Rn				Rt						
size												opc																			

**32-bit LDUMIN (size == 10 && A == 0 && R == 0)**

LDUMIN <Ws>, <Wt>, [<Xn|SP>]

**32-bit LDUMINA (size == 10 && A == 1 && R == 0)**

LDUMINA <Ws>, <Wt>, [<Xn|SP>]

**32-bit LDUMINAL (size == 10 && A == 1 && R == 1)**

LDUMINAL <Ws>, <Wt>, [<Xn|SP>]

**32-bit LDUMINL (size == 10 && A == 0 && R == 1)**

LDUMINL <Ws>, <Wt>, [<Xn|SP>]

**64-bit LDUMIN (size == 11 && A == 0 && R == 0)**

LDUMIN <Xs>, <Xt>, [<Xn|SP>]

**64-bit LDUMINA (size == 11 && A == 1 && R == 0)**

LDUMINA <Xs>, <Xt>, [<Xn|SP>]

**64-bit LDUMINAL (size == 11 && A == 1 && R == 1)**

LDUMINAL <Xs>, <Xt>, [<Xn|SP>]

**64-bit LDUMINL (size == 11 && A == 0 && R == 1)**

LDUMINL <Xs>, <Xt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

integer datasize = 8 << UInt(size);
integer regsize = if datasize == 64 then 64 else 32;
AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

**Assembler Symbols**

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xs> Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xt> Is the 64-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

**Alias Conditions**

Alias	Is preferred when
<a href="#">STUMIN</a> , <a href="#">STUMINL</a>	A == '0' && Rt == '11111'



## Operation

```
bits(64) address;
bits(datasize) value;
bits(datasize) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_UMIN, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, regsize);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDUMINB, LDUMINAB, LDUMINALB, LDUMINLB

Atomic unsigned minimum on byte in memory atomically loads an 8-bit byte from memory, compares it against the value held in a register, and stores the smaller value back to memory, treating the values as unsigned numbers. The value initially loaded from memory is returned in the destination register.

- If the destination register is not WZR, LDUMINAB and LDUMINALB load from memory with acquire semantics.
- LDUMINLB and LDUMINALB store to memory with release semantics.
- LDUMINB has neither acquire nor release semantics.

For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This instruction is used by the alias [STUMINB, STUMINLB](#).

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	A	R	1	Rs					0	1	1	1	0	0	Rn					Rt				
size											opc																				

### LDUMINAB (A == 1 && R == 0)

LDUMINAB <Ws>, <Wt>, [<Xn|SP>]

### LDUMINALB (A == 1 && R == 1)

LDUMINALB <Ws>, <Wt>, [<Xn|SP>]

### LDUMINB (A == 0 && R == 0)

LDUMINB <Ws>, <Wt>, [<Xn|SP>]

### LDUMINLB (A == 0 && R == 1)

LDUMINLB <Ws>, <Wt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">STUMINB, STUMINLB</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(8) value;
bits(8) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_UMIN, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDUMINH, LDUMINAH, LDUMINALH, LDUMINLH

Atomic unsigned minimum on halfword in memory atomically loads a 16-bit halfword from memory, compares it against the value held in a register, and stores the smaller value back to memory, treating the values as unsigned numbers. The value initially loaded from memory is returned in the destination register.

- If the destination register is not WZR, LDUMINAH and LDUMINALH load from memory with acquire semantics.
- LDUMINLH and LDUMINALH store to memory with release semantics.
- LDUMINH has neither acquire nor release semantics.

For more information about memory ordering semantics see [Load-Acquire, Store-Release](#).

For information about memory accesses see [Load/Store addressing modes](#).

This instruction is used by the alias [STUMINH, STUMINLH](#).

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	A	R	1	Rs					0	1	1	1	0	0	Rn					Rt				
size											opc																				

### LDUMINAH (A == 1 && R == 0)

LDUMINAH <Ws>, <Wt>, [<Xn|SP>]

### LDUMINALH (A == 1 && R == 1)

LDUMINALH <Ws>, <Wt>, [<Xn|SP>]

### LDUMINH (A == 0 && R == 0)

LDUMINH <Ws>, <Wt>, [<Xn|SP>]

### LDUMINLH (A == 0 && R == 1)

LDUMINLH <Ws>, <Wt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">STUMINH, STUMINLH</a>	A == '0' && Rt == '11111'

## Operation

```
bits(64) address;
bits(16) value;
bits(16) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

value = X[s];
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = MemAtomic(address, MemAtomicOp_UMIN, value, ldacctype, stacctype);

if t != 31 then
    X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDUR

Load Register (unscaled) calculates an address from a base register and an immediate offset, loads a 32-bit word or 64-bit doubleword from memory, zero-extends it, and writes it to a register. For information about memory accesses, see [Load/Store addressing modes](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
1	x	1	1	1	0	0	0	0	1	0	imm9									0	0	Rn						Rt							
size										opc																									

## 32-bit (size == 10)

```
LDUR <Wt>, [<Xn|SP>{, #<sim>}]
```

## 64-bit (size == 11)

```
LDUR <Xt>, [<Xn|SP>{, #<sim>}]
```

```
integer scale = UInt(size);
bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer regsize;

regsize = if size == '11' then 64 else 32;
integer datasize = 8 << scale;
boolean tag_checked = n != 31;
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(datasize) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = Mem[address, datasize DIV 8, AccType_NORMAL];
X[t] = ZeroExtend(data, regsize);
```

## Operational information

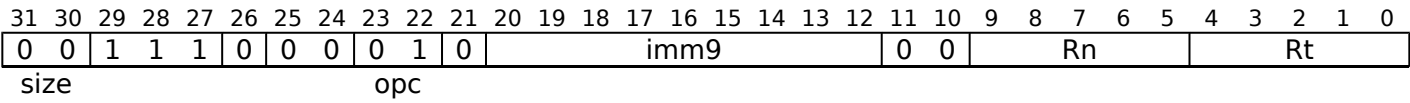
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDURB

Load Register Byte (unscaled) calculates an address from a base register and an immediate offset, loads a byte from memory, zero-extends it, and writes it to a register. For information about memory accesses, see [Load/Store addressing modes](#).



## Unscaled offset

```
LDURB <Wt>, [<Xn|SP>{, #<sim>}]  
  
bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);  
integer t = UInt(Rt);  
  
boolean tag_checked = n != 31;
```

## Operation

```
if HaveMTEExt() then  
    SetTagCheckedInstruction(tag_checked);  
  
bits(64) address;  
bits(8) data;  
  
if n == 31 then  
    CheckSPAlignment();  
    address = SP[];  
else  
    address = X[n];  
  
address = address + offset;  
  
data = Mem[address, 1, AccType_NORMAL];  
X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

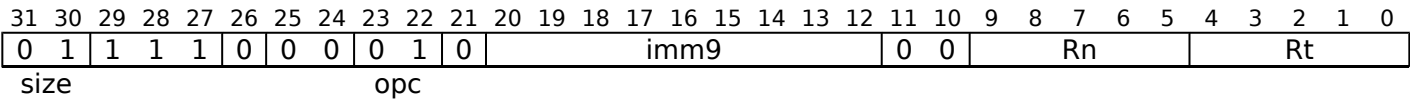
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# LDURH

Load Register Halfword (unscaled) calculates an address from a base register and an immediate offset, loads a halfword from memory, zero-extends it, and writes it to a register. For information about memory accesses, see [Load/Store addressing modes](#).



## Unscaled offset

```
LDURH <Wt>, [<Xn|SP>{, #<sim>}]  
  
bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);  
integer t = UInt(Rt);  
  
boolean tag_checked = n != 31;
```

## Operation

```
if HaveMTEExt() then  
    SetTagCheckedInstruction(tag_checked);  
  
bits(64) address;  
bits(16) data;  
  
if n == 31 then  
    CheckSPAlignment();  
    address = SP[];  
else  
    address = X[n];  
  
address = address + offset;  
  
data = Mem[address, 2, AccType_NORMAL];  
X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDURSB

Load Register Signed Byte (unscaled) calculates an address from a base register and an immediate offset, loads a signed byte from memory, sign-extends it, and writes it to a register. For information about memory accesses, see [Load/Store addressing modes](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	1	x	0	imm9									0	0	Rn				Rt					
size									opc																						

## 32-bit (opc == 11)

```
LDURSB <Wt>, [<Xn|SP>{, #<sim>}]
```

## 64-bit (opc == 10)

```
LDURSB <Xt>, [<Xn|SP>{, #<sim>}]
```

```
bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
MemOp memop;
boolean signed;
integer regsize;

if opc<1> == '0' then
    // store or zero-extending load
    memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;
    regsize = 32;
    signed = FALSE;
else
    // sign-extending load
    memop = MemOp_LOAD;
    regsize = if opc<0> == '1' then 32 else 64;
    signed = TRUE;

boolean tag_checked = memop != MemOp_PREFETCH && (n != 31);
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(8) data;

if n == 31 then
    if memop != MemOp_PREFETCH then CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

case memop of
    when MemOp_STORE
        data = X[t];
        Mem[address, 1, AccType_NORMAL] = data;

    when MemOp_LOAD
        data = Mem[address, 1, AccType_NORMAL];
        if signed then
            X[t] = SignExtend(data, regsize);
        else
            X[t] = ZeroExtend(data, regsize);

    when MemOp_PREFETCH
        Prefetch(address, t<4:0>);
```

## Operational information

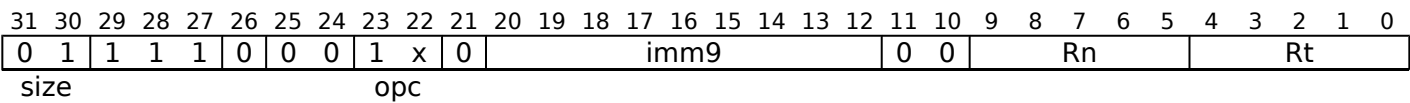
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDURSH

Load Register Signed Halfword (unscaled) calculates an address from a base register and an immediate offset, loads a signed halfword from memory, sign-extends it, and writes it to a register. For information about memory accesses, see [Load/Store addressing modes](#).



## 32-bit (opc == 11)

```
LDURSH <Wt>, [<Xn|SP>{, #<sim>}]
```

## 64-bit (opc == 10)

```
LDURSH <Xt>, [<Xn|SP>{, #<sim>}]
```

```
bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
MemOp memop;
boolean signed;
integer regsize;

if opc<1> == '0' then
    // store or zero-extending load
    memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;
    regsize = 32;
    signed = FALSE;
else
    // sign-extending load
    memop = MemOp_LOAD;
    regsize = if opc<0> == '1' then 32 else 64;
    signed = TRUE;

boolean tag_checked = memop != MemOp_PREFETCH && (n != 31);
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(16) data;

if n == 31 then
    if memop != MemOp_PREFETCH then CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

case memop of
    when MemOp_STORE
        data = X[t];
        Mem[address, 2, AccType_NORMAL] = data;

    when MemOp_LOAD
        data = Mem[address, 2, AccType_NORMAL];
        if signed then
            X[t] = SignExtend(data, regsize);
        else
            X[t] = ZeroExtend(data, regsize);

    when MemOp_PREFETCH
        Prefetch(address, t<4:0>);
```

## Operational information

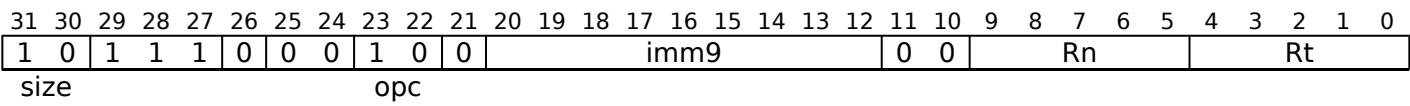
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDURSW

Load Register Signed Word (unscaled) calculates an address from a base register and an immediate offset, loads a signed word from memory, sign-extends it, and writes it to a register. For information about memory accesses, see [Load/Store addressing modes](#).



## Unscaled offset

```
LDURSW <Xt>, [<Xn|SP>{, #<sim>}]  
  
bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);  
integer t = UInt(Rt);  
  
boolean tag_checked = n != 31;
```

## Operation

```
if HaveMTEExt() then  
    SetTagCheckedInstruction(tag_checked);  
  
bits(64) address;  
bits(32) data;  
  
if n == 31 then  
    CheckSPAlignment();  
    address = SP[];  
else  
    address = X[n];  
  
address = address + offset;  
  
data = Mem[address, 4, AccType_NORMAL];  
X[t] = SignExtend(data, 64);
```

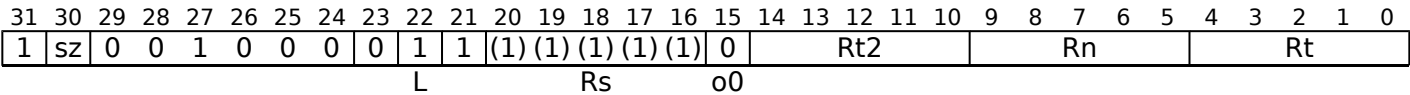
## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDXP

Load Exclusive Pair of Registers derives an address from a base register value, loads two 32-bit words or two 64-bit doublewords from memory, and writes them to two registers. A 32-bit pair requires the address to be doubleword aligned and is single-copy atomic at doubleword granularity. A 64-bit pair requires the address to be quadword aligned and is single-copy atomic for each doubleword at doubleword granularity. The PE marks the physical address being accessed as an exclusive access. This exclusive access mark is checked by Store Exclusive instructions. See [Synchronization and semaphores](#). For information about memory accesses see [Load/Store addressing modes](#).



## 32-bit (sz == 0)

LDXP <Wt1>, <Wt2>, [<Xn|SP>{, #0}]

## 64-bit (sz == 1)

LDXP <Xt1>, <Xt2>, [<Xn|SP>{, #0}]

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer t2 = UInt(Rt2);

integer elsize = 32 << UInt(sz);
integer datasize = elsize * 2;
boolean tag_checked = n != 31;
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [LDXP](#).

## Assembler Symbols

- <Wt1> Is the 32-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
- <Wt2> Is the 32-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
- <Xt1> Is the 64-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt2> Is the 64-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(datasize) data;
constant integer dbytes = datasize DIV 8;
boolean rt_unknown = FALSE;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if t == t2 then
    Constraint c = ConstrainUnpredictable(Unpredictable_LDPOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rt_unknown = TRUE;    // result is UNKNOWN
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

// Tell the Exclusives monitors to record a sequence of one or more atomic
// memory reads from virtual address range [address, address+dbytes-1].
// The Exclusives monitor will only be set if all the reads are from the
// same dbytes-aligned physical address, to allow for the possibility of
// an atomicity break if the translation is changed between reads.
AArch64.SetExclusiveMonitors(address, dbytes);

if rt_unknown then
    // ConstrainedUNPREDICTABLE case
    X[t] = bits(datasize) UNKNOWN;    // In this case t = t2
elsif elsize == 32 then
    // 32-bit load exclusive pair (atomic)
    data = Mem[address, dbytes, AccType_ATOMIC];
    if BigEndian() then
        X[t] = data<datasize-1:elsize>;
        X[t2] = data<elsize-1:0>;
    else
        X[t] = data<elsize-1:0>;
        X[t2] = data<datasize-1:elsize>;
else // elsize == 64
    // 64-bit load exclusive pair (not atomic),
    // but must be 128-bit aligned
    if address != Align(address, dbytes) then
        AArch64.Abort(address, AArch64.AlignmentFault(AccType_ATOMIC, FALSE, FALSE));
    X[t] = Mem[address, 8, AccType_ATOMIC];
    X[t2] = Mem[address+8, 8, AccType_ATOMIC];
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

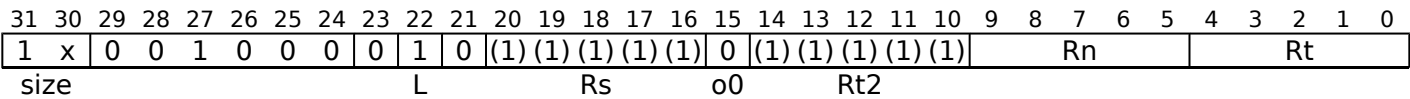
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# LDXR

Load Exclusive Register derives an address from a base register value, loads a 32-bit word or a 64-bit doubleword from memory, and writes it to a register. The memory access is atomic. The PE marks the physical address being accessed as an exclusive access. This exclusive access mark is checked by Store Exclusive instructions. See [Synchronization and semaphores](#). For information about memory accesses see [Load/Store addressing modes](#).



## 32-bit (size == 10)

```
LDXR <Wt>, [<Xn|SP>{, #0}]
```

## 64-bit (size == 11)

```
LDXR <Xt>, [<Xn|SP>{, #0}]
```

```
integer n = UInt(Rn);
integer t = UInt(Rt);

integer elsize = 8 << UInt(size);
integer regsize = if elsize == 64 then 64 else 32;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(elsize) data;
constant integer dbytes = elsize DIV 8;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

// Tell the Exclusives monitors to record a sequence of one or more atomic
// memory reads from virtual address range [address, address+dbytes-1].
// The Exclusives monitor will only be set if all the reads are from the
// same dbytes-aligned physical address, to allow for the possibility of
// an atomicity break if the translation is changed between reads.
AArch64.SetExclusiveMonitors(address, dbytes);

data = Mem[address, dbytes, AccType_ATOMIC];
X[t] = ZeroExtend(data, regsize);
```

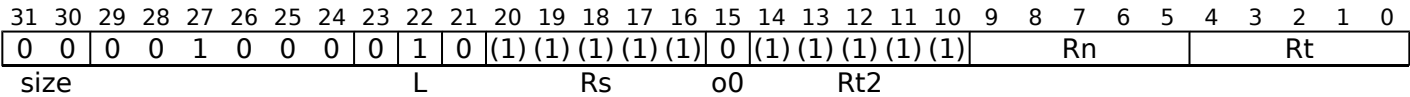
## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.



# LDXRB

Load Exclusive Register Byte derives an address from a base register value, loads a byte from memory, zero-extends it and writes it to a register. The PE marks the physical address being accessed as an exclusive access. This exclusive access mark is checked by Store Exclusive instructions. See [Synchronization and semaphores](#). For information about memory accesses see [Load/Store addressing modes](#).



## No offset

```
LDXRB <Wt>, [<Xn|SP>{, #0}]

integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(8) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

// Tell the Exclusives monitors to record a sequence of one or more atomic
// memory reads from virtual address range [address, address+dbytes-1].
// The Exclusives monitor will only be set if all the reads are from the
// same dbytes-aligned physical address, to allow for the possibility of
// an atomicity break if the translation is changed between reads.
AArch64.SetExclusiveMonitors(address, 1);

data = Mem[address, 1, AccType_ATOMIC];
X[t] = ZeroExtend(data, 32);
```

## Operational information

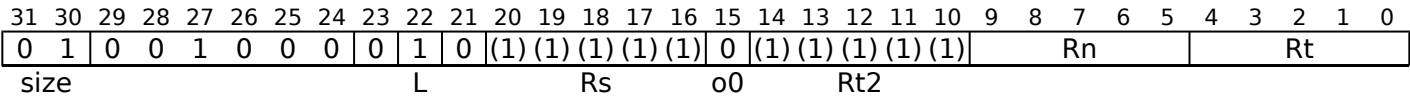
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDXRH

Load Exclusive Register Halfword derives an address from a base register value, loads a halfword from memory, zero-extends it and writes it to a register. The memory access is atomic. The PE marks the physical address being accessed as an exclusive access. This exclusive access mark is checked by Store Exclusive instructions. See [Synchronization and semaphores](#). For information about memory accesses see [Load/Store addressing modes](#).



## No offset

```
LDXRH <Wt>, [<Xn|SP>{, #0}]

integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(16) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

// Tell the Exclusives monitors to record a sequence of one or more atomic
// memory reads from virtual address range [address, address+dbytes-1].
// The Exclusives monitor will only be set if all the reads are from the
// same dbytes-aligned physical address, to allow for the possibility of
// an atomicity break if the translation is changed between reads.
AArch64.SetExclusiveMonitors(address, 2);

data = Mem[address, 2, AccType_ATOMIC];
X[t] = ZeroExtend(data, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LSL (register)

Logical Shift Left (register) shifts a register value left by a variable number of bits, shifting in zeros, and writes the result to the destination register. The remainder obtained by dividing the second source register by the data size defines the number of bits by which the first source register is left-shifted.

This is an alias of [LSLV](#). This means:

- The encodings in this description are named to match the encodings of [LSLV](#).
  - The description of [LSLV](#) gives the operational pseudocode for this instruction.
- |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |   |   |   |    |   |   |   |   |
|-----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|---|---|---|---|----|---|---|---|---|
| 31  | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9  | 8 | 7 | 6 | 5 | 4  | 3 | 2 | 1 | 0 |
| sf  | 0  | 0  | 1  | 1  | 0  | 1  | 0  | 1  | 1  | 0  | Rm |    |    |    |    | 0  | 0  | 1  | 0  | 0  | 0  | Rn |   |   |   |   | Rd |   |   |   |   |
| op2 |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |   |   |   |    |   |   |   |   |

## 32-bit (sf == 0)

LSL <Wd>, <Wn>, <Wm>

is equivalent to

[LSLV](#) <Wd>, <Wn>, <Wm>

and is always the preferred disassembly.

## 64-bit (sf == 1)

LSL <Xd>, <Xn>, <Xm>

is equivalent to

[LSLV](#) <Xd>, <Xn>, <Xm>

and is always the preferred disassembly.

## Assembler Symbols

- |      |   |
|------|---|
| <Wd> | Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.  |
| <Wn> | Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.   |
| <Wm> | Is the 32-bit name of the second general-purpose source register holding a shift amount from 0 to 31 in its bottom 5 bits, encoded in the "Rm" field. |
| <Xd> | Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.  |
| <Xn> | Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.   |
| <Xm> | Is the 64-bit name of the second general-purpose source register holding a shift amount from 0 to 63 in its bottom 6 bits, encoded in the "Rm" field. |

## Operation

The description of [LSLV](#) gives the operational pseudocode for this instruction.

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.



# LSL (immediate)

Logical Shift Left (immediate) shifts a register value left by an immediate number of bits, shifting in zeros, and writes the result to the destination register.

This is an alias of [UBFM](#). This means:

- The encodings in this description are named to match the encodings of [UBFM](#).
- The description of [UBFM](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
sf	1	0	1	0	0	1	1	0	N	immr						!= x11111						Rn						Rd					
opc										imms																							

## 32-bit (sf == 0 && N == 0 && imms != 011111)

LSL <Wd>, <Wn>, #<shift>

is equivalent to

[UBFM](#) <Wd>, <Wn>, #(-<shift> MOD 32), #(31-<shift>)

and is the preferred disassembly when `imms + 1 == immr`.

## 64-bit (sf == 1 && N == 1 && imms != 111111)

LSL <Xd>, <Xn>, #<shift>

is equivalent to

[UBFM](#) <Xd>, <Xn>, #(-<shift> MOD 64), #(63-<shift>)

and is the preferred disassembly when `imms + 1 == immr`.

## Assembler Symbols

- |         |  |
|---------|--|
| <Wd>    | Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.   |
| <Wn>    | Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.  |
| <Xd>    | Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.   |
| <Xn>    | Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.  |
| <shift> | For the 32-bit variant: is the shift amount, in the range 0 to 31.<br>For the 64-bit variant: is the shift amount, in the range 0 to 63. |

## Operation

The description of [UBFM](#) gives the operational pseudocode for this instruction.

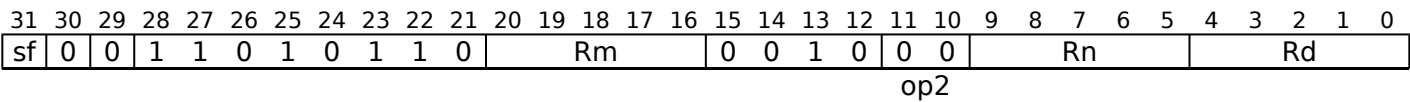
## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# LSLV

Logical Shift Left Variable shifts a register value left by a variable number of bits, shifting in zeros, and writes the result to the destination register. The remainder obtained by dividing the second source register by the data size defines the number of bits by which the first source register is left-shifted.

This instruction is used by the alias [LSL \(register\)](#).



## 32-bit (sf == 0)

LSLV <Wd>, <Wn>, <Wm>

## 64-bit (sf == 1)

LSLV <Xd>, <Xn>, <Xm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
ShiftType shift_type = DecodeShift(op2);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register holding a shift amount from 0 to 31 in its bottom 5 bits, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register holding a shift amount from 0 to 63 in its bottom 6 bits, encoded in the "Rm" field.

## Operation

```
bits(datasize) result;
bits(datasize) operand2 = X[m];

result = ShiftReg(n, shift_type, UInt(operand2) MOD datasize);
X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

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# LSR (register)

Logical Shift Right (register) shifts a register value right by a variable number of bits, shifting in zeros, and writes the result to the destination register. The remainder obtained by dividing the second source register by the data size defines the number of bits by which the first source register is right-shifted.

This is an alias of [LSRV](#). This means:

- The encodings in this description are named to match the encodings of [LSRV](#).
- The description of [LSRV](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	0	1	1	0	1	0	1	1	0	Rm					0	0	1	0	0	1	Rn					Rd				
op2																															

## 32-bit (sf == 0)

LSR <Wd>, <Wn>, <Wm>

is equivalent to

[LSRV](#) <Wd>, <Wn>, <Wm>

and is always the preferred disassembly.

## 64-bit (sf == 1)

LSR <Xd>, <Xn>, <Xm>

is equivalent to

[LSRV](#) <Xd>, <Xn>, <Xm>

and is always the preferred disassembly.

## Assembler Symbols

- |      |   |
|------|---|
| <Wd> | Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.  |
| <Wn> | Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.   |
| <Wm> | Is the 32-bit name of the second general-purpose source register holding a shift amount from 0 to 31 in its bottom 5 bits, encoded in the "Rm" field. |
| <Xd> | Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.  |
| <Xn> | Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.   |
| <Xm> | Is the 64-bit name of the second general-purpose source register holding a shift amount from 0 to 63 in its bottom 6 bits, encoded in the "Rm" field. |

## Operation

The description of [LSRV](#) gives the operational pseudocode for this instruction.

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.



## LSR (immediate)

Logical Shift Right (immediate) shifts a register value right by an immediate number of bits, shifting in zeros, and writes the result to the destination register.

This is an alias of [UBFM](#). This means:

- The encodings in this description are named to match the encodings of [UBFM](#).
- The description of [UBFM](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf		1 0		1 0 0		1 1 0		N		immr						x 1 1 1 1 1					Rn					Rd					
opc										imms																					

### 32-bit (sf == 0 && N == 0 && imms == 011111)

LSR <Wd>, <Wn>, #<shift>

is equivalent to

[UBFM](#) <Wd>, <Wn>, #<shift>, #31

and is always the preferred disassembly.

### 64-bit (sf == 1 && N == 1 && imms == 111111)

LSR <Xd>, <Xn>, #<shift>

is equivalent to

[UBFM](#) <Xd>, <Xn>, #<shift>, #63

and is always the preferred disassembly.

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
<shift>	For the 32-bit variant: is the shift amount, in the range 0 to 31, encoded in the "immr" field. For the 64-bit variant: is the shift amount, in the range 0 to 63, encoded in the "immr" field.

## Operation

The description of [UBFM](#) gives the operational pseudocode for this instruction.

## Operational information

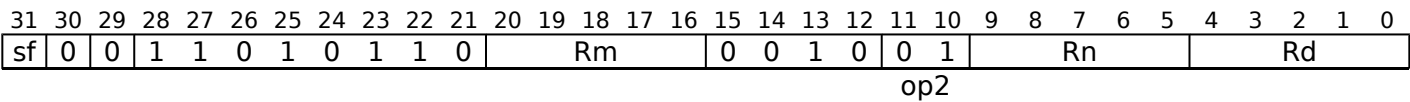
If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

# LSRV

Logical Shift Right Variable shifts a register value right by a variable number of bits, shifting in zeros, and writes the result to the destination register. The remainder obtained by dividing the second source register by the data size defines the number of bits by which the first source register is right-shifted.

This instruction is used by the alias [LSR \(register\)](#).



## 32-bit (sf == 0)

LSRV <Wd>, <Wn>, <Wm>

## 64-bit (sf == 1)

LSRV <Xd>, <Xn>, <Xm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
ShiftType shift_type = DecodeShift(op2);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register holding a shift amount from 0 to 31 in its bottom 5 bits, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register holding a shift amount from 0 to 63 in its bottom 6 bits, encoded in the "Rm" field.

## Operation

```
bits(datasize) result;
bits(datasize) operand2 = X[m];

result = ShiftReg(n, shift_type, UInt(operand2) MOD datasize);
X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

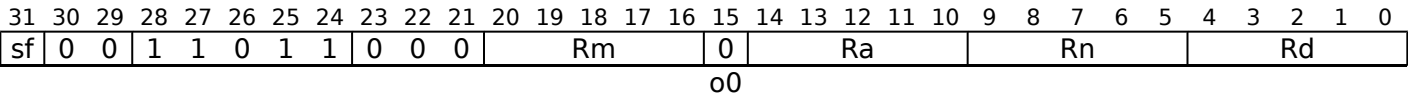
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# MADD

Multiply-Add multiplies two register values, adds a third register value, and writes the result to the destination register.

This instruction is used by the alias [MUL](#).



## 32-bit (sf == 0)

MADD <Wd>, <Wn>, <Wm>, <Wa>

## 64-bit (sf == 1)

MADD <Xd>, <Xn>, <Xm>, <Xa>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer a = UInt(Ra);
integer destsize = if sf == '1' then 64 else 32;
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.
- <Wa> Is the 32-bit name of the third general-purpose source register holding the addend, encoded in the "Ra" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.
- <Xa> Is the 64-bit name of the third general-purpose source register holding the addend, encoded in the "Ra" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">MUL</a>	Ra == '11111'

## Operation

```
bits(destsize) operand1 = X[n];
bits(destsize) operand2 = X[m];
bits(destsize) operand3 = X[a];

integer result;

result = UInt(operand3) + (UInt(operand1) * UInt(operand2));
X[d] = result<destsize-1:0>;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# MNEG

Multiply-Negate multiplies two register values, negates the product, and writes the result to the destination register.

This is an alias of [MSUB](#). This means:

- The encodings in this description are named to match the encodings of [MSUB](#).
- The description of [MSUB](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
sf	0	0	1	1	0	1	1	0	0	0	Rm					1	1	1	1	1	1	Rn					Rd					
o0																Ra																

## 32-bit (sf == 0)

MNEG <Wd>, <Wn>, <Wm>

is equivalent to

[MSUB](#) <Wd>, <Wn>, <Wm>, WZR

and is always the preferred disassembly.

## 64-bit (sf == 1)

MNEG <Xd>, <Xn>, <Xm>

is equivalent to

[MSUB](#) <Xd>, <Xn>, <Xm>, XZR

and is always the preferred disassembly.

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
<Wm>	Is the 32-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.

## Operation

The description of [MSUB](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.





# MOV (to/from SP)

Move between register and stack pointer: Rd = Rn.

This is an alias of [ADD \(immediate\)](#). This means:

- The encodings in this description are named to match the encodings of [ADD \(immediate\)](#).
- The description of [ADD \(immediate\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
sf	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Rn						Rd					
op			S						sh			imm12																					

## 32-bit (sf == 0)

MOV <Wd|WSP>, <Wn|WSP>

is equivalent to

ADD <Wd|WSP>, <Wn|WSP>, #0

and is the preferred disassembly when (Rd == '11111' || Rn == '11111').

## 64-bit (sf == 1)

MOV <Xd|SP>, <Xn|SP>

is equivalent to

ADD <Xd|SP>, <Xn|SP>, #0

and is the preferred disassembly when (Rd == '11111' || Rn == '11111').

## Assembler Symbols

- <Wd|WSP> Is the 32-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Wn|WSP> Is the 32-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.
- <Xd|SP> Is the 64-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Xn|SP> Is the 64-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [ADD \(immediate\)](#) gives the operational pseudocode for this instruction.

## MOV (inverted wide immediate)

Move (inverted wide immediate) moves an inverted 16-bit immediate value to a register.

This is an alias of [MOVN](#). This means:

- The encodings in this description are named to match the encodings of [MOVN](#).
- The description of [MOVN](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf		0 0		1 0 0		1 0 1		hw		imm16																		Rd			
opc																															

### 32-bit (sf == 0 && hw == 0x)

MOV <Wd>, #<imm>

is equivalent to

MOVN <Wd>, #<imm16>, LSL #<shift>

and is the preferred disassembly when `!(IsZero(imm16) && hw != '00') && ! IsOnes(imm16)`.

### 64-bit (sf == 1)

MOV <Xd>, #<imm>

is equivalent to

MOVN <Xd>, #<imm16>, LSL #<shift>

and is the preferred disassembly when `!(IsZero(imm16) && hw != '00')`.

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<imm>	For the 32-bit variant: is a 32-bit immediate, the bitwise inverse of which can be encoded in "imm16:hw", but excluding 0xffff0000 and 0x0000ffff  For the 64-bit variant: is a 64-bit immediate, the bitwise inverse of which can be encoded in "imm16:hw".
<shift>	For the 32-bit variant: is the amount by which to shift the immediate left, either 0 (the default) or 16, encoded in the "hw" field as <shift>/16.  For the 64-bit variant: is the amount by which to shift the immediate left, either 0 (the default), 16, 32 or 48, encoded in the "hw" field as <shift>/16.

## Operation

The description of [MOVN](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.



## MOV (wide immediate)

Move (wide immediate) moves a 16-bit immediate value to a register.

This is an alias of [MOVZ](#). This means:

- The encodings in this description are named to match the encodings of [MOVZ](#).
- The description of [MOVZ](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf		1 0		1 0 0 1 0 1		hw		imm16																Rd							
opc																															

### 32-bit (sf == 0 && hw == 0x)

MOV <Wd>, #<imm>

is equivalent to

MOVZ <Wd>, #<imm16>, LSL #<shift>

and is the preferred disassembly when ! (IsZero(imm16) && hw != '00').

### 64-bit (sf == 1)

MOV <Xd>, #<imm>

is equivalent to

MOVZ <Xd>, #<imm16>, LSL #<shift>

and is the preferred disassembly when ! (IsZero(imm16) && hw != '00').

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<imm>	For the 32-bit variant: is a 32-bit immediate which can be encoded in "imm16:hw". For the 64-bit variant: is a 64-bit immediate which can be encoded in "imm16:hw".
<shift>	For the 32-bit variant: is the amount by which to shift the immediate left, either 0 (the default) or 16, encoded in the "hw" field as <shift>/16.  For the 64-bit variant: is the amount by which to shift the immediate left, either 0 (the default), 16, 32 or 48, encoded in the "hw" field as <shift>/16.

## Operation

The description of [MOVZ](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

## MOV (bitmask immediate)

Move (bitmask immediate) writes a bitmask immediate value to a register.

This is an alias of [ORR \(immediate\)](#). This means:

- The encodings in this description are named to match the encodings of [ORR \(immediate\)](#).
- The description of [ORR \(immediate\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
sf	0	1	1	0	0	1	0	0	N	immr						imms						1	1	1	1	1	Rd					
opc										Rn																						

### 32-bit (sf == 0 && N == 0)

MOV <Wd|WSP>, #<imm>

is equivalent to

ORR <Wd|WSP>, WZR, #<imm>

and is the preferred disassembly when ! MoveWidePreferred(sf, N, imms, immr).

### 64-bit (sf == 1)

MOV <Xd|SP>, #<imm>

is equivalent to

ORR <Xd|SP>, XZR, #<imm>

and is the preferred disassembly when ! MoveWidePreferred(sf, N, imms, immr).

## Assembler Symbols

- <Wd|WSP> Is the 32-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Xd|SP> Is the 64-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <imm> For the 32-bit variant: is the bitmask immediate, encoded in "imms:immr", but excluding values which could be encoded by MOVZ or MOVN.  
For the 64-bit variant: is the bitmask immediate, encoded in "N:imms:immr", but excluding values which could be encoded by MOVZ or MOVN.

## Operation

The description of [ORR \(immediate\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# MOV (register)

Move (register) copies the value in a source register to the destination register.

This is an alias of [ORR \(shifted register\)](#). This means:

- The encodings in this description are named to match the encodings of [ORR \(shifted register\)](#).
- The description of [ORR \(shifted register\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	1	0	1	0	1	0	0	0	0	Rm					0	0	0	0	0	0	1	1	1	1	1	Rd				
opc						shift			N								imm6					Rn									

## 32-bit (sf == 0)

MOV <Wd>, <Wm>

is equivalent to

[ORR](#) <Wd>, WZR, <Wm>

and is always the preferred disassembly.

## 64-bit (sf == 1)

MOV <Xd>, <Xm>

is equivalent to

[ORR](#) <Xd>, XZR, <Xm>

and is always the preferred disassembly.

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wm> Is the 32-bit name of the general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xm> Is the 64-bit name of the general-purpose source register, encoded in the "Rm" field.

## Operation

The description of [ORR \(shifted register\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

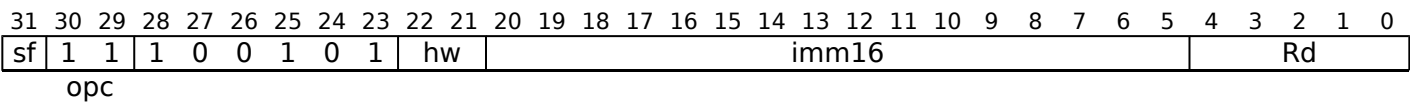
- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# MOVK

Move wide with keep moves an optionally-shifted 16-bit immediate value into a register, keeping other bits unchanged.



## 32-bit (sf == 0 && hw == 0x)

```
MOVK <Wd>, #<imm>{, LSL #<shift>}
```

## 64-bit (sf == 1)

```
MOVK <Xd>, #<imm>{, LSL #<shift>}
```

```
integer d = UInt(Rd);
integer datasize = if sf == '1' then 64 else 32;
integer pos;

if sf == '0' && hw<1> == '1' then UNDEFINED;
pos = UInt(hw:'0000');
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <imm> Is the 16-bit unsigned immediate, in the range 0 to 65535, encoded in the "imm16" field.
- <shift> For the 32-bit variant: is the amount by which to shift the immediate left, either 0 (the default) or 16, encoded in the "hw" field as <shift>/16.  
For the 64-bit variant: is the amount by which to shift the immediate left, either 0 (the default), 16, 32 or 48, encoded in the "hw" field as <shift>/16.

## Operation

```
bits(datasize) result;

result = X[d];
result<pos+15:pos> = imm16;
X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

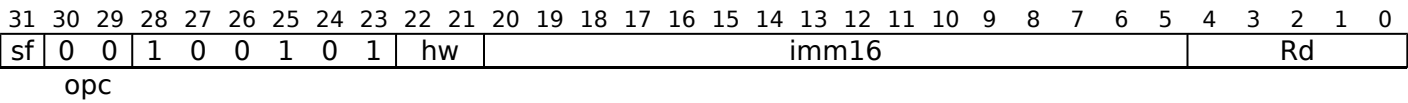
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# MOVN

Move wide with NOT moves the inverse of an optionally-shifted 16-bit immediate value to a register.

This instruction is used by the alias [MOV \(inverted wide immediate\)](#).



## 32-bit (sf == 0 && hw == 0x)

```
MOVN <Wd>, #<imm>{, LSL #<shift>}
```

## 64-bit (sf == 1)

```
MOVN <Xd>, #<imm>{, LSL #<shift>}
```

```
integer d = UInt(Rd);
integer datasize = if sf == '1' then 64 else 32;
integer pos;

if sf == '0' && hw<1> == '1' then UNDEFINED;
pos = UInt(hw:'0000');
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <imm> Is the 16-bit unsigned immediate, in the range 0 to 65535, encoded in the "imm16" field.
- <shift> For the 32-bit variant: is the amount by which to shift the immediate left, either 0 (the default) or 16, encoded in the "hw" field as <shift>/16.  
For the 64-bit variant: is the amount by which to shift the immediate left, either 0 (the default), 16, 32 or 48, encoded in the "hw" field as <shift>/16.

## Alias Conditions

Alias	Of variant	Is preferred when
<a href="#">MOV (inverted wide immediate)</a>	64-bit	! ( <a href="#">IsZero</a> (imm16) && hw != '00' )
<a href="#">MOV (inverted wide immediate)</a>	32-bit	! ( <a href="#">IsZero</a> (imm16) && hw != '00' ) && ! <a href="#">IsOnes</a> (imm16)

## Operation

```
bits(datasize) result;

result = Zeros();

result<pos+15:pos> = imm16;
result = NOT(result);
X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.



- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

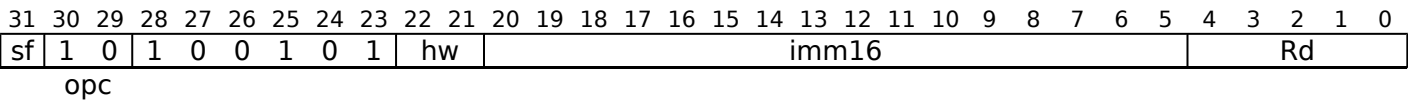
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# MOVZ

Move wide with zero moves an optionally-shifted 16-bit immediate value to a register.

This instruction is used by the alias [MOV \(wide immediate\)](#).



## 32-bit (sf == 0 && hw == 0x)

```
MOVZ <Wd>, #<imm>{, LSL #<shift>}
```

## 64-bit (sf == 1)

```
MOVZ <Xd>, #<imm>{, LSL #<shift>}
```

```
integer d = UInt(Rd);
integer datasize = if sf == '1' then 64 else 32;
integer pos;

if sf == '0' && hw<1> == '1' then UNDEFINED;
pos = UInt(hw:'0000');
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <imm> Is the 16-bit unsigned immediate, in the range 0 to 65535, encoded in the "imm16" field.
- <shift> For the 32-bit variant: is the amount by which to shift the immediate left, either 0 (the default) or 16, encoded in the "hw" field as <shift>/16.  
  
For the 64-bit variant: is the amount by which to shift the immediate left, either 0 (the default), 16, 32 or 48, encoded in the "hw" field as <shift>/16.

## Alias Conditions

Alias	Is preferred when
<a href="#">MOV (wide immediate)</a>	! ( <a href="#">IsZero</a> (imm16) && hw != '00' )

## Operation

```
bits(datasize) result;

result = Zeros();

result<pos+15:pos> = imm16;
X[d] = result;
```

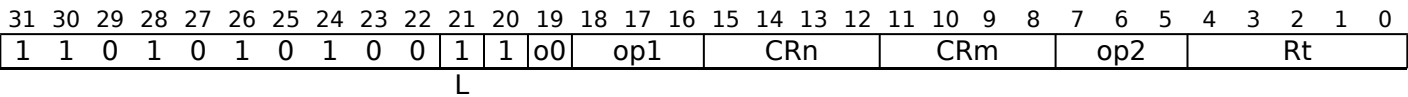
## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.



MRS

Move System Register allows the PE to read an AArch64 System register into a general-purpose register.



System

```
MRS <Xt>, (<systemreg>|S<op0>_<op1>_<Cn>_<Cm>_<op2>)  
  
AArch64.CheckSystemAccess('1':o0, op1, CRn, CRm, op2, Rt, L);  
  
integer t = UInt(Rt);  
  
integer sys_op0 = 2 + UInt(o0);  
integer sys_op1 = UInt(op1);  
integer sys_op2 = UInt(op2);  
integer sys_crn = UInt(CRn);  
integer sys_crm = UInt(CRm);
```

Assembler Symbols

- <Xt> Is the 64-bit name of the general-purpose destination register, encoded in the "Rt" field.
- <systemreg> Is a System register name, encoded in the "o0:op1:CRn:CRm:op2".  
The System register names are defined in 'AArch64 System Registers' in the System Register XML.
- <op0> Is an unsigned immediate, encoded in "o0":

o0	<op0>
0	2
1	3
- <op1> Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the "op1" field.
- <Cn> Is a name 'Cn', with 'n' in the range 0 to 15, encoded in the "CRn" field.
- <Cm> Is a name 'Cm', with 'm' in the range 0 to 15, encoded in the "CRm" field.
- <op2> Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the "op2" field.

Operation

```
X[t] = AArch64.SysRegRead(sys_op0, sys_op1, sys_crn, sys_crm, sys_op2);
```

## MSR (immediate)

Move immediate value to Special Register moves an immediate value to selected bits of the PSTATE. For more information, see [Process state, PSTATE](#).

The bits that can be written by this instruction are:

- PSTATE.D, PSTATE.A, PSTATE.I, PSTATE.F, and PSTATE.SP.
- If [ARMv8.0-SSBS](#) is implemented, PSTATE.SSBS.
- If [ARMv8.1-PAN](#) is implemented, PSTATE.PAN.
- If [ARMv8.2-UAO](#) is implemented, PSTATE.UAO.
- If [ARMv8.4-DIT](#) is implemented, PSTATE.DIT.
- If [ARMv8.5-MemTag](#) is implemented, PSTATE.TCO.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	op1	0	1	0	0	CRm				op2				1	1	1	1	1	0

## System

MSR <pstatefield>, #<imm>

```
if op1 == '000' && op2 == '000' then SEE "CFINV";
if op1 == '000' && op2 == '001' then SEE "XAFLAG";
if op1 == '000' && op2 == '010' then SEE "AXFLAG";
```

```
AArch64.CheckSystemAccess('00', op1, '0100', CRm, op2, '11111', '0');
```

```
PSTATEField field;
```

```
case op1:op2 of
  when '000 011'
    if !HaveUA0Ext() then
      UNDEFINED;
    field = PSTATEField\_UA0;
  when '000 100'
    if !HavePANExt() then
      UNDEFINED;
    field = PSTATEField\_PAN;
  when '000 101' field = PSTATEField\_SP;
  when '011 010'
    if !HaveDITExt() then
      UNDEFINED;
    field = PSTATEField\_DIT;
  when '011 100'
    if !HaveMTEExt() then
      UNDEFINED;
    field = PSTATEField\_TCO;
  when '011 110' field = PSTATEField\_DAIFSet;
  when '011 111' field = PSTATEField\_DAIFClr;
  when '011 001'
    if !HaveSSBSExt() then
      UNDEFINED;
    field = PSTATEField\_SSBS;
  otherwise UNDEFINED;
```

```
// Check that an AArch64 MSR/MRS access to the DAIF flags is permitted
```

```
if PSTATE.EL == EL0 && field IN {PSTATEField\_DAIFSet, PSTATEField\_DAIFClr} then
```

```
  if !ELUsingAArch32(EL1) && ((EL2Enabled() && HCR_EL2.<E2H,TGE> == '11') || SCTLR_EL1.UMA == '0') then
```

```
    if EL2Enabled() && !ELUsingAArch32(EL2) && HCR_EL2.TGE == '1' then
```

```
      AArch64.SystemAccessTrap(EL2, 0x18);
```

```
    else
```

```
      AArch64.SystemAccessTrap(EL1, 0x18);
```

## Assembler Symbols

<pstatefield> Is a PSTATE field name, encoded in “op1:op2”:

op1	op2	<pstatefield>	Architectural Feature
000	00x	<a href="#">SEE_PSTATE</a>	-
000	010	<a href="#">SEE_PSTATE</a>	-
000	011	UA0	ARMv8.2-UA0
000	100	PAN	ARMv8.1-PAN
000	101	SPSel	-
000	11x	RESERVED	-
001	xxx	RESERVED	-
010	xxx	RESERVED	-
011	000	RESERVED	-
011	001	SSBS	ARMv8.0-SSBS
011	010	DIT	ARMv8.4-DIT
011	011	RESERVED	-
011	100	TC0	ARMv8.5-MemTag
011	101	RESERVED	-
011	110	DAIFSet	-
011	111	DAIFClr	-
1xx	xxx	RESERVED	-

<imm> Is a 4-bit unsigned immediate, in the range 0 to 15, encoded in the "CRm" field.

## Operation

```

case field of
  when PSTATEField\_SSBS
    PSTATE.SSBS = CRm<0>;
  when PSTATEField\_SP
    PSTATE.SP = CRm<0>;
  when PSTATEField\_DAIFSet
    PSTATE.D = PSTATE.D OR CRm<3>;
    PSTATE.A = PSTATE.A OR CRm<2>;
    PSTATE.I = PSTATE.I OR CRm<1>;
    PSTATE.F = PSTATE.F OR CRm<0>;
  when PSTATEField\_DAIFClr
    PSTATE.D = PSTATE.D AND NOT(CRm<3>);
    PSTATE.A = PSTATE.A AND NOT(CRm<2>);
    PSTATE.I = PSTATE.I AND NOT(CRm<1>);
    PSTATE.F = PSTATE.F AND NOT(CRm<0>);
  when PSTATEField\_PAN
    PSTATE.PAN = CRm<0>;
  when PSTATEField\_UA0
    PSTATE.UA0 = CRm<0>;
  when PSTATEField\_DIT
    PSTATE.DIT = CRm<0>;
  when PSTATEField\_TC0
    PSTATE.TC0 = CRm<0>;

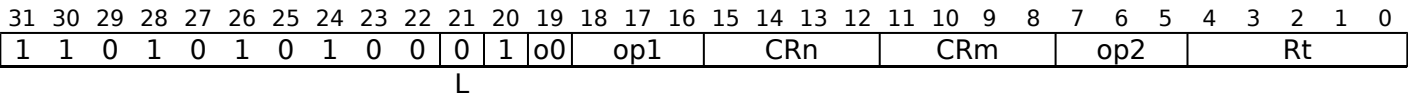
```

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## MSR (register)

Move general-purpose register to System Register allows the PE to write an AArch64 System register from a general-purpose register.



### System

```
MSR (<systemreg>|S<op0>_<op1>_<Cn>_<Cm>_<op2>), <Xt>

AArch64.CheckSystemAccess('1':o0, op1, CRn, CRm, op2, Rt, L);

integer t = UInt(Rt);

integer sys_op0 = 2 + UInt(o0);
integer sys_op1 = UInt(op1);
integer sys_op2 = UInt(op2);
integer sys_crn = UInt(CRn);
integer sys_crm = UInt(CRm);
```

### Assembler Symbols

- <systemreg> Is a System register name, encoded in the "o0:op1:CRn:CRm:op2".  
The System register names are defined in *AArch64 System Registers in the System Register XML*.
- <op0> Is an unsigned immediate, encoded in "o0":
- | o0 | <op0> |
|----|-------|
| 0  | 2     |
| 1  | 3     |
- <op1> Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the "op1" field.
- <Cn> Is a name 'Cn', with 'n' in the range 0 to 15, encoded in the "CRn" field.
- <Cm> Is a name 'Cm', with 'm' in the range 0 to 15, encoded in the "CRm" field.
- <op2> Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the "op2" field.
- <Xt> Is the 64-bit name of the general-purpose source register, encoded in the "Rt" field.

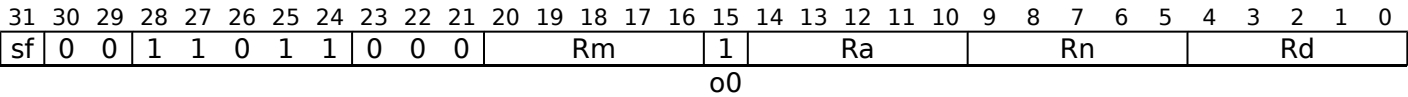
### Operation

```
AArch64.SysRegWrite(sys_op0, sys_op1, sys_crn, sys_crm, sys_op2, X[t]);
```

# MSUB

Multiply-Subtract multiplies two register values, subtracts the product from a third register value, and writes the result to the destination register.

This instruction is used by the alias [MNEG](#).



## 32-bit (sf == 0)

MSUB <Wd>, <Wn>, <Wm>, <Wa>

## 64-bit (sf == 1)

MSUB <Xd>, <Xn>, <Xm>, <Xa>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer a = UInt(Ra);
integer destsize = if sf == '1' then 64 else 32;
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.
- <Wa> Is the 32-bit name of the third general-purpose source register holding the minuend, encoded in the "Ra" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.
- <Xa> Is the 64-bit name of the third general-purpose source register holding the minuend, encoded in the "Ra" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">MNEG</a>	Ra == '11111'

## Operation

```
bits(destsize) operand1 = X[n];
bits(destsize) operand2 = X[m];
bits(destsize) operand3 = X[a];

integer result;

result = UInt(operand3) - (UInt(operand1) * UInt(operand2));
X[d] = result<destsize-1:0>;
```



## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# MUL

Multiply:  $Rd = Rn * Rm$ .

This is an alias of [MADD](#). This means:

- The encodings in this description are named to match the encodings of [MADD](#).
- The description of [MADD](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
sf	0	0	1	1	0	1	1	0	0	0	Rm					0	1	1	1	1	1	Rn					Rd					
																o0		Ra														

## 32-bit (sf == 0)

MUL [<Wd>](#), [<Wn>](#), [<Wm>](#)

is equivalent to

[MADD](#) [<Wd>](#), [<Wn>](#), [<Wm>](#), WZR

and is always the preferred disassembly.

## 64-bit (sf == 1)

MUL [<Xd>](#), [<Xn>](#), [<Xm>](#)

is equivalent to

[MADD](#) [<Xd>](#), [<Xn>](#), [<Xm>](#), XZR

and is always the preferred disassembly.

## Assembler Symbols

<a href="#">&lt;Wd&gt;</a>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<a href="#">&lt;Wn&gt;</a>	Is the 32-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
<a href="#">&lt;Wm&gt;</a>	Is the 32-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.
<a href="#">&lt;Xd&gt;</a>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<a href="#">&lt;Xn&gt;</a>	Is the 64-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
<a href="#">&lt;Xm&gt;</a>	Is the 64-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.

## Operation

The description of [MADD](#) gives the operational pseudocode for this instruction.

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# MVN

Bitwise NOT writes the bitwise inverse of a register value to the destination register.

This is an alias of [ORN \(shifted register\)](#). This means:

- The encodings in this description are named to match the encodings of [ORN \(shifted register\)](#).
- The description of [ORN \(shifted register\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
sf	0	1	0	1	0	1	0	shift	1	Rm						imm6						1	1	1	1	1	Rd					
opc								N								Rn																

## 32-bit (sf == 0)

MVN <Wd>, <Wm>{, <shift> #<amount>}

is equivalent to

ORN <Wd>, WZR, <Wm>{, <shift> #<amount>}

and is always the preferred disassembly.

## 64-bit (sf == 1)

MVN <Xd>, <Xm>{, <shift> #<amount>}

is equivalent to

ORN <Xd>, XZR, <Xm>{, <shift> #<amount>}

and is always the preferred disassembly.

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wm> Is the 32-bit name of the general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xm> Is the 64-bit name of the general-purpose source register, encoded in the "Rm" field.
- <shift> Is the optional shift to be applied to the final source, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	ROR

- <amount> For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.
- For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field,

## Operation

The description of [ORN \(shifted register\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.

- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# NEG (shifted register)

Negate (shifted register) negates an optionally-shifted register value, and writes the result to the destination register.

This is an alias of [SUB \(shifted register\)](#). This means:

- The encodings in this description are named to match the encodings of [SUB \(shifted register\)](#).
- The description of [SUB \(shifted register\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
sf	1	0	0	1	0	1	1	shift	0	Rm						imm6						1	1	1	1	1	Rd					
op S										Rn																						

## 32-bit (sf == 0)

NEG <Wd>, <Wm>{, <shift> #<amount>}

is equivalent to

SUB <Wd>, WZR, <Wm> {, <shift> #<amount>}

and is always the preferred disassembly.

## 64-bit (sf == 1)

NEG <Xd>, <Xm>{, <shift> #<amount>}

is equivalent to

SUB <Xd>, XZR, <Xm> {, <shift> #<amount>}

and is always the preferred disassembly.

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wm> Is the 32-bit name of the general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xm> Is the 64-bit name of the general-purpose source register, encoded in the "Rm" field.
- <shift> Is the optional shift type to be applied to the second source operand, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	RESERVED

- <amount> For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.
- For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field.

## Operation

The description of [SUB \(shifted register\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:

- The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# NEGS

Negate, setting flags, negates an optionally-shifted register value, and writes the result to the destination register. It updates the condition flags based on the result.

This is an alias of [SUBS \(shifted register\)](#). This means:

- The encodings in this description are named to match the encodings of [SUBS \(shifted register\)](#).
- The description of [SUBS \(shifted register\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
sf	1	1	0	1	0	1	1	shift	0	Rm						imm6						1	1	1	1	1	Rd					
op S										Rn																						

## 32-bit (sf == 0)

NEGS <Wd>, <Wm>{, <shift> #<amount>}

is equivalent to

[SUBS](#) <Wd>, WZR, <Wm> {, <shift> #<amount>}

and is always the preferred disassembly.

## 64-bit (sf == 1)

NEGS <Xd>, <Xm>{, <shift> #<amount>}

is equivalent to

[SUBS](#) <Xd>, XZR, <Xm> {, <shift> #<amount>}

and is always the preferred disassembly.

## Assembler Symbols

<Wd>

Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.

<Wm>

Is the 32-bit name of the general-purpose source register, encoded in the "Rm" field.

<Xd>

Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.

<Xm>

Is the 64-bit name of the general-purpose source register, encoded in the "Rm" field.

<shift>

Is the optional shift type to be applied to the second source operand, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	RESERVED

<amount>

For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.

For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field.

## Operation

The description of [SUBS \(shifted register\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# NGC

Negate with Carry negates the sum of a register value and the value of NOT (Carry flag), and writes the result to the destination register.

This is an alias of [SBC](#). This means:

- The encodings in this description are named to match the encodings of [SBC](#).
- The description of [SBC](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	1	0	1	1	0	1	0	0	0	0	Rm					0	0	0	0	0	0	1	1	1	1	1	Rd				
op S											Rn																				

## 32-bit (sf == 0)

NGC <Wd>, <Wm>

is equivalent to

[SBC](#) <Wd>, WZR, <Wm>

and is always the preferred disassembly.

## 64-bit (sf == 1)

NGC <Xd>, <Xm>

is equivalent to

[SBC](#) <Xd>, XZR, <Xm>

and is always the preferred disassembly.

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wm> Is the 32-bit name of the general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xm> Is the 64-bit name of the general-purpose source register, encoded in the "Rm" field.

## Operation

The description of [SBC](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# NGCS

Negate with Carry, setting flags, negates the sum of a register value and the value of NOT (Carry flag), and writes the result to the destination register. It updates the condition flags based on the result.

This is an alias of [SBCS](#). This means:

- The encodings in this description are named to match the encodings of [SBCS](#).
- The description of [SBCS](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	1	1	1	1	0	1	0	0	0	0	Rm					0	0	0	0	0	0	1	1	1	1	1	Rd				
op S											Rn																				

## 32-bit (sf == 0)

NGCS <Wd>, <Wm>

is equivalent to

[SBCS](#) <Wd>, WZR, <Wm>

and is always the preferred disassembly.

## 64-bit (sf == 1)

NGCS <Xd>, <Xm>

is equivalent to

[SBCS](#) <Xd>, XZR, <Xm>

and is always the preferred disassembly.

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wm> Is the 32-bit name of the general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xm> Is the 64-bit name of the general-purpose source register, encoded in the "Rm" field.

## Operation

The description of [SBCS](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# NOP

No Operation does nothing, other than advance the value of the program counter by 4. This instruction can be used for instruction alignment purposes.

The timing effects of including a NOP instruction in a program are not guaranteed. It can increase execution time, leave it unchanged, or even reduce it. Therefore, NOP instructions are not suitable for timing loops.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	1	1	1	1	1			
																				CRm				op2											

## System

```
NOP
// Empty.
```

## Operation

```
// do nothing
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# ORN (shifted register)

Bitwise OR NOT (shifted register) performs a bitwise (inclusive) OR of a register value and the complement of an optionally-shifted register value, and writes the result to the destination register.

This instruction is used by the alias [MVN](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	1	0	1	0	1	0	shift	1	Rm					imm6					Rn					Rd						
opc								N																							

## 32-bit (sf == 0)

ORN <Wd>, <Wn>, <Wm>{, <shift> #<amount>}

## 64-bit (sf == 1)

ORN <Xd>, <Xn>, <Xm>{, <shift> #<amount>}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
if sf == '0' && imm6<5> == '1' then UNDEFINED;

ShiftType shift_type = DecodeShift(shift);
integer shift_amount = UInt(imm6);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <shift> Is the optional shift to be applied to the final source, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	ROR
- <amount> For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.  
For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field,

## Alias Conditions

Alias	Is preferred when
<a href="#">MVN</a>	Rn == '11111'

## Operation

```
bits(datasize) operand1 = X[n];  
bits(datasize) operand2 = ShiftReg(m, shift_type, shift_amount);  
  
operand2 = NOT(operand2);  
  
result = operand1 OR operand2;  
X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

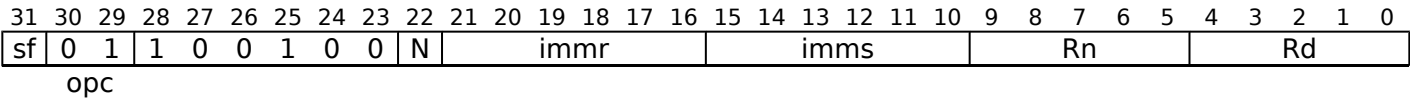
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# ORR (immediate)

Bitwise OR (immediate) performs a bitwise (inclusive) OR of a register value and an immediate register value, and writes the result to the destination register.

This instruction is used by the alias [MOV \(bitmask immediate\)](#).



## 32-bit (sf == 0 && N == 0)

ORR <Wd|WSP>, <Wn>, #<imm>

## 64-bit (sf == 1)

ORR <Xd|SP>, <Xn>, #<imm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer datasize = if sf == '1' then 64 else 32;
bits(datasize) imm;
if sf == '0' && N != '0' then UNDEFINED;
(imm, -) = DecodeBitMasks(N, imms, immr, TRUE);
```

## Assembler Symbols

<Wd WSP>	Is the 32-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
<Xd SP>	Is the 64-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
<imm>	For the 32-bit variant: is the bitmask immediate, encoded in "imms:immr". For the 64-bit variant: is the bitmask immediate, encoded in "N:imms:immr".

## Alias Conditions

Alias	Is preferred when
<a href="#">MOV (bitmask immediate)</a>	Rn == '11111' && ! <a href="#">MoveWidePreferred</a> (sf, N, imms, immr)

## Operation

```
bits(datasize) result;
bits(datasize) operand1 = X[n];

result = operand1 OR imm;
if d == 31 then
    SP[] = result;
else
    X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.

- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# ORR (shifted register)

Bitwise OR (shifted register) performs a bitwise (inclusive) OR of a register value and an optionally-shifted register value, and writes the result to the destination register.

This instruction is used by the alias [MOV \(register\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	1	0	1	0	1	0	shift	0	Rm						imm6						Rn						Rd			
opc								N																							

## 32-bit (sf == 0)

ORR <Wd>, <Wn>, <Wm>{, <shift> #<amount>}

## 64-bit (sf == 1)

ORR <Xd>, <Xn>, <Xm>{, <shift> #<amount>}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
if sf == '0' && imm6<5> == '1' then UNDEFINED;

ShiftType shift_type = DecodeShift(shift);
integer shift_amount = UInt(imm6);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <shift> Is the optional shift to be applied to the final source, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	ROR
- <amount> For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.  
For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field,

## Alias Conditions

Alias	Is preferred when
<a href="#">MOV (register)</a>	shift == '00' && imm6 == '000000' && Rn == '11111'



## Operation

```
bits(datasize) operand1 = X[n];  
bits(datasize) operand2 = ShiftReg(m, shift_type, shift_amount);  
  
result = operand1 OR operand2;  
X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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PACDA, PACDZA

Pointer Authentication Code for Data address, using key A. This instruction computes and inserts a pointer authentication code for a data address, using a modifier and key A.

The address is in the general-purpose register that is specified by <Xd>.

The modifier is:

- In the general-purpose register or stack pointer that is specified by <Xn|SP> for PACDA.
- The value zero, for PACDZA.

Integer  
(Armv8.3)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	1	0	1	1	0	0	0	0	0	1	0	0	Z	0	1	0	Rn					Rd				

PACDA (Z == 0)

PACDA <Xd>, <Xn|SP>

PACDZA (Z == 1 && Rn == 11111)

PACDZA <Xd>

```
boolean source_is_sp = FALSE;
integer d = UInt(Rd);
integer n = UInt(Rn);

if !HavePACExt() then
    UNDEFINED;

if Z == '0' then // PACDA
    if n == 31 then source_is_sp = TRUE;
else // PACDZA
    if n != 31 then UNDEFINED;
```

Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn|SP> Is the 64-bit name of the general-purpose source register or stack pointer, encoded in the "Rn" field.

Operation

```
if source_is_sp then
    X[d] = AddPACDA(X[d], SP[]);
else
    X[d] = AddPACDA(X[d], X[n]);
```

PACDB, PACDZB

Pointer Authentication Code for Data address, using key B. This instruction computes and inserts a pointer authentication code for a data address, using a modifier and key B.

The address is in the general-purpose register that is specified by <Xd>.

The modifier is:

- In the general-purpose register or stack pointer that is specified by <Xn|SP> for PACDB.
- The value zero, for PACDZB.

Integer  
(Armv8.3)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	1	0	1	1	0	0	0	0	0	1	0	0	Z	0	1	1	Rn					Rd				

PACDB (Z == 0)

PACDB <Xd>, <Xn|SP>

PACDZB (Z == 1 && Rn == 11111)

```
PACDZB <Xd>

boolean source_is_sp = FALSE;
integer d = UInt(Rd);
integer n = UInt(Rn);

if !HavePACExt() then
    UNDEFINED;

if Z == '0' then // PACDB
    if n == 31 then source_is_sp = TRUE;
else // PACDZB
    if n != 31 then UNDEFINED;
```

Assembler Symbols

<Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.

<Xn|SP> Is the 64-bit name of the general-purpose source register or stack pointer, encoded in the "Rn" field.

Operation

```
if source_is_sp then
    X[d] = AddPACDB(X[d], SP[]);
else
    X[d] = AddPACDB(X[d], X[n]);
```

# PACGA

Pointer Authentication Code, using Generic key. This instruction computes the pointer authentication code for an address in the first source register, using a modifier in the second source register, and the Generic key. The computed pointer authentication code is returned in the upper 32 bits of the destination register.

## Integer (Armv8.3)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	1	0	1	0	1	1	0	Rm					0	0	1	1	0	0	Rn					Rd				

## Integer

```
PACGA <Xd>, <Xn>, <Xm|SP>

boolean source_is_sp = FALSE;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if !HavePACExt() then
    UNDEFINED;

if m == 31 then source_is_sp = TRUE;
```

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm|SP> Is the 64-bit name of the second general-purpose source register or stack pointer, encoded in the "Rm" field.

## Operation

```
if source_is_sp then
    X[d] = AddPACGA(X[n], SP[]);
else
    X[d] = AddPACGA(X[n], X[m]);
```

PACIA, PACIA1716, PACIASP, PACIAZ, PACIZA

Pointer Authentication Code for Instruction address, using key A. This instruction computes and inserts a pointer authentication code for an instruction address, using a modifier and key A.

The address is:

- In the general-purpose register that is specified by <Xd> for PACIA and PACIZA.
- In X17, for PACIA1716.
- In X30, for PACIASP and PACIAZ.

The modifier is:

- In the general-purpose register or stack pointer that is specified by <Xn|SP> for PACIA.
- The value zero, for PACIZA and PACIAZ.
- In X16, for PACIA1716.
- In SP, for PACIASP.

It has encodings from 2 classes: [Integer](#) and [System](#)

Integer  
(Armv8.3)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	1	0	1	1	0	0	0	0	0	1	0	0	Z	0	0	0	Rn				Rd					

PACIA (Z == 0)

PACIA <Xd>, <Xn|SP>

PACIZA (Z == 1 && Rn == 11111)

PACIZA <Xd>

```
boolean source_is_sp = FALSE;
integer d = UInt(Rd);
integer n = UInt(Rn);

if !HavePACExt() then
    UNDEFINED;

if Z == '0' then // PACIA
    if n == 31 then source_is_sp = TRUE;
else // PACIZA
    if n != 31 then UNDEFINED;
```

System  
(Armv8.3)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	x	1	0	0	x	1	1	1	1	1
												CRm				op2															

## PACIA1716 (CRm == 0001 && op2 == 000)

PACIA1716

## PACIASP (CRm == 0011 && op2 == 001)

PACIASP

## PACIAZ (CRm == 0011 && op2 == 000)

PACIAZ

```
integer d;  
integer n;  
boolean source_is_sp = FALSE;  
  
case CRm:op2 of  
  when '0011 000'    // PACIAZ  
    d = 30;  
    n = 31;  
  when '0011 001'    // PACIASP  
    d = 30;  
    source_is_sp = TRUE;  
    if HaveBTIExt() then  
      // Check for branch target compatibility between PSTATE.BTYPE  
      // and implicit branch target of PACIASP instruction.  
      SetBTypeCompatible(BTypeCompatible_PACIXSP());  
  
  when '0001 000'    // PACIA1716  
    d = 17;  
    n = 16;  
  when '0001 010' SEE "PACIB";  
  when '0001 100' SEE "AUTIA";  
  when '0001 110' SEE "AUTIB";  
  when '0011 01x' SEE "PACIB";  
  when '0011 10x' SEE "AUTIA";  
  when '0011 11x' SEE "AUTIB";  
  when '0000 111' SEE "XPACLRI";  
  otherwise SEE "HINT";
```

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn|SP> Is the 64-bit name of the general-purpose source register or stack pointer, encoded in the "Rn" field.

## Operation

```
if HavePACExt() then  
  if source_is_sp then  
    X[d] = AddPACIA(X[d], SP[]);  
  else  
    X[d] = AddPACIA(X[d], X[n]);
```

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PACIB, PACIB1716, PACIBSP, PACIBZ, PACIZB

Pointer Authentication Code for Instruction address, using key B. This instruction computes and inserts a pointer authentication code for an instruction address, using a modifier and key B.

The address is:

- In the general-purpose register that is specified by <Xd> for PACIB and PACIZB.
- In X17, for PACIB1716.
- In X30, for PACIBSP and PACIBZ.

The modifier is:

- In the general-purpose register or stack pointer that is specified by <Xn|SP> for PACIB.
- The value zero, for PACIZB and PACIBZ.
- In X16, for PACIB1716.
- In SP, for PACIBSP.

It has encodings from 2 classes: [Integer](#) and [System](#)

Integer  
(Armv8.3)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	1	0	1	1	0	0	0	0	0	1	0	0	Z	0	0	1	Rn				Rd					

PACIB (Z == 0)

PACIB <Xd>, <Xn|SP>

PACIZB (Z == 1 && Rn == 11111)

PACIZB <Xd>

```
boolean source_is_sp = FALSE;
integer d = UInt(Rd);
integer n = UInt(Rn);

if !HavePACExt() then
    UNDEFINED;

if Z == '0' then // PACIB
    if n == 31 then source_is_sp = TRUE;
else // PACIZB
    if n != 31 then UNDEFINED;
```

System  
(Armv8.3)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0					
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	x	1	0	1	x	1	1	1	1	1					
																					CRm				op2											

## PACIB1716 (CRm == 0001 && op2 == 010)

PACIB1716

## PACIBSP (CRm == 0011 && op2 == 011)

PACIBSP

## PACIBZ (CRm == 0011 && op2 == 010)

PACIBZ

```
integer d;  
integer n;  
boolean source_is_sp = FALSE;  
  
case CRm:op2 of  
  when '0011 010'    // PACIBZ  
    d = 30;  
    n = 31;  
  when '0011 011'    // PACIBSP  
    d = 30;  
    source_is_sp = TRUE;  
    if HaveBTIExt() then  
      // Check for branch target compatibility between PSTATE.BTYPE  
      // and implicit branch target of PACIBSP instruction.  
      SetBTypeCompatible(BTypeCompatible_PACIXSP());  
  when '0001 010'    // PACIB1716  
    d = 17;  
    n = 16;  
  when '0001 000' SEE "PACIA";  
  when '0001 100' SEE "AUTIA";  
  when '0001 110' SEE "AUTIB";  
  when '0011 00x' SEE "PACIA";  
  when '0011 10x' SEE "AUTIA";  
  when '0011 11x' SEE "AUTIB";  
  when '0000 111' SEE "XPACLRI";  
  otherwise SEE "HINT";
```

## Assembler Symbols

<Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.

<Xn|SP> Is the 64-bit name of the general-purpose source register or stack pointer, encoded in the "Rn" field.

## Operation

```
if HavePACExt() then  
  if source_is_sp then  
    X[d] = AddPACIB(X[d], SP[]);  
  else  
    X[d] = AddPACIB(X[d], X[n]);
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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## PRFM (immediate)

Prefetch Memory (immediate) signals the memory system that data memory accesses from a specified address are likely to occur in the near future. The memory system can respond by taking actions that are expected to speed up the memory accesses when they do occur, such as preloading the cache line containing the specified address into one or more caches.

The effect of an PRFM instruction is IMPLEMENTATION DEFINED. For more information, see *Prefetch memory*.

For information about memory accesses, see *Load/Store addressing modes*.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	1	1	0	0	1	1	0	imm12												Rn				Rt					
size										opc																					

### Unsigned offset

PRFM (<prfop>|<#imm5>), [<Xn|SP>{, #<pimm>}]

```
bits(64) offset = LSL(ZeroExtend(imm12, 64), 3);
```

### Assembler Symbols

- <prfop> Is the prefetch operation, defined as <type><target><policy>.  
<type> is one of:
- PLD**  
Prefetch for load, encoded in the "Rt<4:3>" field as 0b00.
  - PLI**  
Preload instructions, encoded in the "Rt<4:3>" field as 0b01.
  - PST**  
Prefetch for store, encoded in the "Rt<4:3>" field as 0b10.
- <target> is one of:
- L1**  
Level 1 cache, encoded in the "Rt<2:1>" field as 0b00.
  - L2**  
Level 2 cache, encoded in the "Rt<2:1>" field as 0b01.
  - L3**  
Level 3 cache, encoded in the "Rt<2:1>" field as 0b10.
- <policy> is one of:
- KEEP**  
Retained or temporal prefetch, allocated in the cache normally. Encoded in the "Rt<0>" field as 0.
  - STRM**  
Streaming or non-temporal prefetch, for data that is used only once. Encoded in the "Rt<0>" field as 1.
- For more information on these prefetch operations, see *Prefetch memory*.  
For other encodings of the "Rt" field, use <imm5>.
- <imm5> Is the prefetch operation encoding as an immediate, in the range 0 to 31, encoded in the "Rt" field.  
This syntax is only for encodings that are not accessible using <prfop>.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <pimm> Is the optional positive immediate byte offset, a multiple of 8 in the range 0 to 32760, defaulting to 0 and encoded in the "imm12" field as <pimm>/8.

### Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(FALSE);

bits(64) address;

if n == 31 then
    address = SP[];
else
    address = X[n];

address = address + offset;

Prefetch(address, t<4:0>);
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

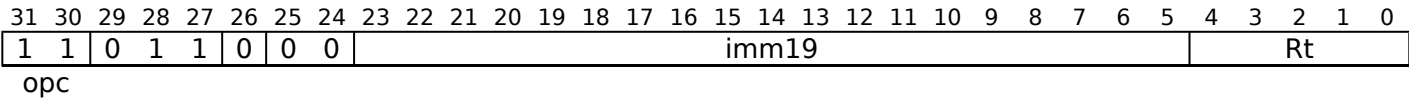
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# PRFM (literal)

Prefetch Memory (literal) signals the memory system that data memory accesses from a specified address are likely to occur in the near future. The memory system can respond by taking actions that are expected to speed up the memory accesses when they do occur, such as preloading the cache line containing the specified address into one or more caches.

The effect of an PRFM instruction is IMPLEMENTATION DEFINED. For more information, see [Prefetch memory](#).

For information about memory accesses, see [Load/Store addressing modes](#).



## Literal

```
PRFM (<prfop>|<#imm5>), <label>

integer t = UInt(Rt);
bits(64) offset;

offset = SignExtend(imm19:'00', 64);
```

## Assembler Symbols

- <prfop> Is the prefetch operation, defined as <type><target><policy>.  
<type> is one of:  
**PLD** Prefetch for load, encoded in the "Rt<4:3>" field as 0b00.  
**PLI** Preload instructions, encoded in the "Rt<4:3>" field as 0b01.  
**PST** Prefetch for store, encoded in the "Rt<4:3>" field as 0b10.  
<target> is one of:  
**L1** Level 1 cache, encoded in the "Rt<2:1>" field as 0b00.  
**L2** Level 2 cache, encoded in the "Rt<2:1>" field as 0b01.  
**L3** Level 3 cache, encoded in the "Rt<2:1>" field as 0b10.  
<policy> is one of:  
**KEEP** Retained or temporal prefetch, allocated in the cache normally. Encoded in the "Rt<0>" field as 0.  
**STRM** Streaming or non-temporal prefetch, for data that is used only once. Encoded in the "Rt<0>" field as 1.  
  
For more information on these prefetch operations, see [Prefetch memory](#).  
For other encodings of the "Rt" field, use <imm5>.
- <imm5> Is the prefetch operation encoding as an immediate, in the range 0 to 31, encoded in the "Rt" field.  
This syntax is only for encodings that are not accessible using <prfop>.
- <label> Is the program label from which the data is to be loaded. Its offset from the address of this instruction, in the range +/-1MB, is encoded as "imm19" times 4.

## Operation

```
bits(64) address = PC[] + offset;  
if HaveMTEExt() then  
    SetTagCheckedInstruction(FALSE);  
Prefetch(address, t<4:0>);
```

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## PRFM (register)

Prefetch Memory (register) signals the memory system that data memory accesses from a specified address are likely to occur in the near future. The memory system can respond by taking actions that are expected to speed up the memory accesses when they do occur, such as preloading the cache line containing the specified address into one or more caches.

The effect of an PRFM instruction is IMPLEMENTATION DEFINED. For more information, see [Prefetch memory](#).

For information about memory accesses, see [Load/Store addressing modes](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
1	1	1	1	1	0	0	0	1	0	1	Rm				option			S	1	0	Rn				Rt										
size								opc																											

### Integer

PRFM (<prfop>|<#imm5>), [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]

```
if option<1> == '0' then UNDEFINED;    // sub-word index
ExtendType extend_type = DecodeRegExtend(option);
integer shift = if S == '1' then 3 else 0;
```

### Assembler Symbols

- <prfop> Is the prefetch operation, defined as <type><target><policy>. <type> is one of:
- PLD**  
Prefetch for load, encoded in the "Rt<4:3>" field as 0b00.
  - PLI**  
Preload instructions, encoded in the "Rt<4:3>" field as 0b01.
  - PST**  
Prefetch for store, encoded in the "Rt<4:3>" field as 0b10.
- <target> is one of:
- L1**  
Level 1 cache, encoded in the "Rt<2:1>" field as 0b00.
  - L2**  
Level 2 cache, encoded in the "Rt<2:1>" field as 0b01.
  - L3**  
Level 3 cache, encoded in the "Rt<2:1>" field as 0b10.
- <policy> is one of:
- KEEP**  
Retained or temporal prefetch, allocated in the cache normally. Encoded in the "Rt<0>" field as 0.
  - STRM**  
Streaming or non-temporal prefetch, for data that is used only once. Encoded in the "Rt<0>" field as 1.
- For more information on these prefetch operations, see [Prefetch memory](#).  
For other encodings of the "Rt" field, use <imm5>.
- <imm5> Is the prefetch operation encoding as an immediate, in the range 0 to 31, encoded in the "Rt" field. This syntax is only for encodings that are not accessible using <prfop>.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Wm> When option<0> is set to 0, is the 32-bit name of the general-purpose index register, encoded in the "Rm" field.
- <Xm> When option<0> is set to 1, is the 64-bit name of the general-purpose index register, encoded in the "Rm" field.

<extend> Is the index extend/shift specifier, defaulting to LSL, and which must be omitted for the LSL option when <amount> is omitted. encoded in “option”:

option	<extend>
010	UXTW
011	LSL
110	SXTW
111	SCTX

<amount> Is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in “S”:

S	<amount>
0	#0
1	#3

### Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer m = UInt(Rm);
```

### Operation

```
bits(64) offset = ExtendReg(m, extend_type, shift);
if HaveMTEExt() then
    SetTagCheckedInstruction(FALSE);

bits(64) address;

if n == 31 then
    address = SP[];
else
    address = X[n];

address = address + offset;

Prefetch(address, t<4:0>);
```

# PRFUM

Prefetch Memory (unscaled offset) signals the memory system that data memory accesses from a specified address are likely to occur in the near future. The memory system can respond by taking actions that are expected to speed up the memory accesses when they do occur, such as preloading the cache line containing the specified address into one or more caches.

The effect of an PRFUM instruction is IMPLEMENTATION DEFINED. For more information, see [Prefetch memory](#).

For information about memory accesses, see [Load/Store addressing modes](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	1	1	0	0	0	1	0	0	imm9									0	0	Rn				Rt					
size										opc																					

## Unscaled offset

PRFUM (<prfop>|<#imm5>), [<Xn|SP>{, <#simm>}]

bits(64) offset = [SignExtend](#)(imm9, 64);

## Assembler Symbols

- <prfop>

Is the prefetch operation, defined as <type><target><policy>.  
<type> is one of:  
**PLD**  
Prefetch for load, encoded in the "Rt<4:3>" field as 0b00.  
**PLI**  
Preload instructions, encoded in the "Rt<4:3>" field as 0b01.  
**PST**  
Prefetch for store, encoded in the "Rt<4:3>" field as 0b10.  
<target> is one of:  
**L1**  
Level 1 cache, encoded in the "Rt<2:1>" field as 0b00.  
**L2**  
Level 2 cache, encoded in the "Rt<2:1>" field as 0b01.  
**L3**  
Level 3 cache, encoded in the "Rt<2:1>" field as 0b10.  
<policy> is one of:  
**KEEP**  
Retained or temporal prefetch, allocated in the cache normally. Encoded in the "Rt<0>" field as 0.  
**STRM**  
Streaming or non-temporal prefetch, for data that is used only once. Encoded in the "Rt<0>" field as 1.  
  
For more information on these prefetch operations, see [Prefetch memory](#).  
For other encodings of the "Rt" field, use <imm5>.
- <imm5>

Is the prefetch operation encoding as an immediate, in the range 0 to 31, encoded in the "Rt" field.  
This syntax is only for encodings that are not accessible using <prfop>.
- <Xn|SP>

Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <simm>

Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);  
integer t = UInt(Rt);
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(FALSE);

bits(64) address;

if n == 31 then
    address = SP[];
else
    address = X[n];

address = address + offset;

Prefetch(address, t<4:0>);
```

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# PSB CSYNC

Profiling Synchronization Barrier. This instruction is a barrier that ensures that all existing profiling data for the current PE has been formatted, and profiling buffer addresses have been translated such that all writes to the profiling buffer have been initiated. A following DSB instruction completes when the writes to the profiling buffer have completed.

If the Statistical Profiling Extension is not implemented, this instruction executes as a NOP.

## System (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0			
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	1	0	0	0	1	1	1	1	1	1			
																				CRm				op2										

## System

```
PSB CSYNC

if !HaveStatisticalProfiling() then EndOfInstruction();
```

## Operation

```
ProfilingSynchronizationBarrier();
```

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PSSBB

Physical Speculative Store Bypass Barrier is a memory barrier which prevents speculative loads from bypassing earlier stores to the same physical address.

The semantics of the Physical Speculative Store Bypass Barrier are:

- When a load to a location appears in program order after the PSSBB, then the load does not speculatively read an entry earlier in the coherence order for that location than the entry generated by the latest store satisfying all of the following conditions:
  - The store is to the same location as the load.
  - The store appears in program order before the PSSBB.
- When a load to a location appears in program order before the PSSBB, then the load does not speculatively read data from any store satisfying all of the following conditions:
  - The store is to the same location as the load.
  - The store appears in program order after the PSSBB.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0							
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	1	0	1	0	0	1	0	0	1	1	1	1	1							
																				CRm						opc												

System

PSSBB

```
// No additional decoding required
```

Operation

```
SpeculativeStoreBypassBarrierToPA\(\);
```

# RBIT

Reverse Bits reverses the bit order in a register.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
sf	1	0	1	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	Rn						Rd					

## 32-bit (sf == 0)

RBIT <Wd>, <Wn>

## 64-bit (sf == 1)

RBIT <Xd>, <Xn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer datasize = if sf == '1' then 64 else 32;
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.

## Operation

```
bits(datasize) operand = X[n];
bits(datasize) result;

for i = 0 to datasize-1
    result<datasize-1-i> = operand<i>;

X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# RET

Return from subroutine branches unconditionally to an address in a register, with a hint that this is a subroutine return.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	1	0	0	1	0	1	1	1	1	1	0	0	0	0	0	0	Rn				0	0	0	0	0	
Z								op				A								M	Rm										

## Integer

```
RET {<Xn>}  
  
integer n = UInt(Rn);
```

## Assembler Symbols

<Xn> Is the 64-bit name of the general-purpose register holding the address to be branched to, encoded in the "Rn" field. Defaults to X30 if absent.

## Operation

```
bits(64) target = X[n];  
BranchTo(target, BranchType_RET);
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# RETAA, RETAB

Return from subroutine, with pointer authentication. This instruction authenticates the address that is held in LR, using SP as the modifier and the specified key, branches to the authenticated address, with a hint that this instruction is a subroutine return.

Key A is used for RETAA, and key B is used for RETAB.

If the authentication passes, the PE continues execution at the target of the branch. If the authentication fails, a Translation fault is generated.

The authenticated address is not written back to LR.

## Integer (Armv8.3)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	1	0	0	1	0	1	1	1	1	1	0	0	0	0	1	M	1	1	1	1	1	1	1	1	1	1
Z							op				A										Rn					Rm					

### RETAA (M == 0)

RETAA

### RETAB (M == 1)

RETAB

```
boolean use_key_a = (M == '0');  
  
if !HavePACExt() then  
    UNDEFINED;
```

## Operation

```
bits(64) target = X[30];  
bits(64) modifier = SP[];  
  
if use_key_a then  
    target = AuthIA(target, modifier, TRUE);  
else  
    target = AuthIB(target, modifier, TRUE);  
  
BranchTo(target, BranchType_RET);
```

## REV

Reverse Bytes reverses the byte order in a register.

This instruction is used by the pseudo-instruction [REV64](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0			
sf	1	0	1	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1	x	Rn				Rd								
																					opc													

### 32-bit (sf == 0 && opc == 10)

REV <Wd>, <Wn>

### 64-bit (sf == 1 && opc == 11)

REV <Xd>, <Xn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer datasize = if sf == '1' then 64 else 32;

integer container_size;
case opc of
    when '00'
        Unreachable();
    when '01'
        container_size = 16;
    when '10'
        container_size = 32;
    when '11'
        if sf == '0' then UNDEFINED;
        container_size = 64;
```

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.

## Operation

```
bits(datasize) operand = X[n];
bits(datasize) result;

integer containers = datasize DIV container_size;
integer elements_per_container = container_size DIV 8;
integer index = 0;
integer rev_index;
for c = 0 to containers-1
    rev_index = index + ((elements_per_container - 1) * 8);
    for e = 0 to elements_per_container-1
        result<rev_index+7:rev_index> = operand<index+7:index>;
        index = index + 8;
        rev_index = rev_index - 8;

X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

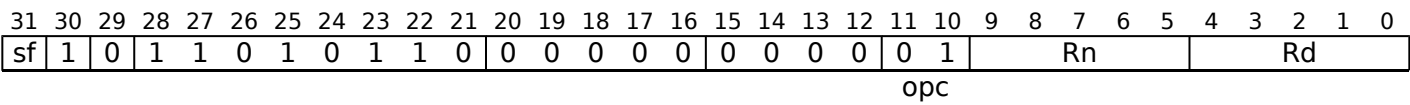
- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# REV16

Reverse bytes in 16-bit halfwords reverses the byte order in each 16-bit halfword of a register.



## 32-bit (sf == 0)

REV16 <Wd>, <Wn>

## 64-bit (sf == 1)

REV16 <Xd>, <Xn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer datasize = if sf == '1' then 64 else 32;

integer container_size;
case opc of
  when '00'
    Unreachable();
  when '01'
    container_size = 16;
  when '10'
    container_size = 32;
  when '11'
    if sf == '0' then UNDEFINED;
    container_size = 64;
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.

## Operation

```
bits(datasize) operand = X[n];
bits(datasize) result;

integer containers = datasize DIV container_size;
integer elements_per_container = container_size DIV 8;
integer index = 0;
integer rev_index;
for c = 0 to containers-1
  rev_index = index + ((elements_per_container - 1) * 8);
  for e = 0 to elements_per_container-1
    result<rev_index+7:rev_index> = operand<index+7:index>;
    index = index + 8;
    rev_index = rev_index - 8;

X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:



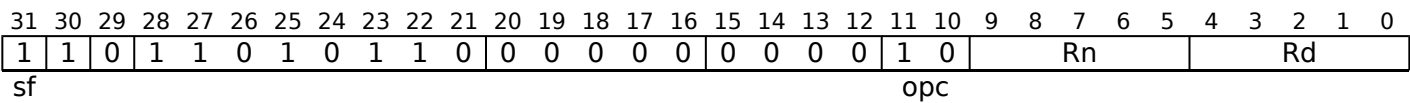
- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# REV32

Reverse bytes in 32-bit words reverses the byte order in each 32-bit word of a register.



## 64-bit

```
REV32 <Xd>, <Xn>

integer d = UInt(Rd);
integer n = UInt(Rn);

integer datasize = if sf == '1' then 64 else 32;

integer container_size;
case opc of
  when '00'
    Unreachable();
  when '01'
    container_size = 16;
  when '10'
    container_size = 32;
  when '11'
    if sf == '0' then UNDEFINED;
    container_size = 64;
```

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.

## Operation

```
bits(datasize) operand = X[n];
bits(datasize) result;

integer containers = datasize DIV container_size;
integer elements_per_container = container_size DIV 8;
integer index = 0;
integer rev_index;
for c = 0 to containers-1
  rev_index = index + ((elements_per_container - 1) * 8);
  for e = 0 to elements_per_container-1
    result<rev_index+7:rev_index> = operand<index+7:index>;
    index = index + 8;
    rev_index = rev_index - 8;

X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

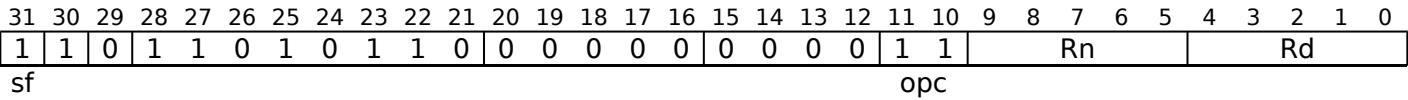


# REV64

Reverse Bytes reverses the byte order in a 64-bit general-purpose register.  
When assembling for Armv8.2, an assembler must support this pseudo-instruction. It is OPTIONAL whether an assembler supports this pseudo-instruction when assembling for an architecture earlier than Armv8.2.

This is a pseudo-instruction of [REV](#). This means:

- The encodings in this description are named to match the encodings of [REV](#).
- The assembler syntax is used only for assembly, and is not used on disassembly.
- The description of [REV](#) gives the operational pseudocode for this instruction.



## 64-bit

REV64 <Xd>, <Xn>

is equivalent to

[REV](#) <Xd>, <Xn>

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.

## Operation

The description of [REV](#) gives the operational pseudocode for this instruction.

## Operational information

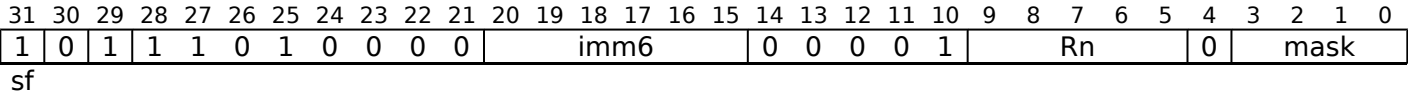
If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

# RMIF

Performs a rotation right of a value held in a general purpose register by an immediate value, and then inserts a selection of the bottom four bits of the result of the rotation into the PSTATE flags, under the control of a second immediate mask.

## Integer (Armv8.4)



## Integer

```
RMIF <Xn>, #<shift>, #<mask>

if !HaveFlagManipulateExt() then UNDEFINED;
integer lsb = UInt(imm6);
integer n = UInt(Rn);
```

## Assembler Symbols

- <Xn> Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
- <shift> Is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field,
- <mask> Is the flag bit mask, an immediate in the range 0 to 15, which selects the bits that are inserted into the NZCV condition flags, encoded in the "mask" field.

## Operation

```
bits(4) tmp;
bits(64) tmpreg = X[n];
tmp = (tmpreg:tmpreg)<lsb+3:lsb>;
if mask<3> == '1' then PSTATE.N = tmp<3>;
if mask<2> == '1' then PSTATE.Z = tmp<2>;
if mask<1> == '1' then PSTATE.C = tmp<1>;
if mask<0> == '1' then PSTATE.V = tmp<0>;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# ROR (immediate)

Rotate right (immediate) provides the value of the contents of a register rotated by a variable number of bits. The bits that are rotated off the right end are inserted into the vacated bit positions on the left.

This is an alias of [EXTR](#). This means:

- The encodings in this description are named to match the encodings of [EXTR](#).
  - The description of [EXTR](#) gives the operational pseudocode for this instruction.
- |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |      |    |    |    |    |   |    |   |   |    |   |   |   |   |   |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|------|----|----|----|----|---|----|---|---|----|---|---|---|---|---|
| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14   | 13 | 12 | 11 | 10 | 9 | 8  | 7 | 6 | 5  | 4 | 3 | 2 | 1 | 0 |
| sf | 0  | 0  | 1  | 0  | 0  | 1  | 1  | 1  | N  | 0  | Rm |    |    |    |    |    | imms |    |    |    |    |   | Rn |   |   | Rd |   |   |   |   |   |

## 32-bit (sf == 0 && N == 0 && imms == 0xxxxx)

ROR <Wd>, <Ws>, #<shift>

is equivalent to

[EXTR](#) <Wd>, <Ws>, <Ws>, #<shift>

and is the preferred disassembly when Rn == Rm.

## 64-bit (sf == 1 && N == 1)

ROR <Xd>, <Xs>, #<shift>

is equivalent to

[EXTR](#) <Xd>, <Xs>, <Xs>, #<shift>

and is the preferred disassembly when Rn == Rm.

## Assembler Symbols

- |         |  |
|---------|--|
| <Wd>    | Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.                   |
| <Ws>    | Is the 32-bit name of the general-purpose source register, encoded in the "Rn" and "Rm" fields.              |
| <Xd>    | Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.                   |
| <Xs>    | Is the 64-bit name of the general-purpose source register, encoded in the "Rn" and "Rm" fields.              |
| <shift> | For the 32-bit variant: is the amount by which to rotate, in the range 0 to 31, encoded in the "imms" field. |
|         | For the 64-bit variant: is the amount by which to rotate, in the range 0 to 63, encoded in the "imms" field. |

## Operation

The description of [EXTR](#) gives the operational pseudocode for this instruction.

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

## ROR (register)

Rotate Right (register) provides the value of the contents of a register rotated by a variable number of bits. The bits that are rotated off the right end are inserted into the vacated bit positions on the left. The remainder obtained by dividing the second source register by the data size defines the number of bits by which the first source register is right-shifted.

This is an alias of [RORV](#). This means:

- The encodings in this description are named to match the encodings of [RORV](#).
- The description of [RORV](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf		0	0	1	1	0	1	0	1	1	0	Rm				0	0	1	0	1	1	Rn				Rd					
op2																															

### 32-bit (sf == 0)

ROR <Wd>, <Wn>, <Wm>

is equivalent to

RORV <Wd>, <Wn>, <Wm>

and is always the preferred disassembly.

### 64-bit (sf == 1)

ROR <Xd>, <Xn>, <Xm>

is equivalent to

RORV <Xd>, <Xn>, <Xm>

and is always the preferred disassembly.

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Wm>	Is the 32-bit name of the second general-purpose source register holding a shift amount from 0 to 31 in its bottom 5 bits, encoded in the "Rm" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the second general-purpose source register holding a shift amount from 0 to 63 in its bottom 6 bits, encoded in the "Rm" field.

## Operation

The description of [RORV](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

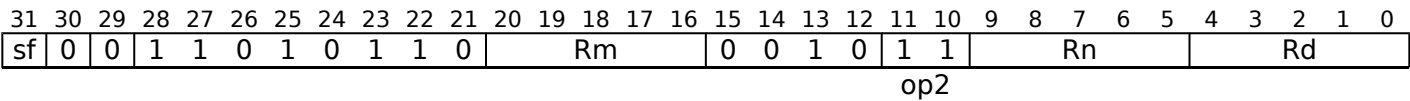




# RORV

Rotate Right Variable provides the value of the contents of a register rotated by a variable number of bits. The bits that are rotated off the right end are inserted into the vacated bit positions on the left. The remainder obtained by dividing the second source register by the data size defines the number of bits by which the first source register is right-shifted.

This instruction is used by the alias [ROR \(register\)](#).



## 32-bit (sf == 0)

RORV <Wd>, <Wn>, <Wm>

## 64-bit (sf == 1)

RORV <Xd>, <Xn>, <Xm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
ShiftType shift_type = DecodeShift(op2);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register holding a shift amount from 0 to 31 in its bottom 5 bits, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register holding a shift amount from 0 to 63 in its bottom 6 bits, encoded in the "Rm" field.

## Operation

```
bits(datasize) result;
bits(datasize) operand2 = X[m];

result = ShiftReg(n, shift_type, UInt(operand2) MOD datasize);
X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

SB

Speculation Barrier is a barrier that controls speculation.

The semantics of the Speculation Barrier are that the execution, until the barrier completes, of any instruction that appears later in the program order than the barrier:

- Cannot be performed speculatively to the extent that such speculation can be observed through side-channels as a result of control flow speculation or data value speculation.
- Can be speculatively executed as a result of predicting that a potentially exception generating instruction has not generated an exception.

In particular, any instruction that appears later in the program order than the barrier cannot cause a speculative allocation into any caching structure where the allocation of that entry could be indicative of any data value present in memory or in the registers.

The SB instruction:

- Cannot be speculatively executed as a result of control flow speculation or data value speculation.
- Can be speculatively executed as a result of predicting that a potentially exception generating instruction has not generated an exception. The potentially exception generating instruction can complete once it is known not to be speculative, and all data values generated by instructions appearing in program order before the SB instruction have their predicted values confirmed.

When the prediction of the instruction stream is not informed by data taken from the register outputs of the speculative execution of instructions appearing in program order after an uncompleted SB instruction, the SB instruction has no effect on the use of prediction resources to predict the instruction stream that is being fetched.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	1	(0)	(0)	(0)	(0)	1	1	1	1	1	1	1	1
																CRm				opc											

System

SB

if !HaveSBExt() then UNDEFINED;

Operation

SpeculationBarrier();

# SBC

Subtract with Carry subtracts a register value and the value of NOT (Carry flag) from a register value, and writes the result to the destination register.

This instruction is used by the alias [NGC](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	1	0	1	1	0	1	0	0	0	0	Rm					0	0	0	0	0	0	Rn					Rd				
op S																															

## 32-bit (sf == 0)

SBC <Wd>, <Wn>, <Wm>

## 64-bit (sf == 1)

SBC <Xd>, <Xn>, <Xm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
```

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Wm>	Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">NGC</a>	Rn == '11111'

## Operation

```
bits(datasize) result;
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = X[m];

operand2 = NOT(operand2);

(result, -) = AddWithCarry(operand1, operand2, PSTATE.C);

X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.

- The values of the NZCV flags.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# SBCS

Subtract with Carry, setting flags, subtracts a register value and the value of NOT (Carry flag) from a register value, and writes the result to the destination register. It updates the condition flags based on the result.

This instruction is used by the alias [NGCS](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf		1	1	1	1	0	1	0	0	0	0	Rm				0	0	0	0	0	0	Rn				Rd					
op S																															

## 32-bit (sf == 0)

SBCS <Wd>, <Wn>, <Wm>

## 64-bit (sf == 1)

SBCS <Xd>, <Xn>, <Xm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
```

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Wm>	Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">NGCS</a>	Rn == '11111'

## Operation

```
bits(datasize) result;
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = X[m];
bits(4) nzcw;

operand2 = NOT(operand2);

(result, nzcw) = AddWithCarry(operand1, operand2, PSTATE.C);

PSTATE.<N,Z,C,V> = nzcw;

X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.

- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# SBFIZ

Signed Bitfield Insert in Zeros copies a bitfield of <width> bits from the least significant bits of the source register to bit position <lsb> of the destination register, setting the destination bits below the bitfield to zero, and the bits above the bitfield to a copy of the most significant bit of the bitfield.

This is an alias of [SBFM](#). This means:

- The encodings in this description are named to match the encodings of [SBFM](#).
- The description of [SBFM](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	0	1	0	0	1	1	0	N	immr					imms					Rn					Rd						
opc																															

## 32-bit (sf == 0 && N == 0)

SBFIZ <Wd>, <Wn>, #<lsb>, #<width>

is equivalent to

SBFM <Wd>, <Wn>, #(-<lsb> MOD 32), #(<width>-1)

and is the preferred disassembly when `UInt(imms) < UInt(immr)`.

## 64-bit (sf == 1 && N == 1)

SBFIZ <Xd>, <Xn>, #<lsb>, #<width>

is equivalent to

SBFM <Xd>, <Xn>, #(-<lsb> MOD 64), #(<width>-1)

and is the preferred disassembly when `UInt(imms) < UInt(immr)`.

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
- <lsb> For the 32-bit variant: is the bit number of the lsb of the destination bitfield, in the range 0 to 31.  
For the 64-bit variant: is the bit number of the lsb of the destination bitfield, in the range 0 to 63.
- <width> For the 32-bit variant: is the width of the bitfield, in the range 1 to 32-<lsb>.  
For the 64-bit variant: is the width of the bitfield, in the range 1 to 64-<lsb>.

## Operation

The description of [SBFM](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.





SBFM

Signed Bitfield Move is usually accessed via one of its aliases, which are always preferred for disassembly.

If <imms> is greater than or equal to <immr>, this copies a bitfield of (<imms>-<immr>+1) bits starting from bit position <immr> in the source register to the least significant bits of the destination register.

If <imms> is less than <immr>, this copies a bitfield of (<imms>+1) bits from the least significant bits of the source register to bit position (regsize-<immr>) of the destination register, where regsize is the destination register size of 32 or 64 bits.

In both cases the destination bits below the bitfield are set to zero, and the bits above the bitfield are set to a copy of the most significant bit of the bitfield.

This instruction is used by the aliases [ASR \(immediate\)](#), [SBFIZ](#), [SBFX](#), [SXTB](#), [SXTH](#), and [SXTW](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	0	1	0	0	1	1	0	N	immr						imms						Rn				Rd					
opc																															

32-bit (sf == 0 && N == 0)

SBFM <Wd>, <Wn>, #<immr>, #<imms>

64-bit (sf == 1 && N == 1)

SBFM <Xd>, <Xn>, #<immr>, #<imms>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer datasize = if sf == '1' then 64 else 32;

integer R;
integer S;
bits(datasize) wmask;
bits(datasize) tmask;

if sf == '1' && N != '1' then UNDEFINED;
if sf == '0' && (N != '0' || immr<5> != '0' || imms<5> != '0') then UNDEFINED;

R = UInt(immr);
S = UInt(imms);
(wmask, tmask) = DecodeBitMasks(N, imms, immr, FALSE);
```

Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
- <immr> For the 32-bit variant: is the right rotate amount, in the range 0 to 31, encoded in the "immr" field.  
For the 64-bit variant: is the right rotate amount, in the range 0 to 63, encoded in the "immr" field.
- <imms> For the 32-bit variant: is the leftmost bit number to be moved from the source, in the range 0 to 31, encoded in the "imms" field.  
For the 64-bit variant: is the leftmost bit number to be moved from the source, in the range 0 to 63, encoded in the "imms" field.

Alias Conditions

Alias	Of variant	Is preferred when
<a href="#">ASR (immediate)</a>	32-bit	imms == '011111'

Alias	Of variant	Is preferred when
<a href="#">ASR (immediate)</a>	64-bit	<code>imms == '111111'</code>
<a href="#">SBEIZ</a>		<code>UInt(imms) &lt; UInt(immr)</code>
<a href="#">SBFX</a>		<code>BFXPreferred(sf, opc&lt;1&gt;, imms, immr)</code>
<a href="#">SXTB</a>		<code>immr == '000000' &amp;&amp; imms == '000111'</code>
<a href="#">SXTH</a>		<code>immr == '000000' &amp;&amp; imms == '001111'</code>
<a href="#">SXTW</a>		<code>immr == '000000' &amp;&amp; imms == '011111'</code>

## Operation

```
bits(datasize) src = X[n];

// perform bitfield move on low bits
bits(datasize) bot = ROR(src, R) AND wmask;

// determine extension bits (sign, zero or dest register)
bits(datasize) top = Replicate(src<S>);

// combine extension bits and result bits
X[d] = (top AND NOT(tmask)) OR (bot AND tmask);
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# SBFX

Signed Bitfield Extract copies a bitfield of <width> bits starting from bit position <lsb> in the source register to the least significant bits of the destination register, and sets destination bits above the bitfield to a copy of the most significant bit of the bitfield.

This is an alias of [SBFM](#). This means:

- The encodings in this description are named to match the encodings of [SBFM](#).
- The description of [SBFM](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf		0	0	1	0	0	1	1	0	N	immr					imms					Rn					Rd					
opc																															

## 32-bit (sf == 0 && N == 0)

SBFX <Wd>, <Wn>, #<lsb>, #<width>

is equivalent to

[SBFM](#) <Wd>, <Wn>, #<lsb>, #(<lsb>+<width>-1)

and is the preferred disassembly when `BFXPreferred(sf, opc<1>, imms, immr)`.

## 64-bit (sf == 1 && N == 1)

SBFX <Xd>, <Xn>, #<lsb>, #<width>

is equivalent to

[SBFM](#) <Xd>, <Xn>, #<lsb>, #(<lsb>+<width>-1)

and is the preferred disassembly when `BFXPreferred(sf, opc<1>, imms, immr)`.

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
<lsb>	For the 32-bit variant: is the bit number of the lsb of the source bitfield, in the range 0 to 31. For the 64-bit variant: is the bit number of the lsb of the source bitfield, in the range 0 to 63.
<width>	For the 32-bit variant: is the width of the bitfield, in the range 1 to 32-<lsb>. For the 64-bit variant: is the width of the bitfield, in the range 1 to 64-<lsb>.

## Operation

The description of [SBFM](#) gives the operational pseudocode for this instruction.

## Operational information

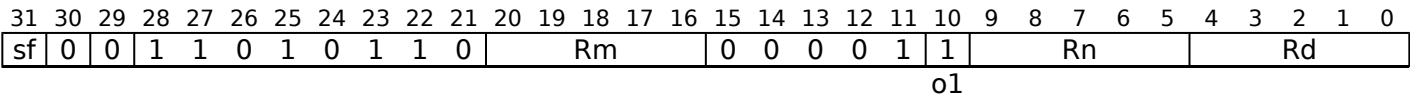
If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.



SDIV

Signed Divide divides a signed integer register value by another signed integer register value, and writes the result to the destination register. The condition flags are not affected.



32-bit (sf == 0)

```
SDIV <Wd>, <Wn>, <Wm>
```

64-bit (sf == 1)

```
SDIV <Xd>, <Xn>, <Xm>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
```

Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.

Operation

```
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = X[m];
integer result;

if IsZero(operand2) then
    result = 0;
else
    result = RoundTowardsZero(Real(Int(operand1, FALSE)) / Real(Int(operand2, FALSE)));

X[d] = result<datasize-1:0>;
```

# SETF8, SETF16

Set the PSTATE.NZV flags based on the value in the specified general-purpose register. SETF8 treats the value as an 8 bit value, and SETF16 treats the value as an 16 bit value.  
The PSTATE.C flag is not affected by these instructions.

## Integer (Armv8.4)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	sz	0	0	1	0	Rn				0	1	1	0	1	
sf																															

### SETF8 (sz == 0)

SETF8 <Wn>

### SETF16 (sz == 1)

SETF16 <Wn>

```
if !HaveFlagManipulateExt() then UNDEFINED;
integer msb = if sz == '1' then 15 else 7;
integer n = UInt(Rn);
```

## Assembler Symbols

<Wn> Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.

## Operation

```
bits(32) tmpreg = X[n];
PSTATE.N = tmpreg<msb>;
PSTATE.Z = if (tmpreg<msb:0> == Zeros(msb + 1)) then '1' else '0';
PSTATE.V = tmpreg<msb+1> EOR tmpreg<msb>;
//PSTATE.C unchanged;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# SEV

Send Event is a hint instruction. It causes an event to be signaled to all PEs in the multiprocessor system. For more information, see [Wait for Event mechanism and Send event](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	1	0	0	1	1	1	1	1
																CRm				op2											

## System

SEV

// Empty.

## Operation

[SendEvent\(\)](#);

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SEVL

Send Event Local is a hint instruction that causes an event to be signaled locally without requiring the event to be signaled to other PEs in the multiprocessor system. It can prime a wait-loop which starts with a WFE instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	1	0	1	1	1	1	1	1				
																					CRm				op2										

System

SEVL

```
// Empty.
```

Operation

```
SendEventLocal();
```

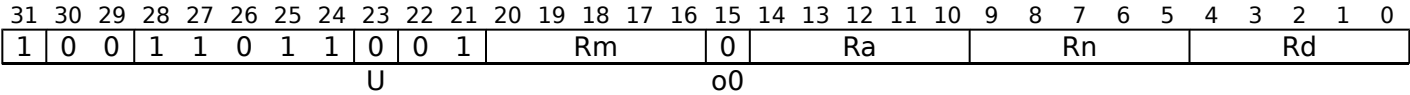
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SMADDL

Signed Multiply-Add Long multiplies two 32-bit register values, adds a 64-bit register value, and writes the result to the 64-bit destination register.

This instruction is used by the alias [SMULL](#).



64-bit

SMADDL <Xd>, <Wn>, <Wm>, <Xa>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer a = UInt(Ra);
```

Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.
- <Xa> Is the 64-bit name of the third general-purpose source register holding the addend, encoded in the "Ra" field.

Alias Conditions

Alias	Is preferred when
<a href="#">SMULL</a>	Ra == '11111'

Operation

```
bits(32) operand1 = X[n];
bits(32) operand2 = X[m];
bits(64) operand3 = X[a];

integer result;

result = Int(operand3, FALSE) + (Int(operand1, FALSE) * Int(operand2, FALSE));
X[d] = result<63:0>;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# SMC

Secure Monitor Call causes an exception to EL3.

SMC is available only for software executing at EL1 or higher. It is UNDEFINED in EL0.

If the values of *HCR\_EL2.TSC* and *SCR\_EL3.SMD* are both 0, execution of an SMC instruction at EL1 or higher generates a Secure Monitor Call exception, recording it in *ESR\_ELx*, using the EC value 0x17, that is taken to EL3.

If the value of *HCR\_EL2.TSC* is 1 and EL2 is enabled in the current Security state, execution of an SMC instruction at EL1 generates an exception that is taken to EL2, regardless of the value of *SCR\_EL3.SMD*. For more information, see *Traps to EL2 of Non-secure EL1 execution of SMC instructions*.

If the value of *HCR\_EL2.TSC* is 0 and the value of *SCR\_EL3.SMD* is 1, the SMC instruction is UNDEFINED.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	0	0	0	0	imm16																0	0	0	1	1

## System

```
SMC #<imm>

// Empty.
```

## Assembler Symbols

<imm> Is a 16-bit unsigned immediate, in the range 0 to 65535, encoded in the "imm16" field.

## Operation

```
AArch64.CheckForSMCUndefOrTrap(imm16);

if SCR_EL3.SMD == '1' then
    // SMC disabled
    UNDEFINED;
else
    AArch64.CallSecureMonitor(imm16);
```

# SMNEGL

Signed Multiply-Negate Long multiplies two 32-bit register values, negates the product, and writes the result to the 64-bit destination register.

This is an alias of [SMSUBL](#). This means:

- The encodings in this description are named to match the encodings of [SMSUBL](#).
- The description of [SMSUBL](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	1	0	1	1	0	0	1	Rm					1	1	1	1	1	1	Rn					Rd				
								U								o0		Ra													

## 64-bit

SMNEGL <Xd>, <Wn>, <Wm>

is equivalent to

[SMSUBL](#) <Xd>, <Wn>, <Wm>, XZR

and is always the preferred disassembly.

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.

## Operation

The description of [SMSUBL](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

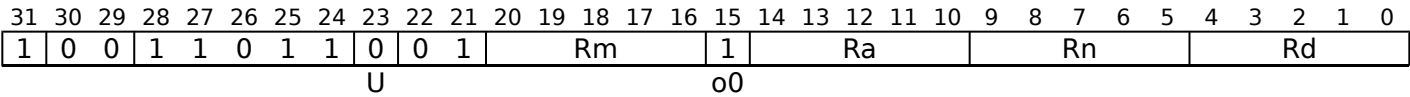
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# SMSUBL

Signed Multiply-Subtract Long multiplies two 32-bit register values, subtracts the product from a 64-bit register value, and writes the result to the 64-bit destination register.

This instruction is used by the alias [SMNEGL](#).



## 64-bit

SMSUBL <Xd>, <Wn>, <Wm>, <Xa>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer a = UInt(Ra);
```

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.
- <Xa> Is the 64-bit name of the third general-purpose source register holding the minuend, encoded in the "Ra" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">SMNEGL</a>	Ra == '11111'

## Operation

```
bits(32) operand1 = X[n];
bits(32) operand2 = X[m];
bits(64) operand3 = X[a];

integer result;

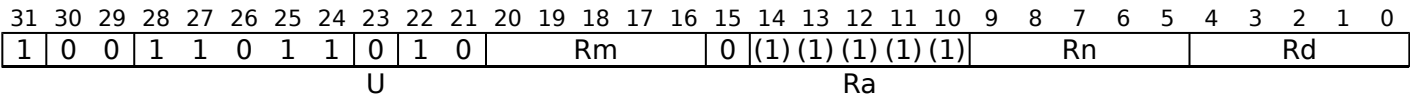
result = Int(operand3, FALSE) - (Int(operand1, FALSE) * Int(operand2, FALSE));
X[d] = result<63:0>;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# SMULH

Signed Multiply High multiplies two 64-bit register values, and writes bits[127:64] of the 128-bit result to the 64-bit destination register.



## 64-bit

SMULH <Xd>, <Xn>, <Xm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
```

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.

## Operation

```
bits(64) operand1 = X[n];
bits(64) operand2 = X[m];

integer result;

result = Int(operand1, FALSE) * Int(operand2, FALSE);

X[d] = result<127:64>;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# SMULL

Signed Multiply Long multiplies two 32-bit register values, and writes the result to the 64-bit destination register.

This is an alias of [SMADDL](#). This means:

- The encodings in this description are named to match the encodings of [SMADDL](#).
- The description of [SMADDL](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	1	0	1	1	0	0	1	Rm					0	1	1	1	1	1	Rn					Rd				
U								o0				Ra																			

## 64-bit

SMULL <Xd>, <Wn>, <Wm>

is equivalent to

[SMADDL](#) <Xd>, <Wn>, <Wm>, XZR

and is always the preferred disassembly.

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.

## Operation

The description of [SMADDL](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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SSBB

Speculative Store Bypass Barrier is a memory barrier which prevents speculative loads from bypassing earlier stores to the same virtual address under certain conditions.

The semantics of the Speculative Store Bypass Barrier are:

- When a load to a location appears in program order after the SSBB, then the load does not speculatively read an entry earlier in the coherence order for that location than the entry generated by the latest store satisfying all of the following conditions:
  - The store is to the same location as the load.
  - The store uses the same virtual address as the load.
  - The store appears in program order before the SSBB.
- When a load to a location appears in program order before the SSBB, then the load does not speculatively read data from any store satisfying all of the following conditions:
  - The store is to the same location as the load.
  - The store uses the same virtual address as the load.
  - The store appears in program order after the SSBB.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	1	0	0	0	0	1	0	0	1	1	1	1	1
																CRm				opc											

System

SSBB

// No additional decoding required

Operation

[SpeculativeStoreBypassBarrierToVA\(\)](#);

## ST2G

Store Allocation Tags stores an Allocation Tag to two Tag granules of memory. The address used for the store is calculated from the base register and an immediate signed offset scaled by the Tag granule. The Allocation Tag is calculated from the Logical Address Tag in the source register.

This instruction generates an Unchecked access.

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Signed offset](#)

### Post-index (Armv8.5)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	1	0	1	imm9									0	1	Xn				Xt					

### Post-index

ST2G <Xt|SP>, [<Xn|SP>], #<sim>

```
if !HaveMTEExt() then UNDEFINED;
integer n = UInt(Xn);
integer t = UInt(Xt);
bits(64) offset = LSL(SignExtend(imm9, 64), LOG2_TAG_GRANULE);
boolean writeback = TRUE;
boolean postindex = TRUE;
```

### Pre-index (Armv8.5)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	1	0	1	imm9									1	1	Xn				Xt					

### Pre-index

ST2G <Xt|SP>, [<Xn|SP>, #<sim>]!

```
if !HaveMTEExt() then UNDEFINED;
integer n = UInt(Xn);
integer t = UInt(Xt);
bits(64) offset = LSL(SignExtend(imm9, 64), LOG2_TAG_GRANULE);
boolean writeback = TRUE;
boolean postindex = FALSE;
```

### Signed offset (Armv8.5)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	1	0	1	imm9									1	0	Xn				Xt					

### Signed offset

ST2G <Xt|SP>, [<Xn|SP>{, #<sim>}]

```
if !HaveMTEExt() then UNDEFINED;
integer n = UInt(Xn);
integer t = UInt(Xt);
bits(64) offset = LSL(SignExtend(imm9, 64), LOG2_TAG_GRANULE);
boolean writeback = FALSE;
boolean postindex = FALSE;
```



## Assembler Symbols

<Xt SP>	Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Xt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Xn" field.
<sim>	Is the optional signed immediate offset, a multiple of 16 in the range -4096 to 4080, defaulting to 0 and encoded in the "imm9" field.

## Operation

```
bits(64) address;
bits(64) data = if t == 31 then SP[] else X[t];
bits(4) tag = AArch64.AllocationTagFromAddress(data);

SetTagCheckedInstruction(FALSE);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

AArch64.MemTag[address, AccType_NORMAL] = tag;
AArch64.MemTag[address+TAG_GRANULE, AccType_NORMAL] = tag;

if writeback then
    if postindex then
        address = address + offset;

    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

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# STADD, STADDL

Atomic add on word or doubleword in memory, without return, atomically loads a 32-bit word or 64-bit doubleword from memory, adds the value held in a register to it, and stores the result back to memory.

- STADD does not have release semantics.
- STADDL stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDADD, LDADDA, LDADDAL, LDADDL](#). This means:

- The encodings in this description are named to match the encodings of [LDADD, LDADDA, LDADDAL, LDADDL](#).
- The description of [LDADD, LDADDA, LDADDAL, LDADDL](#) gives the operational pseudocode for this instruction.

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	0	0	R	1	Rs				0	0	0	0	0	0	Rn				1	1	1	1	1		
size								A				opc								Rt											

### 32-bit LDADD alias (size == 10 && R == 0)

STADD <Ws>, [<Xn|SP>]

is equivalent to

LDADD <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### 32-bit LDADDL alias (size == 10 && R == 1)

STADDL <Ws>, [<Xn|SP>]

is equivalent to

LDADDL <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### 64-bit LDADD alias (size == 11 && R == 0)

STADD <Xs>, [<Xn|SP>]

is equivalent to

LDADD <Xs>, XZR, [<Xn|SP>]

and is always the preferred disassembly.

### 64-bit LDADDL alias (size == 11 && R == 1)

STADDL <Xs>, [<Xn|SP>]

is equivalent to

LDADDL <Xs>, XZR, [<Xn|SP>]

and is always the preferred disassembly.

## Assembler Symbols

<Ws>	Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xs>	Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDADD](#), [LDADDA](#), [LDADDAL](#), [LDADDL](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# STADDB, STADDLB

Atomic add on byte in memory, without return, atomically loads an 8-bit byte from memory, adds the value held in a register to it, and stores the result back to memory.

- STADDB does not have release semantics.
  - STADDLB stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.
- For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDADDB, LDADDAB, LDADDALB, LDADDLB](#). This means:

- The encodings in this description are named to match the encodings of [LDADDB, LDADDAB, LDADDALB, LDADDLB](#).
- The description of [LDADDB, LDADDAB, LDADDALB, LDADDLB](#) gives the operational pseudocode for this instruction.

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	0	R	1	Rs				0	0	0	0	0	0	Rn				1	1	1	1	1		
size								A				opc								Rt											

### No memory ordering (R == 0)

STADDB <Ws>, [<Xn|SP>]

is equivalent to

[LDADDB](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### Release (R == 1)

STADDLB <Ws>, [<Xn|SP>]

is equivalent to

[LDADDLB](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDADDB, LDADDAB, LDADDALB, LDADDLB](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

# STADDH, STADDLH

Atomic add on halfword in memory, without return, atomically loads a 16-bit halfword from memory, adds the value held in a register to it, and stores the result back to memory.

- STADDH does not have release semantics.
  - STADDLH stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.
- For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDADDH, LDADDAH, LDADDALH, LDADDLH](#). This means:

- The encodings in this description are named to match the encodings of [LDADDH, LDADDAH, LDADDALH, LDADDLH](#).
- The description of [LDADDH, LDADDAH, LDADDALH, LDADDLH](#) gives the operational pseudocode for this instruction.

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	0	R	1	Rs				0	0	0	0	0	0	Rn				1	1	1	1	1		
size								A				opc								Rt											

### No memory ordering (R == 0)

STADDH <Ws>, [<Xn|SP>]

is equivalent to

[LDADDH](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### Release (R == 1)

STADDLH <Ws>, [<Xn|SP>]

is equivalent to

[LDADDLH](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDADDH, LDADDAH, LDADDALH, LDADDLH](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

# STCLR, STCLRL

Atomic bit clear on word or doubleword in memory, without return, atomically loads a 32-bit word or 64-bit doubleword from memory, performs a bitwise AND with the complement of the value held in a register on it, and stores the result back to memory.

- STCLR does not have release semantics.
  - STCLRL stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.
- For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDCLR, LDCLRA, LDCLRAL, LDCLRL](#). This means:

- The encodings in this description are named to match the encodings of [LDCLR, LDCLRA, LDCLRAL, LDCLRL](#).
- The description of [LDCLR, LDCLRA, LDCLRAL, LDCLRL](#) gives the operational pseudocode for this instruction.

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	0	0	R	1	Rs				0	0	0	1	0	0	Rn				1	1	1	1	1		
size								A				opc								Rt											

### 32-bit LDCLR alias (size == 10 && R == 0)

STCLR <Ws>, [<Xn|SP>]

is equivalent to

LDCLR <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### 32-bit LDCLRL alias (size == 10 && R == 1)

STCLRL <Ws>, [<Xn|SP>]

is equivalent to

LDCLRL <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### 64-bit LDCLR alias (size == 11 && R == 0)

STCLR <Xs>, [<Xn|SP>]

is equivalent to

LDCLR <Xs>, XZR, [<Xn|SP>]

and is always the preferred disassembly.

### 64-bit LDCLRL alias (size == 11 && R == 1)

STCLRL <Xs>, [<Xn|SP>]

is equivalent to

LDCLRL <Xs>, XZR, [<Xn|SP>]

and is always the preferred disassembly.

## Assembler Symbols

<Ws>	Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xs>	Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDCLR](#), [LDCLRA](#), [LDCLRAL](#), [LDCLRL](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# STCLRB, STCLRLB

Atomic bit clear on byte in memory, without return, atomically loads an 8-bit byte from memory, performs a bitwise AND with the complement of the value held in a register on it, and stores the result back to memory.

- STCLRB does not have release semantics.
  - STCLRLB stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.
- For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDCLRB, LDCLRAB, LDCLRALB, LDCLRLB](#). This means:

- The encodings in this description are named to match the encodings of [LDCLRB, LDCLRAB, LDCLRALB, LDCLRLB](#).
- The description of [LDCLRB, LDCLRAB, LDCLRALB, LDCLRLB](#) gives the operational pseudocode for this instruction.

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	0	R	1	Rs				0	0	0	1	0	0	Rn				1	1	1	1	1		
size								A				opc								Rt											

### No memory ordering (R == 0)

STCLRB <Ws>, [<Xn|SP>]

is equivalent to

[LDCLRB](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### Release (R == 1)

STCLRLB <Ws>, [<Xn|SP>]

is equivalent to

[LDCLRLB](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDCLRB, LDCLRAB, LDCLRALB, LDCLRLB](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.



# STCLR<sub>H</sub>, STCLR<sub>LH</sub>

Atomic bit clear on halfword in memory, without return, atomically loads a 16-bit halfword from memory, performs a bitwise AND with the complement of the value held in a register on it, and stores the result back to memory.

- STCLR<sub>H</sub> does not have release semantics.
  - STCLR<sub>LH</sub> stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.
- For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDCLR<sub>H</sub>](#), [LDCLR<sub>RAH</sub>](#), [LDCLR<sub>ALH</sub>](#), [LDCLR<sub>LH</sub>](#). This means:

- The encodings in this description are named to match the encodings of [LDCLR<sub>H</sub>](#), [LDCLR<sub>RAH</sub>](#), [LDCLR<sub>ALH</sub>](#), [LDCLR<sub>LH</sub>](#).
- The description of [LDCLR<sub>H</sub>](#), [LDCLR<sub>RAH</sub>](#), [LDCLR<sub>ALH</sub>](#), [LDCLR<sub>LH</sub>](#) gives the operational pseudocode for this instruction.

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	0	R	1	Rs				0	0	0	1	0	0	Rn				1	1	1	1	1		
size								A				opc								Rt											

### No memory ordering (R == 0)

STCLR<sub>H</sub> <Ws>, [[<Xn|SP>](#)]

is equivalent to

[LDCLR<sub>H</sub>](#) <Ws>, WZR, [[<Xn|SP>](#)]

and is always the preferred disassembly.

### Release (R == 1)

STCLR<sub>LH</sub> <Ws>, [[<Xn|SP>](#)]

is equivalent to

[LDCLR<sub>LH</sub>](#) <Ws>, WZR, [[<Xn|SP>](#)]

and is always the preferred disassembly.

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDCLR<sub>H</sub>](#), [LDCLR<sub>RAH</sub>](#), [LDCLR<sub>ALH</sub>](#), [LDCLR<sub>LH</sub>](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# STEOR, STEORL

Atomic exclusive OR on word or doubleword in memory, without return, atomically loads a 32-bit word or 64-bit doubleword from memory, performs an exclusive OR with the value held in a register on it, and stores the result back to memory.

- STEOR does not have release semantics.
- STEORL stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDEOR, LDEORA, LDEORAL, LDEORL](#). This means:

- The encodings in this description are named to match the encodings of [LDEOR, LDEORA, LDEORAL, LDEORL](#).
- The description of [LDEOR, LDEORA, LDEORAL, LDEORL](#) gives the operational pseudocode for this instruction.

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	0	0	R	1	Rs					0	0	1	0	0	0	Rn					1	1	1	1	1
size				A								opc										Rt									

### 32-bit LDEOR alias (size == 10 && R == 0)

STEOR <Ws>, [<Xn|SP>]

is equivalent to

LDEOR <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### 32-bit LDEORL alias (size == 10 && R == 1)

STEORL <Ws>, [<Xn|SP>]

is equivalent to

LDEORL <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### 64-bit LDEOR alias (size == 11 && R == 0)

STEOR <Xs>, [<Xn|SP>]

is equivalent to

LDEOR <Xs>, XZR, [<Xn|SP>]

and is always the preferred disassembly.

### 64-bit LDEORL alias (size == 11 && R == 1)

STEORL <Xs>, [<Xn|SP>]

is equivalent to

LDEORL <Xs>, XZR, [<Xn|SP>]

and is always the preferred disassembly.

## Assembler Symbols

<Ws>	Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xs>	Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDEOR](#), [LDEORA](#), [LDEORAL](#), [LDEORL](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# STEORB, STEORLB

Atomic exclusive OR on byte in memory, without return, atomically loads an 8-bit byte from memory, performs an exclusive OR with the value held in a register on it, and stores the result back to memory.

- STEORB does not have release semantics.
  - STEORLB stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.
- For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDEORB, LDEORAB, LDEORALB, LDEORLB](#). This means:

- The encodings in this description are named to match the encodings of [LDEORB, LDEORAB, LDEORALB, LDEORLB](#).
- The description of [LDEORB, LDEORAB, LDEORALB, LDEORLB](#) gives the operational pseudocode for this instruction.

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	0	1	1	1	0	0	0	0	R	1	Rs				0	0	1	0	0	0	Rn				1	1	1	1	1			
size								A				opc								Rt												

### No memory ordering (R == 0)

STEORB <Ws>, [<Xn|SP>]

is equivalent to

[LDEORB](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### Release (R == 1)

STEORLB <Ws>, [<Xn|SP>]

is equivalent to

[LDEORLB](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDEORB, LDEORAB, LDEORALB, LDEORLB](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

# STEORH, STEORLH

Atomic exclusive OR on halfword in memory, without return, atomically loads a 16-bit halfword from memory, performs an exclusive OR with the value held in a register on it, and stores the result back to memory.

- STEORH does not have release semantics.
- STEORLH stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDEORH, LDEORAH, LDEORALH, LDEORLH](#). This means:

- The encodings in this description are named to match the encodings of [LDEORH, LDEORAH, LDEORALH, LDEORLH](#).
- The description of [LDEORH, LDEORAH, LDEORALH, LDEORLH](#) gives the operational pseudocode for this instruction.

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	0	R	1	Rs				0	0	1	0	0	0	Rn				1	1	1	1	1		
size					A					opc										Rt											

### No memory ordering (R == 0)

STEORH <Ws>, [<Xn|SP>]

is equivalent to

LDEORH <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### Release (R == 1)

STEORLH <Ws>, [<Xn|SP>]

is equivalent to

LDEORLH <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

## Assembler Symbols

- <Ws>
- Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP>
- Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDEORH, LDEORAH, LDEORALH, LDEORLH](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

# STG

Store Allocation Tag stores an Allocation Tag to memory. The address used for the store is calculated from the base register and an immediate signed offset scaled by the Tag granule. The Allocation Tag is calculated from the Logical Address Tag in the source register.

This instruction generates an Unchecked access.

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Signed offset](#)

## Post-index (Armv8.5)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	0	0	1	imm9									0	1	Xn				Xt					

## Post-index

STG <Xt|SP>, [<Xn|SP>], #<sim>

```
integer n = UInt(Xn);
integer t = UInt(Xt);
bits(64) offset = LSL(SignExtend(imm9, 64), LOG2_TAG_GRANULE);
boolean writeback = TRUE;
boolean postindex = TRUE;
```

## Pre-index (Armv8.5)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	0	0	1	imm9									1	1	Xn				Xt					

## Pre-index

STG <Xt|SP>, [<Xn|SP>, #<sim>]!

```
integer n = UInt(Xn);
integer t = UInt(Xt);
bits(64) offset = LSL(SignExtend(imm9, 64), LOG2_TAG_GRANULE);
boolean writeback = TRUE;
boolean postindex = FALSE;
```

## Signed offset (Armv8.5)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	0	0	1	imm9									1	0	Xn				Xt					

## Signed offset

STG <Xt|SP>, [<Xn|SP>{, #<sim>}]

```
if !HaveMTEExt() then UNDEFINED;
integer n = UInt(Xn);
integer t = UInt(Xt);
bits(64) offset = LSL(SignExtend(imm9, 64), LOG2_TAG_GRANULE);
boolean writeback = FALSE;
boolean postindex = FALSE;
```

## Assembler Symbols

<Xt SP>	Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Xt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Xn" field.
<sim>	Is the optional signed immediate offset, a multiple of 16 in the range -4096 to 4080, defaulting to 0 and encoded in the "imm9" field.

## Operation

```
bits(64) address;  
  
SetTagCheckedInstruction(FALSE);  
  
if n == 31 then  
    CheckSPAlignment();  
    address = SP[];  
else  
    address = X[n];  
  
if !postindex then  
    address = address + offset;  
  
bits(64) data = if t == 31 then SP[] else X[t];  
bits(4) tag = AArch64.AllocationTagFromAddress(data);  
AArch64.MemTag[address, AccType\_NORMAL] = tag;  
  
if writeback then  
    if postindex then  
        address = address + offset;  
  
    if n == 31 then  
        SP[] = address;  
    else  
        X[n] = address;
```

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# STGM

Store Tag Multiple writes a naturally aligned block of N Allocation Tags, where the size of N is identified in GMID\_EL1.BS, and the Allocation Tag written to address A is taken from the source register at  $4 * A < 7:4 > + 3:4 * A < 7:4 >$ .

This instruction is UNDEFINED at EL0.

This instruction generates an Unchecked access.

If `ID_AA64PFR1_EL1.MTE` != 0b0010, this instruction is UNDEFINED.

## Integer (Armv8.5)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	Xn					Xt				

## Integer

```
STGM <Xt>, [<Xn|SP>]

if !HaveMTEExt() then UNDEFINED;
integer t = UInt(Xt);
integer n = UInt(Xn);
```

## Assembler Symbols

- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Xt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Xn" field.

## Operation

```
if PSTATE.EL == EL0 then
    UNDEFINED;

bits(64) data = X[t];
bits(64) address;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

integer size = 4 * (2 ^ (UInt(GMID_EL1.BS)));
address = Align(address, size);
integer count = size >> LOG2_TAG_GRANULE;
integer index = UInt(address < LOG2_TAG_GRANULE + 3: LOG2_TAG_GRANULE >);

for i = 0 to count-1
    bits(4) tag = data < (index*4)+3: index*4 >;
    AArch64.MemTag[address, AccType_NORMAL] = tag;
    address = address + TAG_GRANULE;
    index = index + 1;
```



## STGP

Store Allocation Tag and Pair of registers stores an Allocation Tag and two 64-bit doublewords to memory, from two registers. The address used for the store is calculated from the base register and an immediate signed offset scaled by the Tag granule. The Allocation Tag is calculated from the Logical Address Tag in the base register.

This instruction generates an Unchecked access.

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Signed offset](#)

### Post-index (Armv8.5)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	0	1	0	simm7							Xt2				Xn				Xt						

### Post-index

STGP <Xt1>, <Xt2>, [<Xn|SP>], #<imm>

```
integer n = UInt(Xn);
integer t = UInt(Xt);
integer t2 = UInt(Xt2);
bits(64) offset = LSL(SignExtend(simm7, 64), LOG2_TAG_GRANULE);
boolean writeback = TRUE;
boolean postindex = TRUE;
```

### Pre-index (Armv8.5)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	1	0	simm7							Xt2				Xn				Xt						

### Pre-index

STGP <Xt1>, <Xt2>, [<Xn|SP>, #<imm>]!

```
integer n = UInt(Xn);
integer t = UInt(Xt);
integer t2 = UInt(Xt2);
bits(64) offset = LSL(SignExtend(simm7, 64), LOG2_TAG_GRANULE);
boolean writeback = TRUE;
boolean postindex = FALSE;
```

### Signed offset (Armv8.5)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	1	0	0	simm7							Xt2				Xn				Xt						

### Signed offset

STGP <Xt1>, <Xt2>, [<Xn|SP>{, #<imm>}]

```
if !HaveMTEExt() then UNDEFINED;
integer n = UInt(Xn);
integer t = UInt(Xt);
integer t2 = UInt(Xt2);
bits(64) offset = LSL(SignExtend(simm7, 64), LOG2_TAG_GRANULE);
boolean writeback = FALSE;
boolean postindex = FALSE;
```

## Assembler Symbols

<Xt1>	Is the 64-bit name of the first general-purpose register to be transferred, encoded in the "Xt" field.
<Xt2>	Is the 64-bit name of the second general-purpose register to be transferred, encoded in the "Xt2" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Xn" field.
<imm>	For the post-index and pre-index variant: is the signed immediate offset, a multiple of 16 in the range -1024 to 1008, encoded in the "simm7" field.  For the signed offset variant: is the optional signed immediate offset, a multiple of 16 in the range -1024 to 1008, defaulting to 0 and encoded in the "simm7" field.

## Operation

```
bits(64) address;
bits(64) data1;
bits(64) data2;

SetTagCheckedInstruction(FALSE);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data1 = X[t];
data2 = X[t2];

if !postindex then
    address = address + offset;

Mem[address, 8, AccType_NORMAL] = data1;
Mem[address+8, 8, AccType_NORMAL] = data2;

AArch64.MemTag[address, AccType_NORMAL] = AArch64.AllocationTagFromAddress(address);

if writeback then
    if postindex then
        address = address + offset;

    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

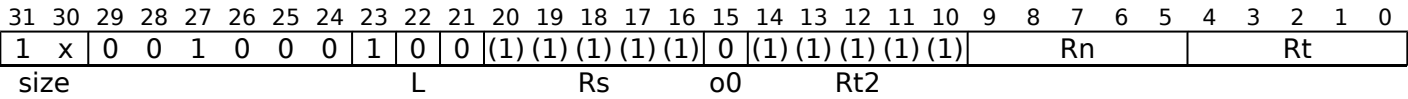
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STLLR

Store LORelease Register stores a 32-bit word or a 64-bit doubleword to a memory location, from a register. The instruction also has memory ordering semantics as described in *Load LOAcquire, Store LORelease*. For information about memory accesses, see *Load/Store addressing modes*.

No offset  
(Armv8.1)



32-bit (size == 10)

```
STLLR <Wt>, [<Xn|SP>{, #0}]
```

64-bit (size == 11)

```
STLLR <Xt>, [<Xn|SP>{, #0}]

integer n = UInt(Rn);
integer t = UInt(Rt);

integer elsize = 8 << UInt(size);
boolean tag_checked = n != 31;
```

Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Operation

```
bits(64) address;
bits(elsize) data;
constant integer dbytes = elsize DIV 8;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = X[t];
Mem[address, dbytes, AccType_LIMITEDORDERED] = data;
```

Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

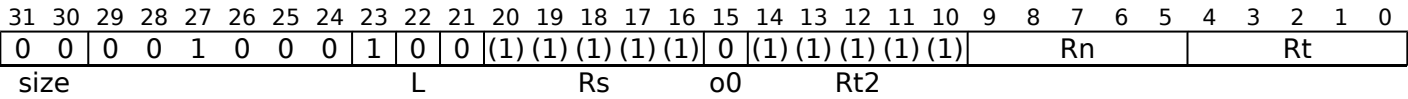
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STLLRB

Store LORelease Register Byte stores a byte from a 32-bit register to a memory location. The instruction also has memory ordering semantics as described in *Load LOAcquire, Store LORelease*. For information about memory accesses, see *Load/Store addressing modes*.

No offset  
(Armv8.1)



No offset

```
STLLRB <Wt>, [<Xn|SP>{, #0}]

integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Operation

```
bits(64) address;
bits(8) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = X[t];
Mem[address, 1, AccType_LIMITEDORDERED] = data;
```

Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

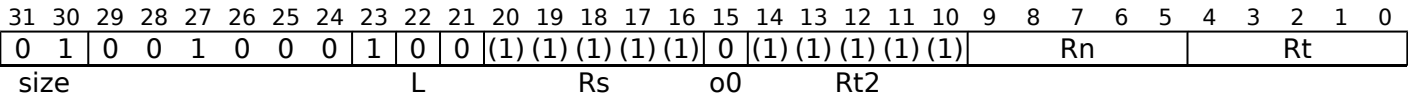
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STLLRH

Store LORelease Register Halfword stores a halfword from a 32-bit register to a memory location. The instruction also has memory ordering semantics as described in *Load LOAcquire, Store LORelease*. For information about memory accesses, see *Load/Store addressing modes*.

No offset  
(Armv8.1)



No offset

```
STLLRH <Wt>, [<Xn|SP>{, #0}]

integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Operation

```
bits(64) address;
bits(16) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = X[t];
Mem[address, 2, AccType_LIMITEDORDERED] = data;
```

Operational information

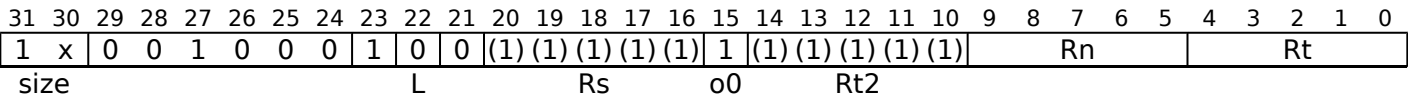
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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STLR

Store-Release Register stores a 32-bit word or a 64-bit doubleword to a memory location, from a register. The instruction also has memory ordering semantics as described in *Load-Acquire, Store-Release*. For information about memory accesses, see *Load/Store addressing modes*.



32-bit (size == 10)

```
STLR <Wt>, [<Xn|SP>{, #0}]
```

64-bit (size == 11)

```
STLR <Xt>, [<Xn|SP>{, #0}]
```

```
integer n = UInt(Rn);
integer t = UInt(Rt);

integer elsize = 8 << UInt(size);
boolean tag_checked = n != 31;
```

Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Operation

```
bits(64) address;
bits(elsize) data;
constant integer dbytes = elsize DIV 8;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

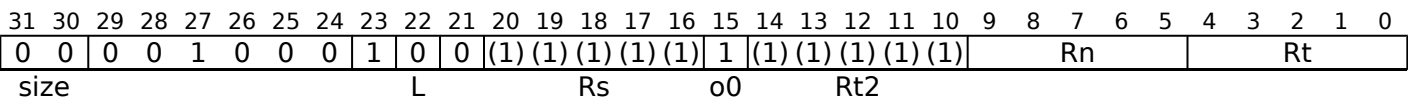
data = X[t];
Mem[address, dbytes, AccType_ORDERED] = data;
```

Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

STLRB

Store-Release Register Byte stores a byte from a 32-bit register to a memory location. The instruction also has memory ordering semantics as described in *Load-Acquire, Store-Release*. For information about memory accesses, see *Load/Store addressing modes*.



No offset

```
STLRB <Wt>, [<Xn|SP>{, #0}]

integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Operation

```
bits(64) address;
bits(8) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = X[t];
Mem[address, 1, AccType_ORDERED] = data;
```

Operational information

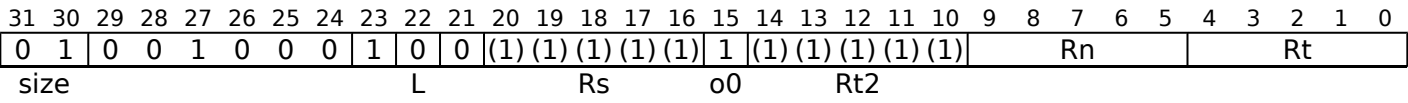
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# STLRH

Store-Release Register Halfword stores a halfword from a 32-bit register to a memory location. The instruction also has memory ordering semantics as described in *Load-Acquire, Store-Release*. For information about memory accesses, see *Load/Store addressing modes*.



## No offset

```
STLRH <Wt>, [<Xn|SP>{, #0}]

integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(16) data;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

data = X[t];
Mem[address, 2, AccType_ORDERED] = data;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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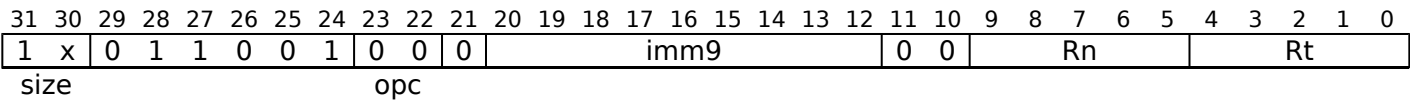
# STLUR

Store-Release Register (unscaled) calculates an address from a base register value and an immediate offset, and stores a 32-bit word or a 64-bit doubleword to the calculated address, from a register.

The instruction has memory ordering semantics as described in *Load-Acquire, Load-AcquirePC, and Store-Release*

For information about memory accesses, see *Load/Store addressing modes*.

## Unscaled offset (Armv8.4)



### 32-bit (size == 10)

```
STLUR <Wt>, [<Xn|SP>{, #<sim>}]
```

### 64-bit (size == 11)

```
STLUR <Xt>, [<Xn|SP>{, #<sim>}]
```

```
integer scale = UInt(size);
bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

integer datasize = 8 << scale;
boolean tag_checked = n != 31;
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(datasize) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = X[t];
Mem[address, datasize DIV 8, AccType_ORDERED] = data;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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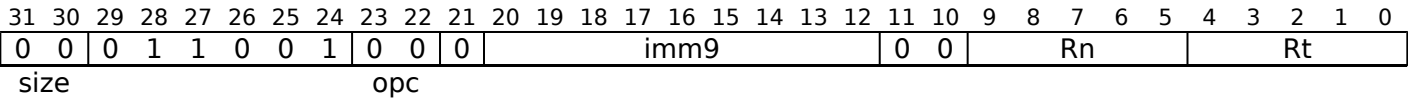
# STLURB

Store-Release Register Byte (unscaled) calculates an address from a base register value and an immediate offset, and stores a byte to the calculated address, from a 32-bit register.

The instruction has memory ordering semantics as described in *Load-Acquire, Load-AcquirePC, and Store-Release*

For information about memory accesses, see *Load/Store addressing modes*.

## Unscaled offset (Armv8.4)



## Unscaled offset

```
STLURB <Wt>, [<Xn|SP>{, #<simm>}]

bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <simm> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(8) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = X[t];
Mem[address, 1, AccType_ORDERED] = data;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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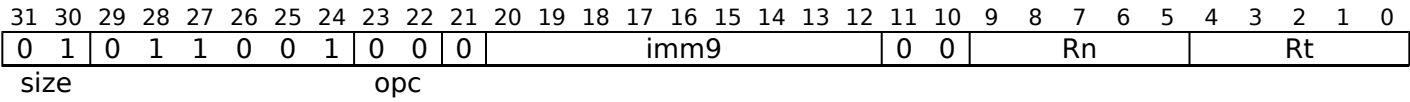
# STLURH

Store-Release Register Halfword (unscaled) calculates an address from a base register value and an immediate offset, and stores a halfword to the calculated address, from a 32-bit register.

The instruction has memory ordering semantics as described in *Load-Acquire, Load-AcquirePC, and Store-Release*

For information about memory accesses, see *Load/Store addressing modes*.

## Unscaled offset (Armv8.4)



## Unscaled offset

```
STLURH <Wt>, [<Xn|SP>{, #<simm>}]

bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <simm> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = n != 31;
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(16) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = X[t];
Mem[address, 2, AccType_ORDERED] = data;
```

## Operational information

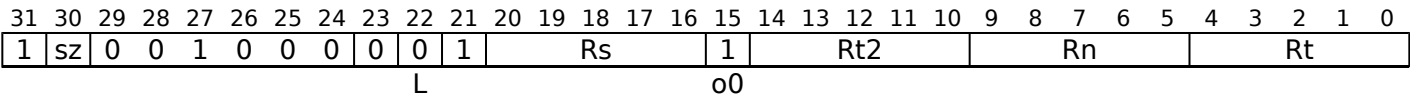
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# STLXP

Store-Release Exclusive Pair of registers stores two 32-bit words or two 64-bit doublewords to a memory location if the PE has exclusive access to the memory address, from two registers, and returns a status value of 0 if the store was successful, or of 1 if no store was performed. See [Synchronization and semaphores](#). A 32-bit pair requires the address to be doubleword aligned and is single-copy atomic at doubleword granularity. A 64-bit pair requires the address to be quadword aligned and, if the Store-Exclusive succeeds, it causes a single-copy atomic update of the 128-bit memory location being updated. The instruction also has memory ordering semantics as described in [Load-Acquire, Store-Release](#). For information about memory accesses see [Load/Store addressing modes](#).



## 32-bit (sz == 0)

STLXP <Ws>, <Wt1>, <Wt2>, [<Xn|SP>{, #0}]

## 64-bit (sz == 1)

STLXP <Ws>, <Xt1>, <Xt2>, [<Xn|SP>{, #0}]

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer t2 = UInt(Rt2);    // ignored by load/store single register
integer s = UInt(Rs);      // ignored by all loads and store-release

integer elsize = 32 << UInt(sz);
integer datasize = elsize * 2;
boolean tag_checked = n != 31;
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [STLXP](#).

## Assembler Symbols

- <Ws>

Is the 32-bit name of the general-purpose register into which the status result of the store exclusive is written, encoded in the "Rs" field. The value returned is:  
**0** If the operation updates memory.  
**1** If the operation fails to update memory.
- <Xt1>

Is the 64-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt2>

Is the 64-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
- <Wt1>

Is the 32-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
- <Wt2>

Is the 32-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
- <Xn|SP>

Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Aborts and alignment

If a synchronous Data Abort exception is generated by the execution of this instruction:

- Memory is not updated.
- <Ws> is not updated.

Accessing an address that is not aligned to the size of the data being accessed causes an Alignment fault Data Abort exception to be generated, subject to the following rules:

- If AArch64.ExclusiveMonitorsPass() returns TRUE, the exception is generated.
- Otherwise, it is IMPLEMENTATION DEFINED whether the exception is generated.

If AArch64.ExclusiveMonitorsPass() returns FALSE and the memory address, if accessed, would generate a synchronous Data Abort exception, it is IMPLEMENTATION DEFINED whether the exception is generated.

## Operation

```
bits(64) address;
bits(datasize) data;
constant integer dbytes = datasize DIV 8;
boolean rt_unknown = FALSE;
boolean rn_unknown = FALSE;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if s == t || (s == t2) then
    Constraint c = ConstrainUnpredictable(Unpredictable_DATAOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rt_unknown = TRUE;    // store UNKNOWN value
        when Constraint_NONE     rt_unknown = FALSE;   // store original value
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();
if s == n && n != 31 then
    Constraint c = ConstrainUnpredictable(Unpredictable_BASEOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rn_unknown = TRUE;    // address is UNKNOWN
        when Constraint_NONE     rn_unknown = FALSE;   // address is original base
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();

if n == 31 then
    CheckSPAlignment();
    address = SP[];
elsif rn_unknown then
    address = bits(64) UNKNOWN;
else
    address = X[n];

if rt_unknown then
    data = bits(datasize) UNKNOWN;
else
    bits(datasize DIV 2) el1 = X[t];
    bits(datasize DIV 2) el2 = X[t2];
    data = if BigEndian() then el1:el2 else el2:el1;
bit status = '1';
// Check whether the Exclusive monitors are set to include the
// physical memory locations corresponding to virtual address
// range [address, address+dbytes-1].
if AArch64.ExclusiveMonitorsPass(address, dbytes) then
    // This atomic write will be rejected if it does not refer
    // to the same physical locations after address translation.
    Mem[address, dbytes, AccType_ORDEREDATOMIC] = data;
    status = ExclusiveMonitorsStatus();
X[s] = ZeroExtend(status, 32);
```

## Operational information

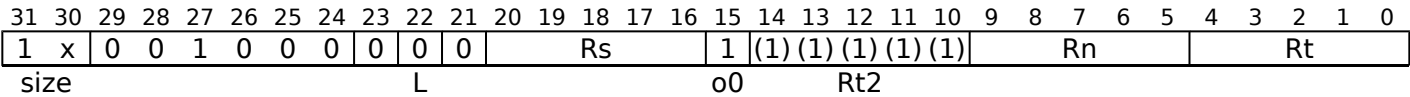
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# STLXR

Store-Release Exclusive Register stores a 32-bit word or a 64-bit doubleword to memory if the PE has exclusive access to the memory address, from two registers, and returns a status value of 0 if the store was successful, or of 1 if no store was performed. See *Synchronization and semaphores*. The memory access is atomic. The instruction also has memory ordering semantics as described in *Load-Acquire, Store-Release*. For information about memory accesses see *Load/Store addressing modes*.



## 32-bit (size == 10)

```
STLXR <Ws>, <Wt>, [<Xn|SP>{, #0}]
```

## 64-bit (size == 11)

```
STLXR <Ws>, <Xt>, [<Xn|SP>{, #0}]
```

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer s = UInt(Rs);    // ignored by all loads and store-release

integer elsize = 8 << UInt(size);
boolean tag_checked = n != 31;
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see *Architectural Constraints on UNPREDICTABLE behaviors*, and particularly *STLXR*.

## Assembler Symbols

- <Ws>

Is the 32-bit name of the general-purpose register into which the status result of the store exclusive is written, encoded in the "Rs" field. The value returned is:  
**0**  
If the operation updates memory.  
**1**  
If the operation fails to update memory.
- <Xt>

Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Wt>

Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP>

Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Aborts and alignment

If a synchronous Data Abort exception is generated by the execution of this instruction:

- Memory is not updated.
- <Ws> is not updated.

Accessing an address that is not aligned to the size of the data being accessed causes an Alignment fault Data Abort exception to be generated, subject to the following rules:

- If AArch64.ExclusiveMonitorsPass() returns TRUE, the exception is generated.
- Otherwise, it is IMPLEMENTATION DEFINED whether the exception is generated.

If AArch64.ExclusiveMonitorsPass() returns FALSE and the memory address, if accessed, would generate a synchronous Data Abort exception, it is IMPLEMENTATION DEFINED whether the exception is generated.

## Operation

```
bits(64) address;
bits(elsize) data;
constant integer dbytes = elsize DIV 8;
boolean rt_unknown = FALSE;
boolean rn_unknown = FALSE;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if s == t then
    Constraint c = ConstrainUnpredictable(Unpredictable_DATAOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rt_unknown = TRUE;    // store UNKNOWN value
        when Constraint_NONE     rt_unknown = FALSE;   // store original value
        when Constraint_UNDEF     UNDEFINED;
        when Constraint_NOP       EndOfInstruction();
if s == n && n != 31 then
    Constraint c = ConstrainUnpredictable(Unpredictable_BASEOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rn_unknown = TRUE;    // address is UNKNOWN
        when Constraint_NONE     rn_unknown = FALSE;   // address is original base
        when Constraint_UNDEF     UNDEFINED;
        when Constraint_NOP       EndOfInstruction();

if n == 31 then
    CheckSPAlignment();
    address = SP[];
elsif rn_unknown then
    address = bits(64) UNKNOWN;
else
    address = X[n];

if rt_unknown then
    data = bits(elsize) UNKNOWN;
else
    data = X[t];

bit status = '1';
// Check whether the Exclusives monitors are set to include the
// physical memory locations corresponding to virtual address
// range [address, address+dbytes-1].
if AArch64.ExclusiveMonitorsPass(address, dbytes) then
    // This atomic write will be rejected if it does not refer
    // to the same physical locations after address translation.
    Mem[address, dbytes, AccType_ORDEREDATOMIC] = data;
    status = ExclusiveMonitorsStatus();
X[s] = ZeroExtend(status, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

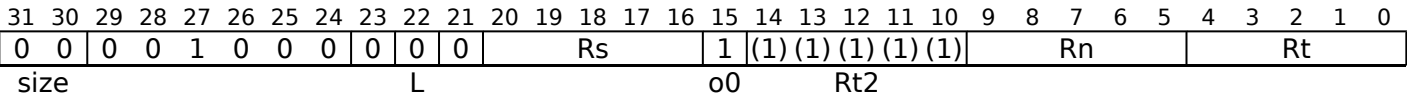
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STLXRB

Store-Release Exclusive Register Byte stores a byte from a 32-bit register to memory if the PE has exclusive access to the memory address, and returns a status value of 0 if the store was successful, or of 1 if no store was performed. See [Synchronization and semaphores](#). The memory access is atomic. The instruction also has memory ordering semantics as described in [Load-Acquire, Store-Release](#). For information about memory accesses see [Load/Store addressing modes](#).



No offset

```
STLXRB <Ws>, <Wt>, [<Xn|SP>{, #0}]

integer n = UInt(Rn);
integer t = UInt(Rt);
integer s = UInt(Rs);    // ignored by all loads and store-release

boolean tag_checked = n != 31;
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [STLXRB](#).

Assembler Symbols

- <Ws>

Is the 32-bit name of the general-purpose register into which the status result of the store exclusive is written, encoded in the "Rs" field. The value returned is:  
**0** If the operation updates memory.  
**1** If the operation fails to update memory.
- <Wt>

Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP>

Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Aborts

If a synchronous Data Abort exception is generated by the execution of this instruction:

- Memory is not updated.
- <Ws> is not updated.

If AArch64.ExclusiveMonitorsPass() returns FALSE and the memory address, if accessed, would generate a synchronous Data Abort exception, it is IMPLEMENTATION DEFINED whether the exception is generated.

## Operation

```
bits(64) address;
bits(8) data;
boolean rt_unknown = FALSE;
boolean rn_unknown = FALSE;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if s == t then
    Constraint c = ConstrainUnpredictable(Unpredictable_DATAOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rt_unknown = TRUE;    // store UNKNOWN value
        when Constraint_NONE     rt_unknown = FALSE;   // store original value
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();
if s == n && n != 31 then
    Constraint c = ConstrainUnpredictable(Unpredictable_BASEOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rn_unknown = TRUE;    // address is UNKNOWN
        when Constraint_NONE     rn_unknown = FALSE;   // address is original base
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();

if n == 31 then
    CheckSPAlignment();
    address = SP[];
elsif rn_unknown then
    address = bits(64) UNKNOWN;
else
    address = X[n];

if rt_unknown then
    data = bits(8) UNKNOWN;
else
    data = X[t];

bit status = '1';
// Check whether the Exclusives monitors are set to include the
// physical memory locations corresponding to virtual address
// range [address, address+dbytes-1].
if AArch64.ExclusiveMonitorsPass(address, 1) then
    // This atomic write will be rejected if it does not refer
    // to the same physical locations after address translation.
    Mem[address, 1, AccType_ORDEREDATOMIC] = data;
    status = ExclusiveMonitorsStatus();
X[s] = ZeroExtend(status, 32);
```

## Operational information

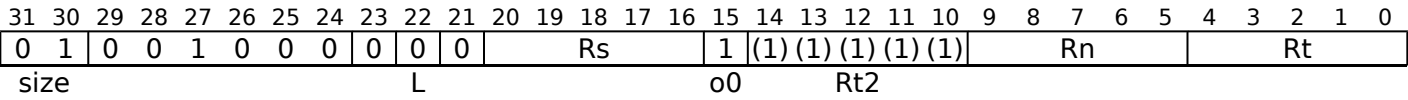
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# STLXRH

Store-Release Exclusive Register Halfword stores a halfword from a 32-bit register to memory if the PE has exclusive access to the memory address, and returns a status value of 0 if the store was successful, or of 1 if no store was performed. See [Synchronization and semaphores](#). The memory access is atomic. The instruction also has memory ordering semantics as described in [Load-Acquire, Store-Release](#). For information about memory accesses see [Load/Store addressing modes](#).



## No offset

```
STLXRH <Ws>, <Wt>, [<Xn|SP>{, #0}]

integer n = UInt(Rn);
integer t = UInt(Rt);
integer s = UInt(Rs);    // ignored by all loads and store-release

boolean tag_checked = n != 31;
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [STLXRH](#).

## Assembler Symbols

- <Ws>

Is the 32-bit name of the general-purpose register into which the status result of the store exclusive is written, encoded in the "Rs" field. The value returned is:  
**0** If the operation updates memory.  
**1** If the operation fails to update memory.
- <Wt>

Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP>

Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Aborts and alignment

If a synchronous Data Abort exception is generated by the execution of this instruction:

- Memory is not updated.
- <Ws> is not updated.

A non halfword-aligned memory address causes an Alignment fault Data Abort exception to be generated, subject to the following rules:

- If AArch64.ExclusiveMonitorsPass() returns TRUE, the exception is generated.
- Otherwise, it is IMPLEMENTATION DEFINED whether the exception is generated.

If AArch64.ExclusiveMonitorsPass() returns FALSE and the memory address, if accessed, would generate a synchronous Data Abort exception, it is IMPLEMENTATION DEFINED whether the exception is generated.

## Operation

```
bits(64) address;
bits(16) data;
boolean rt_unknown = FALSE;
boolean rn_unknown = FALSE;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if s == t then
    Constraint c = ConstrainUnpredictable(Unpredictable_DATAOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rt_unknown = TRUE;    // store UNKNOWN value
        when Constraint_NONE     rt_unknown = FALSE;   // store original value
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();
    if s == n && n != 31 then
        Constraint c = ConstrainUnpredictable(Unpredictable_BASEOVERLAP);
        assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
        case c of
            when Constraint_UNKNOWN rn_unknown = TRUE;    // address is UNKNOWN
            when Constraint_NONE     rn_unknown = FALSE;   // address is original base
            when Constraint_UNDEF    UNDEFINED;
            when Constraint_NOP      EndOfInstruction();

    if n == 31 then
        CheckSPAlignment();
        address = SP[];
    elsif rn_unknown then
        address = bits(64) UNKNOWN;
    else
        address = X[n];

    if rt_unknown then
        data = bits(16) UNKNOWN;
    else
        data = X[t];

    bit status = '1';
    // Check whether the Exclusives monitors are set to include the
    // physical memory locations corresponding to virtual address
    // range [address, address+dbytes-1].
    if AArch64.ExclusiveMonitorsPass(address, 2) then
        // This atomic write will be rejected if it does not refer
        // to the same physical locations after address translation.
        Mem[address, 2, AccType_ORDEREDATOMIC] = data;
        status = ExclusiveMonitorsStatus();
    X[s] = ZeroExtend(status, 32);
```

## Operational information

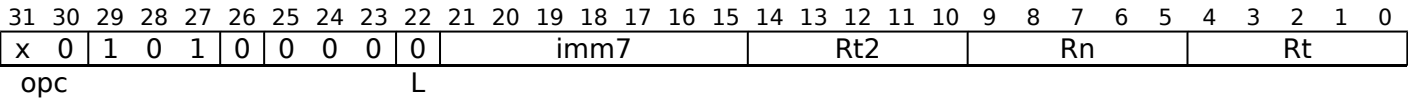
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# STNP

Store Pair of Registers, with non-temporal hint, calculates an address from a base register value and an immediate offset, and stores two 32-bit words or two 64-bit doublewords to the calculated address, from two registers. For information about memory accesses, see [Load/Store addressing modes](#). For information about Non-temporal pair instructions, see [Load/Store Non-temporal pair](#).



## 32-bit (opc == 00)

STNP <Wt1>, <Wt2>, [<Xn|SP>{, #<imm>}]

## 64-bit (opc == 10)

STNP <Xt1>, <Xt2>, [<Xn|SP>{, #<imm>}]

// Empty.

## Assembler Symbols

- <Wt1> Is the 32-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
- <Wt2> Is the 32-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
- <Xt1> Is the 64-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt2> Is the 64-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> For the 32-bit variant: is the optional signed immediate byte offset, a multiple of 4 in the range -256 to 252, defaulting to 0 and encoded in the "imm7" field as <imm>/4.  
For the 64-bit variant: is the optional signed immediate byte offset, a multiple of 8 in the range -512 to 504, defaulting to 0 and encoded in the "imm7" field as <imm>/8.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer t2 = UInt(Rt2);
if opc<0> == '1' then UNDEFINED;
integer scale = 2 + UInt(opc<1>);
integer datasize = 8 << scale;
bits(64) offset = LSL(SignExtend(imm7, 64), scale);
boolean tag_checked = n != 31;
```

## Operation

```
bits(64) address;
bits(datasize) data1;
bits(datasize) data2;
constant integer dbytes = datasize DIV 8;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data1 = X[t];
data2 = X[t2];
Mem[address, dbytes, AccType_STREAM] = data1;
Mem[address+dbytes, dbytes, AccType_STREAM] = data2;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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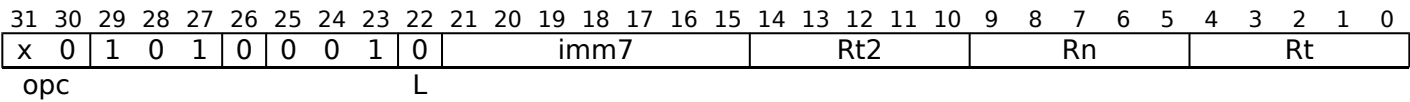
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# STP

Store Pair of Registers calculates an address from a base register value and an immediate offset, and stores two 32-bit words or two 64-bit doublewords to the calculated address, from two registers. For information about memory accesses, see [Load/Store addressing modes](#).

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Signed offset](#)

## Post-index



### 32-bit (opc == 00)

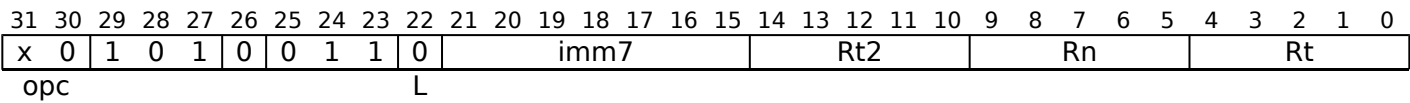
STP <Wt1>, <Wt2>, [<Xn|SP>], #<imm>

### 64-bit (opc == 10)

STP <Xt1>, <Xt2>, [<Xn|SP>], #<imm>

```
boolean wback = TRUE;
boolean postindex = TRUE;
```

## Pre-index



### 32-bit (opc == 00)

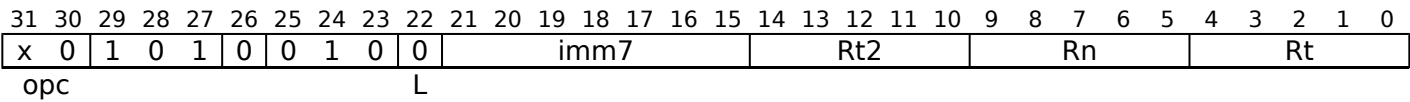
STP <Wt1>, <Wt2>, [<Xn|SP>, #<imm>]!

### 64-bit (opc == 10)

STP <Xt1>, <Xt2>, [<Xn|SP>, #<imm>]!

```
boolean wback = TRUE;
boolean postindex = FALSE;
```

## Signed offset



### 32-bit (opc == 00)

STP <Wt1>, <Wt2>, [<Xn|SP>{, #<imm>}]

### 64-bit (opc == 10)

STP <Xt1>, <Xt2>, [<Xn|SP>{, #<imm>}]

```
boolean wback = FALSE;
boolean postindex = FALSE;
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [STP](#).

## Assembler Symbols

<Wt1>	Is the 32-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
<Wt2>	Is the 32-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
<Xt1>	Is the 64-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
<Xt2>	Is the 64-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<imm>	<p>For the 32-bit post-index and 32-bit pre-index variant: is the signed immediate byte offset, a multiple of 4 in the range -256 to 252, encoded in the "imm7" field as &lt;imm&gt;/4.</p> <p>For the 32-bit signed offset variant: is the optional signed immediate byte offset, a multiple of 4 in the range -256 to 252, defaulting to 0 and encoded in the "imm7" field as &lt;imm&gt;/4.</p> <p>For the 64-bit post-index and 64-bit pre-index variant: is the signed immediate byte offset, a multiple of 8 in the range -512 to 504, encoded in the "imm7" field as &lt;imm&gt;/8.</p> <p>For the 64-bit signed offset variant: is the optional signed immediate byte offset, a multiple of 8 in the range -512 to 504, defaulting to 0 and encoded in the "imm7" field as &lt;imm&gt;/8.</p>

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer t2 = UInt(Rt2);
if L:opc<0> == '01' || opc == '11' then UNDEFINED;
integer scale = 2 + UInt(opc<1>);
integer datasize = 8 << scale;
bits(64) offset = LSL(SignExtend(imm7, 64), scale);
boolean tag_checked = wback || n != 31;
```



## Operation

```
bits(64) address;
bits(datasize) data1;
bits(datasize) data2;
constant integer dbytes = datasize DIV 8;
boolean rt_unknown = FALSE;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if wback && (t == n || t2 == n) && n != 31 then
    Constraint c = ConstrainUnpredictable(Unpredictable_WBOVERLAPST);
    assert c IN {Constraint_NONE, Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_NONE    rt_unknown = FALSE;    // value stored is pre-writeback
        when Constraint_UNKNOWN  rt_unknown = TRUE;     // value stored is UNKNOWN
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

if rt_unknown && t == n then
    data1 = bits(datasize) UNKNOWN;
else
    data1 = X[t];
if rt_unknown && t2 == n then
    data2 = bits(datasize) UNKNOWN;
else
    data2 = X[t2];
Mem[address, dbytes, AccType_NORMAL] = data1;
Mem[address+dbytes, dbytes, AccType_NORMAL] = data2;

if wback then
    if postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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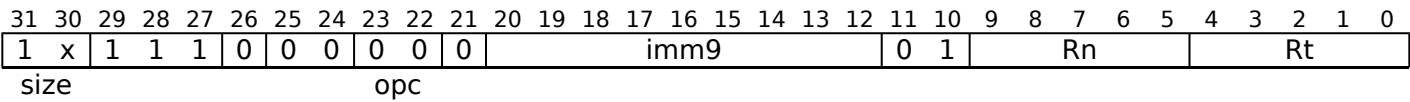
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# STR (immediate)

Store Register (immediate) stores a word or a doubleword from a register to memory. The address that is used for the store is calculated from a base register and an immediate offset. For information about memory accesses, see [Load/Store addressing modes](#).

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Unsigned offset](#)

## Post-index



### 32-bit (size == 10)

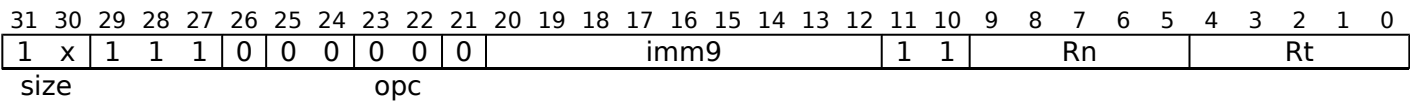
STR <Wt>, [<Xn|SP>], #<sim>

### 64-bit (size == 11)

STR <Xt>, [<Xn|SP>], #<sim>

```
boolean wback = TRUE;
boolean postindex = TRUE;
integer scale = UInt(size);
bits(64) offset = SignExtend(imm9, 64);
```

## Pre-index



### 32-bit (size == 10)

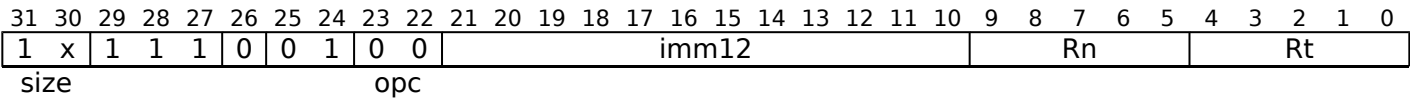
STR <Wt>, [<Xn|SP>, #<sim>]!

### 64-bit (size == 11)

STR <Xt>, [<Xn|SP>, #<sim>]!

```
boolean wback = TRUE;
boolean postindex = FALSE;
integer scale = UInt(size);
bits(64) offset = SignExtend(imm9, 64);
```

## Unsigned offset



### 32-bit (size == 10)

```
STR <Wt>, [<Xn|SP>{, #<pimm>}]
```

### 64-bit (size == 11)

```
STR <Xt>, [<Xn|SP>{, #<pimm>}]
```

```
boolean wback = FALSE;  
boolean postindex = FALSE;  
integer scale = UInt(size);  
bits(64) offset = LSL(ZeroExtend(imm12, 64), scale);
```

## Assembler Symbols

<Wt>	Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
<Xt>	Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<sim>	Is the signed immediate byte offset, in the range -256 to 255, encoded in the "imm9" field.
<pimm>	For the 32-bit variant: is the optional positive immediate byte offset, a multiple of 4 in the range 0 to 16380, defaulting to 0 and encoded in the "imm12" field as <pimm>/4. For the 64-bit variant: is the optional positive immediate byte offset, a multiple of 8 in the range 0 to 32760, defaulting to 0 and encoded in the "imm12" field as <pimm>/8.

## Shared Decode

```
integer n = UInt(Rn);  
integer t = UInt(Rt);  
  
integer datasize = 8 << scale;  
boolean tag_checked = wback || n != 31;
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(datasize) data;

boolean rt_unknown = FALSE;

if wback && n == t && n != 31 then
    c = ConstrainUnpredictable(Unpredictable_WBOVERLAPST);
    assert c IN {Constraint_NONE, Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_NONE    rt_unknown = FALSE;    // value stored is original value
        when Constraint_UNKNOWN  rt_unknown = TRUE;    // value stored is UNKNOWN
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

if rt_unknown then
    data = bits(datasize) UNKNOWN;
else
    data = X[t];
Mem[address, datasize DIV 8, AccType_NORMAL] = data;

if wback then
    if postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

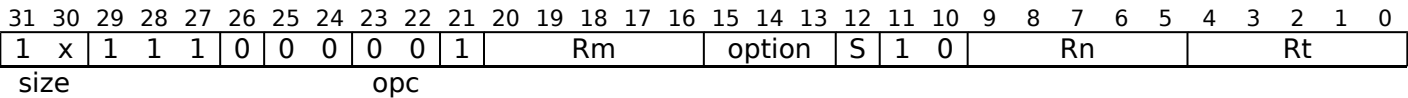
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STR (register)

Store Register (register) calculates an address from a base register value and an offset register value, and stores a 32-bit word or a 64-bit doubleword to the calculated address, from a register. For information about memory accesses, see [Load/Store addressing modes](#).

The instruction uses an offset addressing mode, that calculates the address used for the memory access from a base register value and an offset register value. The offset can be optionally shifted and extended.



32-bit (size == 10)

```
STR <Wt>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]
```

64-bit (size == 11)

```
STR <Xt>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]
```

```
integer scale = UInt(size);
if option<1> == '0' then UNDEFINED;    // sub-word index
ExtendType extend_type = DecodeRegExtend(option);
integer shift = if S == '1' then scale else 0;
```

Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Wm> When option<0> is set to 0, is the 32-bit name of the general-purpose index register, encoded in the "Rm" field.
- <Xm> When option<0> is set to 1, is the 64-bit name of the general-purpose index register, encoded in the "Rm" field.
- <extend> Is the index extend/shift specifier, defaulting to LSL, and which must be omitted for the LSL option when <amount> is omitted. encoded in "option":

option	<extend>
010	UXTW
011	LSL
110	SXTW
111	SCTX

- <amount> For the 32-bit variant: is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in "S":

S	<amount>
0	#0
1	#2

- For the 64-bit variant: is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in "S":

S	<amount>
0	#0
1	#3

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer m = UInt(Rm);

integer datasize = 8 << scale;
```

## Operation

```
bits(64) offset = ExtendReg(m, extend_type, shift);
if HaveMTEExt() then
    SetTagCheckedInstruction(TRUE);

bits(64) address;
bits(datasize) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = X[t];
Mem[address, datasize DIV 8, AccType_NORMAL] = data;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# STRB (immediate)

Store Register Byte (immediate) stores the least significant byte of a 32-bit register to memory. The address that is used for the store is calculated from a base register and an immediate offset. For information about memory accesses, see [Load/Store addressing modes](#).

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Unsigned offset](#)

## Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	0	0	0	imm9									0	1	Rn				Rt					
size										opc																					

## Post-index

```
STRB <Wt>, [<Xn|SP>], #<simm>

boolean wback = TRUE;
boolean postindex = TRUE;
bits(64) offset = SignExtend(imm9, 64);
```

## Pre-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	0	0	0	imm9									1	1	Rn				Rt					
size										opc																					

## Pre-index

```
STRB <Wt>, [<Xn|SP>, #<simm>]!

boolean wback = TRUE;
boolean postindex = FALSE;
bits(64) offset = SignExtend(imm9, 64);
```

## Unsigned offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	1	0	0	imm12												Rn				Rt					
size										opc																					

## Unsigned offset

```
STRB <Wt>, [<Xn|SP>{, #<pimm>}]

boolean wback = FALSE;
boolean postindex = FALSE;
bits(64) offset = LSL(ZeroExtend(imm12, 64), 0);
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [STRB \(immediate\)](#).

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <simm> Is the signed immediate byte offset, in the range -256 to 255, encoded in the "imm9" field.

<pimm> Is the optional positive immediate byte offset, in the range 0 to 4095, defaulting to 0 and encoded in the "imm12" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = wback || n != 31;
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(8) data;

boolean rt_unknown = FALSE;

if wback && n == t && n != 31 then
    c = ConstrainUnpredictable(Unpredictable_WBOVERLAPST);
    assert c IN {Constraint_NONE, Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_NONE    rt_unknown = FALSE;    // value stored is original value
        when Constraint_UNKNOWN rt_unknown = TRUE;     // value stored is UNKNOWN
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

if rt_unknown then
    data = bits(8) UNKNOWN;
else
    data = X[t];
Mem[address, 1, AccType_NORMAL] = data;

if wback then
    if postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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## STRB (register)

Store Register Byte (register) calculates an address from a base register value and an offset register value, and stores a byte from a 32-bit register to the calculated address. For information about memory accesses, see [Load/Store addressing modes](#).

The instruction uses an offset addressing mode, that calculates the address used for the memory access from a base register value and an offset register value. The offset can be optionally shifted and extended.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	0	0	1	Rm				option			S	1	0	Rn				Rt						
size											opc																				

### Extended register (option != 011)

STRB <Wt>, [<Xn|SP>, (<Wm>|<Xm>), <extend> {<amount>}]

### Shifted register (option == 011)

STRB <Wt>, [<Xn|SP>, <Xm>{, LSL <amount>}]

```
if option<1> == '0' then UNDEFINED; // sub-word index
ExtendType extend_type = DecodeRegExtend(option);
```

## Assembler Symbols

- <Wt>

Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP>

Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Wm>

When option<0> is set to 0, is the 32-bit name of the general-purpose index register, encoded in the "Rm" field.
- <Xm>

When option<0> is set to 1, is the 64-bit name of the general-purpose index register, encoded in the "Rm" field.
- <extend>

Is the index extend specifier, encoded in "option":

option	<extend>
010	UXTW
110	SXTW
111	SCTX
- <amount>

Is the index shift amount, it must be #0, encoded in "S" as 0 if omitted, or as 1 if present.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer m = UInt(Rm);
```

## Operation

```
bits(64) offset = ExtendReg(m, extend_type, 0);
if HaveMTEExt() then
    SetTagCheckedInstruction(TRUE);

bits(64) address;
bits(8) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = X[t];
Mem[address, 1, AccType_NORMAL] = data;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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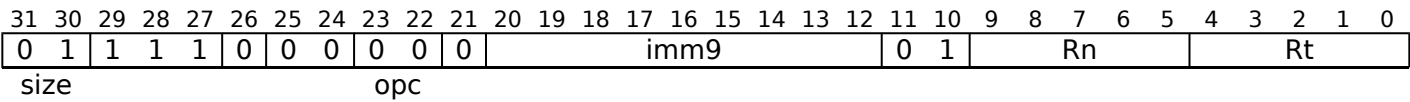
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# STRH (immediate)

Store Register Halfword (immediate) stores the least significant halfword of a 32-bit register to memory. The address that is used for the store is calculated from a base register and an immediate offset. For information about memory accesses, see [Load/Store addressing modes](#).

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Unsigned offset](#)

## Post-index

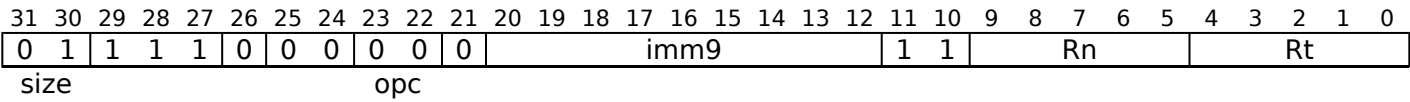


## Post-index

```
STRH <Wt>, [<Xn|SP>], #<simm>

boolean wback = TRUE;
boolean postindex = TRUE;
bits(64) offset = SignExtend(imm9, 64);
```

## Pre-index

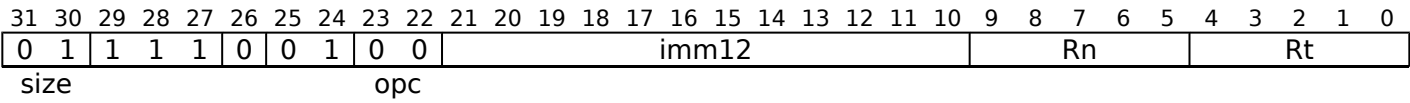


## Pre-index

```
STRH <Wt>, [<Xn|SP>, #<simm>]!

boolean wback = TRUE;
boolean postindex = FALSE;
bits(64) offset = SignExtend(imm9, 64);
```

## Unsigned offset



## Unsigned offset

```
STRH <Wt>, [<Xn|SP>{, #<pimm>}]

boolean wback = FALSE;
boolean postindex = FALSE;
bits(64) offset = LSL(ZeroExtend(imm12, 64), 1);
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [STRH \(immediate\)](#).

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <simm> Is the signed immediate byte offset, in the range -256 to 255, encoded in the "imm9" field.

<pimm> Is the optional positive immediate byte offset, a multiple of 2 in the range 0 to 8190, defaulting to 0 and encoded in the "imm12" field as <pimm>/2.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

boolean tag_checked = wback || n != 31;
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(16) data;

boolean rt_unknown = FALSE;

if wback && n == t && n != 31 then
    c = ConstrainUnpredictable(Unpredictable_WBOVERLAPST);
    assert c IN {Constraint_NONE, Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_NONE    rt_unknown = FALSE;    // value stored is original value
        when Constraint_UNKNOWN  rt_unknown = TRUE;     // value stored is UNKNOWN
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

if rt_unknown then
    data = bits(16) UNKNOWN;
else
    data = X[t];
Mem[address, 2, AccType_NORMAL] = data;

if wback then
    if postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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## STRH (register)

Store Register Halfword (register) calculates an address from a base register value and an offset register value, and stores a halfword from a 32-bit register to the calculated address. For information about memory accesses, see [Load/Store addressing modes](#).

The instruction uses an offset addressing mode, that calculates the address used for the memory access from a base register value and an offset register value. The offset can be optionally shifted and extended.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	0	0	1	Rm				option			S	1	0	Rn				Rt						
size											opc																				

### 32-bit

STRH <Wt>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]

```
if option<1> == '0' then UNDEFINED;    // sub-word index
ExtendType extend_type = DecodeRegExtend(option);
integer shift = if S == '1' then 1 else 0;
```

### Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Wm> When option<0> is set to 0, is the 32-bit name of the general-purpose index register, encoded in the "Rm" field.
- <Xm> When option<0> is set to 1, is the 64-bit name of the general-purpose index register, encoded in the "Rm" field.
- <extend> Is the index extend/shift specifier, defaulting to LSL, and which must be omitted for the LSL option when <amount> is omitted. encoded in "option":

option	<extend>
010	UXTW
011	LSL
110	SXTW
111	SCTX

- <amount> Is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in "S":

S	<amount>
0	#0
1	#1

### Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer m = UInt(Rm);
```

## Operation

```
bits(64) offset = ExtendReg(m, extend_type, shift);
if HaveMTEExt() then
    SetTagCheckedInstruction(TRUE);

bits(64) address;
bits(16) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = X[t];
Mem[address, 2, AccType_NORMAL] = data;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# STSET, STSETL

Atomic bit set on word or doubleword in memory, without return, atomically loads a 32-bit word or 64-bit doubleword from memory, performs a bitwise OR with the value held in a register on it, and stores the result back to memory.

- STSET does not have release semantics.
  - STSETL stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.
- For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDSET, LDSETA, LDSETAL, LDSETL](#). This means:

- The encodings in this description are named to match the encodings of [LDSET, LDSETA, LDSETAL, LDSETL](#).
- The description of [LDSET, LDSETA, LDSETAL, LDSETL](#) gives the operational pseudocode for this instruction.

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	0	0	R	1	Rs				0	0	1	1	0	0	Rn				1	1	1	1	1		
size				A				opc														Rt									

### 32-bit LDSET alias (size == 10 && R == 0)

STSET <Ws>, [<Xn|SP>]

is equivalent to

LDSET <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### 32-bit LDSETL alias (size == 10 && R == 1)

STSETL <Ws>, [<Xn|SP>]

is equivalent to

LDSETL <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### 64-bit LDSET alias (size == 11 && R == 0)

STSET <Xs>, [<Xn|SP>]

is equivalent to

LDSET <Xs>, XZR, [<Xn|SP>]

and is always the preferred disassembly.

### 64-bit LDSETL alias (size == 11 && R == 1)

STSETL <Xs>, [<Xn|SP>]

is equivalent to

LDSETL <Xs>, XZR, [<Xn|SP>]

and is always the preferred disassembly.

## Assembler Symbols

<Ws>	Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xs>	Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDSET](#), [LDSETA](#), [LDSETAL](#), [LDSETL](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# STSETB, STSETLB

Atomic bit set on byte in memory, without return, atomically loads an 8-bit byte from memory, performs a bitwise OR with the value held in a register on it, and stores the result back to memory.

- STSETB does not have release semantics.
  - STSETLB stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.
- For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDSETB, LDSETAB, LDSETALB, LDSETLB](#). This means:

- The encodings in this description are named to match the encodings of [LDSETB, LDSETAB, LDSETALB, LDSETLB](#).
- The description of [LDSETB, LDSETAB, LDSETALB, LDSETLB](#) gives the operational pseudocode for this instruction.

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	0	R	1	Rs				0	0	1	1	0	0	Rn				1	1	1	1	1		
size								A				opc								Rt											

### No memory ordering (R == 0)

STSETB <Ws>, [<Xn|SP>]

is equivalent to

[LDSETB](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### Release (R == 1)

STSETLB <Ws>, [<Xn|SP>]

is equivalent to

[LDSETLB](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDSETB, LDSETAB, LDSETALB, LDSETLB](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

# STSETH, STSETLH

Atomic bit set on halfword in memory, without return, atomically loads a 16-bit halfword from memory, performs a bitwise OR with the value held in a register on it, and stores the result back to memory.

- STSETH does not have release semantics.
  - STSETLH stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.
- For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDSETH, LDSETAH, LDSETALH, LDSETLH](#). This means:

- The encodings in this description are named to match the encodings of [LDSETH, LDSETAH, LDSETALH, LDSETLH](#).
- The description of [LDSETH, LDSETAH, LDSETALH, LDSETLH](#) gives the operational pseudocode for this instruction.

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	0	R	1	Rs				0	0	1	1	0	0	Rn				1	1	1	1	1		
size					A					opc										Rt											

### No memory ordering (R == 0)

STSETH *<Ws>*, [*<Xn|SP>*]  
is equivalent to  
[LDSETH](#) *<Ws>*, WZR, [*<Xn|SP>*]  
and is always the preferred disassembly.

### Release (R == 1)

STSETLH *<Ws>*, [*<Xn|SP>*]  
is equivalent to  
[LDSETLH](#) *<Ws>*, WZR, [*<Xn|SP>*]  
and is always the preferred disassembly.

## Assembler Symbols

- <Ws>* Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP>* Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDSETH, LDSETAH, LDSETALH, LDSETLH](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

# STSMAX, STSMAXL

Atomic signed maximum on word or doubleword in memory, without return, atomically loads a 32-bit word or 64-bit doubleword from memory, compares it against the value held in a register, and stores the larger value back to memory, treating the values as signed numbers.

- STSMAX does not have release semantics.
- STSMAXL stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDSMAX, LDSMAXA, LDSMAXAL, LDSMAXL](#). This means:

- The encodings in this description are named to match the encodings of [LDSMAX, LDSMAXA, LDSMAXAL, LDSMAXL](#).
- The description of [LDSMAX, LDSMAXA, LDSMAXAL, LDSMAXL](#) gives the operational pseudocode for this instruction.

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	0	0	R	1	Rs				0	1	0	0	0	0	Rn				1	1	1	1	1		
size				A								opc								Rt											

### 32-bit LDSMAX alias (size == 10 && R == 0)

STSMAX *<Ws>*, [*<Xn|SP>*]

is equivalent to

*LDSMAX* *<Ws>*, WZR, [*<Xn|SP>*]

and is always the preferred disassembly.

### 32-bit LDSMAXL alias (size == 10 && R == 1)

STSMAXL *<Ws>*, [*<Xn|SP>*]

is equivalent to

*LDSMAXL* *<Ws>*, WZR, [*<Xn|SP>*]

and is always the preferred disassembly.

### 64-bit LDSMAX alias (size == 11 && R == 0)

STSMAX *<Xs>*, [*<Xn|SP>*]

is equivalent to

*LDSMAX* *<Xs>*, XZR, [*<Xn|SP>*]

and is always the preferred disassembly.

### 64-bit LDSMAXL alias (size == 11 && R == 1)

STSMAXL *<Xs>*, [*<Xn|SP>*]

is equivalent to

*LDSMAXL* *<Xs>*, XZR, [*<Xn|SP>*]

and is always the preferred disassembly.

## Assembler Symbols

<Ws>	Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xs>	Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDSMAX](#), [LDSMAXA](#), [LDSMAXAL](#), [LDSMAXL](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# STSMAXB, STSMAXB

Atomic signed maximum on byte in memory, without return, atomically loads an 8-bit byte from memory, compares it against the value held in a register, and stores the larger value back to memory, treating the values as signed numbers.

- STSMAXB does not have release semantics.
  - STSMAXB stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.
- For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDSMAXB, LDSMAXAB, LDSMAXALB, LDSMAXLB](#). This means:

- The encodings in this description are named to match the encodings of [LDSMAXB, LDSMAXAB, LDSMAXALB, LDSMAXLB](#).
- The description of [LDSMAXB, LDSMAXAB, LDSMAXALB, LDSMAXLB](#) gives the operational pseudocode for this instruction.

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	0	R	1	Rs				0	1	0	0	0	0	Rn				1	1	1	1	1		
size				A								opc										Rt									

### No memory ordering (R == 0)

STSMAXB <Ws>, [<Xn|SP>]

is equivalent to

[LDSMAXB](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### Release (R == 1)

STSMAXB <Ws>, [<Xn|SP>]

is equivalent to

[LDSMAXLB](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDSMAXB, LDSMAXAB, LDSMAXALB, LDSMAXLB](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

# STSMAXH, STSMAXLH

Atomic signed maximum on halfword in memory, without return, atomically loads a 16-bit halfword from memory, compares it against the value held in a register, and stores the larger value back to memory, treating the values as signed numbers.

- STSMAXH does not have release semantics.
- STSMAXLH stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDSMAXH](#), [LDSMAXAH](#), [LDSMAXALH](#), [LDSMAXLH](#). This means:

- The encodings in this description are named to match the encodings of [LDSMAXH](#), [LDSMAXAH](#), [LDSMAXALH](#), [LDSMAXLH](#).
- The description of [LDSMAXH](#), [LDSMAXAH](#), [LDSMAXALH](#), [LDSMAXLH](#) gives the operational pseudocode for this instruction.

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	0	R	1			Rs			0	1	0	0	0	0			Rn			1	1	1	1	1
size								A				opc												Rt							

### No memory ordering (R == 0)

STSMAXH <Ws>, [<Xn|SP>]

is equivalent to

[LDSMAXH](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### Release (R == 1)

STSMAXLH <Ws>, [<Xn|SP>]

is equivalent to

[LDSMAXLH](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDSMAXH](#), [LDSMAXAH](#), [LDSMAXALH](#), [LDSMAXLH](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# STSMIN, STSMINL

Atomic signed minimum on word or doubleword in memory, without return, atomically loads a 32-bit word or 64-bit doubleword from memory, compares it against the value held in a register, and stores the smaller value back to memory, treating the values as signed numbers.

- STSMIN does not have release semantics.
- STSMINL stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDSMIN](#), [LDSMINA](#), [LDSMINAL](#), [LDSMINL](#). This means:

- The encodings in this description are named to match the encodings of [LDSMIN](#), [LDSMINA](#), [LDSMINAL](#), [LDSMINL](#).
- The description of [LDSMIN](#), [LDSMINA](#), [LDSMINAL](#), [LDSMINL](#) gives the operational pseudocode for this instruction.

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	0	0	R	1	Rs				0	1	0	1	0	0	Rn				1	1	1	1	1		
size				A				opc								Rt															

### 32-bit LDSMIN alias (size == 10 && R == 0)

STSMIN *<Ws>*, [*<Xn|SP>*]

is equivalent to

*LDSMIN* *<Ws>*, WZR, [*<Xn|SP>*]

and is always the preferred disassembly.

### 32-bit LDSMINL alias (size == 10 && R == 1)

STSMINL *<Ws>*, [*<Xn|SP>*]

is equivalent to

*LDSMINL* *<Ws>*, WZR, [*<Xn|SP>*]

and is always the preferred disassembly.

### 64-bit LDSMIN alias (size == 11 && R == 0)

STSMIN *<Xs>*, [*<Xn|SP>*]

is equivalent to

*LDSMIN* *<Xs>*, XZR, [*<Xn|SP>*]

and is always the preferred disassembly.

### 64-bit LDSMINL alias (size == 11 && R == 1)

STSMINL *<Xs>*, [*<Xn|SP>*]

is equivalent to

*LDSMINL* *<Xs>*, XZR, [*<Xn|SP>*]

and is always the preferred disassembly.

## Assembler Symbols

<Ws>	Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xs>	Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDSDMIN, LDSDMINA, LDSDMINAL, LDSDMINL](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# STSMINB, STSMINLB

Atomic signed minimum on byte in memory, without return, atomically loads an 8-bit byte from memory, compares it against the value held in a register, and stores the smaller value back to memory, treating the values as signed numbers.

- STSMINB does not have release semantics.
- STSMINLB stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDSMINB](#), [LDSMINAB](#), [LDSMINALB](#), [LDSMINLB](#). This means:

- The encodings in this description are named to match the encodings of [LDSMINB](#), [LDSMINAB](#), [LDSMINALB](#), [LDSMINLB](#).
- The description of [LDSMINB](#), [LDSMINAB](#), [LDSMINALB](#), [LDSMINLB](#) gives the operational pseudocode for this instruction.

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	0	R	1			Rs			0	1	0	1	0	0			Rn			1	1	1	1	1
size								A				opc																Rt			

### No memory ordering (R == 0)

STSMINB <Ws>, [<Xn|SP>]  
is equivalent to  
[LDSMINB](#) <Ws>, WZR, [<Xn|SP>]  
and is always the preferred disassembly.

### Release (R == 1)

STSMINLB <Ws>, [<Xn|SP>]  
is equivalent to  
[LDSMINLB](#) <Ws>, WZR, [<Xn|SP>]  
and is always the preferred disassembly.

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDSMINB](#), [LDSMINAB](#), [LDSMINALB](#), [LDSMINLB](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

# STSMINH, STSMINLH

Atomic signed minimum on halfword in memory, without return, atomically loads a 16-bit halfword from memory, compares it against the value held in a register, and stores the smaller value back to memory, treating the values as signed numbers.

- STSMINH does not have release semantics.
- STSMINLH stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDSMINH](#), [LDSMINAH](#), [LDSMINALH](#), [LDSMINLH](#). This means:

- The encodings in this description are named to match the encodings of [LDSMINH](#), [LDSMINAH](#), [LDSMINALH](#), [LDSMINLH](#).
- The description of [LDSMINH](#), [LDSMINAH](#), [LDSMINALH](#), [LDSMINLH](#) gives the operational pseudocode for this instruction.

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	0	R	1	Rs					0	1	0	1	0	0	Rn					1	1	1	1	1
size					A					opc										Rt											

### No memory ordering (R == 0)

STSMINH <Ws>, [<Xn|SP>]  
is equivalent to  
[LDSMINH](#) <Ws>, WZR, [<Xn|SP>]  
and is always the preferred disassembly.

### Release (R == 1)

STSMINLH <Ws>, [<Xn|SP>]  
is equivalent to  
[LDSMINLH](#) <Ws>, WZR, [<Xn|SP>]  
and is always the preferred disassembly.

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDSMINH](#), [LDSMINAH](#), [LDSMINALH](#), [LDSMINLH](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

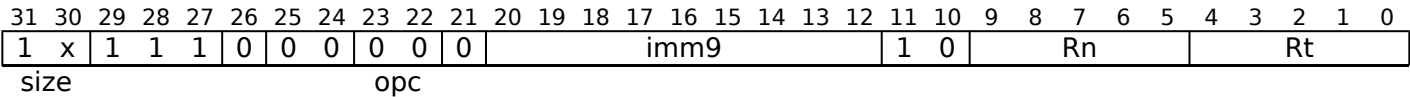
STTR

Store Register (unprivileged) stores a word or doubleword from a register to memory. The address that is used for the store is calculated from a base register and an immediate offset.

Memory accesses made by the instruction behave as if the instruction was executed at EL0 if the *Effective value* of PSTATE.UAO is 0 and either:

- The instruction is executed at EL1.
- The instruction is executed at EL2 when the *Effective value* of HCR\_EL2.{E2H, TGE} is {1, 1}.

Otherwise, the memory access operates with the restrictions determined by the Exception level at which the instruction is executed. For information about memory accesses, see *Load/Store addressing modes*.



32-bit (size == 10)

```
STTR <Wt>, [<Xn|SP>{, #<sim>}]
```

64-bit (size == 11)

```
STTR <Xt>, [<Xn|SP>{, #<sim>}]
```

```
integer scale = UInt(size);
bits(64) offset = SignExtend(imm9, 64);
```

Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

unpriv_at_el1 = PSTATE.EL == EL1 && !(EL2Enabled() && HaveNVExt() && HCR_EL2.<NV,NV1> == '11');
unpriv_at_el2 = PSTATE.EL == EL2 && HaveVirtHostExt() && HCR_EL2.<E2H,TGE> == '11';

user_access_override = HaveUA0Ext() && PSTATE.UAO == '1';
if !user_access_override && (unpriv_at_el1 || unpriv_at_el2) then
    acctype = AccType_UNPRIV;
else
    acctype = AccType_NORMAL;

integer datasize = 8 << scale;
boolean tag_checked = n != 31;
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(datasize) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = X[t];
Mem[address, datasize DIV 8, acctype] = data;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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## STTRB

Store Register Byte (unprivileged) stores a byte from a 32-bit register to memory. The address that is used for the store is calculated from a base register and an immediate offset.

Memory accesses made by the instruction behave as if the instruction was executed at EL0 if the *Effective value* of PSTATE.UAO is 0 and either:

- The instruction is executed at EL1.
- The instruction is executed at EL2 when the *Effective value* of *HCR\_EL2*.{E2H, TGE} is {1, 1}.

Otherwise, the memory access operates with the restrictions determined by the Exception level at which the instruction is executed. For information about memory accesses, see *Load/Store addressing modes*.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
0	0	1	1	1	0	0	0	0	0	0	imm9									1	0	Rn				Rt									
size										opc																									

### Unscaled offset

STTRB <Wt>, [<Xn|SP>{, #<sim>}]

```
bits(64) offset = SignExtend(imm9, 64);
```

### Assembler Symbols

<Wt>	Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<sim>	Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

### Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

unpriv_at_el1 = PSTATE.EL == EL1 && !(EL2Enabled() && HaveNVExt() && HCR_EL2.<NV,NV1> == '11');
unpriv_at_el2 = PSTATE.EL == EL2 && HaveVirtHostExt() && HCR_EL2.<E2H,TGE> == '11';

user_access_override = HaveUA0Ext() && PSTATE.UAO == '1';
if !user_access_override && (unpriv_at_el1 || unpriv_at_el2) then
    acctype = AccType_UNPRIV;
else
    acctype = AccType_NORMAL;

boolean tag_checked = n != 31;
```

### Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(8) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = X[t];
Mem[address, 1, acctype] = data;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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## STTRH

Store Register Halfword (unprivileged) stores a halfword from a 32-bit register to memory. The address that is used for the store is calculated from a base register and an immediate offset.

Memory accesses made by the instruction behave as if the instruction was executed at EL0 if the *Effective value* of PSTATE.UAO is 0 and either:

- The instruction is executed at EL1.
- The instruction is executed at EL2 when the *Effective value* of *HCR\_EL2*.{E2H, TGE} is {1, 1}.

Otherwise, the memory access operates with the restrictions determined by the Exception level at which the instruction is executed. For information about memory accesses, see *Load/Store addressing modes*.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	0	0	0	imm9									1	0	Rn				Rt					
size									opc																						

### Unscaled offset

STTRH <Wt>, [<Xn|SP>{, #<sim>}]

```
bits(64) offset = SignExtend(imm9, 64);
```

### Assembler Symbols

<Wt>	Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<sim>	Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

### Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

unpriv_at_el1 = PSTATE.EL == EL1 && !(EL2Enabled() && HaveNVExt() && HCR_EL2.<NV,NV1> == '11');
unpriv_at_el2 = PSTATE.EL == EL2 && HaveVirtHostExt() && HCR_EL2.<E2H,TGE> == '11';

user_access_override = HaveUA0Ext() && PSTATE.UAO == '1';
if !user_access_override && (unpriv_at_el1 || unpriv_at_el2) then
    acctype = AccType_UNPRIV;
else
    acctype = AccType_NORMAL;

boolean tag_checked = n != 31;
```

### Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(16) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = X[t];
Mem[address, 2, acctype] = data;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# STUMAX, STUMAXL

Atomic unsigned maximum on word or doubleword in memory, without return, atomically loads a 32-bit word or 64-bit doubleword from memory, compares it against the value held in a register, and stores the larger value back to memory, treating the values as unsigned numbers.

- STUMAX does not have release semantics.
- STUMAXL stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDUMAX, LDUMAXA, LDUMAXAL, LDUMAXL](#). This means:

- The encodings in this description are named to match the encodings of [LDUMAX, LDUMAXA, LDUMAXAL, LDUMAXL](#).
- The description of [LDUMAX, LDUMAXA, LDUMAXAL, LDUMAXL](#) gives the operational pseudocode for this instruction.

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	0	0	R	1					Rs	0	1	1	0	0	0				Rn		1	1	1	1	1
size								A								opc								Rt							

### 32-bit LDUMAX alias (size == 10 && R == 0)

STUMAX <Ws>, [[<Xn|SP>](#)]

is equivalent to

[LDUMAX](#) <Ws>, WZR, [[<Xn|SP>](#)]

and is always the preferred disassembly.

### 32-bit LDUMAXL alias (size == 10 && R == 1)

STUMAXL <Ws>, [[<Xn|SP>](#)]

is equivalent to

[LDUMAXL](#) <Ws>, WZR, [[<Xn|SP>](#)]

and is always the preferred disassembly.

### 64-bit LDUMAX alias (size == 11 && R == 0)

STUMAX <Xs>, [[<Xn|SP>](#)]

is equivalent to

[LDUMAX](#) <Xs>, XZR, [[<Xn|SP>](#)]

and is always the preferred disassembly.

### 64-bit LDUMAXL alias (size == 11 && R == 1)

STUMAXL <Xs>, [[<Xn|SP>](#)]

is equivalent to

[LDUMAXL](#) <Xs>, XZR, [[<Xn|SP>](#)]

and is always the preferred disassembly.

## Assembler Symbols

<Ws>	Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xs>	Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDUMAX, LDUMAXA, LDUMAXAL, LDUMAXL](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# STUMAXB, STUMAXB

Atomic unsigned maximum on byte in memory, without return, atomically loads an 8-bit byte from memory, compares it against the value held in a register, and stores the larger value back to memory, treating the values as unsigned numbers.

- STUMAXB does not have release semantics.
  - STUMAXB stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.
- For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDUMAXB, LDUMAXB, LDUMAXB, LDUMAXB](#). This means:

- The encodings in this description are named to match the encodings of [LDUMAXB, LDUMAXB, LDUMAXB, LDUMAXB](#).
- The description of [LDUMAXB, LDUMAXB, LDUMAXB, LDUMAXB](#) gives the operational pseudocode for this instruction.

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	0	R	1			Rs			0	1	1	0	0	0			Rn			1	1	1	1	1
size								A				opc								Rt											

### No memory ordering (R == 0)

STUMAXB <Ws>, [<Xn|SP>]

is equivalent to

[LDUMAXB](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### Release (R == 1)

STUMAXB <Ws>, [<Xn|SP>]

is equivalent to

[LDUMAXB](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDUMAXB, LDUMAXB, LDUMAXB, LDUMAXB](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

# STUMAXH, STUMAXLH

Atomic unsigned maximum on halfword in memory, without return, atomically loads a 16-bit halfword from memory, compares it against the value held in a register, and stores the larger value back to memory, treating the values as unsigned numbers.

- STUMAXH does not have release semantics.
- STUMAXLH stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDUMAXH](#), [LDUMAXAH](#), [LDUMAXALH](#), [LDUMAXLH](#). This means:

- The encodings in this description are named to match the encodings of [LDUMAXH](#), [LDUMAXAH](#), [LDUMAXALH](#), [LDUMAXLH](#).
- The description of [LDUMAXH](#), [LDUMAXAH](#), [LDUMAXALH](#), [LDUMAXLH](#) gives the operational pseudocode for this instruction.

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	0	R	1	Rs					0	1	1	0	0	0	Rn					1	1	1	1	1
size					A					opc															Rt						

### No memory ordering (R == 0)

STUMAXH <Ws>, [<Xn|SP>]

is equivalent to

[LDUMAXH](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### Release (R == 1)

STUMAXLH <Ws>, [<Xn|SP>]

is equivalent to

[LDUMAXLH](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDUMAXH](#), [LDUMAXAH](#), [LDUMAXALH](#), [LDUMAXLH](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

# STUMIN, STUMINL

Atomic unsigned minimum on word or doubleword in memory, without return, atomically loads a 32-bit word or 64-bit doubleword from memory, compares it against the value held in a register, and stores the smaller value back to memory, treating the values as unsigned numbers.

- STUMIN does not have release semantics.
- STUMINL stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDUMIN, LDUMINA, LDUMINAL, LDUMINL](#). This means:

- The encodings in this description are named to match the encodings of [LDUMIN, LDUMINA, LDUMINAL, LDUMINL](#).
- The description of [LDUMIN, LDUMINA, LDUMINAL, LDUMINL](#) gives the operational pseudocode for this instruction.

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	x	1	1	1	0	0	0	0	R	1	Rs				0	1	1	1	0	0	Rn				1	1	1	1	1		
size				A				opc								Rt															

### 32-bit LDUMIN alias (size == 10 && R == 0)

STUMIN <Ws>, [<Xn|SP>]

is equivalent to

[LDUMIN](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### 32-bit LDUMINL alias (size == 10 && R == 1)

STUMINL <Ws>, [<Xn|SP>]

is equivalent to

[LDUMINL](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### 64-bit LDUMIN alias (size == 11 && R == 0)

STUMIN <Xs>, [<Xn|SP>]

is equivalent to

[LDUMIN](#) <Xs>, XZR, [<Xn|SP>]

and is always the preferred disassembly.

### 64-bit LDUMINL alias (size == 11 && R == 1)

STUMINL <Xs>, [<Xn|SP>]

is equivalent to

[LDUMINL](#) <Xs>, XZR, [<Xn|SP>]

and is always the preferred disassembly.

## Assembler Symbols

<Ws>	Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xs>	Is the 64-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDUMIN](#), [LDUMINA](#), [LDUMINAL](#), [LDUMINL](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# STUMINB, STUMINLB

Atomic unsigned minimum on byte in memory, without return, atomically loads an 8-bit byte from memory, compares it against the value held in a register, and stores the smaller value back to memory, treating the values as unsigned numbers.

- STUMINB does not have release semantics.
- STUMINLB stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDUMINB, LDUMINAB, LDUMINALB, LDUMINLB](#). This means:

- The encodings in this description are named to match the encodings of [LDUMINB, LDUMINAB, LDUMINALB, LDUMINLB](#).
- The description of [LDUMINB, LDUMINAB, LDUMINALB, LDUMINLB](#) gives the operational pseudocode for this instruction.

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	0	R	1	Rs				0	1	1	1	0	0	Rn				1	1	1	1	1		
size				A								opc										Rt									

### No memory ordering (R == 0)

STUMINB <Ws>, [<Xn|SP>]

is equivalent to

[LDUMINB](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

### Release (R == 1)

STUMINLB <Ws>, [<Xn|SP>]

is equivalent to

[LDUMINLB](#) <Ws>, WZR, [<Xn|SP>]

and is always the preferred disassembly.

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDUMINB, LDUMINAB, LDUMINALB, LDUMINLB](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

# STUMINH, STUMINLH

Atomic unsigned minimum on halfword in memory, without return, atomically loads a 16-bit halfword from memory, compares it against the value held in a register, and stores the smaller value back to memory, treating the values as unsigned numbers.

- STUMINH does not have release semantics.
- STUMINLH stores to memory with release semantics, as described in *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

This is an alias of [LDUMINH, LDUMINAH, LDUMINALH, LDUMINLH](#). This means:

- The encodings in this description are named to match the encodings of [LDUMINH, LDUMINAH, LDUMINALH, LDUMINLH](#).
- The description of [LDUMINH, LDUMINAH, LDUMINALH, LDUMINLH](#) gives the operational pseudocode for this instruction.

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	0	R	1			Rs			0	1	1	1	0	0				Rn		1	1	1	1	1
size								A				opc										Rt									

### No memory ordering (R == 0)

STUMINH <Ws>, [<Xn|SP>]  
is equivalent to  
[LDUMINH](#) <Ws>, WZR, [<Xn|SP>]  
and is always the preferred disassembly.

### Release (R == 1)

STUMINLH <Ws>, [<Xn|SP>]  
is equivalent to  
[LDUMINLH](#) <Ws>, WZR, [<Xn|SP>]  
and is always the preferred disassembly.

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register holding the data value to be operated on with the contents of the memory location, encoded in the "Rs" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

The description of [LDUMINH, LDUMINAH, LDUMINALH, LDUMINLH](#) gives the operational pseudocode for this instruction.

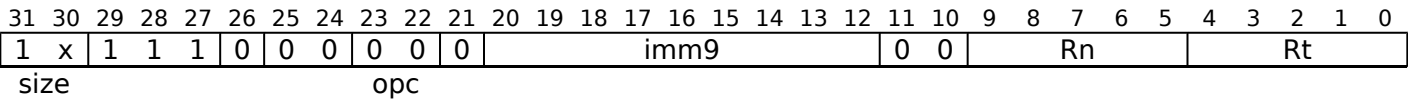
## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.



# STUR

Store Register (unscaled) calculates an address from a base register value and an immediate offset, and stores a 32-bit word or a 64-bit doubleword to the calculated address, from a register. For information about memory accesses, see [Load/Store addressing modes](#).



## 32-bit (size == 10)

```
STUR <Wt>, [<Xn|SP>{, #<sim>}]
```

## 64-bit (size == 11)

```
STUR <Xt>, [<Xn|SP>{, #<sim>}]
```

```
integer scale = UInt(size);
bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);

integer datasize = 8 << scale;
boolean tag_checked = n != 31;
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

bits(64) address;
bits(datasize) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data = X[t];
Mem[address, datasize DIV 8, AccType_NORMAL] = data;
```

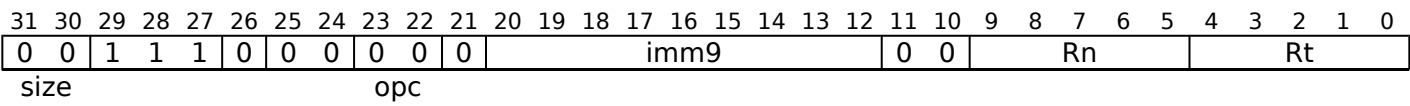
## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.



# STURB

Store Register Byte (unscaled) calculates an address from a base register value and an immediate offset, and stores a byte to the calculated address, from a 32-bit register. For information about memory accesses, see [Load/Store addressing modes](#).



## Unscaled offset

```
STURB <Wt>, [<Xn|SP>{, #<sim>}]  
  
bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);  
integer t = UInt(Rt);  
  
boolean tag_checked = n != 31;
```

## Operation

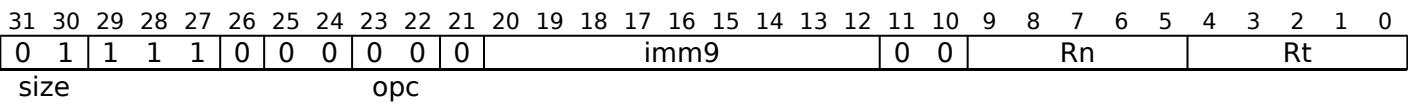
```
if HaveMTEExt() then  
    SetTagCheckedInstruction(tag_checked);  
  
bits(64) address;  
bits(8) data;  
  
if n == 31 then  
    CheckSPAlignment();  
    address = SP[];  
else  
    address = X[n];  
  
address = address + offset;  
  
data = X[t];  
Mem[address, 1, AccType_NORMAL] = data;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

# STURH

Store Register Halfword (unscaled) calculates an address from a base register value and an immediate offset, and stores a halfword to the calculated address, from a 32-bit register. For information about memory accesses, see [Load/Store addressing modes](#).



## Unscaled offset

```
STURH <Wt>, [<Xn|SP>{, #<sim>}]  
  
bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Wt> Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);  
integer t = UInt(Rt);  
  
boolean tag_checked = n != 31;
```

## Operation

```
if HaveMTEExt() then  
    SetTagCheckedInstruction(tag_checked);  
  
bits(64) address;  
bits(16) data;  
  
if n == 31 then  
    CheckSPAlignment();  
    address = SP[];  
else  
    address = X[n];  
  
address = address + offset;  
  
data = X[t];  
Mem[address, 2, AccType_NORMAL] = data;
```

## Operational information

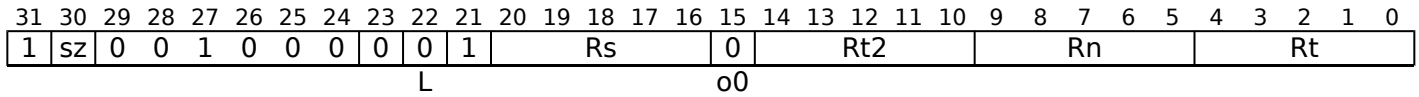
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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## STXP

Store Exclusive Pair of registers stores two 32-bit words or two 64-bit doublewords from two registers to a memory location if the PE has exclusive access to the memory address, and returns a status value of 0 if the store was successful, or of 1 if no store was performed. See [Synchronization and semaphores](#). A 32-bit pair requires the address to be doubleword aligned and is single-copy atomic at doubleword granularity. A 64-bit pair requires the address to be quadword aligned and, if the Store-Exclusive succeeds, it causes a single-copy atomic update of the 128-bit memory location being updated. For information about memory accesses see [Load/Store addressing modes](#).



### 32-bit (sz == 0)

STXP <Ws>, <Wt1>, <Wt2>, [<Xn|SP>{, #0}]

### 64-bit (sz == 1)

STXP <Ws>, <Xt1>, <Xt2>, [<Xn|SP>{, #0}]

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer t2 = UInt(Rt2);    // ignored by load/store single register
integer s = UInt(Rs);      // ignored by all loads and store-release

integer elsize = 32 << UInt(sz);
integer datasize = elsize * 2;
boolean tag_checked = n != 31;
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [STXP](#).

## Assembler Symbols

<Ws>	Is the 32-bit name of the general-purpose register into which the status result of the store exclusive is written, encoded in the "Rs" field. The value returned is: <b>0</b> If the operation updates memory. <b>1</b> If the operation fails to update memory.
<Xt1>	Is the 64-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
<Xt2>	Is the 64-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
<Wt1>	Is the 32-bit name of the first general-purpose register to be transferred, encoded in the "Rt" field.
<Wt2>	Is the 32-bit name of the second general-purpose register to be transferred, encoded in the "Rt2" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

### Aborts and alignment

If a synchronous Data Abort exception is generated by the execution of this instruction:

- Memory is not updated.
- <Ws> is not updated.

Accessing an address that is not aligned to the size of the data being accessed causes an Alignment fault Data Abort exception to be generated, subject to the following rules:

- If AArch64.ExclusiveMonitorsPass() returns TRUE, the exception is generated.
- Otherwise, it is IMPLEMENTATION DEFINED whether the exception is generated.

If AArch64.ExclusiveMonitorsPass() returns FALSE and the memory address, if accessed, would generate a synchronous Data Abort exception, it is IMPLEMENTATION DEFINED whether the exception is generated.

## Operation

```
bits(64) address;
bits(datasize) data;
constant integer dbytes = datasize DIV 8;
boolean rt_unknown = FALSE;
boolean rn_unknown = FALSE;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if s == t || (s == t2) then
    Constraint c = ConstrainUnpredictable(Unpredictable_DATAOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rt_unknown = TRUE;    // store UNKNOWN value
        when Constraint_NONE     rt_unknown = FALSE;   // store original value
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();
if s == n && n != 31 then
    Constraint c = ConstrainUnpredictable(Unpredictable_BASEOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rn_unknown = TRUE;    // address is UNKNOWN
        when Constraint_NONE     rn_unknown = FALSE;   // address is original base
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();

if n == 31 then
    CheckSPAlignment();
    address = SP[];
elsif rn_unknown then
    address = bits(64) UNKNOWN;
else
    address = X[n];

if rt_unknown then
    data = bits(datasize) UNKNOWN;
else
    bits(datasize DIV 2) el1 = X[t];
    bits(datasize DIV 2) el2 = X[t2];
    data = if BigEndian() then el1:el2 else el2:el1;
bit status = '1';
// Check whether the Exclusive monitors are set to include the
// physical memory locations corresponding to virtual address
// range [address, address+dbytes-1].
if AArch64.ExclusiveMonitorsPass(address, dbytes) then
    // This atomic write will be rejected if it does not refer
    // to the same physical locations after address translation.
    Mem[address, dbytes, AccType_ATOMIC] = data;
    status = ExclusiveMonitorsStatus();
X[s] = ZeroExtend(status, 32);
```

## Operational information

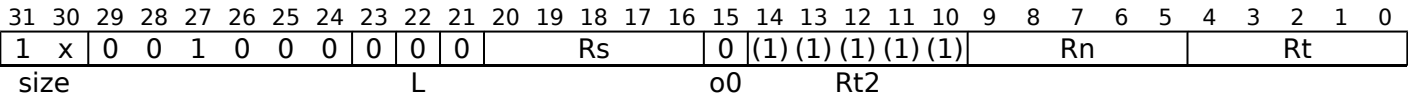
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# STXR

Store Exclusive Register stores a 32-bit word or a 64-bit doubleword from a register to memory if the PE has exclusive access to the memory address, and returns a status value of 0 if the store was successful, or of 1 if no store was performed. See [Synchronization and semaphores](#). For information about memory accesses see [Load/Store addressing modes](#).



## 32-bit (size == 10)

STXR <Ws>, <Wt>, [<Xn|SP>{, #0}]

## 64-bit (size == 11)

STXR <Ws>, <Xt>, [<Xn|SP>{, #0}]

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer s = UInt(Rs);    // ignored by all loads and store-release

integer elsize = 8 << UInt(size);
boolean tag_checked = n != 31;
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [STXR](#).

## Assembler Symbols

- <Ws>      Is the 32-bit name of the general-purpose register into which the status result of the store exclusive is written, encoded in the "Rs" field. The value returned is:  
0            If the operation updates memory.  
1            If the operation fails to update memory.
- <Xt>      Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Wt>      Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP>    Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Aborts and alignment

If a synchronous Data Abort exception is generated by the execution of this instruction:

- Memory is not updated.
- <Ws> is not updated.

Accessing an address that is not aligned to the size of the data being accessed causes an Alignment fault Data Abort exception to be generated, subject to the following rules:

- If AArch64.ExclusiveMonitorsPass() returns TRUE, the exception is generated.
- Otherwise, it is IMPLEMENTATION DEFINED whether the exception is generated.

If AArch64.ExclusiveMonitorsPass() returns FALSE and the memory address, if accessed, would generate a synchronous Data Abort exception, it is IMPLEMENTATION DEFINED whether the exception is generated.

## Operation

```
bits(64) address;
bits(elsize) data;
constant integer dbytes = elsize DIV 8;
boolean rt_unknown = FALSE;
boolean rn_unknown = FALSE;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if s == t then
    Constraint c = ConstrainUnpredictable(Unpredictable_DATAOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rt_unknown = TRUE;    // store UNKNOWN value
        when Constraint_NONE     rt_unknown = FALSE;   // store original value
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();
if s == n && n != 31 then
    Constraint c = ConstrainUnpredictable(Unpredictable_BASEOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rn_unknown = TRUE;    // address is UNKNOWN
        when Constraint_NONE     rn_unknown = FALSE;   // address is original base
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();

if n == 31 then
    CheckSPAlignment();
    address = SP[];
elsif rn_unknown then
    address = bits(64) UNKNOWN;
else
    address = X[n];

if rt_unknown then
    data = bits(elsize) UNKNOWN;
else
    data = X[t];

bit status = '1';
// Check whether the Exclusives monitors are set to include the
// physical memory locations corresponding to virtual address
// range [address, address+dbytes-1].
if AArch64.ExclusiveMonitorsPass(address, dbytes) then
    // This atomic write will be rejected if it does not refer
    // to the same physical locations after address translation.
    Mem[address, dbytes, AccType_ATOMIC] = data;
    status = ExclusiveMonitorsStatus();
X[s] = ZeroExtend(status, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# STXRB

Store Exclusive Register Byte stores a byte from a register to memory if the PE has exclusive access to the memory address, and returns a status value of 0 if the store was successful, or of 1 if no store was performed. See [Synchronization and semaphores](#). The memory access is atomic.

For information about memory accesses see [Load/Store addressing modes](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	1	0	0	0	0	0	0					Rs	0	(1)	(1)	(1)	(1)	(1)										
size								L				o0				Rt2						Rn						Rt			

## No offset

STXRB <Ws>, <Wt>, [<Xn|SP>{, #0}]

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer s = UInt(Rs);    // ignored by all loads and store-release

boolean tag_checked = n != 31;
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [STXRB](#).

## Assembler Symbols

- <Ws>

Is the 32-bit name of the general-purpose register into which the status result of the store exclusive is written, encoded in the "Rs" field. The value returned is:  
**0** If the operation updates memory.  
**1** If the operation fails to update memory.
- <Wt>

Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP>

Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Aborts

If a synchronous Data Abort exception is generated by the execution of this instruction:

- Memory is not updated.
- <Ws> is not updated.

If AArch64.ExclusiveMonitorsPass() returns FALSE and the memory address, if accessed, would generate a synchronous Data Abort exception, it is IMPLEMENTATION DEFINED whether the exception is generated.

## Operation

```
bits(64) address;
bits(8) data;
boolean rt_unknown = FALSE;
boolean rn_unknown = FALSE;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if s == t then
    Constraint c = ConstrainUnpredictable(Unpredictable_DATAOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rt_unknown = TRUE;    // store UNKNOWN value
        when Constraint_NONE     rt_unknown = FALSE;   // store original value
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();
if s == n && n != 31 then
    Constraint c = ConstrainUnpredictable(Unpredictable_BASEOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rn_unknown = TRUE;    // address is UNKNOWN
        when Constraint_NONE     rn_unknown = FALSE;   // address is original base
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();

if n == 31 then
    CheckSPAlignment();
    address = SP[];
elsif rn_unknown then
    address = bits(64) UNKNOWN;
else
    address = X[n];

if rt_unknown then
    data = bits(8) UNKNOWN;
else
    data = X[t];

bit status = '1';
// Check whether the Exclusives monitors are set to include the
// physical memory locations corresponding to virtual address
// range [address, address+dbytes-1].
if AArch64.ExclusiveMonitorsPass(address, 1) then
    // This atomic write will be rejected if it does not refer
    // to the same physical locations after address translation.
    Mem[address, 1, AccType_ATOMIC] = data;
    status = ExclusiveMonitorsStatus();
X[s] = ZeroExtend(status, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

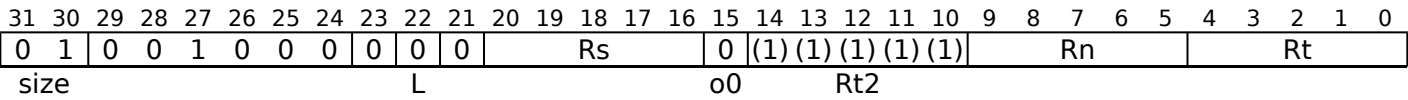
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# STXRH

Store Exclusive Register Halfword stores a halfword from a register to memory if the PE has exclusive access to the memory address, and returns a status value of 0 if the store was successful, or of 1 if no store was performed. See [Synchronization and semaphores](#). The memory access is atomic.

For information about memory accesses see [Load/Store addressing modes](#).



## No offset

```
STXRH <Ws>, <Wt>, [<Xn|SP>{, #0}]

integer n = UInt(Rn);
integer t = UInt(Rt);
integer s = UInt(Rs);    // ignored by all loads and store-release

boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws>

Is the 32-bit name of the general-purpose register into which the status result of the store exclusive is written, encoded in the "Rs" field. The value returned is:

0

If the operation updates memory.

1

If the operation fails to update memory.
- <Wt>

Is the 32-bit name of the general-purpose register to be transferred, encoded in the "Rt" field.
- <Xn|SP>

Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

Aborts and alignment

If a synchronous Data Abort exception is generated by the execution of this instruction:

- Memory is not updated.
- <Ws> is not updated.

A non halfword-aligned memory address causes an Alignment fault Data Abort exception to be generated, subject to the following rules:

- If AArch64.ExclusiveMonitorsPass() returns TRUE, the exception is generated.
- Otherwise, it is IMPLEMENTATION DEFINED whether the exception is generated.

If AArch64.ExclusiveMonitorsPass() returns FALSE and the memory address, if accessed, would generate a synchronous Data Abort exception, it is IMPLEMENTATION DEFINED whether the exception is generated.

## Operation

```
bits(64) address;
bits(16) data;
boolean rt_unknown = FALSE;
boolean rn_unknown = FALSE;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if s == t then
    Constraint c = ConstrainUnpredictable(Unpredictable_DATAOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rt_unknown = TRUE;    // store UNKNOWN value
        when Constraint_NONE     rt_unknown = FALSE;   // store original value
        when Constraint_UNDEF     UNDEFINED;
        when Constraint_NOP       EndOfInstruction();
if s == n && n != 31 then
    Constraint c = ConstrainUnpredictable(Unpredictable_BASEOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_NONE, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rn_unknown = TRUE;    // address is UNKNOWN
        when Constraint_NONE     rn_unknown = FALSE;   // address is original base
        when Constraint_UNDEF     UNDEFINED;
        when Constraint_NOP       EndOfInstruction();

if n == 31 then
    CheckSPAlignment();
    address = SP[];
elsif rn_unknown then
    address = bits(64) UNKNOWN;
else
    address = X[n];

if rt_unknown then
    data = bits(16) UNKNOWN;
else
    data = X[t];

bit status = '1';
// Check whether the Exclusives monitors are set to include the
// physical memory locations corresponding to virtual address
// range [address, address+dbytes-1].
if AArch64.ExclusiveMonitorsPass(address, 2) then
    // This atomic write will be rejected if it does not refer
    // to the same physical locations after address translation.
    Mem[address, 2, AccType_ATOMIC] = data;
    status = ExclusiveMonitorsStatus();
X[s] = ZeroExtend(status, 32);
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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## STZ2G

Store Allocation Tags, Zeroing stores an Allocation Tag to two Tag granules of memory, zeroing the associated data locations. The address used for the store is calculated from the base register and an immediate signed offset scaled by the Tag granule. The Allocation Tag is calculated from the Logical Address Tag in the source register.

This instruction generates an Unchecked access.

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Signed offset](#)

### Post-index (Armv8.5)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	1	1	1	imm9									0	1	Xn				Xt					

### Post-index

STZ2G <Xt|SP>, [<Xn|SP>], #<sim>

```
if !HaveMTEExt() then UNDEFINED;
integer n = UInt(Xn);
integer t = UInt(Xt);
bits(64) offset = LSL(SignExtend(imm9, 64), LOG2_TAG_GRANULE);
boolean writeback = TRUE;
boolean postindex = TRUE;
```

### Pre-index (Armv8.5)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	1	1	1	imm9									1	1	Xn				Xt					

### Pre-index

STZ2G <Xt|SP>, [<Xn|SP>, #<sim>]!

```
if !HaveMTEExt() then UNDEFINED;
integer n = UInt(Xn);
integer t = UInt(Xt);
bits(64) offset = LSL(SignExtend(imm9, 64), LOG2_TAG_GRANULE);
boolean writeback = TRUE;
boolean postindex = FALSE;
```

### Signed offset (Armv8.5)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	1	1	1	imm9									1	0	Xn				Xt					

### Signed offset

STZ2G <Xt|SP>, [<Xn|SP>{, #<sim>}]

```
if !HaveMTEExt() then UNDEFINED;
integer n = UInt(Xn);
integer t = UInt(Xt);
bits(64) offset = LSL(SignExtend(imm9, 64), LOG2_TAG_GRANULE);
boolean writeback = FALSE;
boolean postindex = FALSE;
```

## Assembler Symbols

<Xt SP>	Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Xt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Xn" field.
<sim>	Is the optional signed immediate offset, a multiple of 16 in the range -4096 to 4080, defaulting to 0 and encoded in the "imm9" field.

## Operation

```
bits(64) address;
bits(64) data = if t == 31 then SP[] else X[t];
bits(4) tag = AArch64.AllocationTagFromAddress(data);

SetTagCheckedInstruction(FALSE);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

Mem[address, TAG_GRANULE, AccType_NORMAL] = Zeros(8 * TAG_GRANULE);
Mem[address+TAG_GRANULE, TAG_GRANULE, AccType_NORMAL] = Zeros(8 * TAG_GRANULE);

AArch64.MemTag[address, AccType_NORMAL] = tag;
AArch64.MemTag[address+TAG_GRANULE, AccType_NORMAL] = tag;

if writeback then
    if postindex then
        address = address + offset;

    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

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# STZG

Store Allocation Tag, Zeroing stores an Allocation Tag to memory, zeroing the associated data location. The address used for the store is calculated from the base register and an immediate signed offset scaled by the Tag granule. The Allocation Tag is calculated from the Logical Address Tag in the source register.

This instruction generates an Unchecked access.

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Signed offset](#)

## Post-index (Armv8.5)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	0	1	1	imm9									0	1	Xn				Xt					

## Post-index

STZG <Xt|SP>, [<Xn|SP>], #<sim>

```
if !HaveMTEExt() then UNDEFINED;
integer n = UInt(Xn);
integer t = UInt(Xt);
bits(64) offset = LSL(SignExtend(imm9, 64), LOG2_TAG_GRANULE);
boolean writeback = TRUE;
boolean postindex = TRUE;
```

## Pre-index (Armv8.5)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	0	1	1	imm9									1	1	Xn				Xt					

## Pre-index

STZG <Xt|SP>, [<Xn|SP>, #<sim>]!

```
if !HaveMTEExt() then UNDEFINED;
integer n = UInt(Xn);
integer t = UInt(Xt);
bits(64) offset = LSL(SignExtend(imm9, 64), LOG2_TAG_GRANULE);
boolean writeback = TRUE;
boolean postindex = FALSE;
```

## Signed offset (Armv8.5)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	0	1	1	imm9									1	0	Xn				Xt					

## Signed offset

STZG <Xt|SP>, [<Xn|SP>{, #<sim>}]

```
if !HaveMTEExt() then UNDEFINED;
integer n = UInt(Xn);
integer t = UInt(Xt);
bits(64) offset = LSL(SignExtend(imm9, 64), LOG2_TAG_GRANULE);
boolean writeback = FALSE;
boolean postindex = FALSE;
```

## Assembler Symbols

<Xt SP>	Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Xt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Xn" field.
<sim>	Is the optional signed immediate offset, a multiple of 16 in the range -4096 to 4080, defaulting to 0 and encoded in the "imm9" field.

## Operation

```
bits(64) address;  
  
SetTagCheckedInstruction(FALSE);  
  
if n == 31 then  
    CheckSPAlignment();  
    address = SP[];  
else  
    address = X[n];  
  
if !postindex then  
    address = address + offset;  
  
Mem[address, TAG\_GRANULE, AccType\_NORMAL] = Zeros(TAG\_GRANULE * 8);  
  
bits(64) data = if t == 31 then SP[] else X[t];  
bits(4) tag = AArch64.AllocationTagFromAddress(data);  
AArch64.MemTag[address, AccType\_NORMAL] = tag;  
  
if writeback then  
    if postindex then  
        address = address + offset;  
  
    if n == 31 then  
        SP[] = address;  
    else  
        X[n] = address;
```

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# STZGM

Store Tag and Zero Multiple writes a naturally aligned block of N Allocation Tags and stores zero to the associated data locations, where the size of N is identified in DCZID\_EL0.BS, and the Allocation Tag written to address A is taken from the source register bits<3:0>.

This instruction is UNDEFINED at EL0.

This instruction generates an Unchecked access.

If *ID\_AA64PFR1\_EL1.MTE* != 0b0010, this instruction is UNDEFINED.

## Integer (Armv8.5)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	Xn					Xt				

## Integer

STZGM <Xt>, [<Xn|SP>]

```
if !HaveMTEExt() then UNDEFINED;
integer t = UInt(Xt);
integer n = UInt(Xn);
```

## Assembler Symbols

- <Xt> Is the 64-bit name of the general-purpose register to be transferred, encoded in the "Xt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Xn" field.

## Operation

```
if PSTATE.EL == EL0 then
    UNDEFINED;

bits(64) data = X[t];
bits(4) tag = data<3:0>;
bits(64) address;
if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

integer size = 4 * (2 ^ (UInt(DCZID_EL0.BS)));
address = Align(address, size);
integer count = size >> LOG2_TAG_GRANULE;

for i = 0 to count-1
    AArch64.MemTag[address, AccType_NORMAL] = tag;
    Mem[address, TAG_GRANULE, AccType_NORMAL] = Zeros(8 * TAG_GRANULE);
    address = address + TAG_GRANULE;
```

# SUB (extended register)

Subtract (extended register) subtracts a sign or zero-extended register value, followed by an optional left shift amount, from a register value, and writes the result to the destination register. The argument that is extended from the <Rm> register can be a byte, halfword, word, or doubleword.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	1	0	0	1	0	1	1	0	0	1	Rm				option			imm3			Rn				Rd						
op S																															

## 32-bit (sf == 0)

SUB <Wd|WSP>, <Wn|WSP>, <Wm>{, <extend> {#<amount>}}

## 64-bit (sf == 1)

SUB <Xd|SP>, <Xn|SP>, <R><m>{, <extend> {#<amount>}}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer dataSize = if sf == '1' then 64 else 32;
ExtendType extend_type = DecodeRegExtend(option);
integer shift = UInt(imm3);
if shift > 4 then UNDEFINED;
```

## Assembler Symbols

- <Wd|WSP>

Is the 32-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Wn|WSP>

Is the 32-bit name of the first source general-purpose register or stack pointer, encoded in the "Rn" field.
- <Wm>

Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd|SP>

Is the 64-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Xn|SP>

Is the 64-bit name of the first source general-purpose register or stack pointer, encoded in the "Rn" field.
- <R>

Is a width specifier, encoded in "option":

option	<R>
00x	W
010	W
x11	X
10x	W
110	W
- <m>

Is the number [0-30] of the second general-purpose source register or the name ZR (31), encoded in the "Rm" field.
- <extend>

For the 32-bit variant: is the extension to be applied to the second source operand, encoded in "option":

option	<extend>
000	UXTB
001	UXTH
010	LSL UXTW
011	UXTX
100	SXTB
101	SXTH
110	SXTW
111	SXTX

If "Rd" or "Rn" is '11111' (WSP) and "option" is '010' then LSL is preferred, but may be omitted when "imm3" is '000'. In all other cases <extend> is required and must be UXTW when "option" is '010'.

For the 64-bit variant: is the extension to be applied to the second source operand, encoded in “option”:

option	<extend>
000	UXTB
001	UXTH
010	UXTW
011	LSL UXTX
100	SXTB
101	SXTH
110	SXTW
111	SXTX

If "Rd" or "Rn" is '11111' (SP) and "option" is '011' then LSL is preferred, but may be omitted when "imm3" is '000'. In all other cases <extend> is required and must be UXTX when "option" is '011'.

<amount> Is the left shift amount to be applied after extension in the range 0 to 4, defaulting to 0, encoded in the "imm3" field. It must be absent when <extend> is absent, is required when <extend> is LSL, and is optional when <extend> is present but not LSL.

## Operation

```

bits(datasize) result;
bits(datasize) operand1 = if n == 31 then SP[] else X[n];
bits(datasize) operand2 = ExtendReg(m, extend_type, shift);

operand2 = NOT(operand2);
(result, -) = AddWithCarry(operand1, operand2, '1');

if d == 31 then
    SP[] = result;
else
    X[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

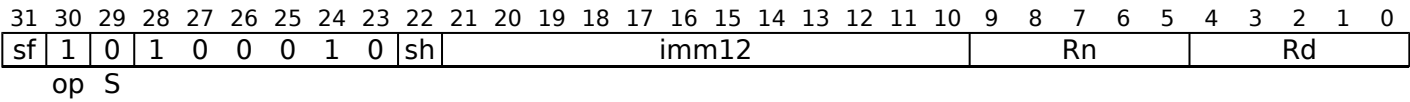
- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# SUB (immediate)

Subtract (immediate) subtracts an optionally-shifted immediate value from a register value, and writes the result to the destination register.



## 32-bit (sf == 0)

```
SUB <Wd|WSP>, <Wn|WSP>, #<imm>{, <shift>}
```

## 64-bit (sf == 1)

```
SUB <Xd|SP>, <Xn|SP>, #<imm>{, <shift>}
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer datasize = if sf == '1' then 64 else 32;
bits(datasize) imm;

case sh of
  when '0' imm = ZeroExtend(imm12, datasize);
  when '1' imm = ZeroExtend(imm12:Zeros(12), datasize);
```

## Assembler Symbols

- <Wd|WSP> Is the 32-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Wn|WSP> Is the 32-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.
- <Xd|SP> Is the 64-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Xn|SP> Is the 64-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.
- <imm> Is an unsigned immediate, in the range 0 to 4095, encoded in the "imm12" field.
- <shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #12

## Operation

```
bits(datasize) result;
bits(datasize) operand1 = if n == 31 then SP[] else X[n];
bits(datasize) operand2;

operand2 = NOT(imm);
(result, -) = AddWithCarry(operand1, operand2, '1');

if d == 31 then
  SP[] = result;
else
  X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.

- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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## SUB (shifted register)

Subtract (shifted register) subtracts an optionally-shifted register value from a register value, and writes the result to the destination register.

This instruction is used by the alias [NEG \(shifted register\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	1	0	0	1	0	1	1	shift	0	Rm						imm6						Rn						Rd			
op S																															

### 32-bit (sf == 0)

SUB <Wd>, <Wn>, <Wm>{, <shift> #<amount>}

### 64-bit (sf == 1)

SUB <Xd>, <Xn>, <Xm>{, <shift> #<amount>}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;

if shift == '11' then UNDEFINED;
if sf == '0' && imm6<5> == '1' then UNDEFINED;

ShiftType shift_type = DecodeShift(shift);
integer shift_amount = UInt(imm6);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <shift> Is the optional shift type to be applied to the second source operand, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	RESERVED

- <amount> For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.  
For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">NEG (shifted register)</a>	Rn == '11111'

## Operation

```
bits(datasize) result;  
bits(datasize) operand1 = X[n];  
bits(datasize) operand2 = ShiftReg(m, shift_type, shift_amount);  
  
operand2 = NOT(operand2);  
(result, -) = AddWithCarry(operand1, operand2, '1');  
  
X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

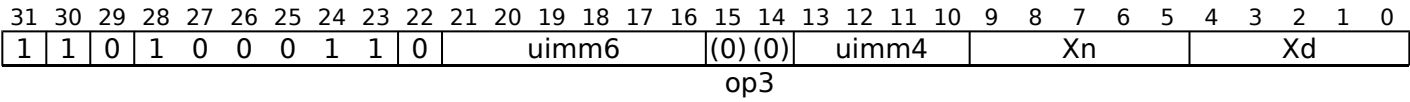
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# SUBG

Subtract with Tag subtracts an immediate value scaled by the Tag granule from the address in the source register, modifies the Logical Address Tag of the address using an immediate value, and writes the result to the destination register. Tags specified in GCR\_EL1.Exclude are excluded from the possible outputs when modifying the Logical Address Tag.

## Integer (Armv8.5)



## Integer

```
SUBG <Xd|SP>, <Xn|SP>, #<uimm6>, #<uimm4>

if !HaveMTEExt() then UNDEFINED;
integer d = UInt(Xd);
integer n = UInt(Xn);
bits(64) offset = LSL(ZeroExtend(uimm6, 64), LOG2_TAG_GRANULE);
```

## Assembler Symbols

- <Xd|SP> Is the 64-bit name of the destination general-purpose register or stack pointer, encoded in the "Xd" field.
- <Xn|SP> Is the 64-bit name of the source general-purpose register or stack pointer, encoded in the "Xn" field.
- <uimm6> Is an unsigned immediate, a multiple of 16 in the range 0 to 1008, encoded in the "uimm6" field.
- <uimm4> Is an unsigned immediate, in the range 0 to 15, encoded in the "uimm4" field.

## Operation

```
bits(64) operand1 = if n == 31 then SP[] else X[n];
bits(4) start_tag = AArch64.AllocationTagFromAddress(operand1);
bits(16) exclude = GCR_EL1.Exclude;
bits(64) result;
bits(4) rtag;

if AArch64.AllocationTagAccessIsEnabled(AccType_NORMAL) then
    rtag = AArch64.ChooseNonExcludedTag(start_tag, uimm4, exclude);
else
    rtag = '0000';

(result, -) = AddWithCarry(operand1, NOT(offset), '1');

result = AArch64.AddressWithAllocationTag(result, AccType_NORMAL, rtag);

if d == 31 then
    SP[] = result;
else
    X[d] = result;
```



# SUBP

Subtract Pointer subtracts the 56-bit address held in the second source register from the 56-bit address held in the first source register, sign-extends the result to 64-bits, and writes the result to the destination register.

## Integer (Armv8.5)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	1	0	1	0	1	1	0	Xm					0	0	0	0	0	0	Xn					Xd				

## Integer

SUBP <Xd>, <Xn|SP>, <Xm|SP>

```
integer d = UInt(Xd);
integer n = UInt(Xn);
integer m = UInt(Xm);
```

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Xd" field.
- <Xn|SP> Is the 64-bit name of the first source general-purpose register or stack pointer, encoded in the "Xn" field.
- <Xm|SP> Is the 64-bit name of the second general-purpose source register or stack pointer, encoded in the "Xm" field.

## Operation

```
bits(64) operand1 = if n == 31 then SP[] else X[n];
bits(64) operand2 = if m == 31 then SP[] else X[m];
operand1 = SignExtend(operand1<55:0>, 64);
operand2 = SignExtend(operand2<55:0>, 64);

bits(64) result;

operand2 = NOT(operand2);
(result, -) = AddWithCarry(operand1, operand2, '1');

X[d] = result;
```

# SUBPS

Subtract Pointer, setting Flags subtracts the 56-bit address held in the second source register from the 56-bit address held in the first source register, sign-extends the result to 64-bits, and writes the result to the destination register. It updates the condition flags based on the result of the subtraction.

This instruction is used by the alias [CMPP](#).

## Integer (Armv8.5)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	1	1	0	1	0	1	1	0	Xm				0	0	0	0	0	0	Xn				Xd						

## Integer

SUBPS <Xd>, <Xn|SP>, <Xm|SP>

```
integer d = UInt(Xd);
integer n = UInt(Xn);
integer m = UInt(Xm);
```

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Xd" field.
- <Xn|SP> Is the 64-bit name of the first source general-purpose register or stack pointer, encoded in the "Xn" field.
- <Xm|SP> Is the 64-bit name of the second general-purpose source register or stack pointer, encoded in the "Xm" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">CMPP</a>	S == '1' && Xd == '11111'

## Operation

```
bits(64) operand1 = if n == 31 then SP[] else X[n];
bits(64) operand2 = if m == 31 then SP[] else X[m];
operand1 = SignExtend(operand1<55:0>, 64);
operand2 = SignExtend(operand2<55:0>, 64);

bits(64) result;
bits(4) nzcvc;

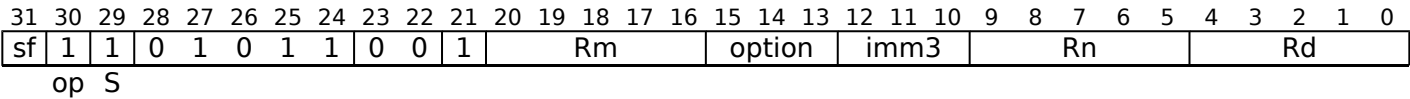
operand2 = NOT(operand2);
(result, nzcvc) = AddWithCarry(operand1, operand2, '1');

PSTATE.<N,Z,C,V> = nzcvc;
X[d] = result;
```

SUBS (extended register)

Subtract (extended register), setting flags, subtracts a sign or zero-extended register value, followed by an optional left shift amount, from a register value, and writes the result to the destination register. The argument that is extended from the <Rm> register can be a byte, halfword, word, or doubleword. It updates the condition flags based on the result.

This instruction is used by the alias [CMP \(extended register\)](#).



32-bit (sf == 0)

SUBS <Wd>, <Wn|WSP>, <Wm>{, <extend> {#<amount>}}

64-bit (sf == 1)

SUBS <Xd>, <Xn|SP>, <R><m>{, <extend> {#<amount>}}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
ExtendType extend_type = DecodeRegExtend(option);
integer shift = UInt(imm3);
if shift > 4 then UNDEFINED;
```

Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn|WSP> Is the 32-bit name of the first source general-purpose register or stack pointer, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn|SP> Is the 64-bit name of the first source general-purpose register or stack pointer, encoded in the "Rn" field.
- <R> Is a width specifier, encoded in "option":

option	<R>
00x	W
010	W
x11	X
10x	W
110	W

- <m> Is the number [0-30] of the second general-purpose source register or the name ZR (31), encoded in the "Rm" field.
- <extend> For the 32-bit variant: is the extension to be applied to the second source operand, encoded in "option":

option	<extend>
000	UXTB
001	UXTH
010	LSL UXTW
011	UXTX
100	SXTB
101	SXTH
110	SXTW
111	SXTX

If "Rn" is '11111' (WSP) and "option" is '010' then LSL is preferred, but may be omitted when "imm3" is '000'. In all other cases <extend> is required and must be UXTW when "option" is '010'.

For the 64-bit variant: is the extension to be applied to the second source operand, encoded in "option":

option	<extend>
000	UXTB
001	UXTH
010	UXTW
011	LSL UXTX
100	SXTB
101	SXTH
110	SXTW
111	SXTX

If "Rn" is '11111' (SP) and "option" is '011' then LSL is preferred, but may be omitted when "imm3" is '000'. In all other cases <extend> is required and must be UXTX when "option" is '011'.

<amount> Is the left shift amount to be applied after extension in the range 0 to 4, defaulting to 0, encoded in the "imm3" field. It must be absent when <extend> is absent, is required when <extend> is LSL, and is optional when <extend> is present but not LSL.

## Alias Conditions

Alias	Is preferred when
<a href="#">CMP (extended register)</a>	Rd == '11111'

## Operation

```

bits(datasize) result;
bits(datasize) operand1 = if n == 31 then SP[] else X[n];
bits(datasize) operand2 = ExtendReg(m, extend_type, shift);
bits(4) nzcvc;

operand2 = NOT(operand2);
(result, nzcvc) = AddWithCarry(operand1, operand2, '1');

PSTATE.<N,Z,C,V> = nzcvc;

X[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

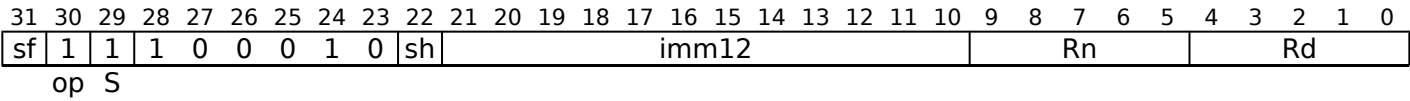
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# SUBS (immediate)

Subtract (immediate), setting flags, subtracts an optionally-shifted immediate value from a register value, and writes the result to the destination register. It updates the condition flags based on the result.

This instruction is used by the alias [CMP \(immediate\)](#).



## 32-bit (sf == 0)

SUBS <Wd>, <Wn|WSP>, #<imm>{, <shift>}

## 64-bit (sf == 1)

SUBS <Xd>, <Xn|SP>, #<imm>{, <shift>}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer datasize = if sf == '1' then 64 else 32;
bits(datasize) imm;

case sh of
  when '0' imm = ZeroExtend(imm12, datasize);
  when '1' imm = ZeroExtend(imm12:Zeros(12), datasize);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn|WSP> Is the 32-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn|SP> Is the 64-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.
- <imm> Is an unsigned immediate, in the range 0 to 4095, encoded in the "imm12" field.
- <shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #12

## Alias Conditions

Alias	Is preferred when
<a href="#">CMP (immediate)</a>	Rd == '11111'

## Operation

```
bits(datasize) result;
bits(datasize) operand1 = if n == 31 then SP[] else X[n];
bits(datasize) operand2;
bits(4) nzcvc;

operand2 = NOT(imm);
(result, nzcvc) = AddWithCarry(operand1, operand2, '1');

PSTATE.<N,Z,C,V> = nzcvc;

X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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## SUBS (shifted register)

Subtract (shifted register), setting flags, subtracts an optionally-shifted register value from a register value, and writes the result to the destination register. It updates the condition flags based on the result.

This instruction is used by the aliases [CMP \(shifted register\)](#), and [NEGS](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	1	1	0	1	0	1	1	shift	0	Rm						imm6						Rn						Rd			
op S																															

### 32-bit (sf == 0)

SUBS <Wd>, <Wn>, <Wm>{, <shift> #<amount>}

### 64-bit (sf == 1)

SUBS <Xd>, <Xn>, <Xm>{, <shift> #<amount>}

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;

if shift == '11' then UNDEFINED;
if sf == '0' && imm6<5> == '1' then UNDEFINED;

ShiftType shift_type = DecodeShift(shift);
integer shift_amount = UInt(imm6);
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <shift> Is the optional shift type to be applied to the second source operand, defaulting to LSL and encoded in "shift":

shift	<shift>
00	LSL
01	LSR
10	ASR
11	RESERVED

- <amount> For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.  
For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">CMP (shifted register)</a>	Rd == '11111'
<a href="#">NEGS</a>	Rn == '11111'

## Operation

```
bits(datasize) result;  
bits(datasize) operand1 = X[n];  
bits(datasize) operand2 = ShiftReg(m, shift_type, shift_amount);  
bits(4) nzcvc;  
  
operand2 = NOT(operand2);  
(result, nzcvc) = AddWithCarry(operand1, operand2, '1');  
  
PSTATE.<N,Z,C,V> = nzcvc;  
  
X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# SVC

Supervisor Call causes an exception to be taken to EL1.  
On executing an SVC instruction, the PE records the exception as a Supervisor Call exception in *ESR\_ELx*, using the EC value 0x15, and the value of the immediate argument.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	0	0	0	0	imm16																0	0	0	0	1

## System

```
SVC #<imm>
// Empty.
```

## Assembler Symbols

<imm> Is a 16-bit unsigned immediate, in the range 0 to 65535, encoded in the "imm16" field.

## Operation

```
AArch64.CheckForSVCTrap(imm16);
AArch64.CallSupervisor(imm16);
```

# SWP, SWPA, SWPAL, SWPL

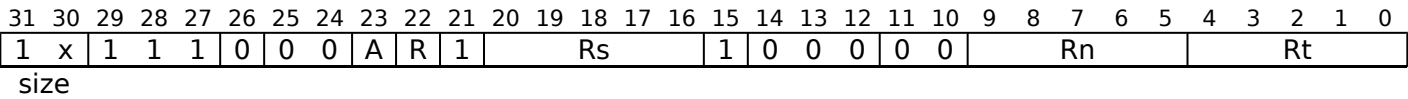
Swap word or doubleword in memory atomically loads a 32-bit word or 64-bit doubleword from a memory location, and stores the value held in a register back to the same memory location. The value initially loaded from memory is returned in the destination register.

- If the destination register is not one of WZR or XZR, SWPA and SWPAL load from memory with acquire semantics.
- SWPL and SWPAL store to memory with release semantics.
- SWP has neither acquire nor release semantics.

For more information about memory ordering semantics see *Load-Acquire, Store-Release*.

For information about memory accesses see *Load/Store addressing modes*.

## Integer (Armv8.1)



### 32-bit SWP (size == 10 && A == 0 && R == 0)

SWP <Ws>, <Wt>, [<Xn|SP>]

### 32-bit SWPA (size == 10 && A == 1 && R == 0)

SWPA <Ws>, <Wt>, [<Xn|SP>]

### 32-bit SWPAL (size == 10 && A == 1 && R == 1)

SWPAL <Ws>, <Wt>, [<Xn|SP>]

### 32-bit SWPL (size == 10 && A == 0 && R == 1)

SWPL <Ws>, <Wt>, [<Xn|SP>]

### 64-bit SWP (size == 11 && A == 0 && R == 0)

SWP <Xs>, <Xt>, [<Xn|SP>]

### 64-bit SWPA (size == 11 && A == 1 && R == 0)

SWPA <Xs>, <Xt>, [<Xn|SP>]

### 64-bit SWPAL (size == 11 && A == 1 && R == 1)

SWPAL <Xs>, <Xt>, [<Xn|SP>]

### 64-bit SWPL (size == 11 && A == 0 && R == 1)

SWPL <Xs>, <Xt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;
```

```
integer t = UInt(Rt);  
integer n = UInt(Rn);  
integer s = UInt(Rs);
```

```
integer datasize = 8 << UInt(size);  
integer regsize = if datasize == 64 then 64 else 32;  
AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;  
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;  
boolean tag_checked = n != 31;
```

## Assembler Symbols

<Ws>	Is the 32-bit name of the general-purpose register to be stored, encoded in the "Rs" field.
<Wt>	Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
<Xs>	Is the 64-bit name of the general-purpose register to be stored, encoded in the "Rs" field.
<Xt>	Is the 64-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(datasize) data;
bits(datasize) store_value;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

store_value = X[s];
data = MemAtomic(address, MemAtomicOp_SWP, store_value, ldacctype, stacctype);
X[t] = ZeroExtend(data, regsize);
```

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# SWPB, SWPAB, SWPALB, SWPLB

Swap byte in memory atomically loads an 8-bit byte from a memory location, and stores the value held in a register back to the same memory location. The value initially loaded from memory is returned in the destination register.

- If the destination register is not WZR, SWPAB and SWPALB load from memory with acquire semantics.
- SWPLB and SWPALB store to memory with release semantics.
- SWPB has neither acquire nor release semantics.

For more information about memory ordering semantics see [Load-Acquire, Store-Release](#).

For information about memory accesses see [Load/Store addressing modes](#).

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	0	A	R	1	Rs					1	0	0	0	0	0	Rn					Rt				
size																															

### SWPAB (A == 1 && R == 0)

SWPAB <Ws>, <Wt>, [<Xn|SP>]

### SWPALB (A == 1 && R == 1)

SWPALB <Ws>, <Wt>, [<Xn|SP>]

### SWPB (A == 0 && R == 0)

SWPB <Ws>, <Wt>, [<Xn|SP>]

### SWPLB (A == 0 && R == 1)

SWPLB <Ws>, <Wt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register to be stored, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(8) data;
bits(8) store_value;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

store_value = X[s];
data = MemAtomic(address, MemAtomicOp_SWP, store_value, ldacctype, stacctype);
X[t] = ZeroExtend(data, 32);
```

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# SWPH, SWPAH, SWPALH, SWPLH

Swap halfword in memory atomically loads a 16-bit halfword from a memory location, and stores the value held in a register back to the same memory location. The value initially loaded from memory is returned in the destination register.

- If the destination register is not WZR, SWPAH and SWPALH load from memory with acquire semantics.
- SWPLH and SWPALH store to memory with release semantics.
- SWPH has neither acquire nor release semantics.

For more information about memory ordering semantics see [Load-Acquire, Store-Release](#).

For information about memory accesses see [Load/Store addressing modes](#).

## Integer (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	A	R	1	Rs			1	0	0	0	0	0	Rn			Rt								
size																															

### SWPAH (A == 1 && R == 0)

SWPAH <Ws>, <Wt>, [<Xn|SP>]

### SWPALH (A == 1 && R == 1)

SWPALH <Ws>, <Wt>, [<Xn|SP>]

### SWPH (A == 0 && R == 0)

SWPH <Ws>, <Wt>, [<Xn|SP>]

### SWPLH (A == 0 && R == 1)

SWPLH <Ws>, <Wt>, [<Xn|SP>]

```
if !HaveAtomicExt() then UNDEFINED;

integer t = UInt(Rt);
integer n = UInt(Rn);
integer s = UInt(Rs);

AccType ldacctype = if A == '1' && Rt != '11111' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
AccType stacctype = if R == '1' then AccType_ORDEREDATOMICRW else AccType_ATOMICRW;
boolean tag_checked = n != 31;
```

## Assembler Symbols

- <Ws> Is the 32-bit name of the general-purpose register to be stored, encoded in the "Rs" field.
- <Wt> Is the 32-bit name of the general-purpose register to be loaded, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

## Operation

```
bits(64) address;
bits(16) data;
bits(16) store_value;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

store_value = X[s];
data = MemAtomic(address, MemAtomicOp_SWP, store_value, ldacctype, stacctype);
X[t] = ZeroExtend(data, 32);
```

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SXTB

Signed Extend Byte extracts an 8-bit value from a register, sign-extends it to the size of the register, and writes the result to the destination register.

This is an alias of [SBFM](#). This means:

- The encodings in this description are named to match the encodings of [SBFM](#).
- The description of [SBFM](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	0	1	0	0	1	1	0	N	0	0	0	0	0	0	0	0	0	1	1	1	Rn				Rd					
opc									immr							imms															

32-bit (sf == 0 && N == 0)

SXTB <Wd>, <Wn>

is equivalent to

[SBFM](#) <Wd>, <Wn>, #0, #7

and is always the preferred disassembly.

64-bit (sf == 1 && N == 1)

SXTB <Xd>, <Wn>

is equivalent to

[SBFM](#) <Xd>, <Xn>, #0, #7

and is always the preferred disassembly.

Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
- <Wn> Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.

Operation

The description of [SBFM](#) gives the operational pseudocode for this instruction.

Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# SXTH

Sign Extend Halfword extracts a 16-bit value, sign-extends it to the size of the register, and writes the result to the destination register.

This is an alias of [SBFM](#). This means:

- The encodings in this description are named to match the encodings of [SBFM](#).
  - The description of [SBFM](#) gives the operational pseudocode for this instruction.
- |     |    |    |    |    |    |    |    |    |      |    |    |    |    |    |    |      |    |    |    |    |    |    |   |   |   |    |   |   |   |   |   |
|-----|----|----|----|----|----|----|----|----|------|----|----|----|----|----|----|------|----|----|----|----|----|----|---|---|---|----|---|---|---|---|---|
| 31  | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22   | 21 | 20 | 19 | 18 | 17 | 16 | 15   | 14 | 13 | 12 | 11 | 10 | 9  | 8 | 7 | 6 | 5  | 4 | 3 | 2 | 1 | 0 |
| sf  | 0  | 0  | 1  | 0  | 0  | 1  | 1  | 0  | N    | 0  | 0  | 0  | 0  | 0  | 0  | 0    | 0  | 1  | 1  | 1  | 1  | Rn |   |   |   | Rd |   |   |   |   |   |
| opc |    |    |    |    |    |    |    |    | immr |    |    |    |    |    |    | imms |    |    |    |    |    |    |   |   |   |    |   |   |   |   |   |

## 32-bit (sf == 0 && N == 0)

SXTH <Wd>, <Wn>

is equivalent to

[SBFM](#) <Wd>, <Wn>, #0, #15

and is always the preferred disassembly.

## 64-bit (sf == 1 && N == 1)

SXTH <Xd>, <Wn>

is equivalent to

[SBFM](#) <Xd>, <Xn>, #0, #15

and is always the preferred disassembly.

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
- <Wn> Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.

## Operation

The description of [SBFM](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# SXTW

Sign Extend Word sign-extends a word to the size of the register, and writes the result to the destination register.

This is an alias of [SBFM](#). This means:

- The encodings in this description are named to match the encodings of [SBFM](#).
- The description of [SBFM](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
1	0	0	1	0	0	1	1	0	1	0	0	0	0	0	0	0	1	1	1	1	1	Rn						Rd					
sf			opc						N	immr						imms																	

## 64-bit

SXTW <Xd>, <Wn>

is equivalent to

[SBFM](#) <Xd>, <Xn>, #0, #31

and is always the preferred disassembly.

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
- <Wn> Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.

## Operation

The description of [SBFM](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

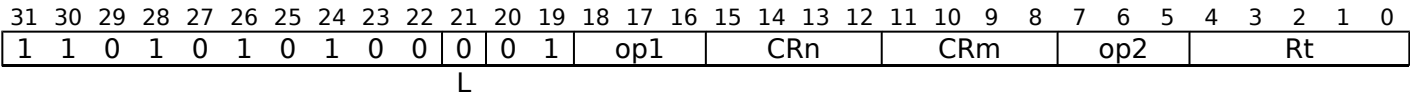
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SYS

System instruction. For more information, see *Op0 equals 0b01, cache maintenance, TLB maintenance, and address translation instructions* for the encodings of System instructions.

This instruction is used by the aliases [AT](#), [CFP](#), [CPP](#), [DC](#), [DVP](#), [IC](#), and [TLBI](#).



System

```
SYS #<op1>, <Cn>, <Cm>, #<op2>{, <Xt>}

AArch64.CheckSystemAccess('01', op1, CRn, CRm, op2, Rt, L);

integer t = UInt(Rt);

integer sys_op1 = UInt(op1);
integer sys_op2 = UInt(op2);
integer sys_crn = UInt(CRn);
integer sys_crm = UInt(CRm);
```

Assembler Symbols

- <op1> Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the "op1" field.
- <Cn> Is a name 'Cn', with 'n' in the range 0 to 15, encoded in the "CRn" field.
- <Cm> Is a name 'Cm', with 'm' in the range 0 to 15, encoded in the "CRm" field.
- <op2> Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the "op2" field.
- <Xt> Is the 64-bit name of the optional general-purpose source register, defaulting to '11111', encoded in the "Rt" field.

Alias Conditions

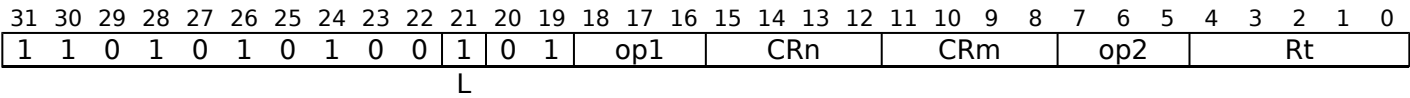
Alias	Is preferred when
<a href="#">AT</a>	CRn == '0111' && CRm == '100x' && SysOp(op1, '0111', CRm, op2) == <a href="#">Sys_AT</a>
<a href="#">CFP</a>	op1 == '011' && CRn == '0111' && CRm == '0011' && op2 == '100'
<a href="#">CPP</a>	op1 == '011' && CRn == '0111' && CRm == '0011' && op2 == '111'
<a href="#">DC</a>	CRn == '0111' && SysOp(op1, '0111', CRm, op2) == <a href="#">Sys_DC</a>
<a href="#">DVP</a>	op1 == '011' && CRn == '0111' && CRm == '0011' && op2 == '101'
<a href="#">IC</a>	CRn == '0111' && SysOp(op1, '0111', CRm, op2) == <a href="#">Sys_IC</a>
<a href="#">TLBI</a>	CRn == '1000' && SysOp(op1, '1000', CRm, op2) == <a href="#">Sys_TLBI</a>

Operation

```
AArch64.SysInstr(1, sys_op1, sys_crn, sys_crm, sys_op2, X[t]);
```

# SYSL

System instruction with result. For more information, see *Op0 equals 0b01, cache maintenance, TLB maintenance, and address translation instructions* for the encodings of System instructions.



## System

```
SYSL <Xt>, #<op1>, <Cn>, <Cm>, #<op2>

AArch64.CheckSystemAccess('01', op1, CRn, CRm, op2, Rt, L);

integer t = UInt(Rt);

integer sys_op1 = UInt(op1);
integer sys_op2 = UInt(op2);
integer sys_crn = UInt(CRn);
integer sys_crm = UInt(CRm);
```

## Assembler Symbols

- <Xt> Is the 64-bit name of the general-purpose destination register, encoded in the "Rt" field.
- <op1> Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the "op1" field.
- <Cn> Is a name 'Cn', with 'n' in the range 0 to 15, encoded in the "CRn" field.
- <Cm> Is a name 'Cm', with 'm' in the range 0 to 15, encoded in the "CRm" field.
- <op2> Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the "op2" field.

## Operation

```
// No architecturally defined instructions here.
X[t] = AArch64.SysInstrWithResult(1, sys_op1, sys_crn, sys_crm, sys_op2);
```

TBL

Programmable table lookup in one or two vector table (zeroing).

Reads each element of the second source (index) vector and uses its value to select an indexed element from a table of elements consisting of one or two consecutive vector registers, where the first or only vector holds the lower numbered elements, and places the indexed table element in the destination vector element corresponding to the index vector element. If an index value is greater than or equal to the number of vector elements then it places zero in the corresponding destination vector element.

Since the index values can select any element in a vector this operation is not naturally vector length agnostic.

It has encodings from 2 classes: [SVE](#) and [SVE2](#)

SVE

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	Zm						0	0	1	1	0	0	Zn				Zd					

SVE

TBL [<Zd>.<T>](#), { [<Zn>.<T>](#) }, [<Zm>.<T>](#)

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
boolean double_table = FALSE;
```

SVE2

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	Zm						0	0	1	0	1	0	Zn				Zd					

SVE2

TBL [<Zd>.<T>](#), { [<Zn1>.<T>](#), [<Zn2>.<T>](#) }, [<Zm>.<T>](#)

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
boolean double_table = TRUE;
```

Assembler Symbols

[<Zd>](#) Is the name of the destination scalable vector register, encoded in the "Zd" field.

[<T>](#) Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

[<Zn>](#) Is the name of the first source scalable vector register, encoded in the "Zn" field.

[<Zn1>](#) Is the name of the first scalable vector register of a multi-vector sequence, encoded in the "Zn" field.

[<Zn2>](#) Is the name of the second scalable vector register of a multi-vector sequence, encoded in the "Zn" field.

[<Zm>](#) Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) indexes = Z[m];
bits(VL) result;
integer table_size = if double_table then VL*2 else VL;
integer table_elems = table_size DIV esize;
bits(table_size) table;

if double_table then
    bits(VL) top = Z[(n + 1) MOD 32];
    bits(VL) bottom = Z[n];
    table = (top:bottom)<table_size-1:0>;
else
    table = Z[n];

for e = 0 to elements-1
    integer idx = UInt(Elem[indexes, e, esize]);
    Elem[result, e, esize] = if idx < table_elems then Elem[table, idx, esize] else Zeros();

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

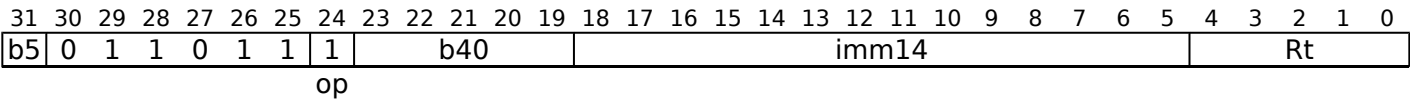
- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# TBNZ

Test bit and Branch if Nonzero compares the value of a bit in a general-purpose register with zero, and conditionally branches to a label at a PC-relative offset if the comparison is not equal. It provides a hint that this is not a subroutine call or return. This instruction does not affect condition flags.



## 14-bit signed PC-relative branch offset

```
TBNZ <R><t>, #<imm>, <label>

integer t = UInt(Rt);

integer datasize = if b5 == '1' then 64 else 32;
integer bit_pos = UInt(b5:b40);
bits(64) offset = SignExtend(imm14:'00', 64);
```

## Assembler Symbols

- <R>

Is a width specifier, encoded in "b5":

b5	<R>
0	W
1	X
- <t>

Is the number [0-30] of the general-purpose register to be tested or the name ZR (31), encoded in the "Rt" field.
- <imm>

Is the bit number to be tested, in the range 0 to 63, encoded in "b5:b40".
- <label>

Is the program label to be conditionally branched to. Its offset from the address of this instruction, in the range +/-32KB, is encoded as "imm14" times 4.

## Operation

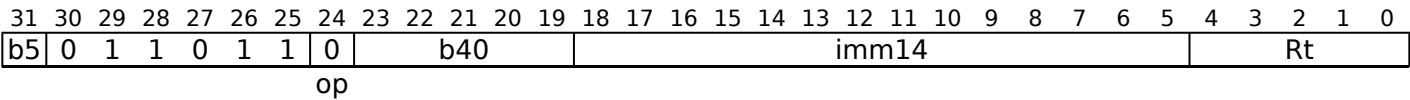
```
bits(datasize) operand = X[t];

if operand<bit_pos> == op then
    BranchTo(PC[] + offset, BranchType_DIR);
```



TBZ

Test bit and Branch if Zero compares the value of a test bit with zero, and conditionally branches to a label at a PC-relative offset if the comparison is equal. It provides a hint that this is not a subroutine call or return. This instruction does not affect condition flags.



14-bit signed PC-relative branch offset

TBZ <R><t>, #<imm>, <label>

```
integer t = UInt(Rt);
integer datasize = if b5 == '1' then 64 else 32;
integer bit_pos = UInt(b5:b40);
bits(64) offset = SignExtend(imm14:'00', 64);
```

Assembler Symbols

- <R> Is a width specifier, encoded in "b5":

b5	<R>
0	W
1	X

In assembler source code an 'X' specifier is always permitted, but a 'W' specifier is only permitted when the bit number is less than 32.
- <t> Is the number [0-30] of the general-purpose register to be tested or the name ZR (31), encoded in the "Rt" field.
- <imm> Is the bit number to be tested, in the range 0 to 63, encoded in "b5:b40".
- <label> Is the program label to be conditionally branched to. Its offset from the address of this instruction, in the range +/-32KB, is encoded as "imm14" times 4.

Operation

```
bits(datasize) operand = X[t];
if operand<bit_pos> == op then
    BranchTo(PC[] + offset, BranchType_DIR);
```

# TCANCEL

This instruction exits Transactional state and discards all state modifications that were performed transactionally. Execution continues at the instruction that follows the TSTART instruction of the outer transaction. The destination register of the TSTART instruction of the outer transaction is written with the immediate operand of TCANCEL.

## System (TME)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	0	0	1	1	imm16																0	0	0	0	0

## System

```
TCANCEL #<imm>

if !HaveTME() then UNDEFINED;
boolean retry = (imm16<15> == '1');
bits(15) reason = imm16<14:0>;
```

## Assembler Symbols

<imm> Is a 16-bit unsigned immediate, in the range 0 to 65535, encoded in the "imm16" field.

## Operation

```
CheckTMEEnabled();

if TSTATE.depth > 0 then
    FailTransaction(TMFailure_CNCL, retry, FALSE, reason);
```

# TCOMMIT

This instruction commits the current transaction. If the current transaction is an outer transaction, then Transactional state is exited, and all state modifications performed transactionally are committed to the architectural state. TCOMMIT takes no inputs and returns no value.

Execution of TCOMMIT is UNDEFINED in Non-transactional state.

## System (TME)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	1	0	0	0	0	0	1	1	1	1	1	1	1

## System

TCOMMIT

```
if !HaveTME() then UNDEFINED;
```

## Operation

```
CheckTMEEnabled();

if TSTATE.depth == 0 then
    UNDEFINED;

if TSTATE.depth == 1 then
    CommitTransactionalWrites();
    ClearExclusiveLocal(ProcessorID());

TSTATE.depth = TSTATE.depth - 1;
```

TLBI

TLB Invalidate operation. For more information, see *op0==0b01, cache maintenance, TLB maintenance, and address translation instructions*.

This is an alias of [SYS](#). This means:

- The encodings in this description are named to match the encodings of [SYS](#).
- The description of [SYS](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	1	op1			1	0	0	0	CRm			op2			Rt					
L											CRn																				

System

TLBI <tlbi\_op>{, <Xt>}

is equivalent to

[SYS](#) #<op1>, C8, <Cm>, #<op2>{, <Xt>}

and is the preferred disassembly when `SysOp(op1, '1000', CRm, op2) == Sys_TLBI`.

Assembler Symbols

- <op1>
- Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the "op1" field.
- <Cm>
- Is a name 'Cm', with 'm' in the range 0 to 15, encoded in the "CRm" field.
- <op2>
- Is a 3-bit unsigned immediate, in the range 0 to 7, encoded in the "op2" field.
- <tlbi\_op>
- Is a TLBI instruction name, as listed for the TLBI system instruction group, encoded in “op1:CRm:op2”:

op1	CRm	op2	<tlbi_op>	Architectural Feature
000	0001	000	VMALLE10S	ARMv8.4-TLBI
000	0001	001	VAE10S	ARMv8.4-TLBI
000	0001	010	ASIDE10S	ARMv8.4-TLBI
000	0001	011	VAAE10S	ARMv8.4-TLBI
000	0001	101	VALE10S	ARMv8.4-TLBI
000	0001	111	VAALE10S	ARMv8.4-TLBI
000	0010	001	RVAE1IS	ARMv8.4-TLBI
000	0010	011	RVAAE1IS	ARMv8.4-TLBI
000	0010	101	RVALE1IS	ARMv8.4-TLBI
000	0010	111	RVAALE1IS	ARMv8.4-TLBI
000	0011	000	VMALLE1IS	-
000	0011	001	VAE1IS	-
000	0011	010	ASIDE1IS	-
000	0011	011	VAAE1IS	-
000	0011	101	VALE1IS	-
000	0011	111	VAALE1IS	-
000	0101	001	RVAE10S	ARMv8.4-TLBI
000	0101	011	RVAAE10S	ARMv8.4-TLBI
000	0101	101	RVALE10S	ARMv8.4-TLBI
000	0101	111	RVAALE10S	ARMv8.4-TLBI
000	0110	001	RVAE1	ARMv8.4-TLBI
000	0110	011	RVAAE1	ARMv8.4-TLBI
000	0110	101	RVALE1	ARMv8.4-TLBI
000	0110	111	RVAALE1	ARMv8.4-TLBI
000	0111	000	VMALLE1	-
000	0111	001	VAE1	-
000	0111	010	ASIDE1	-
000	0111	011	VAAE1	-
000	0111	101	VALE1	-
000	0111	111	VAALE1	-
100	0000	001	IPAS2E1IS	-
100	0000	010	RIPAS2E1IS	ARMv8.4-TLBI
100	0000	101	IPAS2LE1IS	-
100	0000	110	RIPAS2LE1IS	ARMv8.4-TLBI
100	0001	000	ALLE20S	ARMv8.4-TLBI
100	0001	001	VAE20S	ARMv8.4-TLBI
100	0001	100	ALLE10S	ARMv8.4-TLBI
100	0001	101	VALE20S	ARMv8.4-TLBI
100	0001	110	VMALLS12E10S	ARMv8.4-TLBI
100	0010	001	RVAE2IS	ARMv8.4-TLBI
100	0010	101	RVALE2IS	ARMv8.4-TLBI
100	0011	000	ALLE2IS	-
100	0011	001	VAE2IS	-
100	0011	100	ALLE1IS	-
100	0011	101	VALE2IS	-
100	0011	110	VMALLS12E1IS	-
100	0100	000	IPAS2E10S	ARMv8.4-TLBI
100	0100	001	IPAS2E1	-
100	0100	010	RIPAS2E1	ARMv8.4-TLBI
100	0100	011	RIPAS2E10S	ARMv8.4-TLBI
100	0100	100	IPAS2LE10S	ARMv8.4-TLBI
100	0100	101	IPAS2LE1	-
100	0100	110	RIPAS2LE1	ARMv8.4-TLBI
100	0100	111	RIPAS2LE10S	ARMv8.4-TLBI
100	0101	001	RVAE20S	ARMv8.4-TLBI
100	0101	101	RVALE20S	ARMv8.4-TLBI
100	0110	001	RVAE2	ARMv8.4-TLBI
100	0110	101	RVALE2	ARMv8.4-TLBI
100	0111	000	ALLE2	-
100	0111	001	VAE2	-
100	0111	100	ALLE1	-
100	0111	101	VALE2	-
100	0111	110	VMALLS12E1	-
110	0001	000	ALLE30S	ARMv8.4-TLBI
110	0001	001	VAE30S	ARMv8.4-TLBI
110	0001	101	VALE30S	ARMv8.4-TLBI
110	0010	001	RVAE3IS	ARMv8.4-TLBI
110	0010	101	RVALE3IS	ARMv8.4-TLBI

op1	CRm	op2	<tlbi_op>	Architectural Feature
110	0011	000	ALLE3IS	-
110	0011	001	VAE3IS	-
110	0011	101	VALE3IS	-
110	0101	001	RVAE30S	ARMv8.4-TLBI
110	0101	101	RVALE30S	ARMv8.4-TLBI
110	0110	001	RVAE3	ARMv8.4-TLBI
110	0110	101	RVALE3	ARMv8.4-TLBI
110	0111	000	ALLE3	-
110	0111	001	VAE3	-
110	0111	101	VALE3	-

<Xt> Is the 64-bit name of the optional general-purpose source register, defaulting to '11111', encoded in the "Rt" field.

## Operation

The description of [SYS](#) gives the operational pseudocode for this instruction.

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# TSB CSYNC

Trace Synchronization Barrier. This instruction is a barrier that synchronizes the trace operations of instructions. If ARMv8.4-Trace is not implemented, this instruction executes as a NOP.

## System (Armv8.4)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	1	0	0	1	0	1	1	1	1	1
																CRm				op2											

System

```
TSB CSYNC
```

```
if !HaveSelfHostedTrace() then EndOfInstruction();
```

Operation

```
TraceSynchronizationBarrier();
```

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# TST (immediate)

Test bits (immediate), setting the condition flags and discarding the result: Rn AND imm.

This is an alias of [ANDS \(immediate\)](#). This means:

- The encodings in this description are named to match the encodings of [ANDS \(immediate\)](#).
- The description of [ANDS \(immediate\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
sf	1	1	1	0	0	1	0	0	N	immr						imms						Rn				1	1	1	1	1			
opc																												Rd					

## 32-bit (sf == 0 && N == 0)

TST <Wn>, #<imm>

is equivalent to

ANDS WZR, <Wn>, #<imm>

and is always the preferred disassembly.

## 64-bit (sf == 1)

TST <Xn>, #<imm>

is equivalent to

ANDS XZR, <Xn>, #<imm>

and is always the preferred disassembly.

## Assembler Symbols

- <Wn> Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
- <Xn> Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
- <imm> For the 32-bit variant: is the bitmask immediate, encoded in "imms:immr".  
For the 64-bit variant: is the bitmask immediate, encoded in "N:imms:immr".

## Operation

The description of [ANDS \(immediate\)](#) gives the operational pseudocode for this instruction.



# TST (shifted register)

Test (shifted register) performs a bitwise AND operation on a register value and an optionally-shifted register value. It updates the condition flags based on the result, and discards the result.

This is an alias of [ANDS \(shifted register\)](#). This means:

- The encodings in this description are named to match the encodings of [ANDS \(shifted register\)](#).
  - The description of [ANDS \(shifted register\)](#) gives the operational pseudocode for this instruction.
- |     |    |    |    |    |    |    |    |       |    |    |    |    |    |    |    |      |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |    |  |  |  |  |
|-----|----|----|----|----|----|----|----|-------|----|----|----|----|----|----|----|------|----|----|----|----|----|----|---|---|---|---|---|---|---|---|---|----|--|--|--|--|
| 31  | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23    | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15   | 14 | 13 | 12 | 11 | 10 | 9  | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |    |  |  |  |  |
| sf  | 1  | 1  | 0  | 1  | 0  | 1  | 0  | shift | 0  | Rm |    |    |    |    |    | imm6 |    |    |    |    |    | Rn |   |   |   |   |   | 1 | 1 | 1 | 1 | 1  |  |  |  |  |
| opc |    |    |    |    |    |    |    | N     |    |    |    |    |    |    |    |      |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   | Rd |  |  |  |  |

## 32-bit (sf == 0)

TST <Wn>, <Wm>{, <shift> #<amount>}

is equivalent to

[ANDS](#) WZR, <Wn>, <Wm>{, <shift> #<amount>}

and is always the preferred disassembly.

## 64-bit (sf == 1)

TST <Xn>, <Xm>{, <shift> #<amount>}

is equivalent to

[ANDS](#) XZR, <Xn>, <Xm>{, <shift> #<amount>}

and is always the preferred disassembly.

## Assembler Symbols

<Wn>	Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.										
<Wm>	Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.										
<Xn>	Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.										
<Xm>	Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.										
<shift>	Is the optional shift to be applied to the final source, defaulting to LSL and encoded in "shift":										
<table><tr><th>shift</th><th>&lt;shift&gt;</th></tr><tr><td>00</td><td>LSL</td></tr><tr><td>01</td><td>LSR</td></tr><tr><td>10</td><td>ASR</td></tr><tr><td>11</td><td>ROR</td></tr></table>		shift	<shift>	00	LSL	01	LSR	10	ASR	11	ROR
shift	<shift>										
00	LSL										
01	LSR										
10	ASR										
11	ROR										
<amount>	For the 32-bit variant: is the shift amount, in the range 0 to 31, defaulting to 0 and encoded in the "imm6" field.										
	For the 64-bit variant: is the shift amount, in the range 0 to 63, defaulting to 0 and encoded in the "imm6" field,										

## Operation

The description of [ANDS \(shifted register\)](#) gives the operational pseudocode for this instruction.

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:

- The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# TSTART

This instruction starts a new transaction. If the transaction started successfully, the destination register is set to zero. If the transaction failed or was canceled, then all state modifications that were performed transactionally are discarded and the destination register is written with a non-zero value that encodes the cause of the failure.

## System (TME)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	1	0	0	0	1	1	0	0	1	1	0	0	0	0	0	1	1	Rt				

## System

TSTART <Xt>

```
if !HaveTME() then UNDEFINED;
integer t = UInt(Rt);
```

## Assembler Symbols

<Xt> Is the 64-bit name of the general-purpose destination register, encoded in the "Rt" field.

## Operation

```
CheckTMEEnabled();

boolean IsEL1Regime;
case PSTATE.EL of
  when EL0
    IsEL1Regime = S1TranslationRegime() == EL1;
    if IsEL1Regime then
      tme = SCTLR_EL1.TME0;
      tmt = SCTLR_EL1.TMT0;
    else
      tme = SCTLR_EL2.TME0;
      tmt = SCTLR_EL2.TMT0;
  when EL1
    tme = SCTLR_EL1.TME;
    tmt = SCTLR_EL1.TMT;
  when EL2
    tme = SCTLR_EL2.TME;
    tmt = SCTLR_EL2.TMT;
  when EL3
    tme = SCTLR_EL3.TME;
    tmt = SCTLR_EL3.TMT;
  otherwise
    Unreachable();

enable = tme == '1';
trivial = tmt == '1';

if !enable then
  TransactionStartTrap(t);
elseif trivial then
  FailTransaction(TMFailure_TRIVIAL, FALSE);
elseif TSTATE.depth == 255 then
  FailTransaction(TMFailure_NEST, FALSE);
elseif TSTATE.depth == 0 then
  TSTATE.nPC = NextInstrAddr();
  TSTATE.Rt = t;
  ClearExclusiveLocal(ProcessorID());
  TakeTransactionCheckpoint();
  StartTrackingTransactionalReadsWrites();

TSTATE.depth = TSTATE.depth + 1;
X[t] = Zeros(64);
```

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# TTEST

This instruction writes the depth of the transaction to the destination register, or the value 0 otherwise.

## System (TME)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	1	0	0	0	1	1	0	0	1	1	0	0	0	1	0	1	1	Rt				

## System

TTEST <Xt>

```
if !HaveTME() then UNDEFINED;
integer t = UInt(Rt);
```

## Assembler Symbols

<Xt> Is the 64-bit name of the general-purpose destination register, encoded in the "Rt" field.

## Operation

```
CheckTMEEnabled();
X[t] = (TSTATE.depth)<63:0>;
```

# UBFIZ

Unsigned Bitfield Insert in Zeros copies a bitfield of <width> bits from the least significant bits of the source register to bit position <lsb> of the destination register, setting the destination bits above and below the bitfield to zero.

This is an alias of [UBFM](#). This means:

- The encodings in this description are named to match the encodings of [UBFM](#).
- The description of [UBFM](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	1	0	1	0	0	1	1	0	N	immr						imms						Rn						Rd			
opc																															

## 32-bit (sf == 0 && N == 0)

UBFIZ <Wd>, <Wn>, #<lsb>, #<width>

is equivalent to

UBFM <Wd>, <Wn>, #(-<lsb> MOD 32), #(<width>-1)

and is the preferred disassembly when `UInt(imms) < UInt(immr)`.

## 64-bit (sf == 1 && N == 1)

UBFIZ <Xd>, <Xn>, #<lsb>, #<width>

is equivalent to

UBFM <Xd>, <Xn>, #(-<lsb> MOD 64), #(<width>-1)

and is the preferred disassembly when `UInt(imms) < UInt(immr)`.

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
- <lsb> For the 32-bit variant: is the bit number of the lsb of the destination bitfield, in the range 0 to 31.  
For the 64-bit variant: is the bit number of the lsb of the destination bitfield, in the range 0 to 63.
- <width> For the 32-bit variant: is the width of the bitfield, in the range 1 to 32-<lsb>.  
For the 64-bit variant: is the width of the bitfield, in the range 1 to 64-<lsb>.

## Operation

The description of [UBFM](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.



UBFM

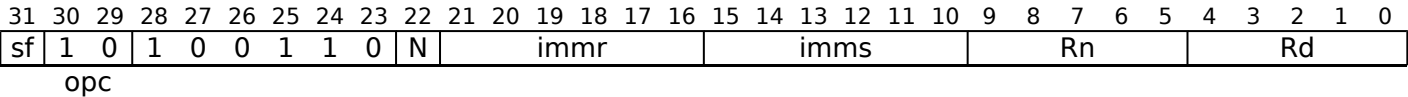
Unigned Bitfield Move is usually accessed via one of its aliases, which are always preferred for disassembly.

If <imms> is greater than or equal to <immr>, this copies a bitfield of (<imms>-<immr>+1) bits starting from bit position <immr> in the source register to the least significant bits of the destination register.

If <imms> is less than <immr>, this copies a bitfield of (<imms>+1) bits from the least significant bits of the source register to bit position (regsize-<immr>) of the destination register, where regsize is the destination register size of 32 or 64 bits.

In both cases the destination bits below and above the bitfield are set to zero.

This instruction is used by the aliases [LSL \(immediate\)](#), [LSR \(immediate\)](#), [UBFIZ](#), [UBFX](#), [UXTB](#), and [UXTH](#).



32-bit (sf == 0 && N == 0)

UBFM <Wd>, <Wn>, #<immr>, #<imms>

64-bit (sf == 1 && N == 1)

UBFM <Xd>, <Xn>, #<immr>, #<imms>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer datasize = if sf == '1' then 64 else 32;

integer R;
bits(datasize) wmask;
bits(datasize) tmask;

if sf == '1' && N != '1' then UNDEFINED;
if sf == '0' && (N != '0' || immr<5> != '0' || imms<5> != '0') then UNDEFINED;

R = UInt(immr);
(wmask, tmask) = DecodeBitMasks(N, imms, immr, FALSE);
```

Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
- <immr> For the 32-bit variant: is the right rotate amount, in the range 0 to 31, encoded in the "immr" field.  
For the 64-bit variant: is the right rotate amount, in the range 0 to 63, encoded in the "immr" field.
- <imms> For the 32-bit variant: is the leftmost bit number to be moved from the source, in the range 0 to 31, encoded in the "imms" field.  
For the 64-bit variant: is the leftmost bit number to be moved from the source, in the range 0 to 63, encoded in the "imms" field.

Alias Conditions

Alias	Of variant	Is preferred when
<a href="#">LSL (immediate)</a>	32-bit	imms != '011111' && imms + 1 == immr
<a href="#">LSL (immediate)</a>	64-bit	imms != '111111' && imms + 1 == immr
<a href="#">LSR (immediate)</a>	32-bit	imms == '011111'



Alias	Of variant	Is preferred when
<a href="#">LSR (immediate)</a>	64-bit	<code>imms == '111111'</code>
<a href="#">UBFIZ</a>		<code>UInt(imms) &lt; UInt(immr)</code>
<a href="#">UBFX</a>		<code>BFXPreferred(sf, opc&lt;1&gt;, imms, immr)</code>
<a href="#">UXTB</a>		<code>immr == '000000' &amp;&amp; imms == '000111'</code>
<a href="#">UXTH</a>		<code>immr == '000000' &amp;&amp; imms == '001111'</code>

## Operation

```
bits(datasize) src = X[n];

// perform bitfield move on low bits
bits(datasize) bot = ROR(src, R) AND wmask;

// combine extension bits and result bits
X[d] = bot AND tmask;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# UBFX

Unsigned Bitfield Extract copies a bitfield of <width> bits starting from bit position <lsb> in the source register to the least significant bits of the destination register, and sets destination bits above the bitfield to zero.

This is an alias of [UBFM](#). This means:

- The encodings in this description are named to match the encodings of [UBFM](#).
- The description of [UBFM](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	1	0	1	0	0	1	1	0	N	immr						imms						Rn						Rd			
opc																															

## 32-bit (sf == 0 && N == 0)

UBFX <Wd>, <Wn>, #<lsb>, #<width>

is equivalent to

UBFM <Wd>, <Wn>, #<lsb>, #(<lsb>+<width>-1)

and is the preferred disassembly when `BFXPreferred(sf, opc<1>, imms, immr)`.

## 64-bit (sf == 1 && N == 1)

UBFX <Xd>, <Xn>, #<lsb>, #<width>

is equivalent to

UBFM <Xd>, <Xn>, #<lsb>, #(<lsb>+<width>-1)

and is the preferred disassembly when `BFXPreferred(sf, opc<1>, imms, immr)`.

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
<lsb>	For the 32-bit variant: is the bit number of the lsb of the source bitfield, in the range 0 to 31. For the 64-bit variant: is the bit number of the lsb of the source bitfield, in the range 0 to 63.
<width>	For the 32-bit variant: is the width of the bitfield, in the range 1 to 32-<lsb>. For the 64-bit variant: is the width of the bitfield, in the range 1 to 64-<lsb>.

## Operation

The description of [UBFM](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.



# UDF

Permanently Undefined generates an Undefined Instruction exception (ESR\_ELx.EC = 0b0000000). The encodings for UDF used in this section are defined as permanently UNDEFINED in the Armv8-A architecture.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	imm16															

## Integer

```
UDF #<imm>

// The imm16 field is ignored by hardware.
UNDEFINED;
```

## Assembler Symbols

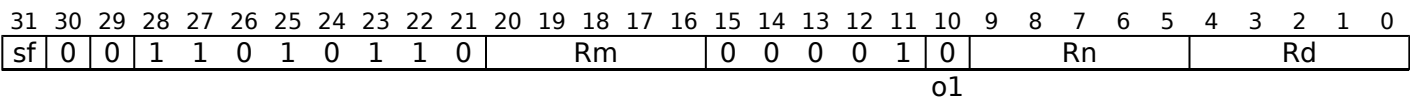
<imm> is a 16-bit unsigned immediate, in the range 0 to 65535, encoded in the "imm16" field. The PE ignores the value of this constant.

## Operation

```
// No operation.
```

# UDIV

Unsigned Divide divides an unsigned integer register value by another unsigned integer register value, and writes the result to the destination register. The condition flags are not affected.



## 32-bit (sf == 0)

```
UDIV <Wd>, <Wn>, <Wm>
```

## 64-bit (sf == 1)

```
UDIV <Xd>, <Xn>, <Xm>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if sf == '1' then 64 else 32;
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register, encoded in the "Rm" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register, encoded in the "Rm" field.

## Operation

```
bits(datasize) operand1 = X[n];
bits(datasize) operand2 = X[m];
integer result;

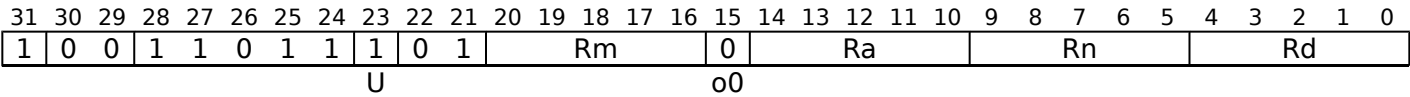
if IsZero(operand2) then
    result = 0;
else
    result = RoundTowardsZero(Real(Int(operand1, TRUE)) / Real(Int(operand2, TRUE)));

X[d] = result<datasize-1:0>;
```

# UMADDL

Unsigned Multiply-Add Long multiplies two 32-bit register values, adds a 64-bit register value, and writes the result to the 64-bit destination register.

This instruction is used by the alias [UMULL](#).



## 64-bit

UMADDL <Xd>, <Wn>, <Wm>, <Xa>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer a = UInt(Ra);
```

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.
- <Xa> Is the 64-bit name of the third general-purpose source register holding the addend, encoded in the "Ra" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">UMULL</a>	Ra == '11111'

## Operation

```
bits(32) operand1 = X[n];
bits(32) operand2 = X[m];
bits(64) operand3 = X[a];

integer result;

result = Int(operand3, TRUE) + (Int(operand1, TRUE) * Int(operand2, TRUE));

X[d] = result<63:0>;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# UMNEGL

Unsigned Multiply-Negate Long multiplies two 32-bit register values, negates the product, and writes the result to the 64-bit destination register.

This is an alias of [UMSUBL](#). This means:

- The encodings in this description are named to match the encodings of [UMSUBL](#).
- The description of [UMSUBL](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	1	0	1	1	1	0	1	Rm					1	1	1	1	1	1	Rn					Rd				
U								o0								Ra															

## 64-bit

UMNEGL <Xd>, <Wn>, <Wm>

is equivalent to

[UMSUBL](#) <Xd>, <Wn>, <Wm>, XZR

and is always the preferred disassembly.

## Assembler Symbols

- |      |  |
|------|--|
| <Xd> | Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.                           |
| <Wn> | Is the 32-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field. |
| <Wm> | Is the 32-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.  |

## Operation

The description of [UMSUBL](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

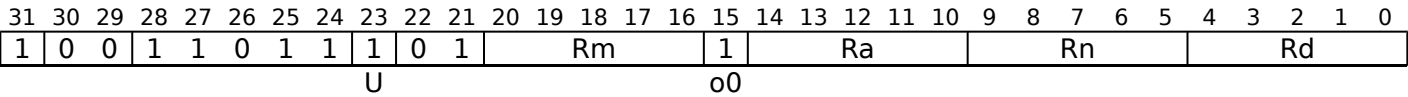
Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# UMSUBL

Unsigned Multiply-Subtract Long multiplies two 32-bit register values, subtracts the product from a 64-bit register value, and writes the result to the 64-bit destination register.

This instruction is used by the alias [UMNEGL](#).



## 64-bit

UMSUBL <Xd>, <Wn>, <Wm>, <Xa>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer a = UInt(Ra);
```

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.
- <Xa> Is the 64-bit name of the third general-purpose source register holding the minuend, encoded in the "Ra" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">UMNEGL</a>	Ra == '11111'

## Operation

```
bits(32) operand1 = X[n];
bits(32) operand2 = X[m];
bits(64) operand3 = X[a];

integer result;

result = Int(operand3, TRUE) - (Int(operand1, TRUE) * Int(operand2, TRUE));
X[d] = result<63:0>;
```

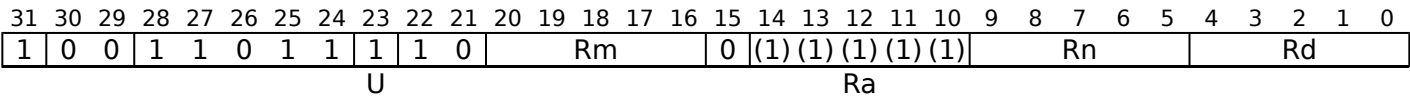
## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.



# UMULH

Unsigned Multiply High multiplies two 64-bit register values, and writes bits[127:64] of the 128-bit result to the 64-bit destination register.



## 64-bit

UMULH <Xd>, <Xn>, <Xm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
```

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xn> Is the 64-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.

## Operation

```
bits(64) operand1 = X[n];
bits(64) operand2 = X[m];

integer result;

result = Int(operand1, TRUE) * Int(operand2, TRUE);

X[d] = result<127:64>;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# UMULL

Unsigned Multiply Long multiplies two 32-bit register values, and writes the result to the 64-bit destination register.

This is an alias of [UMADDL](#). This means:

- The encodings in this description are named to match the encodings of [UMADDL](#).
- The description of [UMADDL](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	1	0	1	1	1	0	1	Rm					0	1	1	1	1	1	Rn					Rd				
U										o0					Ra																

## 64-bit

UMULL <Xd>, <Wn>, <Wm>

is equivalent to

[UMADDL](#) <Xd>, <Wn>, <Wm>, XZR

and is always the preferred disassembly.

## Assembler Symbols

- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the first general-purpose source register holding the multiplicand, encoded in the "Rn" field.
- <Wm> Is the 32-bit name of the second general-purpose source register holding the multiplier, encoded in the "Rm" field.

## Operation

The description of [UMADDL](#) gives the operational pseudocode for this instruction.

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# UXTB

Unsigned Extend Byte extracts an 8-bit value from a register, zero-extends it to the size of the register, and writes the result to the destination register.

This is an alias of [UBFM](#). This means:

- The encodings in this description are named to match the encodings of [UBFM](#).
- The description of [UBFM](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	Rn				Rd					
sf			opc						N		immr				imms																

## 32-bit

UXTB <Wd>, <Wn>

is equivalent to

[UBFM](#) <Wd>, <Wn>, #0, #7

and is always the preferred disassembly.

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.

## Operation

The description of [UBFM](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# UXTH

Unsigned Extend Halfword extracts a 16-bit value from a register, zero-extends it to the size of the register, and writes the result to the destination register.

This is an alias of [UBFM](#). This means:

- The encodings in this description are named to match the encodings of [UBFM](#).
  - The description of [UBFM](#) gives the operational pseudocode for this instruction.
- |    |    |    |     |    |    |    |    |    |    |    |      |    |    |    |      |    |    |    |    |    |    |    |   |   |   |    |   |   |   |   |   |
|----|----|----|-----|----|----|----|----|----|----|----|------|----|----|----|------|----|----|----|----|----|----|----|---|---|---|----|---|---|---|---|---|
| 31 | 30 | 29 | 28  | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20   | 19 | 18 | 17 | 16   | 15 | 14 | 13 | 12 | 11 | 10 | 9  | 8 | 7 | 6 | 5  | 4 | 3 | 2 | 1 | 0 |
| 0  | 1  | 0  | 1   | 0  | 0  | 1  | 1  | 0  | 0  | 0  | 0    | 0  | 0  | 0  | 0    | 0  | 0  | 1  | 1  | 1  | 1  | Rn |   |   |   | Rd |   |   |   |   |   |
| sf |    |    | opc |    |    |    |    |    | N  |    | immr |    |    |    | imms |    |    |    |    |    |    |    |   |   |   |    |   |   |   |   |   |

## 32-bit

UXTH <Wd>, <Wn>

is equivalent to

[UBFM](#) <Wd>, <Wn>, #0, #15

and is always the preferred disassembly.

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Wn> Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.

## Operation

The description of [UBFM](#) gives the operational pseudocode for this instruction.

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

## WFE

Wait For Event is a hint instruction that indicates that the PE can enter a low-power state and remain there until a wakeup event occurs. Wakeup events include the event signaled as a result of executing the SEV instruction on any PE in the multiprocessor system. For more information, see [Wait For Event mechanism and Send event](#).

As described in [Wait For Event mechanism and Send event](#), the execution of a WFE instruction that would otherwise cause entry to a low-power state can be trapped to a higher Exception level. See:

- [Traps to EL1 of EL0 execution of WFE and WFI instructions](#).
- [Traps to EL2 of Non-secure EL0 and EL1 execution of WFE and WFI instructions](#).
- [Traps to EL3 of EL2, EL1, and EL0 execution of WFE and WFI instructions](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	1	0	1	1	1	1	1
																CRm								op2							

## System

WFE

// Empty.

## Operation

```
if IsEventRegisterSet() then
    ClearEventRegister();
else
    trap = FALSE;
    if PSTATE.EL == EL0 then
        // Check for traps described by the OS which may be EL1 or EL2.
        if HaveTWEExt() then
            - = SCTLr[];
            trap = sctlr.nTWE == '0';
            target_el = EL1;
        else
            AArch64.CheckForWfxTrap(EL1, TRUE);

    if !trap && PSTATE.EL IN {EL0, EL1} && EL2Enabled() && !IsInHost() then
        // Check for traps described by the Hypervisor.
        if HaveTWEExt() then
            trap = HCR_EL2.TWE == '1';
            target_el = EL2;
        else
            AArch64.CheckForWfxTrap(EL2, TRUE);

    if !trap && HaveEL(EL3) && PSTATE.EL != EL3 then
        // Check for traps described by the Secure Monitor.
        if HaveTWEExt() then
            trap = SCR_EL3.TWE == '1';
            target_el = EL3;
        else
            AArch64.CheckForWfxTrap(EL3, TRUE);

    if HaveTWEExt() && trap && PSTATE.EL != EL3 then
        (delay_enabled, delay) = WFETrapDelay(target_el);    // (If trap delay is enabled, Delay amount)
        if !AArch64.WaitForEventUntilDelay(delay_enabled, delay) then
            // Event did not arrive until delay expired
            AArch64.WFxTrap(target_el, TRUE);    // Trap WFE
    else
        WaitForEvent();
```

WFI

Wait For Interrupt is a hint instruction that indicates that the PE can enter a low-power state and remain there until a wakeup event occurs. For more information, see *Wait For Interrupt*.

As described in *Wait For Interrupt*, the execution of a WFI instruction that would otherwise cause entry to a low-power state can be trapped to a higher Exception level. See:

- *Traps to EL1 of EL0 execution of WFE and WFI instructions.*
- *Traps to EL2 of Non-secure EL0 and EL1 execution of WFE and WFI instructions.*
- *Traps to EL3 of EL2, EL1, and EL0 execution of WFE and WFI instructions.*

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0			
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	1	1	1	1	1	1	1			
																				CRm				op2										

System

```
WFI
// Empty.
```

Operation

```
if !InterruptPending() then
  if PSTATE.EL == EL0 then
    // Check for traps described by the OS which may be EL1 or EL2.
    AArch64.CheckForWfxTrap(EL1, FALSE);
  if PSTATE.EL IN {EL0, EL1} && EL2Enabled() && !IsInHost() then
    // Check for traps described by the Hypervisor.
    AArch64.CheckForWfxTrap(EL2, FALSE);
  if HaveEL(EL3) && PSTATE.EL != EL3 then
    // Check for traps described by the Secure Monitor.
    AArch64.CheckForWfxTrap(EL3, FALSE);
  WaitForInterrupt();
```

# XAFLAG

Convert floating-point condition flags from external format to Arm format. This instruction converts the state of the PSTATE.{N,Z,C,V} flags from an alternative representation required by some software to a form representing the result of an Arm floating-point scalar compare instruction.

## System (Armv8.5)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	(0)	(0)	(0)	(0)	0	0	1	1	1	1	1	1

CRm

System

XAFLAG

if !HaveFlagFormatExt() then UNDEFINED;

## Operation

```
bit N = NOT(PSTATE.C) AND NOT(PSTATE.Z);
bit Z = PSTATE.Z AND PSTATE.C;
bit C = PSTATE.C OR PSTATE.Z;
bit V = NOT(PSTATE.C) AND PSTATE.Z;

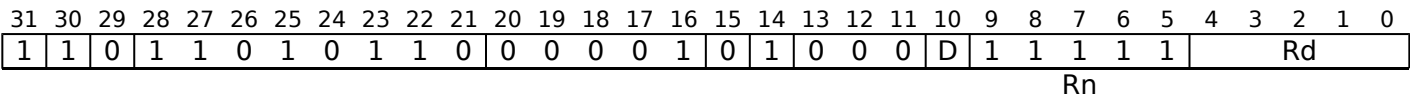
PSTATE.N = N;
PSTATE.Z = Z;
PSTATE.C = C;
PSTATE.V = V;
```

XPACD, XPACI, XPACLRI

Strip Pointer Authentication Code. This instruction removes the pointer authentication code from an address. The address is in the specified general-purpose register for XPACI and XPACD, and is in LR for XPACLRI. The XPACD instruction is used for data addresses, and XPACI and XPACLRI are used for instruction addresses.

It has encodings from 2 classes: Integer and System

Integer (Armv8.3)



XPACD (D == 1)

XPACD <Xd>

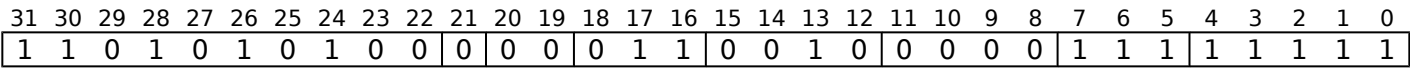
XPACI (D == 0)

XPACI <Xd>

```
boolean data = (D == '1');
integer d = UInt(Rd);

if !HavePACExt() then
    UNDEFINED;
```

System (Armv8.3)



System

XPACLRI

```
integer d = 30;
boolean data = FALSE;
```

Assembler Symbols

<Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.

Operation

```
if HavePACExt() then
    X[d] = Strip(X[d], data);
```



YIELD

YIELD is a hint instruction. Software with a multithreading capability can use a YIELD instruction to indicate to the PE that it is performing a task, for example a spin-lock, that could be swapped out to improve overall system performance. The PE can use this hint to suspend and resume multiple software threads if it supports the capability.

For more information about the recommended use of this instruction, see [The YIELD instruction](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	1	1	1	1	1	1
																CRm				op2											

System

YIELD

```
// Empty.
```

Operation

```
Hint_Yield();
```

## A64 -- SIMD and Floating-point Instructions (alphabetic order)

[ABS](#): Absolute value (vector).

[ADD \(vector\)](#): Add (vector).

[ADDHN, ADDHN2](#): Add returning High Narrow.

[ADDP \(scalar\)](#): Add Pair of elements (scalar).

[ADDP \(vector\)](#): Add Pairwise (vector).

[ADDV](#): Add across Vector.

[AESD](#): AES single round decryption.

[AESE](#): AES single round encryption.

[AESIMC](#): AES inverse mix columns.

[AESMC](#): AES mix columns.

[AND \(vector\)](#): Bitwise AND (vector).

[BCAX](#): Bit Clear and XOR.

[BFCVT](#): Floating-point convert from single-precision to BFloat16 format (scalar).

[BFCVTN, BFCVTN2](#): Floating-point convert from single-precision to BFloat16 format (vector).

[BFDOT \(by element\)](#): BFloat16 floating-point dot product (vector, by element).

[BFDOT \(vector\)](#): BFloat16 floating-point dot product (vector).

[BFMLALB, BFMLALT \(by element\)](#): BFloat16 floating-point widening multiply-add long (by element).

[BFMLALB, BFMLALT \(vector\)](#): BFloat16 floating-point widening multiply-add long (vector).

[BFMMLA](#): BFloat16 floating-point matrix multiply-accumulate into 2x2 matrix.

[BIC \(vector, immediate\)](#): Bitwise bit Clear (vector, immediate).

[BIC \(vector, register\)](#): Bitwise bit Clear (vector, register).

[BIF](#): Bitwise Insert if False.

[BIT](#): Bitwise Insert if True.

[BSL](#): Bitwise Select.

[CLS \(vector\)](#): Count Leading Sign bits (vector).

[CLZ \(vector\)](#): Count Leading Zero bits (vector).

[CMEQ \(register\)](#): Compare bitwise Equal (vector).

[CMEQ \(zero\)](#): Compare bitwise Equal to zero (vector).

[CMGE \(register\)](#): Compare signed Greater than or Equal (vector).

[CMGE \(zero\)](#): Compare signed Greater than or Equal to zero (vector).

[CMGT \(register\)](#): Compare signed Greater than (vector).

[CMGT \(zero\)](#): Compare signed Greater than zero (vector).

[CMHI \(register\)](#): Compare unsigned Higher (vector).

[CMHS \(register\)](#): Compare unsigned Higher or Same (vector).

[CMLE \(zero\)](#): Compare signed Less than or Equal to zero (vector).

[CMLT \(zero\)](#): Compare signed Less than zero (vector).

[CMTST](#): Compare bitwise Test bits nonzero (vector).

[CNT](#): Population Count per byte.

[DUP \(element\)](#): Duplicate vector element to vector or scalar.

[DUP \(general\)](#): Duplicate general-purpose register to vector.

[EOR \(vector\)](#): Bitwise Exclusive OR (vector).

[EOR3](#): Three-way Exclusive OR.

[EXT](#): Extract vector from pair of vectors.

[FABD](#): Floating-point Absolute Difference (vector).

[FABS \(scalar\)](#): Floating-point Absolute value (scalar).

[FABS \(vector\)](#): Floating-point Absolute value (vector).

[FACGE](#): Floating-point Absolute Compare Greater than or Equal (vector).

[FACGT](#): Floating-point Absolute Compare Greater than (vector).

[FADD \(scalar\)](#): Floating-point Add (scalar).

[FADD \(vector\)](#): Floating-point Add (vector).

[FADDP \(scalar\)](#): Floating-point Add Pair of elements (scalar).

[FADDP \(vector\)](#): Floating-point Add Pairwise (vector).

[FCADD](#): Floating-point Complex Add.

[FCCMP](#): Floating-point Conditional quiet Compare (scalar).

[FCCMPE](#): Floating-point Conditional signaling Compare (scalar).

[FCMEQ \(register\)](#): Floating-point Compare Equal (vector).

[FCMEQ \(zero\)](#): Floating-point Compare Equal to zero (vector).

[FCMGE \(register\)](#): Floating-point Compare Greater than or Equal (vector).

[FCMGE \(zero\)](#): Floating-point Compare Greater than or Equal to zero (vector).

[FCMGT \(register\)](#): Floating-point Compare Greater than (vector).

[FCMGT \(zero\)](#): Floating-point Compare Greater than zero (vector).

[FCMLA](#): Floating-point Complex Multiply Accumulate.

[FCMLA \(by element\)](#): Floating-point Complex Multiply Accumulate (by element).

[FCMLE \(zero\)](#): Floating-point Compare Less than or Equal to zero (vector).

[FCMLT \(zero\)](#): Floating-point Compare Less than zero (vector).

[FCMP](#): Floating-point quiet Compare (scalar).

[FCMPE](#): Floating-point signaling Compare (scalar).

[FCSEL](#): Floating-point Conditional Select (scalar).

[FCVT](#): Floating-point Convert precision (scalar).

[FCVTAS \(scalar\)](#): Floating-point Convert to Signed integer, rounding to nearest with ties to Away (scalar).

[FCVTAS \(vector\)](#): Floating-point Convert to Signed integer, rounding to nearest with ties to Away (vector).

[FCVTAU \(scalar\)](#): Floating-point Convert to Unsigned integer, rounding to nearest with ties to Away (scalar).

[FCVTAU \(vector\)](#): Floating-point Convert to Unsigned integer, rounding to nearest with ties to Away (vector).

[FCVTL, FCVTL2](#): Floating-point Convert to higher precision Long (vector).

[FCVTMS \(scalar\)](#): Floating-point Convert to Signed integer, rounding toward Minus infinity (scalar).

[FCVTMS \(vector\)](#): Floating-point Convert to Signed integer, rounding toward Minus infinity (vector).

[FCVTMU \(scalar\)](#): Floating-point Convert to Unsigned integer, rounding toward Minus infinity (scalar).

[FCVTMU \(vector\)](#): Floating-point Convert to Unsigned integer, rounding toward Minus infinity (vector).

[FCVTN, FCVTN2](#): Floating-point Convert to lower precision Narrow (vector).

[FCVTNS \(scalar\)](#): Floating-point Convert to Signed integer, rounding to nearest with ties to even (scalar).

[FCVTNS \(vector\)](#): Floating-point Convert to Signed integer, rounding to nearest with ties to even (vector).

[FCVTNU \(scalar\)](#): Floating-point Convert to Unsigned integer, rounding to nearest with ties to even (scalar).

[FCVTNU \(vector\)](#): Floating-point Convert to Unsigned integer, rounding to nearest with ties to even (vector).

[FCVTPS \(scalar\)](#): Floating-point Convert to Signed integer, rounding toward Plus infinity (scalar).

[FCVTPS \(vector\)](#): Floating-point Convert to Signed integer, rounding toward Plus infinity (vector).

[FCVTPU \(scalar\)](#): Floating-point Convert to Unsigned integer, rounding toward Plus infinity (scalar).

[FCVTPU \(vector\)](#): Floating-point Convert to Unsigned integer, rounding toward Plus infinity (vector).

[FCVTXN, FCVTXN2](#): Floating-point Convert to lower precision Narrow, rounding to odd (vector).

[FCVTZS \(scalar, fixed-point\)](#): Floating-point Convert to Signed fixed-point, rounding toward Zero (scalar).

[FCVTZS \(scalar, integer\)](#): Floating-point Convert to Signed integer, rounding toward Zero (scalar).

[FCVTZS \(vector, fixed-point\)](#): Floating-point Convert to Signed fixed-point, rounding toward Zero (vector).

[FCVTZS \(vector, integer\)](#): Floating-point Convert to Signed integer, rounding toward Zero (vector).

[FCVTZU \(scalar, fixed-point\)](#): Floating-point Convert to Unsigned fixed-point, rounding toward Zero (scalar).

[FCVTZU \(scalar, integer\)](#): Floating-point Convert to Unsigned integer, rounding toward Zero (scalar).

[FCVTZU \(vector, fixed-point\)](#): Floating-point Convert to Unsigned fixed-point, rounding toward Zero (vector).

[FCVTZU \(vector, integer\)](#): Floating-point Convert to Unsigned integer, rounding toward Zero (vector).

[FDIV \(scalar\)](#): Floating-point Divide (scalar).

[FDIV \(vector\)](#): Floating-point Divide (vector).

[FJCVTZS](#): Floating-point Javascript Convert to Signed fixed-point, rounding toward Zero.

[FMADD](#): Floating-point fused Multiply-Add (scalar).

[FMAX \(scalar\)](#): Floating-point Maximum (scalar).

[FMAX \(vector\)](#): Floating-point Maximum (vector).

[FMAXNM \(scalar\)](#): Floating-point Maximum Number (scalar).

[FMAXNM \(vector\)](#): Floating-point Maximum Number (vector).

[FMAXNMP \(scalar\)](#): Floating-point Maximum Number of Pair of elements (scalar).

[FMAXNMP \(vector\)](#): Floating-point Maximum Number Pairwise (vector).

[FMAXNMV](#): Floating-point Maximum Number across Vector.

[FMAXP \(scalar\)](#): Floating-point Maximum of Pair of elements (scalar).

[FMAXP \(vector\)](#): Floating-point Maximum Pairwise (vector).

[FMAXV](#): Floating-point Maximum across Vector.

[FMIN \(scalar\)](#): Floating-point Minimum (scalar).

[FMIN \(vector\)](#): Floating-point minimum (vector).

[FMINNM \(scalar\)](#): Floating-point Minimum Number (scalar).

[FMINNM \(vector\)](#): Floating-point Minimum Number (vector).

[FMINNMP \(scalar\)](#): Floating-point Minimum Number of Pair of elements (scalar).

[FMINNMP \(vector\)](#): Floating-point Minimum Number Pairwise (vector).

[FMINNMV](#): Floating-point Minimum Number across Vector.

[FMINP \(scalar\)](#): Floating-point Minimum of Pair of elements (scalar).

[FMINP \(vector\)](#): Floating-point Minimum Pairwise (vector).

[FMINV](#): Floating-point Minimum across Vector.

[FMLA \(by element\)](#): Floating-point fused Multiply-Add to accumulator (by element).

[FMLA \(vector\)](#): Floating-point fused Multiply-Add to accumulator (vector).

[FMLAL, FMLAL2 \(by element\)](#): Floating-point fused Multiply-Add Long to accumulator (by element).

[FMLAL, FMLAL2 \(vector\)](#): Floating-point fused Multiply-Add Long to accumulator (vector).

[FMLS \(by element\)](#): Floating-point fused Multiply-Subtract from accumulator (by element).

[FMLS \(vector\)](#): Floating-point fused Multiply-Subtract from accumulator (vector).

[FMLS, FMLSL2 \(by element\)](#): Floating-point fused Multiply-Subtract Long from accumulator (by element).

[FMLS, FMLSL2 \(vector\)](#): Floating-point fused Multiply-Subtract Long from accumulator (vector).

[FMOV \(general\)](#): Floating-point Move to or from general-purpose register without conversion.

[FMOV \(register\)](#): Floating-point Move register without conversion.

[FMOV \(scalar, immediate\)](#): Floating-point move immediate (scalar).

[FMOV \(vector, immediate\)](#): Floating-point move immediate (vector).

[FMSUB](#): Floating-point Fused Multiply-Subtract (scalar).

[FMUL \(by element\)](#): Floating-point Multiply (by element).

[FMUL \(scalar\)](#): Floating-point Multiply (scalar).

[FMUL \(vector\)](#): Floating-point Multiply (vector).

[FMULX](#): Floating-point Multiply extended.

[FMULX \(by element\)](#): Floating-point Multiply extended (by element).

[FNEG \(scalar\)](#): Floating-point Negate (scalar).

[FNEG \(vector\)](#): Floating-point Negate (vector).

[FNMADD](#): Floating-point Negated fused Multiply-Add (scalar).

[FNMSUB](#): Floating-point Negated fused Multiply-Subtract (scalar).

[FNMUL \(scalar\)](#): Floating-point Multiply-Negate (scalar).

[FRECPE](#): Floating-point Reciprocal Estimate.

[FRECPS](#): Floating-point Reciprocal Step.

[FRECPX](#): Floating-point Reciprocal exponent (scalar).

[FRINT32X \(scalar\)](#): Floating-point Round to 32-bit Integer, using current rounding mode (scalar).

[FRINT32X \(vector\)](#): Floating-point Round to 32-bit Integer, using current rounding mode (vector).

[FRINT32Z \(scalar\)](#): Floating-point Round to 32-bit Integer toward Zero (scalar).

[FRINT32Z \(vector\)](#): Floating-point Round to 32-bit Integer toward Zero (vector).

[FRINT64X \(scalar\)](#): Floating-point Round to 64-bit Integer, using current rounding mode (scalar).

[FRINT64X \(vector\)](#): Floating-point Round to 64-bit Integer, using current rounding mode (vector).

[FRINT64Z \(scalar\)](#): Floating-point Round to 64-bit Integer toward Zero (scalar).

[FRINT64Z \(vector\)](#): Floating-point Round to 64-bit Integer toward Zero (vector).

[FRINTA \(scalar\)](#): Floating-point Round to Integral, to nearest with ties to Away (scalar).

[FRINTA \(vector\)](#): Floating-point Round to Integral, to nearest with ties to Away (vector).

[FRINTI \(scalar\)](#): Floating-point Round to Integral, using current rounding mode (scalar).

[FRINTI \(vector\)](#): Floating-point Round to Integral, using current rounding mode (vector).

[FRINTM \(scalar\)](#): Floating-point Round to Integral, toward Minus infinity (scalar).

[FRINTM \(vector\)](#): Floating-point Round to Integral, toward Minus infinity (vector).

[FRINTN \(scalar\)](#): Floating-point Round to Integral, to nearest with ties to even (scalar).

[FRINTN \(vector\)](#): Floating-point Round to Integral, to nearest with ties to even (vector).

[FRINTP \(scalar\)](#): Floating-point Round to Integral, toward Plus infinity (scalar).

[FRINTP \(vector\)](#): Floating-point Round to Integral, toward Plus infinity (vector).

[FRINTX \(scalar\)](#): Floating-point Round to Integral exact, using current rounding mode (scalar).

[FRINTX \(vector\)](#): Floating-point Round to Integral exact, using current rounding mode (vector).

[FRINTZ \(scalar\)](#): Floating-point Round to Integral, toward Zero (scalar).

[FRINTZ \(vector\)](#): Floating-point Round to Integral, toward Zero (vector).

[FRSQRT](#): Floating-point Reciprocal Square Root Estimate.

[FRSQRTS](#): Floating-point Reciprocal Square Root Step.

[FSQRT \(scalar\)](#): Floating-point Square Root (scalar).

[FSQRT \(vector\)](#): Floating-point Square Root (vector).

[FSUB \(scalar\)](#): Floating-point Subtract (scalar).

[FSUB \(vector\)](#): Floating-point Subtract (vector).

[INS \(element\)](#): Insert vector element from another vector element.

[INS \(general\)](#): Insert vector element from general-purpose register.

[LD1 \(multiple structures\)](#): Load multiple single-element structures to one, two, three, or four registers.

[LD1 \(single structure\)](#): Load one single-element structure to one lane of one register.

[LD1R](#): Load one single-element structure and Replicate to all lanes (of one register).

[LD2 \(multiple structures\)](#): Load multiple 2-element structures to two registers.

[LD2 \(single structure\)](#): Load single 2-element structure to one lane of two registers.

[LD2R](#): Load single 2-element structure and Replicate to all lanes of two registers.

[LD3 \(multiple structures\)](#): Load multiple 3-element structures to three registers.

[LD3 \(single structure\)](#): Load single 3-element structure to one lane of three registers).

[LD3R](#): Load single 3-element structure and Replicate to all lanes of three registers.

[LD4 \(multiple structures\)](#): Load multiple 4-element structures to four registers.

[LD4 \(single structure\)](#): Load single 4-element structure to one lane of four registers.

[LD4R](#): Load single 4-element structure and Replicate to all lanes of four registers.

[LDNP \(SIMD&FP\)](#): Load Pair of SIMD&FP registers, with Non-temporal hint.

[LDP \(SIMD&FP\)](#): Load Pair of SIMD&FP registers.

[LDR \(immediate, SIMD&FP\)](#): Load SIMD&FP Register (immediate offset).

[LDR \(literal, SIMD&FP\)](#): Load SIMD&FP Register (PC-relative literal).

[LDR \(register, SIMD&FP\)](#): Load SIMD&FP Register (register offset).

[LDUR \(SIMD&FP\)](#): Load SIMD&FP Register (unscaled offset).

[MLA \(by element\)](#): Multiply-Add to accumulator (vector, by element).

[MLA \(vector\)](#): Multiply-Add to accumulator (vector).

[MLS \(by element\)](#): Multiply-Subtract from accumulator (vector, by element).

[MLS \(vector\)](#): Multiply-Subtract from accumulator (vector).

[MOV \(element\)](#): Move vector element to another vector element: an alias of INS (element).

[MOV \(from general\)](#): Move general-purpose register to a vector element: an alias of INS (general).

[MOV \(scalar\)](#): Move vector element to scalar: an alias of DUP (element).

[MOV \(to general\)](#): Move vector element to general-purpose register: an alias of UMOV.

[MOV \(vector\)](#): Move vector: an alias of ORR (vector, register).

[MOVI](#): Move Immediate (vector).

[MUL \(by element\)](#): Multiply (vector, by element).

[MUL \(vector\)](#): Multiply (vector).

[MVN](#): Bitwise NOT (vector): an alias of NOT.

[MVNI](#): Move inverted Immediate (vector).

[NEG \(vector\)](#): Negate (vector).

[NOT](#): Bitwise NOT (vector).

[ORN \(vector\)](#): Bitwise inclusive OR NOT (vector).

[ORR \(vector, immediate\)](#): Bitwise inclusive OR (vector, immediate).

[ORR \(vector, register\)](#): Bitwise inclusive OR (vector, register).

[PMUL](#): Polynomial Multiply.

[PMULL, PMULL2](#): Polynomial Multiply Long.

[RADDHN, RADDHN2](#): Rounding Add returning High Narrow.

[RAX1](#): Rotate and Exclusive OR.

[RBIT \(vector\)](#): Reverse Bit order (vector).

[REV16 \(vector\)](#): Reverse elements in 16-bit halfwords (vector).

[REV32 \(vector\)](#): Reverse elements in 32-bit words (vector).

[REV64](#): Reverse elements in 64-bit doublewords (vector).

[RSHRN, RSHRN2](#): Rounding Shift Right Narrow (immediate).

[RSUBHN, RSUBHN2](#): Rounding Subtract returning High Narrow.

[SABA](#): Signed Absolute difference and Accumulate.

[SABAL, SABAL2](#): Signed Absolute difference and Accumulate Long.

[SABD](#): Signed Absolute Difference.

[SABDL, SABDL2](#): Signed Absolute Difference Long.

[SADALP](#): Signed Add and Accumulate Long Pairwise.

[SADDL, SADDL2](#): Signed Add Long (vector).

[SADDLP](#): Signed Add Long Pairwise.

[SADDLV](#): Signed Add Long across Vector.

[SADDW, SADDW2](#): Signed Add Wide.

[SCVTF \(scalar, fixed-point\)](#): Signed fixed-point Convert to Floating-point (scalar).

[SCVTF \(scalar, integer\)](#): Signed integer Convert to Floating-point (scalar).

[SCVTF \(vector, fixed-point\)](#): Signed fixed-point Convert to Floating-point (vector).

[SCVTF \(vector, integer\)](#): Signed integer Convert to Floating-point (vector).

[SDOT \(by element\)](#): Dot Product signed arithmetic (vector, by element).

[SDOT \(vector\)](#): Dot Product signed arithmetic (vector).

[SHA1C](#): SHA1 hash update (choose).

[SHA1H](#): SHA1 fixed rotate.

[SHA1M](#): SHA1 hash update (majority).

[SHA1P](#): SHA1 hash update (parity).

[SHA1SU0](#): SHA1 schedule update 0.

[SHA1SU1](#): SHA1 schedule update 1.

[SHA256H](#): SHA256 hash update (part 1).

[SHA256H2](#): SHA256 hash update (part 2).

[SHA256SU0](#): SHA256 schedule update 0.

[SHA256SU1](#): SHA256 schedule update 1.

[SHA512H](#): SHA512 Hash update part 1.

[SHA512H2](#): SHA512 Hash update part 2.



[SHA512SU0](#): SHA512 Schedule Update 0.

[SHA512SU1](#): SHA512 Schedule Update 1.

[SHADD](#): Signed Halving Add.

[SHL](#): Shift Left (immediate).

[SHLL](#), [SHLL2](#): Shift Left Long (by element size).

[SHRN](#), [SHRN2](#): Shift Right Narrow (immediate).

[SHSUB](#): Signed Halving Subtract.

[SLI](#): Shift Left and Insert (immediate).

[SM3PARTW1](#): SM3PARTW1.

[SM3PARTW2](#): SM3PARTW2.

[SM3SS1](#): SM3SS1.

[SM3TT1A](#): SM3TT1A.

[SM3TT1B](#): SM3TT1B.

[SM3TT2A](#): SM3TT2A.

[SM3TT2B](#): SM3TT2B.

[SM4E](#): SM4 Encode.

[SM4EKEY](#): SM4 Key.

[SMAX](#): Signed Maximum (vector).

[SMAXP](#): Signed Maximum Pairwise.

[SMAXV](#): Signed Maximum across Vector.

[SMIN](#): Signed Minimum (vector).

[SMINP](#): Signed Minimum Pairwise.

[SMINV](#): Signed Minimum across Vector.

[SMLAL](#), [SMLAL2 \(by element\)](#): Signed Multiply-Add Long (vector, by element).

[SMLAL](#), [SMLAL2 \(vector\)](#): Signed Multiply-Add Long (vector).

[SMLSL](#), [SMLSL2 \(by element\)](#): Signed Multiply-Subtract Long (vector, by element).

[SMLSL](#), [SMLSL2 \(vector\)](#): Signed Multiply-Subtract Long (vector).

[SMMLA \(vector\)](#): Signed 8-bit integer matrix multiply-accumulate (vector).

[SMOV](#): Signed Move vector element to general-purpose register.

[SMULL](#), [SMULL2 \(by element\)](#): Signed Multiply Long (vector, by element).

[SMULL](#), [SMULL2 \(vector\)](#): Signed Multiply Long (vector).

[SQABS](#): Signed saturating Absolute value.

[SQADD](#): Signed saturating Add.

[SQDMLAL](#), [SQDMLAL2 \(by element\)](#): Signed saturating Doubling Multiply-Add Long (by element).

[SQDMLAL](#), [SQDMLAL2 \(vector\)](#): Signed saturating Doubling Multiply-Add Long.

[SQDMLSL](#), [SQDMLSL2 \(by element\)](#): Signed saturating Doubling Multiply-Subtract Long (by element).

[SQDMLSL, SQDMLSL2 \(vector\)](#): Signed saturating Doubling Multiply-Subtract Long.

[SQDMULH \(by element\)](#): Signed saturating Doubling Multiply returning High half (by element).

[SQDMULH \(vector\)](#): Signed saturating Doubling Multiply returning High half.

[SQDMULL, SQDMULL2 \(by element\)](#): Signed saturating Doubling Multiply Long (by element).

[SQDMULL, SQDMULL2 \(vector\)](#): Signed saturating Doubling Multiply Long.

[SQNEG](#): Signed saturating Negate.

[SQRDMLAH \(by element\)](#): Signed Saturating Rounding Doubling Multiply Accumulate returning High Half (by element).

[SQRDMLAH \(vector\)](#): Signed Saturating Rounding Doubling Multiply Accumulate returning High Half (vector).

[SQRDMLSH \(by element\)](#): Signed Saturating Rounding Doubling Multiply Subtract returning High Half (by element).

[SQRDMLSH \(vector\)](#): Signed Saturating Rounding Doubling Multiply Subtract returning High Half (vector).

[SQRDMULH \(by element\)](#): Signed saturating Rounding Doubling Multiply returning High half (by element).

[SQRDMULH \(vector\)](#): Signed saturating Rounding Doubling Multiply returning High half.

[SQRSHL](#): Signed saturating Rounding Shift Left (register).

[SQRSHRN, QQRSHRN2](#): Signed saturating Rounded Shift Right Narrow (immediate).

[QQRSHRUN, QQRSHRUN2](#): Signed saturating Rounded Shift Right Unsigned Narrow (immediate).

[SQSHL \(immediate\)](#): Signed saturating Shift Left (immediate).

[SQSHL \(register\)](#): Signed saturating Shift Left (register).

[SQSHLU](#): Signed saturating Shift Left Unsigned (immediate).

[SQSHRN, SQSHRN2](#): Signed saturating Shift Right Narrow (immediate).

[SQSHRUN, SQSHRUN2](#): Signed saturating Shift Right Unsigned Narrow (immediate).

[SQSUB](#): Signed saturating Subtract.

[SQXTN, SQXTN2](#): Signed saturating extract Narrow.

[SQXTUN, SQXTUN2](#): Signed saturating extract Unsigned Narrow.

[SRHADD](#): Signed Rounding Halving Add.

[SRI](#): Shift Right and Insert (immediate).

[SRSHL](#): Signed Rounding Shift Left (register).

[SRSHR](#): Signed Rounding Shift Right (immediate).

[SRSRA](#): Signed Rounding Shift Right and Accumulate (immediate).

[SSHL](#): Signed Shift Left (register).

[SSHLL, SSHLL2](#): Signed Shift Left Long (immediate).

[SSHR](#): Signed Shift Right (immediate).

[SSRA](#): Signed Shift Right and Accumulate (immediate).

[SSUBL, SSUBL2](#): Signed Subtract Long.

[SSUBW, SSUBW2](#): Signed Subtract Wide.

[ST1 \(multiple structures\)](#): Store multiple single-element structures from one, two, three, or four registers.

[ST1 \(single structure\)](#): Store a single-element structure from one lane of one register.

[ST2 \(multiple structures\)](#): Store multiple 2-element structures from two registers.

[ST2 \(single structure\)](#): Store single 2-element structure from one lane of two registers.

[ST3 \(multiple structures\)](#): Store multiple 3-element structures from three registers.

[ST3 \(single structure\)](#): Store single 3-element structure from one lane of three registers.

[ST4 \(multiple structures\)](#): Store multiple 4-element structures from four registers.

[ST4 \(single structure\)](#): Store single 4-element structure from one lane of four registers.

[STNP \(SIMD&FP\)](#): Store Pair of SIMD&FP registers, with Non-temporal hint.

[STP \(SIMD&FP\)](#): Store Pair of SIMD&FP registers.

[STR \(immediate, SIMD&FP\)](#): Store SIMD&FP register (immediate offset).

[STR \(register, SIMD&FP\)](#): Store SIMD&FP register (register offset).

[STUR \(SIMD&FP\)](#): Store SIMD&FP register (unscaled offset).

[SUB \(vector\)](#): Subtract (vector).

[SUBHN, SUBHN2](#): Subtract returning High Narrow.

[SUDOT \(by element\)](#): Dot product with signed and unsigned integers (vector, by element).

[SUQADD](#): Signed saturating Accumulate of Unsigned value.

[SXTL, SXTL2](#): Signed extend Long: an alias of SSHLL, SSHLL2.

[TBL](#): Table vector Lookup.

[TBX](#): Table vector lookup extension.

[TRN1](#): Transpose vectors (primary).

[TRN2](#): Transpose vectors (secondary).

[UABA](#): Unsigned Absolute difference and Accumulate.

[UABAL, UABAL2](#): Unsigned Absolute difference and Accumulate Long.

[UABD](#): Unsigned Absolute Difference (vector).

[UABDL, UABDL2](#): Unsigned Absolute Difference Long.

[UADALP](#): Unsigned Add and Accumulate Long Pairwise.

[UADDL, UADDL2](#): Unsigned Add Long (vector).

[UADDLP](#): Unsigned Add Long Pairwise.

[UADDLV](#): Unsigned sum Long across Vector.

[UADDW, UADDW2](#): Unsigned Add Wide.

[UCVTF \(scalar, fixed-point\)](#): Unsigned fixed-point Convert to Floating-point (scalar).

[UCVTF \(scalar, integer\)](#): Unsigned integer Convert to Floating-point (scalar).

[UCVTF \(vector, fixed-point\)](#): Unsigned fixed-point Convert to Floating-point (vector).

[UCVTF \(vector, integer\)](#): Unsigned integer Convert to Floating-point (vector).

[UDOT \(by element\)](#): Dot Product unsigned arithmetic (vector, by element).

[UDOT \(vector\)](#): Dot Product unsigned arithmetic (vector).

[UHADD](#): Unsigned Halving Add.

[UHSUB](#): Unsigned Halving Subtract.

[UMAX](#): Unsigned Maximum (vector).

[UMAXP](#): Unsigned Maximum Pairwise.

[UMAXV](#): Unsigned Maximum across Vector.

[UMIN](#): Unsigned Minimum (vector).

[UMINP](#): Unsigned Minimum Pairwise.

[UMINV](#): Unsigned Minimum across Vector.

[UMLAL](#), [UMLAL2 \(by element\)](#): Unsigned Multiply-Add Long (vector, by element).

[UMLAL](#), [UMLAL2 \(vector\)](#): Unsigned Multiply-Add Long (vector).

[UMLSL](#), [UMLSL2 \(by element\)](#): Unsigned Multiply-Subtract Long (vector, by element).

[UMLSL](#), [UMLSL2 \(vector\)](#): Unsigned Multiply-Subtract Long (vector).

[UMMLA \(vector\)](#): Unsigned 8-bit integer matrix multiply-accumulate (vector).

[UMOV](#): Unsigned Move vector element to general-purpose register.

[UMULL](#), [UMULL2 \(by element\)](#): Unsigned Multiply Long (vector, by element).

[UMULL](#), [UMULL2 \(vector\)](#): Unsigned Multiply long (vector).

[UQADD](#): Unsigned saturating Add.

[UQRSHL](#): Unsigned saturating Rounding Shift Left (register).

[UQRSHRN](#), [UQRSHRN2](#): Unsigned saturating Rounded Shift Right Narrow (immediate).

[UQSHL \(immediate\)](#): Unsigned saturating Shift Left (immediate).

[UQSHL \(register\)](#): Unsigned saturating Shift Left (register).

[UQSHRN](#), [UQSHRN2](#): Unsigned saturating Shift Right Narrow (immediate).

[UQSUB](#): Unsigned saturating Subtract.

[UQXTN](#), [UQXTN2](#): Unsigned saturating extract Narrow.

[URECPE](#): Unsigned Reciprocal Estimate.

[URHADD](#): Unsigned Rounding Halving Add.

[URSHL](#): Unsigned Rounding Shift Left (register).

[URSHR](#): Unsigned Rounding Shift Right (immediate).

[URSQRTE](#): Unsigned Reciprocal Square Root Estimate.

[URSRA](#): Unsigned Rounding Shift Right and Accumulate (immediate).

[USDOT \(by element\)](#): Dot Product with unsigned and signed integers (vector, by element).

[USDOT \(vector\)](#): Dot Product with unsigned and signed integers (vector).

[USHL](#): Unsigned Shift Left (register).

[USHLL](#), [USHLL2](#): Unsigned Shift Left Long (immediate).

[USHR](#): Unsigned Shift Right (immediate).

[USMMLA \(vector\)](#): Unsigned and signed 8-bit integer matrix multiply-accumulate (vector).

[USQADD](#): Unsigned saturating Accumulate of Signed value.

[USRA](#): Unsigned Shift Right and Accumulate (immediate).

[USUBL](#), [USUBL2](#): Unsigned Subtract Long.

[USUBW](#), [USUBW2](#): Unsigned Subtract Wide.

[UXTL](#), [UXTL2](#): Unsigned extend Long: an alias of USHLL, USHLL2.

[UZP1](#): Unzip vectors (primary).

[UZP2](#): Unzip vectors (secondary).

[XAR](#): Exclusive OR and Rotate.

[XTN](#), [XTN2](#): Extract Narrow.

[ZIP1](#): Zip vectors (primary).

[ZIP2](#): Zip vectors (secondary).

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

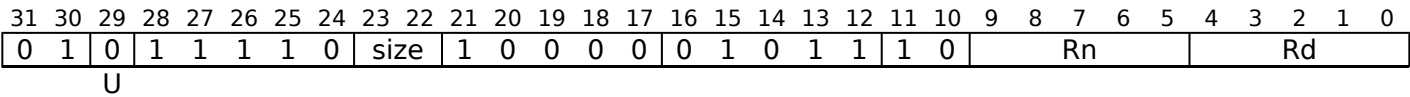
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ABS

Absolute value (vector). This instruction calculates the absolute value of each vector element in the source SIMD&FP register, puts the result into a vector, and writes the vector to the destination SIMD&FP register.  
Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar



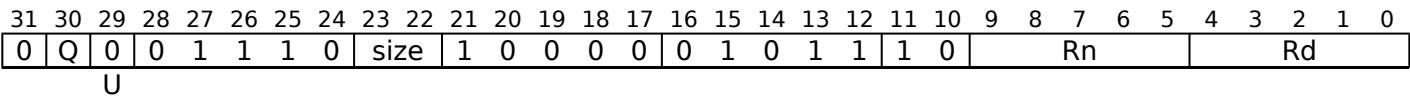
Scalar

```
ABS <V><d>, <V><n>

integer d = UInt(Rd);
integer n = UInt(Rn);

if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean neg = (U == '1');
```

Vector



Vector

```
ABS <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean neg = (U == '1');
```

Assembler Symbols

- <V>

Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D
- <d>

Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n>

Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T>

Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
integer element;

for e = 0 to elements-1
    element = SInt(Elem[operand, e, esize]);
    if neg then
        element = -element;
    else
        element = Abs(element);
    Elem[result, e, esize] = element<esize-1:0>;

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

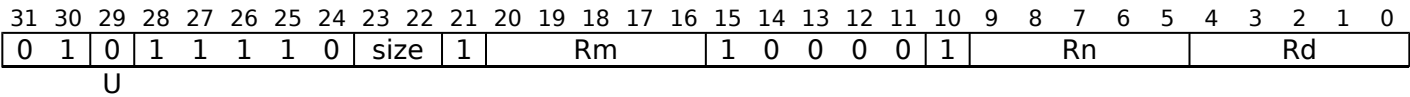
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ADD (vector)

Add (vector). This instruction adds corresponding elements in the two source SIMD&FP registers, places the results into a vector, and writes the vector to the destination SIMD&FP register.  
Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar

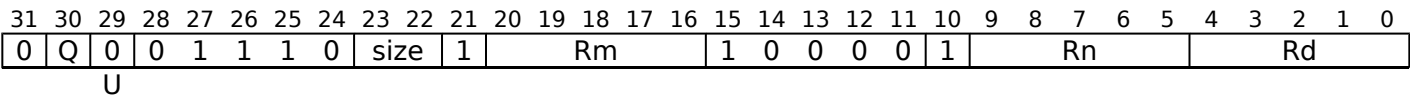


Scalar

```
ADD <V><d>, <V><n>, <V><m>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean sub_op = (U == '1');
```

Vector



Vector

```
ADD <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean sub_op = (U == '1');
```

Assembler Symbols

- <V>

Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D
- <d>

Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n>

Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m>

Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T>

Is an arrangement specifier, encoded in “size:Q”:



size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    if sub_op then
        Elem[result, e, esize] = element1 - element2;
    else
        Elem[result, e, esize] = element1 + element2;

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

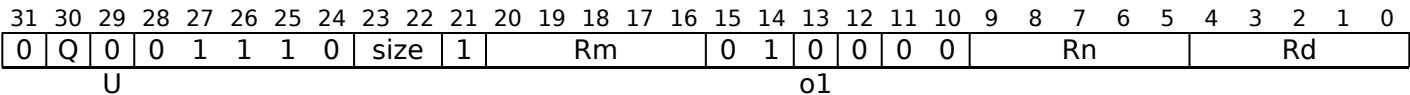
- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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ADDHN, ADDHN2

Add returning High Narrow. This instruction adds each vector element in the first source SIMD&FP register to the corresponding vector element in the second source SIMD&FP register, places the most significant half of the result into a vector, and writes the vector to the lower or upper half of the destination SIMD&FP register. The results are truncated. For rounded results, see [RADDHN](#). The ADDHN instruction writes the vector to the lower half of the destination register and clears the upper half, while the ADDHN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register. Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers, not all the same type

```
ADDHN{2} <Vd>.<Tb>, <Vn>.<Ta>, <Vm>.<Ta>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean sub_op = (o1 == '1');
boolean round = (U == '1');
```

Assembler Symbols

- 2

Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Tb>

Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED
- <Vn>

Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Ta>

Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED
- <Vm>

Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(2*datasize) operand1 = V[n];
bits(2*datasize) operand2 = V[m];
bits(datasize) result;
integer round_const = if round then 1 << (esize - 1) else 0;
bits(2*esize) element1;
bits(2*esize) element2;
bits(2*esize) sum;

for e = 0 to elements-1
    element1 = Elem[operand1, e, 2*esize];
    element2 = Elem[operand2, e, 2*esize];
    if sub_op then
        sum = element1 - element2;
    else
        sum = element1 + element2;
    sum = sum + round_const;
    Elem[result, e, esize] = sum<2*esize-1:esize>;

Vpart[d, part] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# ADDP (scalar)

Add Pair of elements (scalar). This instruction adds two vector elements in the source SIMD&FP register and writes the scalar result into the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	size	1	1	0	0	0	1	1	0	1	1	1	0		Rn					Rd				
											Rn											Rd									

## Advanced SIMD

```
ADDP <V><d>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if size != '11' then UNDEFINED;

integer esize = 8 << UInt(size);
integer datasize = esize * 2;
```

## Assembler Symbols

<V>	Is the destination width specifier, encoded in “size”:								
<table><tr><th>size</th><th>&lt;V&gt;</th></tr><tr><td>0x</td><td>RESERVED</td></tr><tr><td>10</td><td>RESERVED</td></tr><tr><td>11</td><td>D</td></tr></table>	size	<V>	0x	RESERVED	10	RESERVED	11	D	
size	<V>								
0x	RESERVED								
10	RESERVED								
11	D								
<d>	Is the number of the SIMD&FP destination register, encoded in the "Rd" field.								
<Vn>	Is the name of the SIMD&FP source register, encoded in the "Rn" field.								
<T>	Is the source arrangement specifier, encoded in “size”:								
<table><tr><th>size</th><th>&lt;T&gt;</th></tr><tr><td>0x</td><td>RESERVED</td></tr><tr><td>10</td><td>RESERVED</td></tr><tr><td>11</td><td>2D</td></tr></table>	size	<T>	0x	RESERVED	10	RESERVED	11	2D	
size	<T>								
0x	RESERVED								
10	RESERVED								
11	2D								

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
V[d] = Reduce(ReduceOp_ADD, operand, esize);
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

ADDP (vector)

Add Pairwise (vector). This instruction creates a vector by concatenating the vector elements of the first source SIMD&FP register after the vector elements of the second source SIMD&FP register, reads each pair of adjacent vector elements from the concatenated vector, adds each pair of values together, places the result into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	size	1	Rm						1	0	1	1	1	1	Rn						Rd			

Three registers of the same type

```
ADDP <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(2*datasize) concat = operand2:operand1;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    element1 = Elem[concat, 2*e, esize];
    element2 = Elem[concat, (2*e)+1, esize];
    Elem[result, e, esize] = element1 + element2;

V[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:

- The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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ADDV

Add across Vector. This instruction adds every vector element in the source SIMD&FP register together, and writes the scalar result to the destination SIMD&FP register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	size	1	1	0	0	0	1	1	0	1	1	1	0	1	Rn				Rd					

Advanced SIMD

ADDV <V><d>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '100' then UNDEFINED;
if size == '11' then UNDEFINED;

integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
```

Assembler Symbols

<V> Is the destination width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<T> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	RESERVED
10	1	4S
11	x	RESERVED

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
V[d] = Reduce(ReduceOp_ADD, operand, esize);
```

Operational information

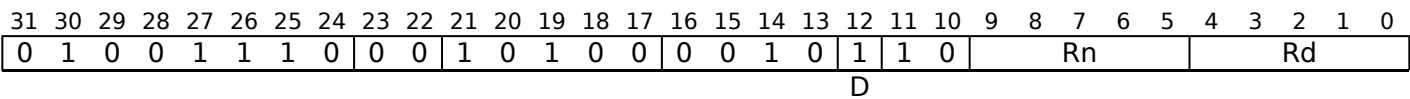
- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.





# AESD

AES single round decryption.



## Advanced SIMD

AESD <Vd>.16B, <Vn>.16B

```
integer d = UInt(Rd);
integer n = UInt(Rn);
if !HaveAESExt() then UNDEFINED;
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the second SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

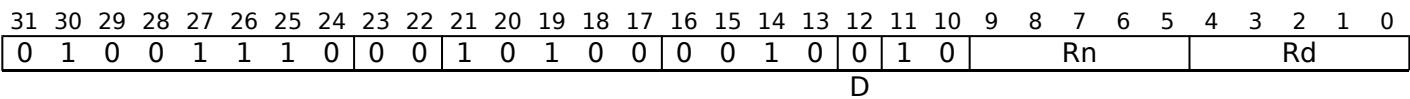
bits(128) operand1 = V[d];
bits(128) operand2 = V[n];
bits(128) result;
result = operand1 EOR operand2;
result = AESInvSubBytes(AESInvShiftRows(result));
V[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# AESE

AESE single round encryption.



## Advanced SIMD

AESE <Vd>.16B, <Vn>.16B

```
integer d = UInt(Rd);
integer n = UInt(Rn);
if !HaveAESExt() then UNDEFINED;
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the second SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) operand1 = V[d];
bits(128) operand2 = V[n];
bits(128) result;
result = operand1 EOR operand2;
result = AESSubBytes(AESShiftRows(result));

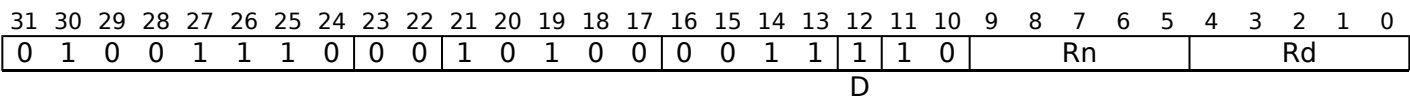
V[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# AESIMC

AES inverse mix columns.



## Advanced SIMD

AESIMC <Vd>.16B, <Vn>.16B

```
integer d = UInt(Rd);
integer n = UInt(Rn);
if !HaveAEEExt() then UNDEFINED;
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) operand = V[n];
bits(128) result;
result = AESInvMixColumns(operand);
V[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

AESMC

AES mix columns.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	1	1	1	0	0	0	1	0	1	0	0	0	0	1	1	0	1	0	Rn				Rd				D	

Advanced SIMD

AESMC <Vd>.16B, <Vn>.16B

```
integer d = UInt(Rd);
integer n = UInt(Rn);
if !HaveAEEExt() then UNDEFINED;
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) operand = V[n];
bits(128) result;
result = AESMixColumns(operand);
V[d] = result;
```

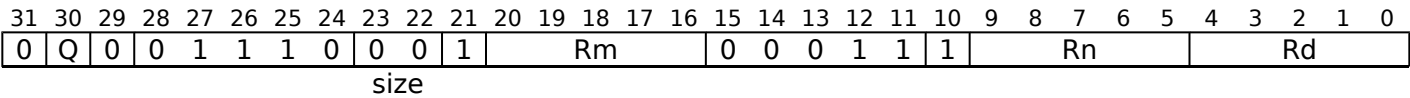
Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# AND (vector)

Bitwise AND (vector). This instruction performs a bitwise AND between the two source SIMD&FP registers, and writes the result to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Three registers of the same type

```
AND <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if Q == '1' then 128 else 64;
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "Q":
- | Q | <T> |
|---|-----|
| 0 | 8B  |
| 1 | 16B |
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

result = operand1 AND operand2;
V[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# BCAX

Bit Clear and Exclusive OR performs a bitwise AND of the 128-bit vector in a source SIMD&FP register and the complement of the vector in another source SIMD&FP register, then performs a bitwise exclusive OR of the resulting vector and the vector in a third source SIMD&FP register, and writes the result to the destination SIMD&FP register. This instruction is implemented only when [ARMv8.2-SHA](#) is implemented.

## Advanced SIMD (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	0	0	1	Rm					0	Ra					Rn					Rd				

## Advanced SIMD

BCAX <Vd>.16B, <Vn>.16B, <Vm>.16B, <Va>.16B

```
if !HaveSHA3Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer a = UInt(Ra);
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Va> Is the name of the third SIMD&FP source register, encoded in the "Ra" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) Vm = V[m];
bits(128) Vn = V[n];
bits(128) Va = V[a];
V[d] = Vn EOR (Vm AND NOT(Va));
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

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# BFCVT

Floating-point convert from single-precision to BFloat16 format (scalar) converts the single-precision floating-point value in the 32-bit SIMD&FP source register to BFloat16 format and writes the result in the 16-bit SIMD&FP destination register.

Unlike the BFloat16 multiplication instructions, this instruction honors all the control bits in the *FPCR* that apply to single-precision arithmetic, including the rounding mode. This instruction can generate a floating-point exception that causes a cumulative exception bit in the *FPSR* to be set, or a synchronous exception to be taken, depending on the enable bits in the *FPCR*. *ID\_AA64ISAR1\_EL1*.BF16 indicates whether this instruction is supported.

## Single-precision to BFloat16 (Armv8.6)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	0	0	1	1	1	1	0	0	1	1	0	0	0	1	1	0	1	0	0	0	0	Rn						Rd					

## Single-precision to BFloat16

```
BFCVT <Hd>, <Sn>

if !HaveBF16Ext() then UNDEFINED;
integer n = UInt(Rn);
integer d = UInt(Rd);
```

## Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(32) operand = V[n];
bits(16) result;

result = FPConvertBF(operand, FPCR);
V[d] = result;
```

BFCVTN, BFCVTN2

Floating-point convert from single-precision to BFloat16 format (vector) reads each single-precision element in the SIMD&FP source vector, converts each value to BFloat16 format, and writes the results in the lower or upper half of the SIMD&FP destination vector. The result elements are half the width of the source elements.

The BFCVTN instruction writes the half-width results to the lower half of the destination vector and clears the upper half to zero, while the BFCVTN2 instruction writes the results to the upper half of the destination vector without affecting the other bits in the register.

Unlike the BFloat16 multiplication instructions, this instruction honors all of the control bits in the *FPCR* that apply to single-precision arithmetic, including the rounding mode. It can also generate a floating-point exception that causes cumulative exception bits in the *FPSR* to be set, or a synchronous exception to be taken, depending on the enable bits in the *FPCR*.

Vector single-precision to BFloat16  
(Armv8.6)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	0	1	0	0	0	0	1	0	1	1	0	1	0	Rn				Rd					

Vector single-precision to BFloat16

```
BFCVTN{2} <Vd>.<Ta>, <Vn>.<4S>

if !HaveBF16Ext() then UNDEFINED;
integer n = UInt(Rn);
integer d = UInt(Rd);
integer part = UInt(Q);
integer elements = 64 DIV 16;
```

Assembler Symbols

- 2

Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in "Q":

Q	2
0	[absent]
1	[present]
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Ta>

Is an arrangement specifier, encoded in "Q":

Q	<Ta>
0	4H
1	8H
- <Vn>

Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(128) operand = V[n];
bits(64) result;

for e = 0 to elements-1
    Elem[result, e, 16] = FPConvertBF(Elem[operand, e, 32], FPCR);
Vpart[d, part] = result;
```



BFDOT (by element)

BFloat16 floating-point dot product (vector, by element). This instruction delimits the source vectors into pairs of 16-bit BF16 elements. Each pair of elements in the first source vector is multiplied by the specified pair of elements in the second source vector. The resulting single-precision products are then summed and added destructively to the single-precision element of the destination vector that aligns with the pair of BF16 values in the first source vector. The instruction ignores the *FPCR* and does not update the *FPSR* exception status.

The BF16 pair within the second source vector is specified using an immediate index. The index range is from 0 to 3 inclusive. *ID\_AA64ISAR1\_EL1*.BF16 indicates whether this instruction is supported.

Vector  
(Armv8.6)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	0	1	L	M	Rm				1	1	1	1	H	0	Rn				Rd					

Vector

BFDOT <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.2H[<index>]

```
if !HaveBF16Ext() then UNDEFINED;
integer n = UInt(Rn);
integer m = UInt(M:Rm);
integer d = UInt(Rd);
integer i = UInt(H:L);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV 32;
```

Assembler Symbols

- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Ta>

Is an arrangement specifier, encoded in "Q":

Q	<Ta>
0	2S
1	4S
- <Vn>

Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Tb>

Is an arrangement specifier, encoded in "Q":

Q	<Tb>
0	4H
1	8H
- <Vm>

Is the name of the second SIMD&FP source register, encoded in the "M:Rm" fields.
- <index>

Is the immediate index of a pair of 16-bit elements in the range 0 to 3, encoded in the "H:L" fields.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(128) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;

for e = 0 to elements-1
    bits(16) elt1_a = Elem[operand1, 2*e+0, 16];
    bits(16) elt1_b = Elem[operand1, 2*e+1, 16];
    bits(16) elt2_a = Elem[operand2, 2*i+0, 16];
    bits(16) elt2_b = Elem[operand2, 2*i+1, 16];

    bits(32) sum = BFAdd(BFMul(elt1_a, elt2_a), BFMul(elt1_b, elt2_b));
    Elem[result, e, 32] = BFAdd(Elem[operand3, e, 32], sum);

V[d] = result;
```

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# BFDOT (vector)

BFloat16 floating-point dot product (vector). This instruction delimits the source vectors into pairs of 16-bit BF16 elements. Within each pair, the elements in the first source vector are multiplied by the corresponding elements in the second source vector. The resulting single-precision products are then summed and added destructively to the single-precision element of the destination vector that aligns with the pair of BF16 values in the first source vector. The instruction ignores the *FPCR* and does not update the *FPSR* exception status.

## Vector (Armv8.6)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	1	0	Rm				1	1	1	1	1	1	Rn				Rd						

## Vector

```
BFDOT <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

if !HaveBF16Ext() then UNDEFINED;
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Rd);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV 32;
```

## Assembler Symbols

- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Ta>

Is an arrangement specifier, encoded in "Q":

Q	<Ta>
0	2S
1	4S
- <Vn>

Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Tb>

Is an arrangement specifier, encoded in "Q":

Q	<Tb>
0	4H
1	8H
- <Vm>

Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;

for e = 0 to elements-1
  bits(16) elt1_a = Elem[operand1, 2*e+0, 16];
  bits(16) elt1_b = Elem[operand1, 2*e+1, 16];
  bits(16) elt2_a = Elem[operand2, 2*e+0, 16];
  bits(16) elt2_b = Elem[operand2, 2*e+1, 16];

  bits(32) sum = BFAdd(BFMul(elt1_a, elt2_a), BFMul(elt1_b, elt2_b));
  Elem[result, e, 32] = BFAdd(Elem[operand3, e, 32], sum);

V[d] = result;
```



BFMLALB, BFMLALT (by element)

BFloat16 floating-point widening multiply-add long (by element) widens the even-numbered (bottom) or odd-numbered (top) 16-bit elements in the first source vector, and the indexed element in the second source vector from Bfloat16 to single-precision format. The instruction then multiplies and adds these values to the overlapping single-precision elements of the destination vector.

This performs a fused multiply-add without intermediate rounding that honors all of the control bits in the *FPCR* that apply to single-precision arithmetic, including the rounding mode. It can also generate a floating-point exception that causes cumulative exception bits in the *FPSR* to be set, or a synchronous exception to be taken, depending on the enable bits in the *FPCR*. *ID\_AA64ISAR1\_EL1*.BF16 indicates whether this instruction is supported.

Vector  
(Armv8.6)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	1	1	L	M	Rm				1	1	1	1	H	0	Rn				Rd					

Vector

```
BFMLAL<bt> <Vd>.4S, <Vn>.8H, <Vm>.H[<index>]
```

```
if !HaveBF16Ext() then UNDEFINED;
integer n = UInt(Rn);
integer m = UInt('0':Rm);
integer d = UInt(Rd);
integer index = UInt(H:L:M);

integer elements = 128 DIV 32;
integer sel = UInt(Q);
```

Assembler Symbols

- <bt>

Is the bottom or top element specifier, encoded in “Q”:

Q	<bt>
0	B
1	T
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Vn>

Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm>

Is the name of the second SIMD&FP source register, in the range V0 to V15, encoded in the "Rm" field.
- <index>

Is the element index, in the range 0 to 7, encoded in the "H:L:M" fields.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(128) operand1 = V[n];
bits(128) operand2 = V[m];
bits(128) operand3 = V[d];
bits(128) result;

bits(32) element2 = Elem[operand2, index, 16]:Zeros(16);

for e = 0 to elements-1
  bits(32) element1 = Elem[operand1, 2*e+sel, 16]:Zeros(16);
  bits(32) addend = Elem[operand3, e, 32];
  Elem[result, e, 32] = FPMulAdd(addend, element1, element2, FPCR);
V[d] = result;
```

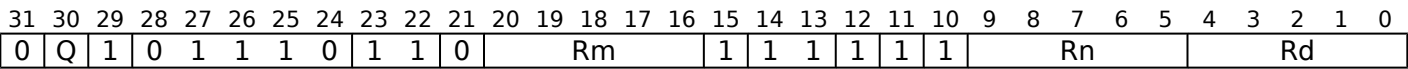


BFMLALB, BFMLALT (vector)

BFloat16 floating-point widening multiply-add long (vector) widens the even-numbered (bottom) or odd-numbered (top) 16-bit elements in the first and second source vectors from Bfloat16 to single-precision format. The instruction then multiplies and adds these values to the overlapping single-precision elements of the destination vector.

This performs a fused multiply-add without intermediate rounding that honors all of the control bits in the *FPCR* that apply to single-precision arithmetic, including the rounding mode. It can also generate a floating-point exception that causes cumulative exception bits in the *FPSR* to be set, or a synchronous exception to be taken, depending on the enable bits in the *FPCR*. *ID\_AA64ISAR1\_EL1*.BF16 indicates whether these instruction is supported.

Vector
(Armv8.6)



Vector

BFMLAL<bt> <Vd>.4S, <Vn>.8H, <Vm>.8H

```
if !HaveBF16Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer elements = 128 DIV 32;
integer sel = UInt(Q);
```

Assembler Symbols

- <bt> Is the bottom or top element specifier, encoded in "Q":
Table: Q | <bt>
0 | B
1 | T
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(128) operand1 = V[n];
bits(128) operand2 = V[m];
bits(128) operand3 = V[d];
bits(128) result;

for e = 0 to elements-1
    bits(32) element1 = Elem[operand1, 2*e+sel, 16]:Zeros(16);
    bits(32) element2 = Elem[operand2, 2*e+sel, 16]:Zeros(16);
    bits(32) addend = Elem[operand3, e, 32];
    Elem[result, e, 32] = FPMulAdd(addend, element1, element2, FPCR);
V[d] = result;
```

# BFMMLA

BFloat16 floating-point matrix multiply-accumulate into 2x2 matrix. This instruction multiplies the 2x4 matrix of BF16 values held in the first 128-bit source vector by the 4x2 BF16 matrix in the second 128-bit source vector. The resulting 2x2 single-precision matrix product is then added destructively to the 2x2 single-precision matrix in the 128-bit destination vector. This is equivalent to performing a 4-way dot product per destination element. The instruction ignores the *FPCR* and does not update the *FPSR* exception status.

Arm expects that the BFMMLA instruction will deliver a peak BF16 multiply throughput that is at least as high as can be achieved using two BFDOT instructions, with a goal that it should have significantly higher throughput.

## Vector (Armv8.6)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	1	1	0	0	1	0	Rm				1	1	1	0	1	1	Rn				Rd						

## Vector

BFMMLA <Vd>.4S, <Vn>.8H, <Vm>.8H

```
if !HaveBF16Ext() then UNDEFINED;
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Rd);
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP third source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(128) op1 = V[n];
bits(128) op2 = V[m];
bits(128) acc = V[d];

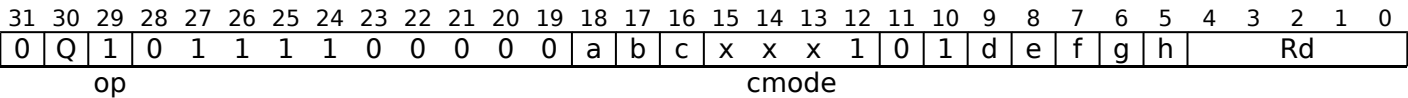
V[d] = BFMatMulAdd(acc, op1, op2);
```



BIC (vector, immediate)

Bitwise bit Clear (vector, immediate). This instruction reads each vector element from the destination SIMD&FP register, performs a bitwise AND between each result and the complement of an immediate constant, places the result into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



16-bit (cmode == 10x1)

BIC <Vd>.<T>, #<imm8>{, LSL #<amount>}

32-bit (cmode == 0xx1)

BIC <Vd>.<T>, #<imm8>{, LSL #<amount>}

```
integer rd = UInt(Rd);

integer datasize = if Q == '1' then 128 else 64;
bits(datasize) imm;
bits(64) imm64;

ImmediateOp operation;
case cmode:op of
  when '0xx01' operation = ImmediateOp_MVNI;
  when '0xx11' operation = ImmediateOp_BIC;
  when '10x01' operation = ImmediateOp_MVNI;
  when '10x11' operation = ImmediateOp_BIC;
  when '110x1' operation = ImmediateOp_MVNI;
  when '1110x' operation = ImmediateOp_MOVI;
  when '11111'
    // FMOV Dn,#imm is in main FP instruction set
    if Q == '0' then UNDEFINED;
    operation = ImmediateOp_MOVI;

imm64 = AdvSIMDExpandImm(op, cmode, a:b:c:d:e:f:g:h);
imm = Replicate(imm64, datasize DIV 64);
```

Assembler Symbols

- <Vd>

Is the name of the SIMD&FP register, encoded in the "Rd" field.
- <T>

For the 16-bit variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the 32-bit variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	2S
1	4S
- <imm8>

Is an 8-bit immediate encoded in "a:b:c:d:e:f:g:h".
- <amount>

For the 16-bit variant: is the shift amount encoded in "cmode<1>":

cmode<1>	<amount>
0	0
1	8

defaulting to 0 if LSL is omitted.

For the 32-bit variant: is the shift amount encoded in “cmode<2:1>”:

cmode<2:1>	<amount>
00	0
01	8
10	16
11	24

defaulting to 0 if LSL is omitted.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand;
bits(datasize) result;

case operation of
  when ImmediateOp_MOVI
    result = imm;
  when ImmediateOp_MVNI
    result = NOT(imm);
  when ImmediateOp_ORR
    operand = V[rd];
    result = operand OR imm;
  when ImmediateOp_BIC
    operand = V[rd];
    result = operand AND NOT(imm);

V[rd] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

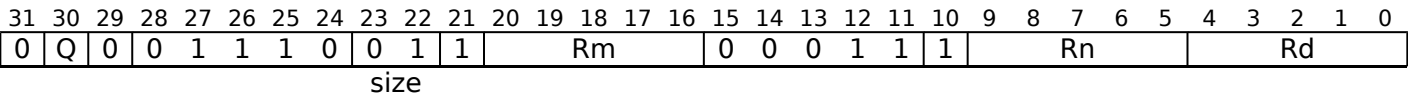
Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# BIC (vector, register)

Bitwise bit Clear (vector, register). This instruction performs a bitwise AND between the first source SIMD&FP register and the complement of the second source SIMD&FP register, and writes the result to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Three registers of the same type

```
BIC <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if Q == '1' then 128 else 64;
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "Q":
- | Q | <T> |
|---|-----|
| 0 | 8B  |
| 1 | 16B |
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

operand2 = NOT(operand2);

result = operand1 AND operand2;
V[d] = result;
```

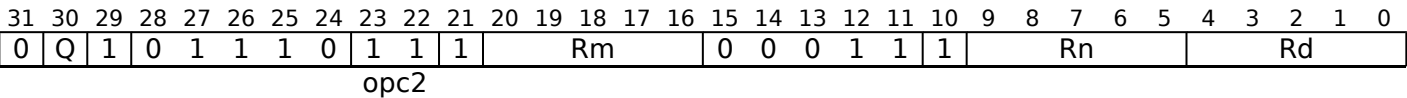
## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

BIF

Bitwise Insert if False. This instruction inserts each bit from the first source SIMD&FP register into the destination SIMD&FP register if the corresponding bit of the second source SIMD&FP register is 0, otherwise leaves the bit in the destination register unchanged.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers of the same type

BIF <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if Q == '1' then 128 else 64;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "Q":

Q	<T>
0	8B
1	16B

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1;
bits(datasize) operand3;
bits(datasize) operand4 = V[n];

operand1 = V[d];
operand3 = NOT(V[m]);

V[d] = operand1 EOR ((operand1 EOR operand4) AND operand3);
```

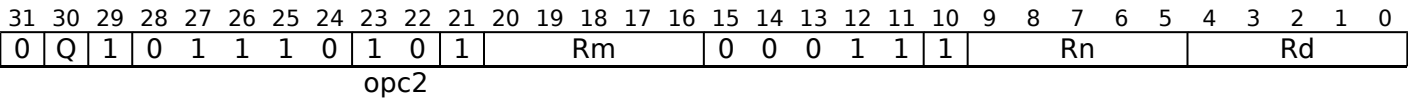
Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

BIT

Bitwise Insert if True. This instruction inserts each bit from the first source SIMD&FP register into the SIMD&FP destination register if the corresponding bit of the second source SIMD&FP register is 1, otherwise leaves the bit in the destination register unchanged.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers of the same type

```
BIT <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if Q == '1' then 128 else 64;
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "Q":

Q	<T>
0	8B
1	16B
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1;
bits(datasize) operand3;
bits(datasize) operand4 = V[n];

operand1 = V[d];
operand3 = V[m];
V[d] = operand1 EOR ((operand1 EOR operand4) AND operand3);
```

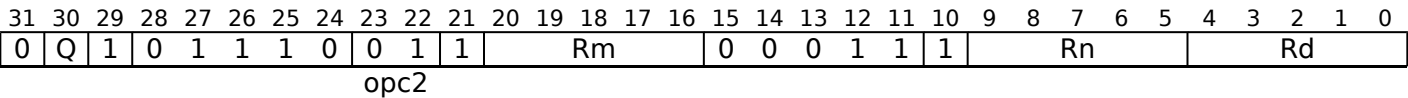
Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

BSL

Bitwise Select. This instruction sets each bit in the destination SIMD&FP register to the corresponding bit from the first source SIMD&FP register when the original destination bit was 1, otherwise from the second source SIMD&FP register.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers of the same type

```
BSL <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if Q == '1' then 128 else 64;
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "Q":

Q	<T>
0	8B
1	16B
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1;
bits(datasize) operand3;
bits(datasize) operand4 = V[n];

operand1 = V[m];
operand3 = V[d];
V[d] = operand1 EOR ((operand1 EOR operand4) AND operand3);
```

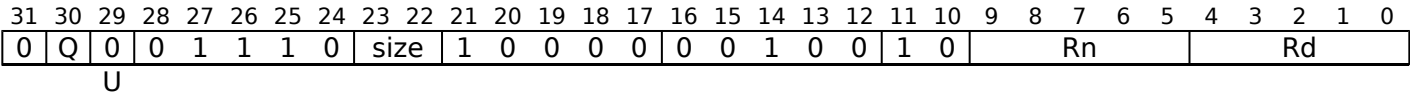
Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

CLS (vector)

Count Leading Sign bits (vector). This instruction counts the number of consecutive bits following the most significant bit that are the same as the most significant bit in each vector element in the source SIMD&FP register, places the result into a vector, and writes the vector to the destination SIMD&FP register. The count does not include the most significant bit itself.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Vector

```
CLS <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CountOp countop = if U == '1' then CountOp_CLZ else CountOp_CLS;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;

integer count;
for e = 0 to elements-1
    if countop == CountOp_CLS then
        count = CountLeadingSignBits(Elem[operand, e, esize]);
    else
        count = CountLeadingZeroBits(Elem[operand, e, esize]);
    Elem[result, e, esize] = count<esize-1:0>;
V[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.

- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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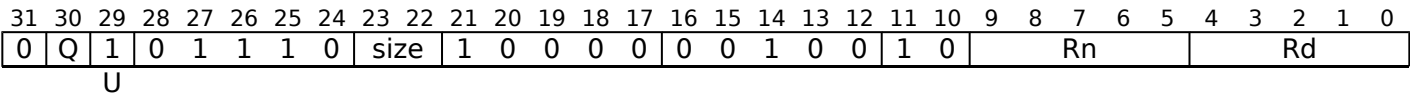
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## CLZ (vector)

Count Leading Zero bits (vector). This instruction counts the number of consecutive zeros, starting from the most significant bit, in each vector element in the source SIMD&FP register, places the result into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



### Vector

CLZ <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CountOp countop = if U == '1' then CountOp_CLZ else CountOp_CLS;
```

### Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

### Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;

integer count;
for e = 0 to elements-1
    if countop == CountOp_CLS then
        count = CountLeadingSignBits(Elem[operand, e, esize]);
    else
        count = CountLeadingZeroBits(Elem[operand, e, esize]);
    Elem[result, e, esize] = count<esize-1:0>;
V[d] = result;
```

### Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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CMEQ (register)

Compare bitwise Equal (vector). This instruction compares each vector element from the first source SIMD&FP register with the corresponding vector element from the second source SIMD&FP register, and if the comparison is equal sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: Scalar and Vector

Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	1	1	1	1	1	1	0	size	1	Rm						1	0	0	0	1	1	Rn						Rd					
U																																	

Scalar

```
CMEQ <V><d>, <V><n>, <V><m>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean and_test = (U == '0');
```

Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	size	1	Rm				1	0	0	0	1	1	Rn				Rd							
U																															

Vector

```
CMEQ <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean and_test = (U == '0');
```

Assembler Symbols

- <V>

Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D
- <d>

Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n>

Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m>

Is the number of the second SIMD&FP source register, encoded in the "Rm" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;
boolean test_passed;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    if and_test then
        test_passed = !IsZero(element1 AND element2);
    else
        test_passed = (element1 == element2);
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# CMEQ (zero)

Compare bitwise Equal to zero (vector). This instruction reads each vector element in the source SIMD&FP register and if the value is equal to zero sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	size	1	0	0	0	0	0	0	1	0	0	1	1	0	Rn				Rd					
U								op																							

## Scalar

```
CMEQ <V><d>, <V><n>, #0

integer d = UInt(Rd);
integer n = UInt(Rn);

if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;

CompareOp comparison;
case op:U of
    when '00' comparison = CompareOp_GT;
    when '01' comparison = CompareOp_GE;
    when '10' comparison = CompareOp_EQ;
    when '11' comparison = CompareOp_LE;
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	size	1	0	0	0	0	0	0	1	0	0	1	1	0	Rn				Rd					
U										op																					

## Vector

```
CMEQ <Vd>.<T>, <Vn>.<T>, #0

integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CompareOp comparison;
case op:U of
    when '00' comparison = CompareOp_GT;
    when '01' comparison = CompareOp_GE;
    when '10' comparison = CompareOp_EQ;
    when '11' comparison = CompareOp_LE;
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
integer element;
boolean test_passed;

for e = 0 to elements-1
  element = SInt(Elem[operand, e, esize]);
  case comparison of
    when CompareOp_GT test_passed = element > 0;
    when CompareOp_GE test_passed = element >= 0;
    when CompareOp_EQ test_passed = element == 0;
    when CompareOp_LE test_passed = element <= 0;
    when CompareOp_LT test_passed = element < 0;
  Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

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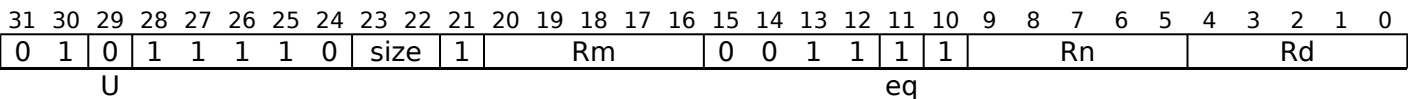
# CMGE (register)

Compare signed Greater than or Equal (vector). This instruction compares each vector element in the first source SIMD&FP register with the corresponding vector element in the second source SIMD&FP register and if the first signed integer value is greater than or equal to the second signed integer value sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

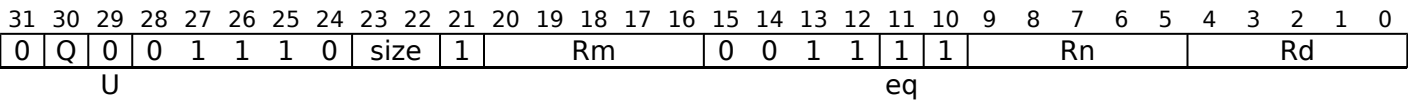


## Scalar

```
CMGE <V><d>, <V><n>, <V><m>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
boolean cmp_eq = (eq == '1');
```

## Vector



## Vector

```
CMGE <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
boolean cmp_eq = (eq == '1');
```

## Assembler Symbols

- <V>

Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D
- <d>

Is the number of the SIMD&FP destination register, in the "Rd" field.

- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

### Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
boolean test_passed;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    test_passed = if cmp_eq then element1 >= element2 else element1 > element2;
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;

```

### Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.



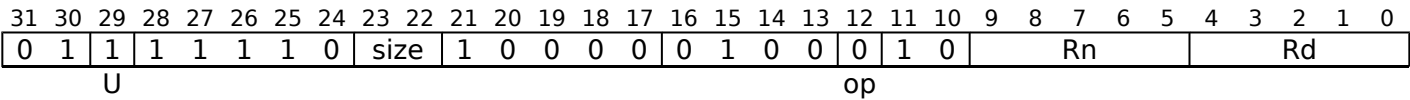
# CMGE (zero)

Compare signed Greater than or Equal to zero (vector). This instruction reads each vector element in the source SIMD&FP register and if the signed integer value is greater than or equal to zero sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar



## Scalar

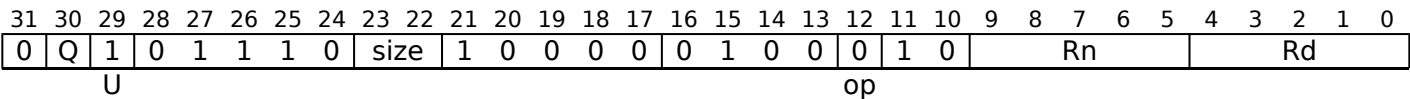
CMGE [<V><d>](#), [<V><n>](#), #0

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;

CompareOp comparison;
case op:U of
    when '00' comparison = CompareOp_GT;
    when '01' comparison = CompareOp_GE;
    when '10' comparison = CompareOp_EQ;
    when '11' comparison = CompareOp_LE;
```

## Vector



## Vector

CMGE [<Vd>.<T>](#), [<Vn>.<T>](#), #0

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CompareOp comparison;
case op:U of
    when '00' comparison = CompareOp_GT;
    when '01' comparison = CompareOp_GE;
    when '10' comparison = CompareOp_EQ;
    when '11' comparison = CompareOp_LE;
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
integer element;
boolean test_passed;

for e = 0 to elements-1
  element = SInt(Elem[operand, e, esize]);
  case comparison of
    when CompareOp_GT test_passed = element > 0;
    when CompareOp_GE test_passed = element >= 0;
    when CompareOp_EQ test_passed = element == 0;
    when CompareOp_LE test_passed = element <= 0;
    when CompareOp_LT test_passed = element < 0;
  Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

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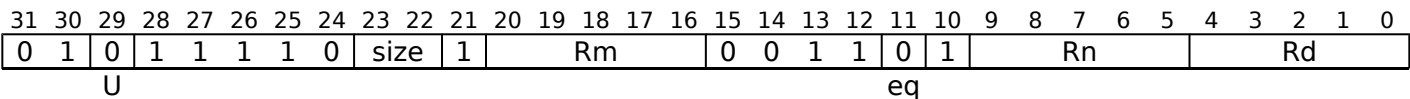
# CMGT (register)

Compare signed Greater than (vector). This instruction compares each vector element in the first source SIMD&FP register with the corresponding vector element in the second source SIMD&FP register and if the first signed integer value is greater than the second signed integer value sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

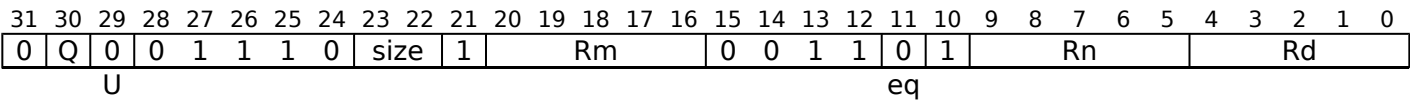


## Scalar

```
CMGT <V><d>, <V><n>, <V><m>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
boolean cmp_eq = (eq == '1');
```

## Vector



## Vector

```
CMGT <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
boolean cmp_eq = (eq == '1');
```

## Assembler Symbols

- <V> Is a width specifier, encoded in “size”:
- | size | <V>      |
|------|----------|
| 0x   | RESERVED |
| 10   | RESERVED |
| 11   | D        |
- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.

- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
boolean test_passed;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    test_passed = if cmp_eq then element1 >= element2 else element1 > element2;
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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## CMGT (zero)

Compare signed Greater than zero (vector). This instruction reads each vector element in the source SIMD&FP register and if the signed integer value is greater than zero sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	size	1	0	0	0	0	0	0	1	0	0	0	1	0	Rn				Rd					
U										op																					

### Scalar

CMGT [<V><d>](#), [<V><n>](#), #0

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
```

```
CompareOp comparison;
case op:U of
  when '00' comparison = CompareOp\_GT;
  when '01' comparison = CompareOp\_GE;
  when '10' comparison = CompareOp\_EQ;
  when '11' comparison = CompareOp\_LE;
```

### Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	size	1	0	0	0	0	0	0	1	0	0	0	0	1	0	Rn				Rd				
U										op																					

### Vector

CMGT [<Vd>.<T>](#), [<Vn>.<T>](#), #0

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

```
CompareOp comparison;
case op:U of
  when '00' comparison = CompareOp\_GT;
  when '01' comparison = CompareOp\_GE;
  when '10' comparison = CompareOp\_EQ;
  when '11' comparison = CompareOp\_LE;
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
integer element;
boolean test_passed;

for e = 0 to elements-1
  element = SInt(Elem[operand, e, esize]);
  case comparison of
    when CompareOp_GT test_passed = element > 0;
    when CompareOp_GE test_passed = element >= 0;
    when CompareOp_EQ test_passed = element == 0;
    when CompareOp_LE test_passed = element <= 0;
    when CompareOp_LT test_passed = element < 0;
  Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

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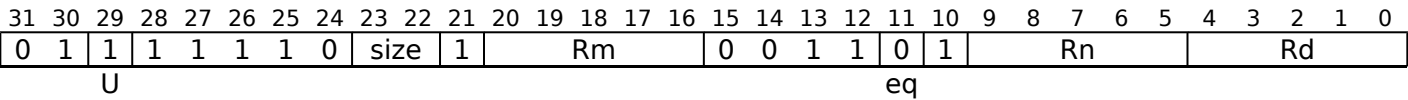
## CMHI (register)

Compare unsigned Higher (vector). This instruction compares each vector element in the first source SIMD&FP register with the corresponding vector element in the second source SIMD&FP register and if the first unsigned integer value is greater than the second unsigned integer value sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar

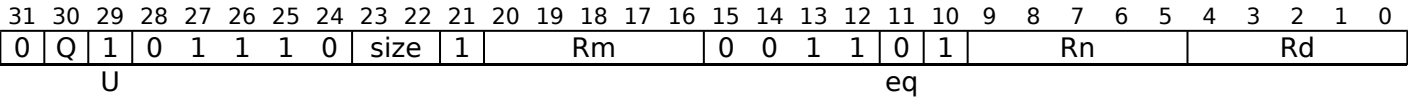


### Scalar

CMHI [<V><d>](#), [<V><n>](#), [<V><m>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
boolean cmp_eq = (eq == '1');
```

### Vector



### Vector

CMHI [<Vd>.<T>](#), [<Vn>.<T>](#), [<Vm>.<T>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
boolean cmp_eq = (eq == '1');
```

### Assembler Symbols

[<V>](#) Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D

[<d>](#) Is the number of the SIMD&FP destination register, in the "Rd" field.

- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

### Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
boolean test_passed;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    test_passed = if cmp_eq then element1 >= element2 else element1 > element2;
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;

```

### Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.



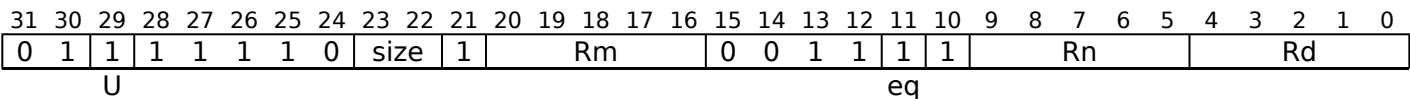
# CMHS (register)

Compare unsigned Higher or Same (vector). This instruction compares each vector element in the first source SIMD&FP register with the corresponding vector element in the second source SIMD&FP register and if the first unsigned integer value is greater than or equal to the second unsigned integer value sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

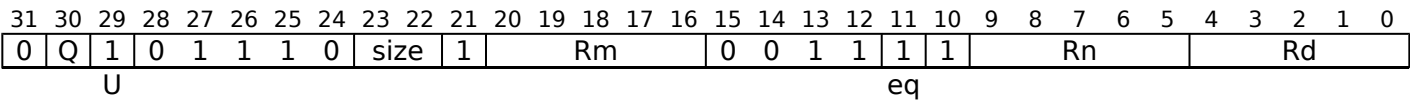


## Scalar

```
CMHS <V><d>, <V><n>, <V><m>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
boolean cmp_eq = (eq == '1');
```

## Vector



## Vector

```
CMHS <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
boolean cmp_eq = (eq == '1');
```

## Assembler Symbols

- <V>

Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D
- <d>

Is the number of the SIMD&FP destination register, in the "Rd" field.

- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

### Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
boolean test_passed;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    test_passed = if cmp_eq then element1 >= element2 else element1 > element2;
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;

```

### Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

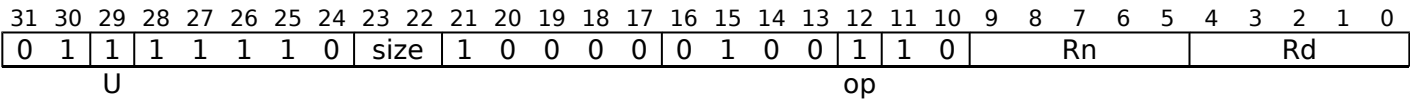
## CMLE (zero)

Compare signed Less than or Equal to zero (vector). This instruction reads each vector element in the source SIMD&FP register and if the signed integer value is less than or equal to zero sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar



### Scalar

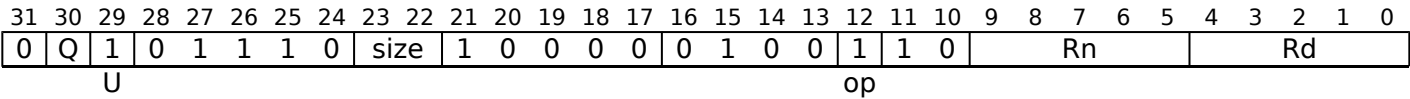
CMLE [<V><d>](#), [<V><n>](#), #0

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;

CompareOp comparison;
case op:U of
    when '00' comparison = CompareOp_GT;
    when '01' comparison = CompareOp_GE;
    when '10' comparison = CompareOp_EQ;
    when '11' comparison = CompareOp_LE;
```

### Vector



### Vector

CMLE [<Vd>.<T>](#), [<Vn>.<T>](#), #0

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CompareOp comparison;
case op:U of
    when '00' comparison = CompareOp_GT;
    when '01' comparison = CompareOp_GE;
    when '10' comparison = CompareOp_EQ;
    when '11' comparison = CompareOp_LE;
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
integer element;
boolean test_passed;

for e = 0 to elements-1
    element = SInt(Elem[operand, e, esize]);
    case comparison of
        when CompareOp_GT test_passed = element > 0;
        when CompareOp_GE test_passed = element >= 0;
        when CompareOp_EQ test_passed = element == 0;
        when CompareOp_LE test_passed = element <= 0;
        when CompareOp_LT test_passed = element < 0;
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

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# CMLT (zero)

Compare signed Less than zero (vector). This instruction reads each vector element in the source SIMD&FP register and if the signed integer value is less than zero sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	size	1	0	0	0	0	0	0	1	0	1	0	1	0	Rn				Rd					

## Scalar

```
CMLT <V><d>, <V><n>, #0

integer d = UInt(Rd);
integer n = UInt(Rn);

if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;

CompareOp comparison = CompareOp_LT;
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	size	1	0	0	0	0	0	0	1	0	1	0	1	0	Rn				Rd					

## Vector

```
CMLT <Vd>.<T>, <Vn>.<T>, #0

integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CompareOp comparison = CompareOp_LT;
```

## Assembler Symbols

- <V>

Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D
- <d>

Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n>

Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T>

Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
integer element;
boolean test_passed;

for e = 0 to elements-1
    element = SInt(Elem[operand, e, esize]);
    case comparison of
        when CompareOp_GT test_passed = element > 0;
        when CompareOp_GE test_passed = element >= 0;
        when CompareOp_EQ test_passed = element == 0;
        when CompareOp_LE test_passed = element <= 0;
        when CompareOp_LT test_passed = element < 0;
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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CMTST

Compare bitwise Test bits nonzero (vector). This instruction reads each vector element in the first source SIMD&FP register, performs an AND with the corresponding vector element in the second source SIMD&FP register, and if the result is not zero, sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero. Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: Scalar and Vector

Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	size	1	Rm					1	0	0	0	1	1	Rn					Rd					
U																															

Scalar

CMTST <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean and_test = (U == '0');
```

Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	size	1	Rm					1	0	0	0	1	1	Rn					Rd					
U																															

Vector

CMTST <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean and_test = (U == '0');
```

Assembler Symbols

- <V>

Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D
- <d>

Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n>

Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m>

Is the number of the second SIMD&FP source register, encoded in the "Rm" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;
boolean test_passed;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    if and_test then
        test_passed = !IsZero(element1 AND element2);
    else
        test_passed = (element1 == element2);
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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CNT

Population Count per byte. This instruction counts the number of bits that have a value of one in each vector element in the source SIMD&FP register, places the result into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	size	1	0	0	0	0	0	0	0	1	0	1	1	0	Rn				Rd					

Vector

```
CNT <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if size != '00' then UNDEFINED;
integer esize = 8;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV 8;
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	x	RESERVED
1x	x	RESERVED

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;

integer count;
for e = 0 to elements-1
    count = BitCount(Elem[operand, e, esize]);
    Elem[result, e, esize] = count<esize-1:0>;
V[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# DUP (element)

Duplicate vector element to vector or scalar. This instruction duplicates the vector element at the specified element index in the source SIMD&FP register into a scalar or each element in a vector, and writes the result to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This instruction is used by the alias [MOV \(scalar\)](#).

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	0	0	imm5					0	0	0	0	0	1	Rn					Rd				

## Scalar

```
DUP <V><d>, <Vn>.<T>[<index>]

integer d = UInt(Rd);
integer n = UInt(Rn);

integer size = LowestSetBit(imm5);
if size > 3 then UNDEFINED;

integer index = UInt(imm5<4:size+1>);
integer idxdsize = if imm5<4> == '1' then 128 else 64;

integer esize = 8 << size;
integer datasize = esize;
integer elements = 1;
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	0	0	imm5					0	0	0	0	0	1	Rn					Rd				

## Vector

```
DUP <Vd>.<T>, <Vn>.<Ts>[<index>]

integer d = UInt(Rd);
integer n = UInt(Rn);

integer size = LowestSetBit(imm5);
if size > 3 then UNDEFINED;

integer index = UInt(imm5<4:size+1>);
integer idxdsize = if imm5<4> == '1' then 128 else 64;

if size == 3 && Q == '0' then UNDEFINED;
integer esize = 8 << size;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

## Assembler Symbols

<T> For the scalar variant: is the element width specifier, encoded in “imm5”:

<b>imm5</b>	<b>&lt;T&gt;</b>
x0000	RESERVED
xxxx1	B
xx10	H
xx100	S
x1000	D

For the vector variant: is an arrangement specifier, encoded in “imm5:Q”:

<b>imm5</b>	<b>Q</b>	<b>&lt;T&gt;</b>
x0000	x	RESERVED
xxxx1	0	8B
xxxx1	1	16B
xx10	0	4H
xx10	1	8H
xx100	0	2S
xx100	1	4S
x1000	0	RESERVED
x1000	1	2D

<Ts> Is an element size specifier, encoded in “imm5”:

<b>imm5</b>	<b>&lt;Ts&gt;</b>
x0000	RESERVED
xxxx1	B
xx10	H
xx100	S
x1000	D

<V> Is the destination width specifier, encoded in “imm5”:

<b>imm5</b>	<b>&lt;V&gt;</b>
x0000	RESERVED
xxxx1	B
xx10	H
xx100	S
x1000	D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<index> Is the element index encoded in “imm5”:

<b>imm5</b>	<b>&lt;index&gt;</b>
x0000	RESERVED
xxxx1	imm5<4:1>
xx10	imm5<4:2>
xx100	imm5<4:3>
x1000	imm5<4>

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(idxdsize) operand = V[n];
bits(datasize) result;
bits(esize) element;

element = Elem[operand, index, esize];
for e = 0 to elements-1
    Elem[result, e, esize] = element;
V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

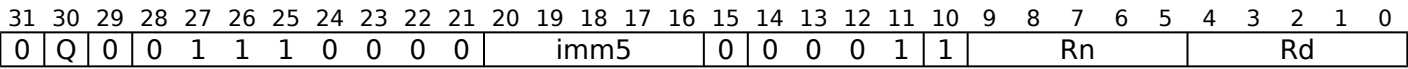
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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DUP (general)

Duplicate general-purpose register to vector. This instruction duplicates the contents of the source general-purpose register into a scalar or each element in a vector, and writes the result to the SIMD&FP destination register. Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Advanced SIMD

```
DUP <Vd>.<T>, <R><n>

integer d = UInt(Rd);
integer n = UInt(Rn);

integer size = LowestSetBit(imm5);
if size > 3 then UNDEFINED;

// imm5<4:size+1> is IGNORED

if size == 3 && Q == '0' then UNDEFINED;
integer esize = 8 << size;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "imm5:Q":

imm5	Q	<T>
x0000	x	RESERVED
xxx1	0	8B
xxx1	1	16B
xx10	0	4H
xx10	1	8H
x100	0	2S
x100	1	4S
x1000	0	RESERVED
x1000	1	2D

- <R> Is the width specifier for the general-purpose source register, encoded in "imm5":

imm5	<R>
x0000	RESERVED
xxx1	W
xx10	W
xx100	W
x1000	X

Unspecified bits in "imm5" are ignored but should be set to zero by an assembler.

- <n> Is the number [0-30] of the general-purpose source register or ZR (31), encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(esize) element = X[n];
bits(datasize) result;

for e = 0 to elements-1
    Elem[result, e, esize] = element;
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# EOR3

Three-way Exclusive OR performs a three-way exclusive OR of the values in the three source SIMD&FP registers, and writes the result to the destination SIMD&FP register.

This instruction is implemented only when **ARMv8.2-SHA** is implemented.

## Advanced SIMD (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	0	0	0	Rm				0	Ra				Rn				Rd							

## Advanced SIMD

EOR3 <Vd>.16B, <Vn>.16B, <Vm>.16B, <Va>.16B

```
if !HaveSHA3Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer a = UInt(Ra);
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Va> Is the name of the third SIMD&FP source register, encoded in the "Ra" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) Vm = V[m];
bits(128) Vn = V[n];
bits(128) Va = V[a];
V[d] = Vn EOR Vm EOR Va;
```

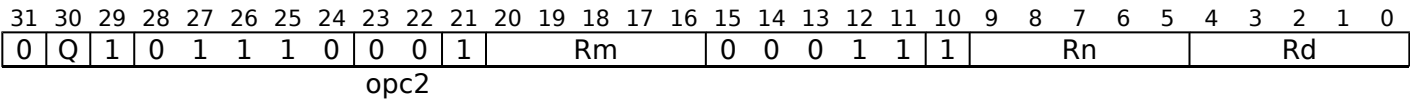
## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

EOR (vector)

Bitwise Exclusive OR (vector). This instruction performs a bitwise Exclusive OR operation between the two source SIMD&FP registers, and places the result in the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers of the same type

EOR <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if Q == '1' then 128 else 64;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "Q":

Q	<T>
0	8B
1	16B

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1;
bits(datasize) operand2;
bits(datasize) operand3;
bits(datasize) operand4 = V[n];

operand1 = V[m];
operand2 = Zeros();
operand3 = Ones();
V[d] = operand1 EOR ((operand2 EOR operand4) AND operand3);
```

Operational information

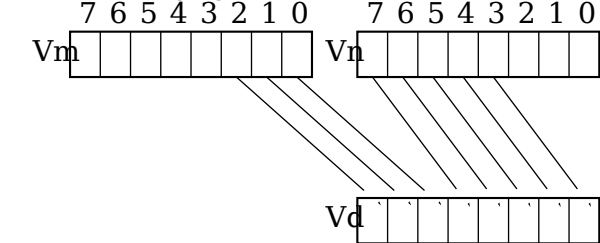
- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.



EXT

Extract vector from pair of vectors. This instruction extracts the lowest vector elements from the second source SIMD&FP register and the highest vector elements from the first source SIMD&FP register, concatenates the results into a vector, and writes the vector to the destination SIMD&FP register vector. The index value specifies the lowest vector element to extract from the first source register, and consecutive elements are extracted from the first, then second, source registers until the destination vector is filled.

The following figure shows an example of the operation of EXT doubleword operation for Q = 0 and imm4<2:0> = 3.



Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	0	0	Rm				0	imm4				0	Rn				Rd						

Advanced SIMD

EXT <Vd>.<T>, <Vn>.<T>, <Vm>.<T>, #<index>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if Q == '0' && imm4<3> == '1' then UNDEFINED;

integer datasize = if Q == '1' then 128 else 64;
integer position = UInt(imm4) << 3;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "Q":

Q	<T>
0	8B
1	16B

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

<index> Is the lowest numbered byte element to be extracted, encoded in "Q:imm4":

Q	imm4<3>	<index>
0	0	imm4<2:0>
0	1	RESERVED
1	x	imm4

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) hi = V[m];
bits(datasize) lo = V[n];
bits(datasize*2) concat = hi:lo;

V[d] = concat<position+datasize-1:position>;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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FABD

Floating-point Absolute Difference (vector). This instruction subtracts the floating-point values in the elements of the second source SIMD&FP register, from the corresponding floating-point values in the elements of the first source SIMD&FP register, places the absolute value of each result in a vector, and writes the vector to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

Scalar half precision  
(Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	1	1	0	Rm				0	0	0	1	0	1	Rn				Rd						

Scalar half precision

```
FABD <Hd>, <Hn>, <Hm>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = esize;
integer elements = 1;
boolean abs = TRUE;
```

Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	1	sz	1	Rm				1	1	0	1	0	1	Rn				Rd						

Scalar single-precision and double-precision

```
FABD <V><d>, <V><n>, <V><m>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
boolean abs = TRUE;
```

Vector half precision  
(Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	1	0	Rm				0	0	0	1	0	1	Rn				Rd						
U																															

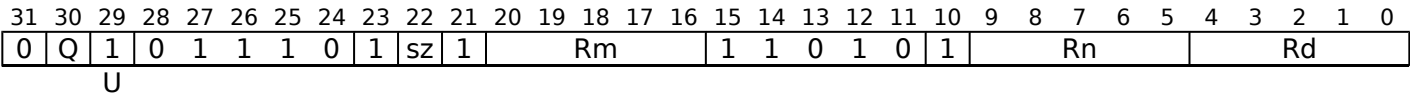
Vector half precision

FABD <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean abs = (U == '1');
```

Vector single-precision and double-precision



Vector single-precision and double-precision

FABD <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean abs = (U == '1');
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the vector half precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the vector single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;
bits(esize) diff;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    diff = FPSub(element1, element2, FPCR);
    Elem[result, e, esize] = if abs then FPAbs(diff) else diff;

V[d] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

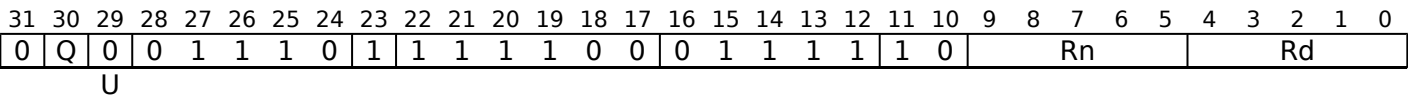
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FABS (vector)

Floating-point Absolute value (vector). This instruction calculates the absolute value of each vector element in the source SIMD&FP register, writes the result to a vector, and writes the vector to the destination SIMD&FP register. Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: Half-precision and Single-precision and double-precision

Half-precision (Armv8.2)



Half-precision

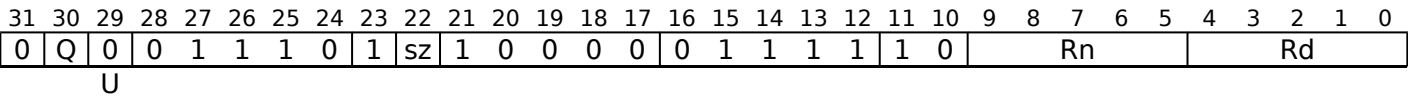
```
FABS <Vd>.<T>, <Vn>.<T>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean neg = (U == '1');
```

Single-precision and double-precision



Single-precision and double-precision

```
FABS <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean neg = (U == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    if neg then
        element = FPNeg(element);
    else
        element = FPAbs(element);
    Elem[result, e, esize] = element;

V[d] = result;

```

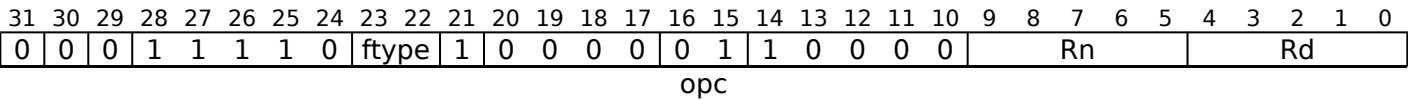
Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FABS (scalar)

Floating-point Absolute value (scalar). This instruction calculates the absolute value in the SIMD&FP source register and writes the result to the SIMD&FP destination register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (Armv8.2)

FABS <Hd>, <Hn>

## Single-precision (ftype == 00)

FABS <Sd>, <Sn>

## Double-precision (ftype == 01)

FABS <Dd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer datasize;
case ftype of
  when '00' datasize = 32;
  when '01' datasize = 64;
  when '10' UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      datasize = 16;
    else
      UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(datasize) result;
bits(datasize) operand = V[n];

result = FPAbs(operand);
V[d] = result;
```





## FACGE

Floating-point Absolute Compare Greater than or Equal (vector). This instruction compares the absolute value of each floating-point value in the first source SIMD&FP register with the absolute value of the corresponding floating-point value in the second source SIMD&FP register and if the first value is greater than or equal to the second value sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

This instruction can generate a floating-point exception. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

### Scalar half precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	0	1	0	Rm				0	0	1	0	1	1	Rn				Rd						
U								E			ac																				

### Scalar half precision

FACGE <Hd>, <Hn>, <Hm>

```
if !HaveFP16Ext() then UNDEFINED;
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = esize;
integer elements = 1;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_E0; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

### Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	0	sz	1	Rm				1	1	1	0	1	1	Rn				Rd						
U								E				ac																			

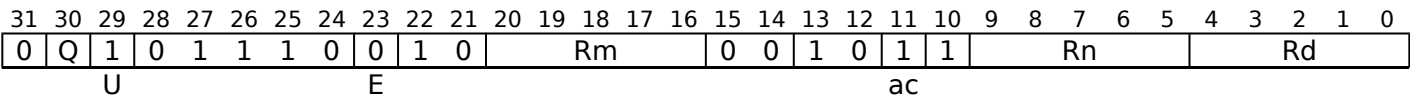
Scalar single-precision and double-precision

FACGE <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

Vector half precision
(Armv8.2)



Vector half precision

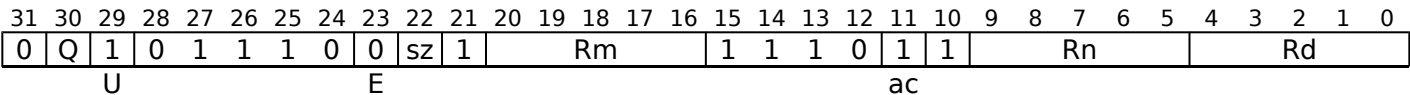
FACGE <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

Vector single-precision and double-precision



Vector single-precision and double-precision

```
FACGE <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the vector half precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the vector single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;
boolean test_passed;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    if abs then
        element1 = FPAbs(element1);
        element2 = FPAbs(element2);
    case cmp of
        when CompareOp_EQ test_passed = FPCompareEQ(element1, element2, FPCR);
        when CompareOp_GE test_passed = FPCompareGE(element1, element2, FPCR);
        when CompareOp_GT test_passed = FPCompareGT(element1, element2, FPCR);
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FACGT

Floating-point Absolute Compare Greater than (vector). This instruction compares the absolute value of each vector element in the first source SIMD&FP register with the absolute value of the corresponding vector element in the second source SIMD&FP register and if the first value is greater than the second value sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	1	1	0	Rm				0	0	1	0	1	1	Rn				Rd						
U								E			ac																				

## Scalar half precision

```
FACGT <Hd>, <Hn>, <Hm>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = esize;
integer elements = 1;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_E0; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

## Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	1	sz	1	Rm				1	1	1	0	1	1	Rn				Rd						
U								E			ac																				

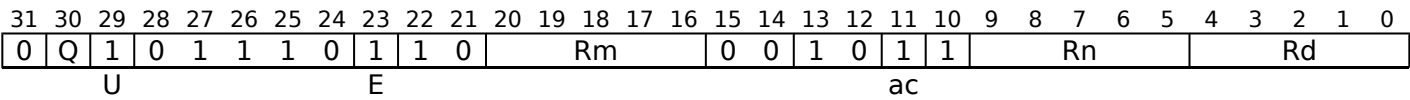
Scalar single-precision and double-precision

FACGT <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

Vector half precision
(Armv8.2)



Vector half precision

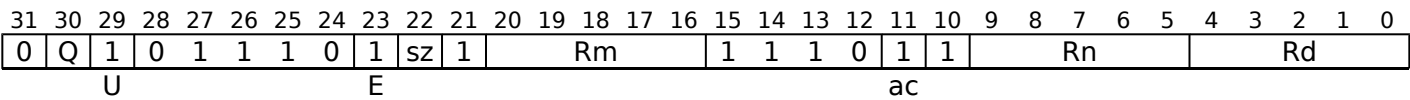
FACGT <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

Vector single-precision and double-precision



Vector single-precision and double-precision

```
FACGT <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the vector half precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the vector single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.



## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;
boolean test_passed;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    if abs then
        element1 = FPAbs(element1);
        element2 = FPAbs(element2);
    case cmp of
        when CompareOp_EQ test_passed = FPCompareEQ(element1, element2, FPCR);
        when CompareOp_GE test_passed = FPCompareGE(element1, element2, FPCR);
        when CompareOp_GT test_passed = FPCompareGT(element1, element2, FPCR);
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FADD (vector)

Floating-point Add (vector). This instruction adds corresponding vector elements in the two source SIMD&FP registers, writes the result into a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are floating-point values.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	1	0	Rm				0	0	0	1	0	1	Rn				Rd						
U																															

## Half-precision

```
FADD <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
```

## Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	sz	1	Rm					1	1	0	1	0	1	Rn					Rd				
U																															

## Single-precision and double-precision

```
FADD <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(2*datasize) concat = operand2:operand1;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    if pair then
        element1 = Elem[concat, 2*e, esize];
        element2 = Elem[concat, (2*e)+1, esize];
    else
        element1 = Elem[operand1, e, esize];
        element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = FPAdd(element1, element2, FPCR);

V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

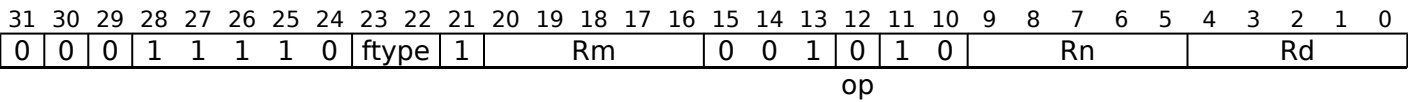
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# FADD (scalar)

Floating-point Add (scalar). This instruction adds the floating-point values of the two source SIMD&FP registers, and writes the result to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (Armv8.2)

```
FADD <Hd>, <Hn>, <Hm>
```

## Single-precision (ftype == 00)

```
FADD <Sd>, <Sn>, <Sm>
```

## Double-precision (ftype == 01)

```
FADD <Dd>, <Dn>, <Dm>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer datasize;
case ftype of
    when '00' datasize = 32;
    when '01' datasize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            datasize = 16;
        else
            UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Dm> Is the 64-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Sm> Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
bits(datasize) result;  
bits(datasize) operand1 = V[n];  
bits(datasize) operand2 = V[m];  
  
result = FPAAdd(operand1, operand2, FPCR);  
V[d] = result;
```

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FADDP (scalar)

Floating-point Add Pair of elements (scalar). This instruction adds two floating-point vector elements in the source SIMD&FP register and writes the scalar result into the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

Half-precision  
(Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	0	1	1	0	0	0	0	1	1	0	1	1	0	Rn				Rd					
SZ																															

Half-precision

FADDP <V><d>, <Vn>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer esize = 16;
integer datasize = 32;
```

Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	0	SZ	1	1	0	0	0	0	1	1	0	1	1	0	Rn				Rd					

Single-precision and double-precision

FADDP <V><d>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32;
integer datasize = 64;
```

Assembler Symbols

- <V>

For the half-precision variant: is the destination width specifier, encoded in "sz":

SZ		<V>
0		H
1		RESERVED
- For the single-precision and double-precision variant: is the destination width specifier, encoded in "sz":

SZ		<V>
0		S
1		D
- <d>

Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <Vn>

Is the name of the SIMD&FP source register, encoded in the "Rn" field.
- <T>

For the half-precision variant: is the source arrangement specifier, encoded in "sz":

<b>sz</b>	<b>&lt;T&gt;</b>
0	2H
1	RESERVED

For the single-precision and double-precision variant: is the source arrangement specifier, encoded in “sz”:

<b>sz</b>	<b>&lt;T&gt;</b>
0	2S
1	2D

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
V[d] = Reduce(ReduceOp_FADD, operand, esize);

```

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# FADDP (vector)

Floating-point Add Pairwise (vector). This instruction creates a vector by concatenating the vector elements of the first source SIMD&FP register after the vector elements of the second source SIMD&FP register, reads each pair of adjacent vector elements from the concatenated vector, adds each pair of values together, places the result into a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are floating-point values.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	1	0	Rm				0	0	0	1	0	1	Rn				Rd						
U																															

### Half-precision

```
FADDP <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
```

### Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	sz	1	Rm					1	1	0	1	0	1	Rn					Rd				
U																															

### Single-precision and double-precision

```
FADDP <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":



Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(2*datasize) concat = operand2:operand1;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    if pair then
        element1 = Elem[concat, 2*e, esize];
        element2 = Elem[concat, (2*e)+1, esize];
    else
        element1 = Elem[operand1, e, esize];
        element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = FPAdd(element1, element2, FPCR);

V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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FCADD

Floating-point Complex Add.

This instruction operates on complex numbers that are represented in SIMD&FP registers as pairs of elements, with the more significant element holding the imaginary part of the number and the less significant element holding the real part of the number. Each element holds a floating-point value. It performs the following computation on the corresponding complex number element pairs from the two source registers:

- Considering the complex number from the second source register on an Argand diagram, the number is rotated counterclockwise by 90 or 270 degrees.
- The rotated complex number is added to the complex number from the first source register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

Vector  
(Armv8.3)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	size	0	Rm				1	1	1	rot	0	1	Rn				Rd							

Vector

FCADD <Vd>.<T>, <Vn>.<T>, <Vm>.<T>, #<rotate>

```
if !HaveFCADDExt() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '00' then UNDEFINED;
if Q == '0' && size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
if !HaveFP16Ext() && esize == 16 then UNDEFINED;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.
- <rotate> Is the rotation, encoded in "rot":

rot	<rotate>
0	90
1	270

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;
bits(esize) element1;
bits(esize) element3;

for e = 0 to (elements DIV 2)-1
    case rot of
        when '0'
            element1 = FPNeg(Elem[operand2, e*2+1, esize]);
            element3 = Elem[operand2, e*2, esize];
        when '1'
            element1 = Elem[operand2, e*2+1, esize];
            element3 = FPNeg(Elem[operand2, e*2, esize]);
    Elem[result, e*2, esize] = FPAAdd(Elem[operand1, e*2, esize], element1, FPCR);
    Elem[result, e*2+1, esize] = FPAAdd(Elem[operand1, e*2+1, esize], element3, FPCR);
V[d] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FCCMP

Floating-point Conditional quiet Compare (scalar). This instruction compares the two SIMD&FP source register values and writes the result to the *PSTATE*.{N, Z, C, V} flags. If the condition does not pass then the *PSTATE*.{N, Z, C, V} flags are set to the flag bit specifier.

It raises an Invalid Operation exception only if either operand is a signaling NaN.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1	1	1	1	0	ftype		1	Rm				cond				0	1	Rn				0	nzcvcv					
																												op			

## Half-precision (ftype == 11) (Armv8.2)

FCCMP <Hn>, <Hm>, #<nzcvcv>, <cond>

## Single-precision (ftype == 00)

FCCMP <Sn>, <Sm>, #<nzcvcv>, <cond>

## Double-precision (ftype == 01)

FCCMP <Dn>, <Dm>, #<nzcvcv>, <cond>

```
integer n = UInt(Rn);
integer m = UInt(Rm);

integer datasize;
case ftype of
    when '00' datasize = 32;
    when '01' datasize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            datasize = 16;
        else
            UNDEFINED;

bits(4) flags = nzcvcv;
```

## Assembler Symbols

- <Dn> Is the 64-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
  - <Dm> Is the 64-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
  - <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
  - <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
  - <Sn> Is the 32-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
  - <Sm> Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
  - <nzcvcv> Is the flag bit specifier, an immediate in the range 0 to 15, giving the alternative state for the 4-bit NZCV condition flags, encoded in the "nzcvcv" field.
  - <cond> Is one of the standard conditions, encoded in the "cond" field in the standard way.
- NaNs

The IEEE 754 standard specifies that the result of a comparison is precisely one of <, ==, > or unordered. If either or both of the operands are NaNs, they are unordered, and all three of (Operand1 < Operand2), (Operand1 == Operand2) and (Operand1 > Operand2) are false. This case results in the **FPSCR** flags being set to N=0, Z=0, C=1, and V=1.

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(datasize) operand1 = V[n];
bits(datasize) operand2;

operand2 = V[m];

if ConditionHolds(cond) then
    flags = FPCompare(operand1, operand2, FALSE, FPCR);
PSTATE.<N,Z,C,V> = flags;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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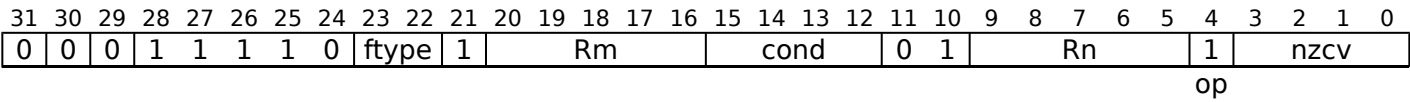
# FCCMPE

Floating-point Conditional signaling Compare (scalar). This instruction compares the two SIMD&FP source register values and writes the result to the *PSTATE*.{N, Z, C, V} flags. If the condition does not pass then the *PSTATE*.{N, Z, C, V} flags are set to the flag bit specifier.

If either operand is any type of NaN, or if either operand is a signaling NaN, the instruction raises an Invalid Operation exception.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (Armv8.2)

FCCMPE <Hn>, <Hm>, #<nzcvcv>, <cond>

## Single-precision (ftype == 00)

FCCMPE <Sn>, <Sm>, #<nzcvcv>, <cond>

## Double-precision (ftype == 01)

FCCMPE <Dn>, <Dm>, #<nzcvcv>, <cond>

```
integer n = UInt(Rn);
integer m = UInt(Rm);

integer datasize;
case ftype of
    when '00' datasize = 32;
    when '01' datasize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            datasize = 16;
        else
            UNDEFINED;

bits(4) flags = nzcvcv;
```

## Assembler Symbols

- <Dn> Is the 64-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Dm> Is the 64-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Sn> Is the 32-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Sm> Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <nzcvcv> Is the flag bit specifier, an immediate in the range 0 to 15, giving the alternative state for the 4-bit NZCV condition flags, encoded in the "nzcvcv" field.
- <cond> Is one of the standard conditions, encoded in the "cond" field in the standard way.

NaNs

The IEEE 754 standard specifies that the result of a comparison is precisely one of <, ==, > or unordered. If either or both of the operands are NaNs, they are unordered, and all three of (Operand1 < Operand2), (Operand1 == Operand2) and (Operand1 > Operand2) are false. This case results in the **FPSCR** flags being set to N=0, Z=0, C=1, and V=1.

FCCMPE raises an Invalid Operation exception if either operand is any type of NaN, and is suitable for testing for <, <=, >, >=, and other predicates that raise an exception when the operands are unordered.

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(datasize) operand1 = V[n];
bits(datasize) operand2;

operand2 = V[m];

if ConditionHolds(cond) then
    flags = FPCompare(operand1, operand2, TRUE, FPCR);
PSTATE.<N,Z,C,V> = flags;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FCMEQ (register)

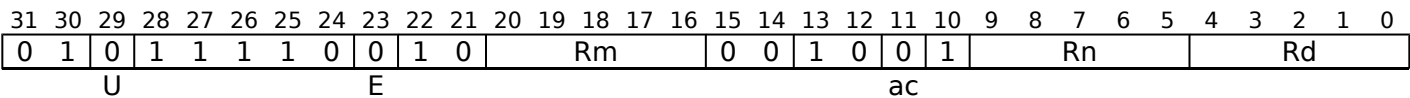
Floating-point Compare Equal (vector). This instruction compares each floating-point value from the first source SIMD&FP register, with the corresponding floating-point value from the second source SIMD&FP register, and if the comparison is equal sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (Armv8.2)



## Scalar half precision

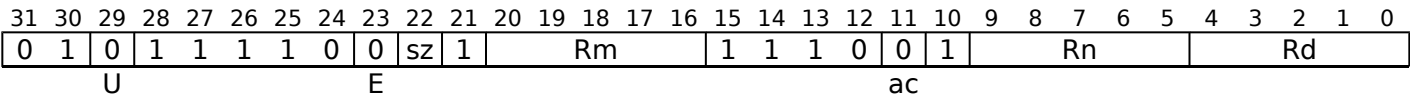
```
FCMEQ <Hd>, <Hn>, <Hm>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = esize;
integer elements = 1;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

## Scalar single-precision and double-precision





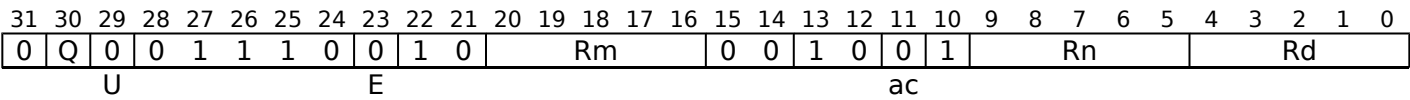
Scalar single-precision and double-precision

FCMEQ <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

Vector half precision
(Armv8.2)



Vector half precision

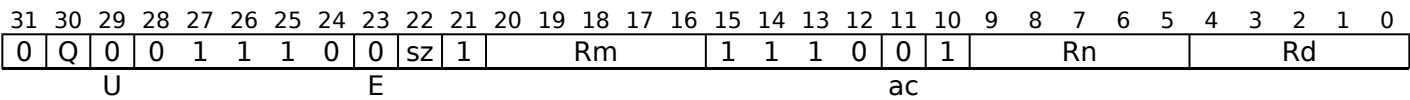
FCMEQ <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

Vector single-precision and double-precision



Vector single-precision and double-precision

```
FCMEQ <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the vector half precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the vector single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;
boolean test_passed;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    if abs then
        element1 = FPAbs(element1);
        element2 = FPAbs(element2);
    case cmp of
        when CompareOp_EQ test_passed = FPCompareEQ(element1, element2, FPCR);
        when CompareOp_GE test_passed = FPCompareGE(element1, element2, FPCR);
        when CompareOp_GT test_passed = FPCompareGT(element1, element2, FPCR);
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FCMEQ (zero)

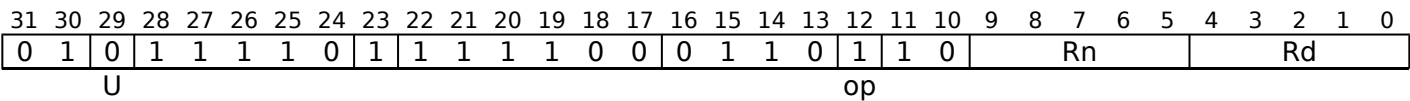
Floating-point Compare Equal to zero (vector). This instruction reads each floating-point value in the source SIMD&FP register and if the value is equal to zero sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (Armv8.2)



### Scalar half precision

```
FCMEQ <Hd>, <Hn>, #0.0

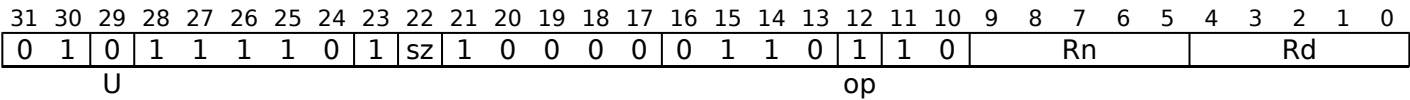
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = esize;
integer elements = 1;

CompareOp comparison;
case op:U of
    when '00' comparison = CompareOp_GT;
    when '01' comparison = CompareOp_GE;
    when '10' comparison = CompareOp_FQ;
    when '11' comparison = CompareOp_LE;
```

## Scalar single-precision and double-precision



Scalar single-precision and double-precision

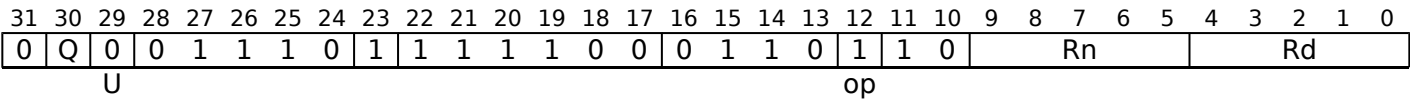
```
FCMEQ <V><d>, <V><n>, #0.0

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;

CompareOp comparison;
case op:U of
    when '00' comparison = CompareOp_GT;
    when '01' comparison = CompareOp_GE;
    when '10' comparison = CompareOp_EQ;
    when '11' comparison = CompareOp_LE;
```

Vector half precision
(Armv8.2)



Vector half precision

```
FCMEQ <Vd>.<T>, <Vn>.<T>, #0.0

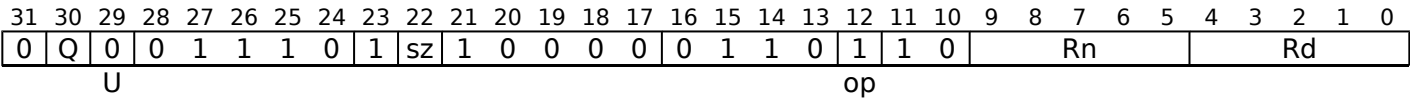
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CompareOp comparison;
case op:U of
    when '00' comparison = CompareOp_GT;
    when '01' comparison = CompareOp_GE;
    when '10' comparison = CompareOp_EQ;
    when '11' comparison = CompareOp_LE;
```

Vector single-precision and double-precision



Vector single-precision and double-precision

```
FCMEQ <Vd>.<T>, <Vn>.<T>, #0.0

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CompareOp comparison;
case op:U of
  when '00' comparison = CompareOp_GT;
  when '01' comparison = CompareOp_GE;
  when '10' comparison = CompareOp_EQ;
  when '11' comparison = CompareOp_LE;
```

Assembler Symbols

- <Hd>

Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn>

Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <V>

Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D
- <d>

Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n>

Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T>

For the vector half precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

  
For the vector single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D
- <Vn>

Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) zero = FPZero('0');
bits(esize) element;
boolean test_passed;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    case comparison of
        when CompareOp_GT test_passed = FPCompareGT(element, zero, FPCR);
        when CompareOp_GE test_passed = FPCompareGE(element, zero, FPCR);
        when CompareOp_EQ test_passed = FPCompareEQ(element, zero, FPCR);
        when CompareOp_LE test_passed = FPCompareGE(zero, element, FPCR);
        when CompareOp_LT test_passed = FPCompareGT(zero, element, FPCR);
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

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# FCMGE (register)

Floating-point Compare Greater than or Equal (vector). This instruction reads each floating-point value in the first source SIMD&FP register and if the value is greater than or equal to the corresponding floating-point value in the second source SIMD&FP register sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	0	1	0	Rm				0	0	1	0	0	1	Rn				Rd						
U								E				ac																			

## Scalar half precision

```
FCMGE <Hd>, <Hn>, <Hm>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = esize;
integer elements = 1;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_E0; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

## Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	0	sz	1	Rm				1	1	1	0	0	1	Rn				Rd						
U								E				ac																			



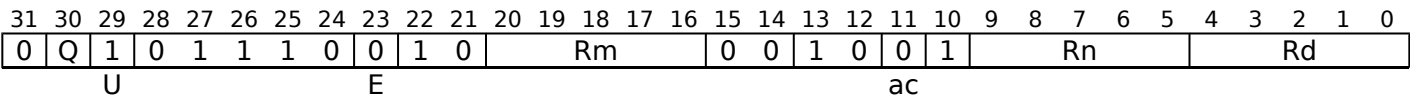
Scalar single-precision and double-precision

FCMGE <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

Vector half precision
(Armv8.2)



Vector half precision

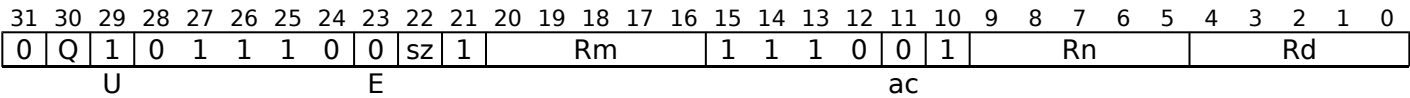
FCMGE <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

Vector single-precision and double-precision



Vector single-precision and double-precision

```
FCMGE <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the vector half precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the vector single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;
boolean test_passed;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    if abs then
        element1 = FPAbs(element1);
        element2 = FPAbs(element2);
    case cmp of
        when CompareOp_EQ test_passed = FPCompareEQ(element1, element2, FPCR);
        when CompareOp_GE test_passed = FPCompareGE(element1, element2, FPCR);
        when CompareOp_GT test_passed = FPCompareGT(element1, element2, FPCR);
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FCMGE (zero)

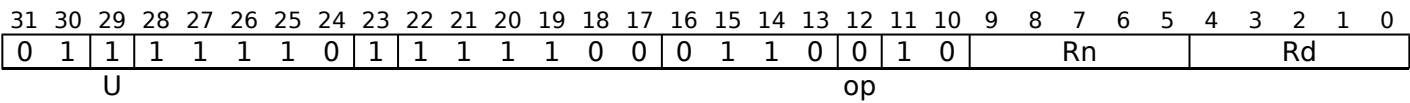
Floating-point Compare Greater than or Equal to zero (vector). This instruction reads each floating-point value in the source SIMD&FP register and if the value is greater than or equal to zero sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (Armv8.2)



### Scalar half precision

```
FCMGE <Hd>, <Hn>, #0.0

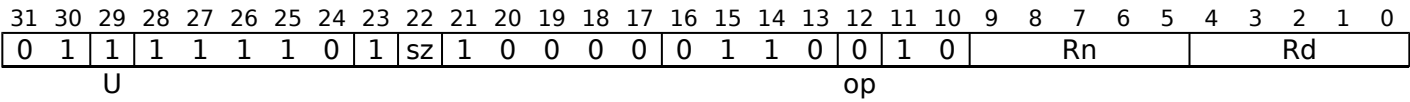
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = esize;
integer elements = 1;

CompareOp comparison;
case op:U of
    when '00' comparison = CompareOp_GT;
    when '01' comparison = CompareOp_GE;
    when '10' comparison = CompareOp_FQ;
    when '11' comparison = CompareOp_LE;
```

## Scalar single-precision and double-precision



Scalar single-precision and double-precision

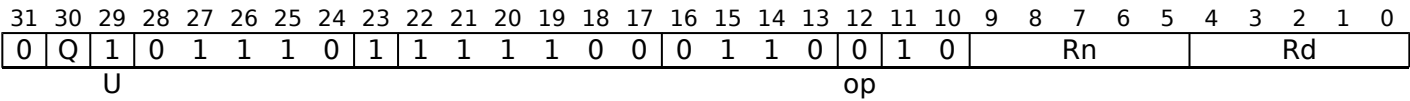
```
FCMGE <V><d>, <V><n>, #0.0

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;

CompareOp comparison;
case op:U of
    when '00' comparison = CompareOp_GT;
    when '01' comparison = CompareOp_GE;
    when '10' comparison = CompareOp_EQ;
    when '11' comparison = CompareOp_LE;
```

Vector half precision
(Armv8.2)



Vector half precision

```
FCMGE <Vd>.<T>, <Vn>.<T>, #0.0

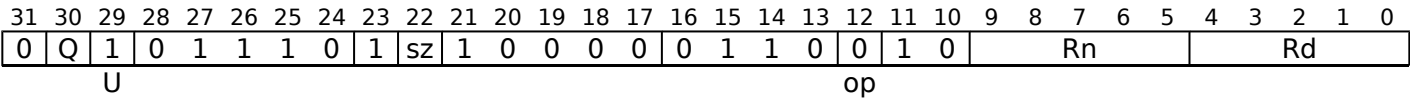
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CompareOp comparison;
case op:U of
    when '00' comparison = CompareOp_GT;
    when '01' comparison = CompareOp_GE;
    when '10' comparison = CompareOp_EQ;
    when '11' comparison = CompareOp_LE;
```

Vector single-precision and double-precision



Vector single-precision and double-precision

```
FCMGE <Vd>.<T>, <Vn>.<T>, #0.0

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CompareOp comparison;
case op:U of
  when '00' comparison = CompareOp_GT;
  when '01' comparison = CompareOp_GE;
  when '10' comparison = CompareOp_EQ;
  when '11' comparison = CompareOp_LE;
```

Assembler Symbols

- <Hd>

Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn>

Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <V>

Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D
- <d>

Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n>

Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T>

For the vector half precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

  
For the vector single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D
- <Vn>

Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) zero = FPZero('0');
bits(esize) element;
boolean test_passed;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    case comparison of
        when CompareOp_GT test_passed = FPCompareGT(element, zero, FPCR);
        when CompareOp_GE test_passed = FPCompareGE(element, zero, FPCR);
        when CompareOp_EQ test_passed = FPCompareEQ(element, zero, FPCR);
        when CompareOp_LE test_passed = FPCompareGE(zero, element, FPCR);
        when CompareOp_LT test_passed = FPCompareGT(zero, element, FPCR);
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FCMGT (register)

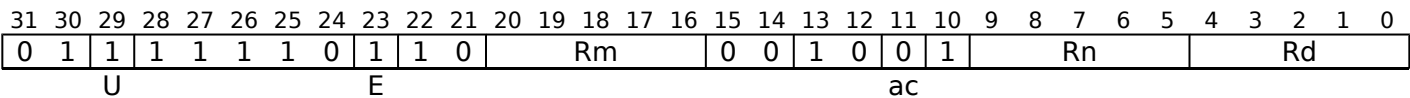
Floating-point Compare Greater than (vector). This instruction reads each floating-point value in the first source SIMD&FP register and if the value is greater than the corresponding floating-point value in the second source SIMD&FP register sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (Armv8.2)



## Scalar half precision

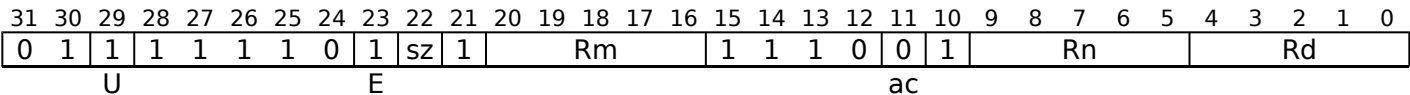
```
FCMGT <Hd>, <Hn>, <Hm>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = esize;
integer elements = 1;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

## Scalar single-precision and double-precision





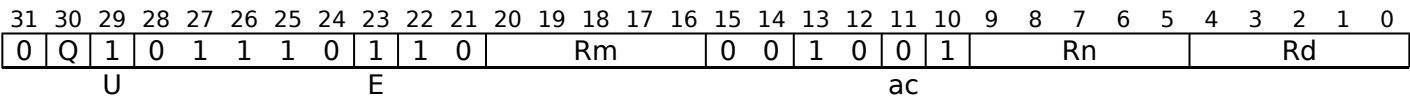
Scalar single-precision and double-precision

FCMGT <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

Vector half precision
(Armv8.2)



Vector half precision

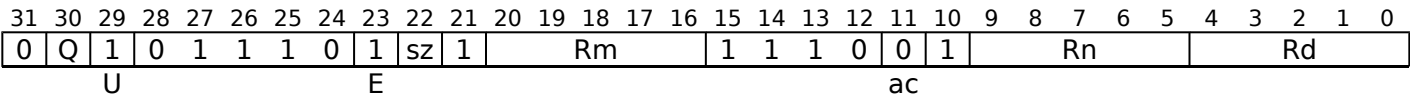
FCMGT <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

Vector single-precision and double-precision



Vector single-precision and double-precision

```
FCMGT <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
CompareOp cmp;
boolean abs;

case E:U:ac of
  when '000' cmp = CompareOp_EQ; abs = FALSE;
  when '010' cmp = CompareOp_GE; abs = FALSE;
  when '011' cmp = CompareOp_GE; abs = TRUE;
  when '110' cmp = CompareOp_GT; abs = FALSE;
  when '111' cmp = CompareOp_GT; abs = TRUE;
  otherwise UNDEFINED;
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the vector half precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the vector single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;
boolean test_passed;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    if abs then
        element1 = FPAbs(element1);
        element2 = FPAbs(element2);
    case cmp of
        when CompareOp_EQ test_passed = FPCompareEQ(element1, element2, FPCR);
        when CompareOp_GE test_passed = FPCompareGE(element1, element2, FPCR);
        when CompareOp_GT test_passed = FPCompareGT(element1, element2, FPCR);
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FCMGT (zero)

Floating-point Compare Greater than zero (vector). This instruction reads each floating-point value in the source SIMD&FP register and if the value is greater than zero sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	1	1	1	1	1	0	0	0	1	1	0	0	1	0	Rn				Rd					
U										op																					

## Scalar half precision

FCMGT <Hd>, <Hn>, #0.0

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);  
integer n = UInt(Rn);

integer esize = 16;  
integer datasize = esize;  
integer elements = 1;

CompareOp comparison;  
case op:U of  
  when '00' comparison = CompareOp\_GT;  
  when '01' comparison = CompareOp\_GE;  
  when '10' comparison = CompareOp\_FQ;  
  when '11' comparison = CompareOp\_LE;

## Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	1	sz	1	0	0	0	0	0	1	1	0	0	1	0	Rn				Rd					
U										op																					

Scalar single-precision and double-precision

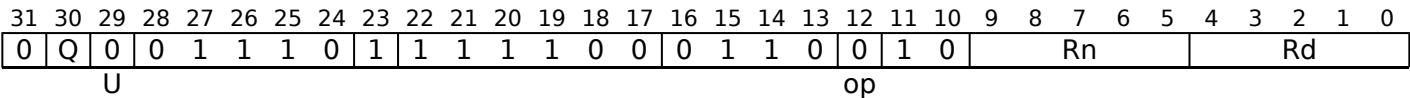
```
FCMGT <V><d>, <V><n>, #0.0

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;

CompareOp comparison;
case op:U of
    when '00' comparison = CompareOp_GT;
    when '01' comparison = CompareOp_GE;
    when '10' comparison = CompareOp_EQ;
    when '11' comparison = CompareOp_LE;
```

Vector half precision
(Armv8.2)



Vector half precision

```
FCMGT <Vd>.<T>, <Vn>.<T>, #0.0

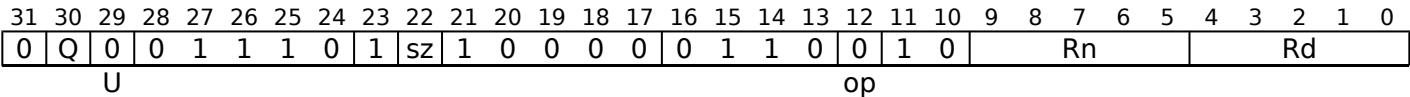
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CompareOp comparison;
case op:U of
    when '00' comparison = CompareOp_GT;
    when '01' comparison = CompareOp_GE;
    when '10' comparison = CompareOp_EQ;
    when '11' comparison = CompareOp_LE;
```

Vector single-precision and double-precision



Vector single-precision and double-precision

```
FCMGT <Vd>.<T>, <Vn>.<T>, #0.0

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CompareOp comparison;
case op:U of
  when '00' comparison = CompareOp_GT;
  when '01' comparison = CompareOp_GE;
  when '10' comparison = CompareOp_EQ;
  when '11' comparison = CompareOp_LE;
```

Assembler Symbols

- <Hd>

Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn>

Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <V>

Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D
- <d>

Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n>

Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T>

For the vector half precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

  
For the vector single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D
- <Vn>

Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) zero = FPZero('0');
bits(esize) element;
boolean test_passed;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    case comparison of
        when CompareOp_GT test_passed = FPCompareGT(element, zero, FPCR);
        when CompareOp_GE test_passed = FPCompareGE(element, zero, FPCR);
        when CompareOp_EQ test_passed = FPCompareEQ(element, zero, FPCR);
        when CompareOp_LE test_passed = FPCompareGE(zero, element, FPCR);
        when CompareOp_LT test_passed = FPCompareGT(zero, element, FPCR);
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FCMLA (by element)

Floating-point Complex Multiply Accumulate (by element).

This instruction operates on complex numbers that are represented in SIMD&FP registers as pairs of elements, with the more significant element holding the imaginary part of the number and the less significant element holding the real part of the number. Each element holds a floating-point value. It performs the following computation on complex numbers from the first source register and the destination register with the specified complex number from the second source register:

- Considering the complex number from the second source register on an Argand diagram, the number is rotated counterclockwise by 0, 90, 180, or 270 degrees.
- The two elements of the transformed complex number are multiplied by:
  - The real element of the complex number from the first source register, if the transformation was a rotation by 0 or 180 degrees.
  - The imaginary element of the complex number from the first source register, if the transformation was a rotation by 90 or 270 degrees.
- The complex number resulting from that multiplication is added to the complex number from the destination register.

The multiplication and addition operations are performed as a fused multiply-add, without any intermediate rounding. This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

## Vector (Armv8.3)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	size	L	M	Rm			0	rot	1	H	0	Rn					Rd							

(size == 01)

FCMLA <Vd>.<T>, <Vn>.<T>, <Vm>.<Ts>[<index>], #<rotate>

(size == 10)

FCMLA <Vd>.<T>, <Vn>.<T>, <Vm>.<Ts>[<index>], #<rotate>

```
if !HaveFCADDExt() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(M:Rm);
if size == '00' || size == '11' then UNDEFINED;
if size == '01' then index = UInt(H:L);
if size == '10' then index = UInt(H);
integer esize = 8 << UInt(size);
if !HaveFP16Ext() && esize == 16 then UNDEFINED;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
if size == '10' && (L == '1' || Q == '0') then UNDEFINED;
if size == '01' && H == '1' && Q == '0' then UNDEFINED;
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":



size	Q	<T>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	RESERVED
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "M:Rm" fields.

<Ts> Is an element size specifier, encoded in "size":

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in "size:H:L":

size	<index>
00	RESERVED
01	H:L
10	H
11	RESERVED

<rotate> Is the rotation, encoded in "rot":

rot	<rotate>
00	0
01	90
10	180
11	270

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;

for e = 0 to (elements DIV 2)-1
    case rot of
        when '00'
            element1 = Elem[operand2, index*2, esize];
            element2 = Elem[operand1, e*2, esize];
            element3 = Elem[operand2, index*2+1, esize];
            element4 = Elem[operand1, e*2, esize];
        when '01'
            element1 = FPNeg(Elem[operand2, index*2+1, esize]);
            element2 = Elem[operand1, e*2+1, esize];
            element3 = Elem[operand2, index*2, esize];
            element4 = Elem[operand1, e*2+1, esize];
        when '10'
            element1 = FPNeg(Elem[operand2, index*2, esize]);
            element2 = Elem[operand1, e*2, esize];
            element3 = FPNeg(Elem[operand2, index*2+1, esize]);
            element4 = Elem[operand1, e*2, esize];
        when '11'
            element1 = Elem[operand2, index*2+1, esize];
            element2 = Elem[operand1, e*2+1, esize];
            element3 = FPNeg(Elem[operand2, index*2, esize]);
            element4 = Elem[operand1, e*2+1, esize];

    Elem[result, e*2, esize] = FPMulAdd(Elem[operand3, e*2, esize], element2, element1, FPCR);
    Elem[result, e*2+1, esize] = FPMulAdd(Elem[operand3, e*2+1, esize], element4, element3, FPCR);

V[d] = result;

```



FCMLA

Floating-point Complex Multiply Accumulate.

This instruction operates on complex numbers that are represented in SIMD&FP registers as pairs of elements, with the more significant element holding the imaginary part of the number and the less significant element holding the real part of the number. Each element holds a floating-point value. It performs the following computation on the corresponding complex number element pairs from the two source registers and the destination register:

- Considering the complex number from the second source register on an Argand diagram, the number is rotated counterclockwise by 0, 90, 180, or 270 degrees.
- The two elements of the transformed complex number are multiplied by:
  - The real element of the complex number from the first source register, if the transformation was a rotation by 0 or 180 degrees.
  - The imaginary element of the complex number from the first source register, if the transformation was a rotation by 90 or 270 degrees.
- The complex number resulting from that multiplication is added to the complex number from the destination register.

The multiplication and addition operations are performed as a fused multiply-add, without any intermediate rounding. This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

Vector  
(Armv8.3)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	Q	1	0	1	1	1	0	size	0	Rm						1	1	0	rot	1	Rn						Rd					

Vector

FCMLA <Vd>.<T>, <Vn>.<T>, <Vm>.<T>, #<rotate>

```
if !HaveFCADDExt() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '00' then UNDEFINED;
if Q == '0' && size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
if !HaveFP16Ext() && esize == 16 then UNDEFINED;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

<rotate> Is the rotation, encoded in "rot":

rot	<rotate>
00	0
01	90
10	180
11	270

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;
bits(esize) element3;
bits(esize) element4;

for e = 0 to (elements DIV 2)-1
    case rot of
        when '00'
            element1 = Elem[operand2, e*2, esize];
            element2 = Elem[operand1, e*2, esize];
            element3 = Elem[operand2, e*2+1, esize];
            element4 = Elem[operand1, e*2+1, esize];
        when '01'
            element1 = FPNeg(Elem[operand2, e*2+1, esize]);
            element2 = Elem[operand1, e*2+1, esize];
            element3 = Elem[operand2, e*2, esize];
            element4 = Elem[operand1, e*2+1, esize];
        when '10'
            element1 = FPNeg(Elem[operand2, e*2, esize]);
            element2 = Elem[operand1, e*2, esize];
            element3 = FPNeg(Elem[operand2, e*2+1, esize]);
            element4 = Elem[operand1, e*2, esize];
        when '11'
            element1 = Elem[operand2, e*2+1, esize];
            element2 = Elem[operand1, e*2+1, esize];
            element3 = FPNeg(Elem[operand2, e*2, esize]);
            element4 = Elem[operand1, e*2+1, esize];

    Elem[result, e*2, esize] = FPMulAdd(Elem[operand3, e*2, esize], element2, element1, FPCR);
    Elem[result, e*2+1, esize] = FPMulAdd(Elem[operand3, e*2+1, esize], element4, element3, FPCR);

V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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## FCMLE (zero)

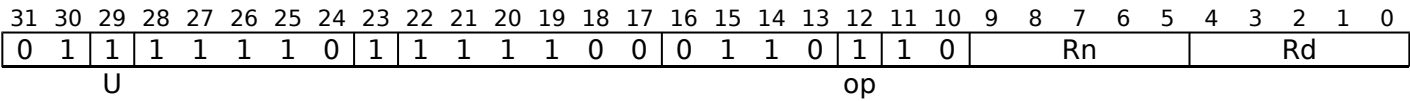
Floating-point Compare Less than or Equal to zero (vector). This instruction reads each floating-point value in the source SIMD&FP register and if the value is less than or equal to zero sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

### Scalar half precision (Armv8.2)



### Scalar half precision

FCMLE <Hd>, <Hn>, #0.0

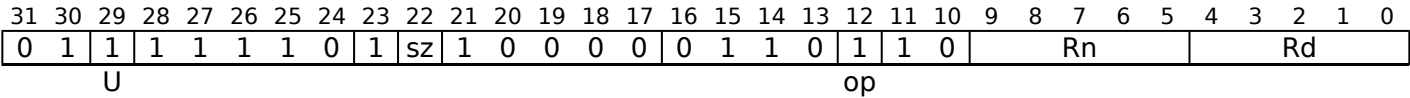
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);  
integer n = UInt(Rn);

integer esize = 16;  
integer datasize = esize;  
integer elements = 1;

CompareOp comparison;  
case op:U of  
  when '00' comparison = CompareOp\_GT;  
  when '01' comparison = CompareOp\_GE;  
  when '10' comparison = CompareOp\_FQ;  
  when '11' comparison = CompareOp\_LE;

### Scalar single-precision and double-precision



Scalar single-precision and double-precision

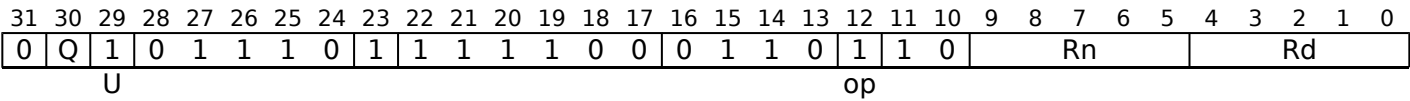
```
FCMLE <V><d>, <V><n>, #0.0

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;

CompareOp comparison;
case op:U of
    when '00' comparison = CompareOp_GT;
    when '01' comparison = CompareOp_GE;
    when '10' comparison = CompareOp_EQ;
    when '11' comparison = CompareOp_LE;
```

Vector half precision
(Armv8.2)



Vector half precision

```
FCMLE <Vd>.<T>, <Vn>.<T>, #0.0

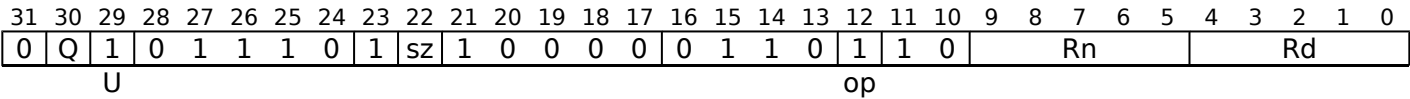
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CompareOp comparison;
case op:U of
    when '00' comparison = CompareOp_GT;
    when '01' comparison = CompareOp_GE;
    when '10' comparison = CompareOp_EQ;
    when '11' comparison = CompareOp_LE;
```

Vector single-precision and double-precision



Vector single-precision and double-precision

```
FCMLE <Vd>.<T>, <Vn>.<T>, #0.0

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CompareOp comparison;
case op:U of
  when '00' comparison = CompareOp_GT;
  when '01' comparison = CompareOp_GE;
  when '10' comparison = CompareOp_EQ;
  when '11' comparison = CompareOp_LE;
```

Assembler Symbols

- <Hd>

Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn>

Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <V>

Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D
- <d>

Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n>

Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T>

For the vector half precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

  
For the vector single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D
- <Vn>

Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) zero = FPZero('0');
bits(esize) element;
boolean test_passed;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    case comparison of
        when CompareOp_GT test_passed = FPCompareGT(element, zero, FPCR);
        when CompareOp_GE test_passed = FPCompareGE(element, zero, FPCR);
        when CompareOp_EQ test_passed = FPCompareEQ(element, zero, FPCR);
        when CompareOp_LE test_passed = FPCompareGE(zero, element, FPCR);
        when CompareOp_LT test_passed = FPCompareGT(zero, element, FPCR);
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

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## FCMLT (zero)

Floating-point Compare Less than zero (vector). This instruction reads each floating-point value in the source SIMD&FP register and if the value is less than zero sets every bit of the corresponding vector element in the destination SIMD&FP register to one, otherwise sets every bit of the corresponding vector element in the destination SIMD&FP register to zero.

This instruction can generate a floating-point exception. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

### Scalar half precision

(Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	1	0	1	1	1	1	0	1	1	1	1	1	0	0	0	1	1	1	0	1	0	Rn						Rd					

### Scalar half precision

FCMLT <Hd>, <Hn>, #0.0

```
if !HaveFP16Ext() then UNDEFINED;
```

```
integer d = UInt(Rd);
```

```
integer n = UInt(Rn);
```

```
integer esize = 16;
```

```
integer datasize = esize;
```

```
integer elements = 1;
```

```
CompareOp comparison = CompareOp_LT;
```

### Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	1	0	1	1	1	1	0	1	sz	1	0	0	0	0	0	1	1	1	0	1	0	Rn						Rd					

### Scalar single-precision and double-precision

FCMLT <V><d>, <V><n>, #0.0

```
integer d = UInt(Rd);
```

```
integer n = UInt(Rn);
```

```
integer esize = 32 << UInt(sz);
```

```
integer datasize = esize;
```

```
integer elements = 1;
```

```
CompareOp comparison = CompareOp_LT;
```

### Vector half precision

(Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	0	0	0	1	1	1	0	1	1	1	1	1	0	0	0	1	1	1	0	1	0	Rn						Rd					

Vector half precision

```
FCMLT <Vd>.<T>, <Vn>.<T>, #0.0

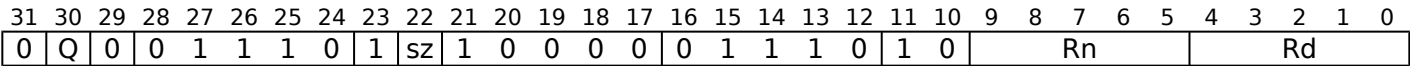
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CompareOp comparison = CompareOp_LT;
```

Vector single-precision and double-precision



Vector single-precision and double-precision

```
FCMLT <Vd>.<T>, <Vn>.<T>, #0.0

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

CompareOp comparison = CompareOp_LT;
```

Assembler Symbols

- <Hd>

Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn>

Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <V>

Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D
- <d>

Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n>

Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T>

For the vector half precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

  
For the vector single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D
- <Vn>

Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) zero = FPZero('0');
bits(esize) element;
boolean test_passed;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    case comparison of
        when CompareOp_GT test_passed = FPCompareGT(element, zero, FPCR);
        when CompareOp_GE test_passed = FPCompareGE(element, zero, FPCR);
        when CompareOp_EQ test_passed = FPCompareEQ(element, zero, FPCR);
        when CompareOp_LE test_passed = FPCompareGE(zero, element, FPCR);
        when CompareOp_LT test_passed = FPCompareGT(zero, element, FPCR);
    Elem[result, e, esize] = if test_passed then Ones() else Zeros();

V[d] = result;
```

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# FCMP

Floating-point quiet Compare (scalar). This instruction compares the two SIMD&FP source register values, or the first SIMD&FP source register value and zero. It writes the result to the *PSTATE*.{N, Z, C, V} flags. It raises an Invalid Operation exception only if either operand is a signaling NaN. A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*. Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1	1	1	1	0	ftype		1	Rm				0	0	1	0	0	0	Rn				0	x	0	0	0		
opc																															

**Half-precision (ftype == 11 && opc == 00)**  
(Armv8.2)

```
FCMP <Hn>, <Hm>
```

**Half-precision, zero (ftype == 11 && Rm == (00000) && opc == 01)**  
(Armv8.2)

```
FCMP <Hn>, #0.0
```

**Single-precision (ftype == 00 && opc == 00)**

```
FCMP <Sn>, <Sm>
```

**Single-precision, zero (ftype == 00 && Rm == (00000) && opc == 01)**

```
FCMP <Sn>, #0.0
```

**Double-precision (ftype == 01 && opc == 00)**

```
FCMP <Dn>, <Dm>
```

**Double-precision, zero (ftype == 01 && Rm == (00000) && opc == 01)**

```
FCMP <Dn>, #0.0
```

```
integer n = UInt(Rn);
integer m = UInt(Rm);    // ignored when opc<0> == '1'

integer datasize;
case ftype of
  when '00' datasize = 32;
  when '01' datasize = 64;
  when '10' UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      datasize = 16;
    else
      UNDEFINED;

boolean signal_all_nans = (opc<1> == '1');
boolean cmp_with_zero = (opc<0> == '1');
```

## Assembler Symbols

<Dn>	For the double-precision variant: is the 64-bit name of the first SIMD&FP source register, encoded in the "Rn" field.  For the double-precision, zero variant: is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Dm>	Is the 64-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
<Hn>	For the half-precision variant: is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.  For the half-precision, zero variant: is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Hm>	Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
<Sn>	For the single-precision variant: is the 32-bit name of the first SIMD&FP source register, encoded in the "Rn" field.  For the single-precision, zero variant: is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Sm>	Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rm" field.

### NaNs

The IEEE 754 standard specifies that the result of a comparison is precisely one of <, ==, > or unordered. If either or both of the operands are NaNs, they are unordered, and all three of (Operand1 < Operand2), (Operand1 == Operand2) and (Operand1 > Operand2) are false. This case results in the **FPSCR** flags being set to N=0, Z=0, C=1, and V=1.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
bits(datasize) operand1 = V[n];  
bits(datasize) operand2;  
  
operand2 = if cmp_with_zero then FPZero('0') else V[m];  
  
PSTATE.<N,Z,C,V> = FPCompare(operand1, operand2, signal_all_nans, FPCR);
```

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## FCMPE

Floating-point signaling Compare (scalar). This instruction compares the two SIMD&FP source register values, or the first SIMD&FP source register value and zero. It writes the result to the *PSTATE*.{N, Z, C, V} flags.

If either operand is any type of NaN, or if either operand is a signaling NaN, the instruction raises an Invalid Operation exception.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1	1	1	1	0	ftype		1	Rm				0	0	1	0	0	0	Rn				1	x	0	0	0	opc	

### Half-precision (ftype == 11 && opc == 10) (Armv8.2)

FCMPE <Hn>, <Hm>

### Half-precision, zero (ftype == 11 && Rm == (00000) && opc == 11) (Armv8.2)

FCMPE <Hn>, #0.0

### Single-precision (ftype == 00 && opc == 10)

FCMPE <Sn>, <Sm>

### Single-precision, zero (ftype == 00 && Rm == (00000) && opc == 11)

FCMPE <Sn>, #0.0

### Double-precision (ftype == 01 && opc == 10)

FCMPE <Dn>, <Dm>

### Double-precision, zero (ftype == 01 && Rm == (00000) && opc == 11)

FCMPE <Dn>, #0.0

```
integer n = UInt(Rn);
integer m = UInt(Rm);    // ignored when opc<0> == '1'

integer datasize;
case ftype of
  when '00' datasize = 32;
  when '01' datasize = 64;
  when '10' UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      datasize = 16;
    else
      UNDEFINED;

boolean signal_all_nans = (opc<1> == '1');
boolean cmp_with_zero = (opc<0> == '1');
```

## Assembler Symbols

<Dn>	For the double-precision variant: is the 64-bit name of the first SIMD&FP source register, encoded in the "Rn" field.  For the double-precision, zero variant: is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Dm>	Is the 64-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
<Hn>	For the half-precision variant: is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.  For the half-precision, zero variant: is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Hm>	Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
<Sn>	For the single-precision variant: is the 32-bit name of the first SIMD&FP source register, encoded in the "Rn" field.  For the single-precision, zero variant: is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Sm>	Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rm" field.

### NaNs

The IEEE 754 standard specifies that the result of a comparison is precisely one of <, ==, > or unordered. If either or both of the operands are NaNs, they are unordered, and all three of (Operand1 < Operand2), (Operand1 == Operand2) and (Operand1 > Operand2) are false. This case results in the **FPSCR** flags being set to N=0, Z=0, C=1, and V=1.

FCMPE raises an Invalid Operation exception if either operand is any type of NaN, and is suitable for testing for <, <=, >, >=, and other predicates that raise an exception when the operands are unordered.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
bits(datasize) operand1 = V[n];  
bits(datasize) operand2;  
  
operand2 = if cmp_with_zero then FPZero('0') else V[m];  
  
PSTATE.<N,Z,C,V> = FPCompare(operand1, operand2, signal_all_nans, FPCR);
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FCSEL

Floating-point Conditional Select (scalar). This instruction allows the SIMD&FP destination register to take the value from either one or the other of two SIMD&FP source registers. If the condition passes, the first SIMD&FP source register value is taken, otherwise the second SIMD&FP source register value is taken.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1	1	1	1	0	ftype	1	Rm					cond					1	1	Rn					Rd				

## Half-precision (ftype == 11) (Armv8.2)

FCSEL <Hd>, <Hn>, <Hm>, <cond>

## Single-precision (ftype == 00)

FCSEL <Sd>, <Sn>, <Sm>, <cond>

## Double-precision (ftype == 01)

FCSEL <Dd>, <Dn>, <Dm>, <cond>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer datasize;
case ftype of
    when '00' datasize = 32;
    when '01' datasize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            datasize = 16;
        else
            UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Dm> Is the 64-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Sm> Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <cond> Is one of the standard conditions, encoded in the "cond" field in the standard way.



## Operation

```
CheckFPAdvSIMDEnabled64();  
bits(datasize) result;  
  
result = if ConditionHolds(cond) then V[n] else V[m];  
  
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FCVT

Floating-point Convert precision (scalar). This instruction converts the floating-point value in the SIMD&FP source register to the precision for the destination register data type using the rounding mode that is determined by the **FPCR** and writes the result to the SIMD&FP destination register.

Depending on the settings in the **CPACR\_EL1**, **CPTR\_EL2**, and **CPTR\_EL3** registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1	1	1	1	0	ftype	1	0	0	0	1	opc	1	0	0	0	0												

**Half-precision to single-precision (ftype == 11 && opc == 00)**

FCVT <Sd>, <Hn>

**Half-precision to double-precision (ftype == 11 && opc == 01)**

FCVT <Dd>, <Hn>

**Single-precision to half-precision (ftype == 00 && opc == 11)**

FCVT <Hd>, <Sn>

**Single-precision to double-precision (ftype == 00 && opc == 01)**

FCVT <Dd>, <Sn>

**Double-precision to half-precision (ftype == 01 && opc == 11)**

FCVT <Hd>, <Dn>

**Double-precision to single-precision (ftype == 01 && opc == 00)**

FCVT <Sd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer srsize;
integer dstsize;

if ftype == opc then UNDEFINED;

case ftype of
  when '00' srsize = 32;
  when '01' srsize = 64;
  when '10' UNDEFINED;
  when '11' srsize = 16;
case opc of
  when '00' dstsize = 32;
  when '01' dstsize = 64;
  when '10' UNDEFINED;
  when '11' dstsize = 16;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

<Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.  
<Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.  
<Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
bits(dstsize) result;  
bits(srcsize) operand = V[n];  
  
result = FPConvert(operand, FPCR);  
V[d] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FCVTAS (vector)

Floating-point Convert to Signed integer, rounding to nearest with ties to Away (vector). This instruction converts each element in a vector from a floating-point value to a signed integer value using the Round to Nearest with Ties to Away rounding mode and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	1	1	1	1	0	0	1	1	1	0	0	1	0	Rn				Rd					
U																															

## Scalar half precision

```
FCVTAS <Hd>, <Hn>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPRounding_TIEAWAY;
boolean unsigned = (U == '1');
```

## Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	sz	1	0	0	0	0	1	1	1	0	0	1	0	Rn				Rd					
U																															

## Scalar single-precision and double-precision

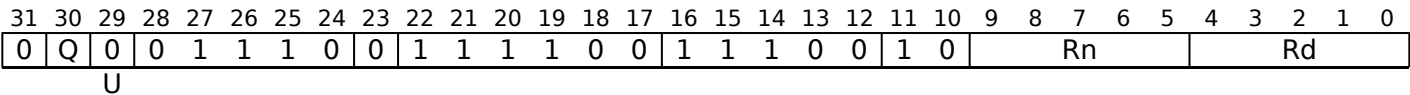
```
FCVTAS <V><d>, <V><n>

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPRounding_TIEAWAY;
boolean unsigned = (U == '1');
```

Vector half precision  
(Armv8.2)



Vector half precision

```
FCVTAS <Vd>.<T>, <Vn>.<T>

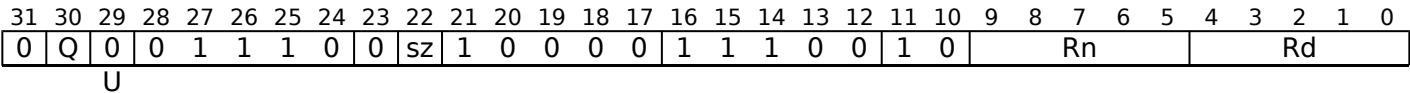
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPRounding_TIEAWAY;
boolean unsigned = (U == '1');
```

Vector single-precision and double-precision



Vector single-precision and double-precision

```
FCVTAS <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPRounding_TIEAWAY;
boolean unsigned = (U == '1');
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the vector half precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the vector single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPToFixed(element, 0, unsigned, FPCR, rounding);

V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

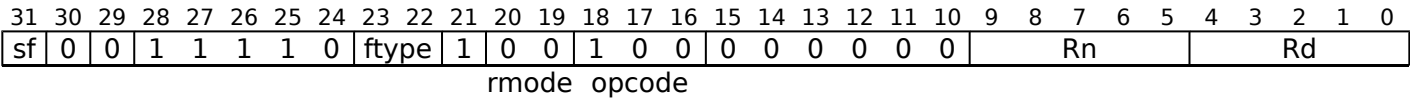
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# FCVTAS (scalar)

Floating-point Convert to Signed integer, rounding to nearest with ties to Away (scalar). This instruction converts the floating-point value in the SIMD&FP source register to a 32-bit or 64-bit signed integer using the Round to Nearest with Ties to Away rounding mode, and writes the result to the general-purpose destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



**Half-precision to 32-bit (sf == 0 && ftype == 11)**  
(Armv8.2)

```
FCVTAS <Wd>, <Hn>
```

**Half-precision to 64-bit (sf == 1 && ftype == 11)**  
(Armv8.2)

```
FCVTAS <Xd>, <Hn>
```

**Single-precision to 32-bit (sf == 0 && ftype == 00)**

```
FCVTAS <Wd>, <Sn>
```

**Single-precision to 64-bit (sf == 1 && ftype == 00)**

```
FCVTAS <Xd>, <Sn>
```

**Double-precision to 32-bit (sf == 0 && ftype == 01)**

```
FCVTAS <Wd>, <Dn>
```

**Double-precision to 64-bit (sf == 1 && ftype == 01)**

```
FCVTAS <Xd>, <Dn>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;

case ftype of
  when '00'
    fltsize = 32;
  when '01'
    fltsize = 64;
  when '10'
    UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      fltsize = 16;
    else
      UNDEFINED;
```

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Hn>	Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Dn>	Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
bits(fltsize) fltval;  
bits(intsize) intval;  
  
fltval = V[n];  
intval = FPToFixed(fltval, 0, FALSE, FPCR, FPRounding_TIEAWAY);  
X[d] = intval;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FCVTAU (vector)

Floating-point Convert to Unsigned integer, rounding to nearest with ties to Away (vector). This instruction converts each element in a vector from a floating-point value to an unsigned integer value using the Round to Nearest with Ties to Away rounding mode and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	0	1	1	1	1	0	0	1	1	1	0	0	1	0	Rn				Rd					
U																															

## Scalar half precision

```
FCVTAU <Hd>, <Hn>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPRounding_TIEAWAY;
boolean unsigned = (U == '1');
```

## Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	0	sz	1	0	0	0	0	1	1	1	0	0	1	0	Rn				Rd					
U																															

## Scalar single-precision and double-precision

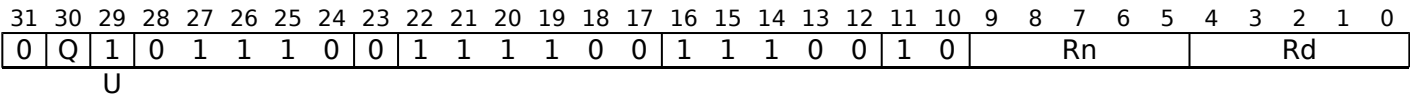
```
FCVTAU <V><d>, <V><n>

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPRounding_TIEAWAY;
boolean unsigned = (U == '1');
```

Vector half precision  
(Armv8.2)



Vector half precision

```
FCVTAU <Vd>.<T>, <Vn>.<T>

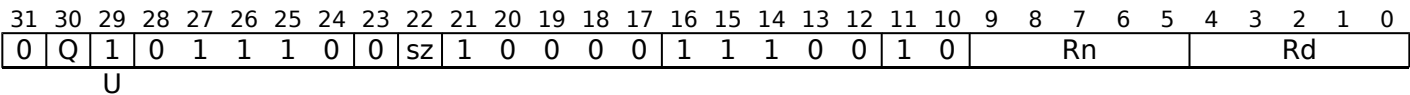
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPRounding_TIEAWAY;
boolean unsigned = (U == '1');
```

Vector single-precision and double-precision



Vector single-precision and double-precision

```
FCVTAU <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPRounding_TIEAWAY;
boolean unsigned = (U == '1');
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D
- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the vector half precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the vector single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPToFixed(element, 0, unsigned, FPCR, rounding);
V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

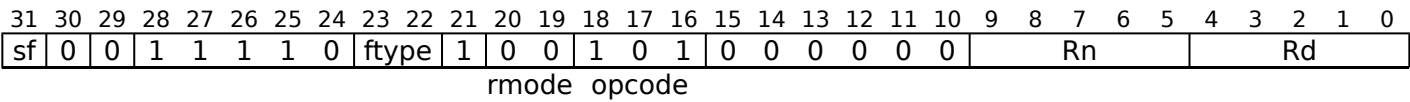
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## FCVTAU (scalar)

Floating-point Convert to Unsigned integer, rounding to nearest with ties to Away (scalar). This instruction converts the floating-point value in the SIMD&FP source register to a 32-bit or 64-bit unsigned integer using the Round to Nearest with Ties to Away rounding mode, and writes the result to the general-purpose destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



### Half-precision to 32-bit (sf == 0 && ftype == 11) (Armv8.2)

FCVTAU <Wd>, <Hn>

### Half-precision to 64-bit (sf == 1 && ftype == 11) (Armv8.2)

FCVTAU <Xd>, <Hn>

### Single-precision to 32-bit (sf == 0 && ftype == 00)

FCVTAU <Wd>, <Sn>

### Single-precision to 64-bit (sf == 1 && ftype == 00)

FCVTAU <Xd>, <Sn>

### Double-precision to 32-bit (sf == 0 && ftype == 01)

FCVTAU <Wd>, <Dn>

### Double-precision to 64-bit (sf == 1 && ftype == 01)

FCVTAU <Xd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;

case ftype of
  when '00'
    fltsize = 32;
  when '01'
    fltsize = 64;
  when '10'
    UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      fltsize = 16;
    else
      UNDEFINED;
```

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Hn>	Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Dn>	Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
bits(fltsize) fltval;  
bits(intsize) intval;  
  
fltval = V[n];  
intval = FPToFixed(fltval, 0, TRUE, FPCR, FPRounding_TIEAWAY);  
X[d] = intval;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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FCVTL, FCVTL2

Floating-point Convert to higher precision Long (vector). This instruction reads each element in a vector in the SIMD&FP source register, converts each value to double the precision of the source element using the rounding mode that is determined by the *FPCR*, and writes each result to the equivalent element of the vector in the SIMD&FP destination register.

Where the operation lengthens a 64-bit vector to a 128-bit vector, the FCVTL2 variant operates on the elements in the top 64 bits of the source register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	sz	1	0	0	0	0	1	0	1	1	1	1	0	Rn					Rd				

Vector single-precision and double-precision

```
FCVTL{2} <Vd>.<Ta>, <Vn>.<Tb>

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16 << UInt(sz);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;
```

Assembler Symbols

2

Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in "Q":

Q	2
0	[absent]
1	[present]

<Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta>

Is an arrangement specifier, encoded in "sz":

sz	<Ta>
0	4S
1	2D

<Vn>

Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<Tb>

Is an arrangement specifier, encoded in "sz:Q":

sz	Q	<Tb>
0	0	4H
0	1	8H
1	0	2S
1	1	4S

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = Vpart[n, part];
bits(2*datasize) result;

for e = 0 to elements-1
    Elem[result, e, 2*esize] = FPConvert(Elem[operand, e, esize], FPCR);

V[d] = result;
```



# FCVTMS (vector)

Floating-point Convert to Signed integer, rounding toward Minus infinity (vector). This instruction converts a scalar or each element in a vector from a floating-point value to a signed integer value using the Round towards Minus Infinity rounding mode, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	1	1	1	1	0	0	1	1	0	1	1	1	0	Rn					Rd				
U								o2								o1															

## Scalar half precision

```
FCVTMS <Hd>, <Hn>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

## Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	sz	1	0	0	0	0	1	1	0	1	1	1	0	Rn				Rd					
U								o2								o1															

## Scalar single-precision and double-precision

```
FCVTMS <V><d>, <V><n>

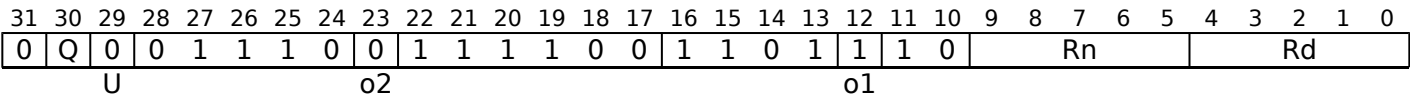
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```



Vector half precision  
(Armv8.2)



Vector half precision

```
FCVTMS <Vd>.<T>, <Vn>.<T>

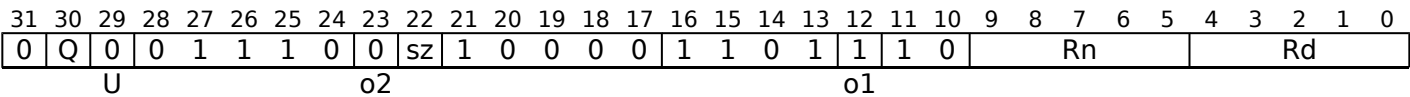
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

Vector single-precision and double-precision



Vector single-precision and double-precision

```
FCVTMS <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the vector half precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the vector single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPToFixed(element, 0, unsigned, FPCR, rounding);
V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

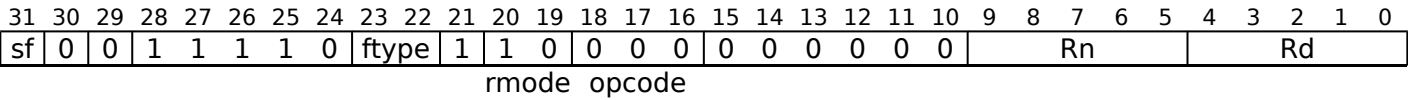
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FCVTMS (scalar)

Floating-point Convert to Signed integer, rounding toward Minus infinity (scalar). This instruction converts the floating-point value in the SIMD&FP source register to a 32-bit or 64-bit signed integer using the Round towards Minus Infinity rounding mode, and writes the result to the general-purpose destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



**Half-precision to 32-bit (sf == 0 && ftype == 11)**  
(Armv8.2)

FCVTMS <Wd>, <Hn>

**Half-precision to 64-bit (sf == 1 && ftype == 11)**  
(Armv8.2)

FCVTMS <Xd>, <Hn>

**Single-precision to 32-bit (sf == 0 && ftype == 00)**

FCVTMS <Wd>, <Sn>

**Single-precision to 64-bit (sf == 1 && ftype == 00)**

FCVTMS <Xd>, <Sn>

**Double-precision to 32-bit (sf == 0 && ftype == 01)**

FCVTMS <Wd>, <Dn>

**Double-precision to 64-bit (sf == 1 && ftype == 01)**

FCVTMS <Xd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;
FPRounding rounding;

case ftype of
  when '00'
    fltsize = 32;
  when '01'
    fltsize = 64;
  when '10'
    UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      fltsize = 16;
    else
      UNDEFINED;

rounding = FPDecodeRounding(rmode);
```

**Assembler Symbols**

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Hn>	Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Dn>	Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
bits(fltsize) fltval;  
bits(intsize) intval;  
  
fltval = V[n];  
intval = FPToFixed(fltval, 0, FALSE, FPCR, rounding);  
X[d] = intval;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FCVTMU (vector)

Floating-point Convert to Unsigned integer, rounding toward Minus infinity (vector). This instruction converts a scalar or each element in a vector from a floating-point value to an unsigned integer value using the Round towards Minus Infinity rounding mode, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	0	1	1	1	1	0	0	1	1	0	1	1	1	0	Rn				Rd					
U								o2				o1																			

## Scalar half precision

```
FCVTMU <Hd>, <Hn>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

## Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	0	sz	1	0	0	0	0	1	1	0	1	1	1	0	Rn				Rd					
U								o2				o1																			

## Scalar single-precision and double-precision

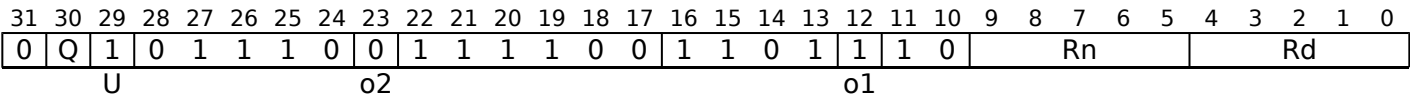
```
FCVTMU <V><d>, <V><n>

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

Vector half precision  
(Armv8.2)



Vector half precision

```
FCVTMU <Vd>.<T>, <Vn>.<T>

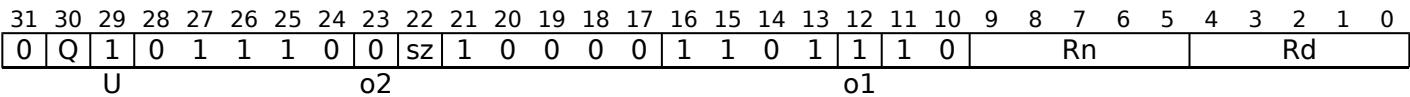
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

Vector single-precision and double-precision



Vector single-precision and double-precision

```
FCVTMU <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the vector half precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the vector single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPToFixed(element, 0, unsigned, FPCR, rounding);

V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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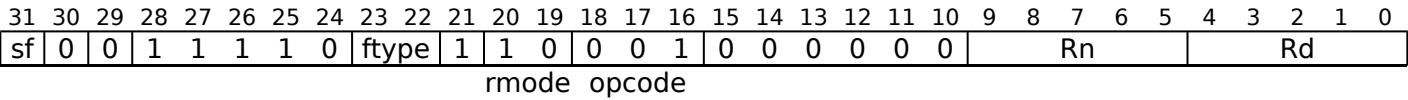


FCVTMU (scalar)

Floating-point Convert to Unsigned integer, rounding toward Minus infinity (scalar). This instruction converts the floating-point value in the SIMD&FP source register to a 32-bit or 64-bit unsigned integer using the Round towards Minus Infinity rounding mode, and writes the result to the general-purpose destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



**Half-precision to 32-bit (sf == 0 && ftype == 11)**  
(Armv8.2)

FCVTMU <Wd>, <Hn>

**Half-precision to 64-bit (sf == 1 && ftype == 11)**  
(Armv8.2)

FCVTMU <Xd>, <Hn>

**Single-precision to 32-bit (sf == 0 && ftype == 00)**

FCVTMU <Wd>, <Sn>

**Single-precision to 64-bit (sf == 1 && ftype == 00)**

FCVTMU <Xd>, <Sn>

**Double-precision to 32-bit (sf == 0 && ftype == 01)**

FCVTMU <Wd>, <Dn>

**Double-precision to 64-bit (sf == 1 && ftype == 01)**

FCVTMU <Xd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;
FPRounding rounding;

case ftype of
  when '00'
    fltsize = 32;
  when '01'
    fltsize = 64;
  when '10'
    UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      fltsize = 16;
    else
      UNDEFINED;

rounding = FPDecodeRounding(rmode);
```

**Assembler Symbols**

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Hn>	Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Dn>	Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
bits(fltsize) fltval;  
bits(intsize) intval;  
  
fltval = V[n];  
intval = FPToFixed(fltval, 0, TRUE, FPCR, rounding);  
X[d] = intval;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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FCVTN, FCVTN2

Floating-point Convert to lower precision Narrow (vector). This instruction reads each vector element in the SIMD&FP source register, converts each result to half the precision of the source element, writes the final result to a vector, and writes the vector to the lower or upper half of the destination SIMD&FP register. The destination vector elements are half as long as the source vector elements. The rounding mode is determined by the *FPCR*.  
The FCVTN instruction writes the vector to the lower half of the destination register and clears the upper half, while the FCVTN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register.  
A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.  
Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	sz	1	0	0	0	0	1	0	1	1	0	1	0	Rn				Rd					

Vector single-precision and double-precision

```
FCVTN{2} <Vd>.<Tb>, <Vn>.<Ta>

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16 << UInt(sz);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;
```

Assembler Symbols

- 2

Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Tb>

Is an arrangement specifier, encoded in “sz:Q”:

sz	Q	<Tb>
0	0	4H
0	1	8H
1	0	2S
1	1	4S
- <Vn>

Is the name of the SIMD&FP source register, encoded in the "Rn" field.
- <Ta>

Is an arrangement specifier, encoded in “sz”:

sz	<Ta>
0	4S
1	2D

## Operation

```
CheckFPAdvSIMDEnabled64();  
bits(2*datasize) operand = V[n];  
bits(datasize) result;  
  
for e = 0 to elements-1  
    Elem[result, e, esize] = FPConvert(Elem[operand, e, 2*esize], FPCR);  
Vpart[d, part] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FCVTNS (vector)

Floating-point Convert to Signed integer, rounding to nearest with ties to even (vector). This instruction converts a scalar or each element in a vector from a floating-point value to a signed integer value using the Round to Nearest rounding mode, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	1	1	1	1	0	0	1	1	0	1	0	1	0	Rn				Rd					
U								o2								o1															

## Scalar half precision

```
FCVTNS <Hd>, <Hn>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

## Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	sz	1	0	0	0	0	1	1	0	1	0	1	0	Rn				Rd					
U								o2								o1															

## Scalar single-precision and double-precision

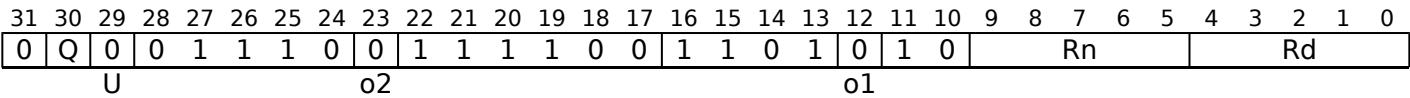
```
FCVTNS <V><d>, <V><n>

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

Vector half precision  
(Armv8.2)



Vector half precision

```
FCVTNS <Vd>.<T>, <Vn>.<T>

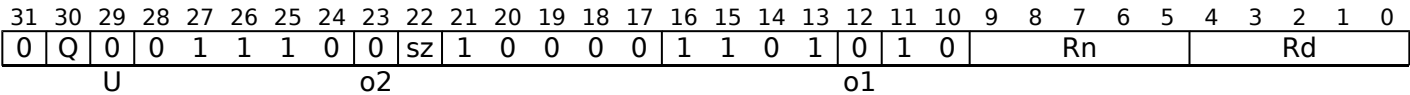
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

Vector single-precision and double-precision



Vector single-precision and double-precision

```
FCVTNS <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the vector half precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the vector single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPToFixed(element, 0, unsigned, FPCR, rounding);

V[d] = result;

```

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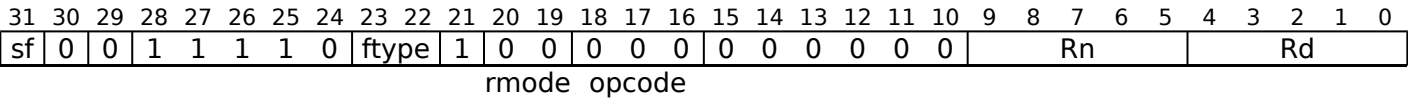


# FCVTNS (scalar)

Floating-point Convert to Signed integer, rounding to nearest with ties to even (scalar). This instruction converts the floating-point value in the SIMD&FP source register to a 32-bit or 64-bit signed integer using the Round to Nearest rounding mode, and writes the result to the general-purpose destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



**Half-precision to 32-bit (sf == 0 && ftype == 11)**  
(Armv8.2)

FCVTNS <Wd>, <Hn>

**Half-precision to 64-bit (sf == 1 && ftype == 11)**  
(Armv8.2)

FCVTNS <Xd>, <Hn>

**Single-precision to 32-bit (sf == 0 && ftype == 00)**

FCVTNS <Wd>, <Sn>

**Single-precision to 64-bit (sf == 1 && ftype == 00)**

FCVTNS <Xd>, <Sn>

**Double-precision to 32-bit (sf == 0 && ftype == 01)**

FCVTNS <Wd>, <Dn>

**Double-precision to 64-bit (sf == 1 && ftype == 01)**

FCVTNS <Xd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;
FPRounding rounding;

case ftype of
  when '00'
    fltsize = 32;
  when '01'
    fltsize = 64;
  when '10'
    UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      fltsize = 16;
    else
      UNDEFINED;

rounding = FPDecodeRounding(rmode);
```

**Assembler Symbols**

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Hn>	Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Dn>	Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
bits(fltsize) fltval;  
bits(intsize) intval;  
  
fltval = V[n];  
intval = FPToFixed(fltval, 0, FALSE, FPCR, rounding);  
X[d] = intval;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FCVTNU (vector)

Floating-point Convert to Unsigned integer, rounding to nearest with ties to even (vector). This instruction converts a scalar or each element in a vector from a floating-point value to an unsigned integer value using the Round to Nearest rounding mode, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	0	1	1	1	1	0	0	1	1	0	1	0	1	0	Rn				Rd					
U								o2				o1																			

## Scalar half precision

```
FCVTNU <Hd>, <Hn>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

## Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	0	sz	1	0	0	0	0	1	1	0	1	0	1	0	Rn				Rd					
U								o2				o1																			

## Scalar single-precision and double-precision

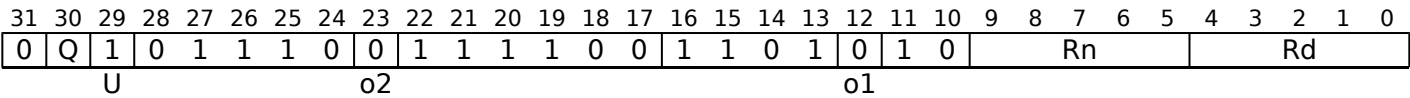
```
FCVTNU <V><d>, <V><n>

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

Vector half precision  
(Armv8.2)



Vector half precision

```
FCVTNU <Vd>.<T>, <Vn>.<T>

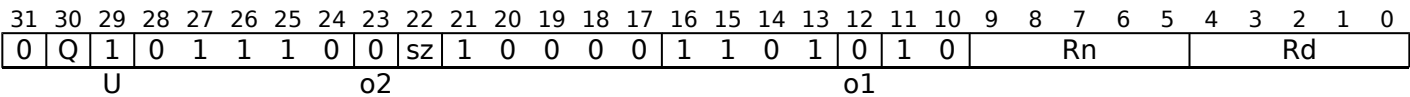
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

Vector single-precision and double-precision



Vector single-precision and double-precision

```
FCVTNU <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the vector half precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the vector single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPToFixed(element, 0, unsigned, FPCR, rounding);
V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

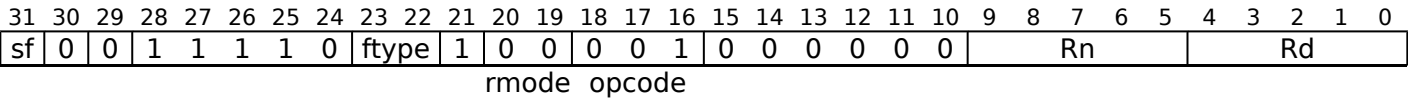
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FCVTNU (scalar)

Floating-point Convert to Unsigned integer, rounding to nearest with ties to even (scalar). This instruction converts the floating-point value in the SIMD&FP source register to a 32-bit or 64-bit unsigned integer using the Round to Nearest rounding mode, and writes the result to the general-purpose destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



**Half-precision to 32-bit (sf == 0 && ftype == 11)**  
(Armv8.2)

FCVTNU <Wd>, <Hn>

**Half-precision to 64-bit (sf == 1 && ftype == 11)**  
(Armv8.2)

FCVTNU <Xd>, <Hn>

**Single-precision to 32-bit (sf == 0 && ftype == 00)**

FCVTNU <Wd>, <Sn>

**Single-precision to 64-bit (sf == 1 && ftype == 00)**

FCVTNU <Xd>, <Sn>

**Double-precision to 32-bit (sf == 0 && ftype == 01)**

FCVTNU <Wd>, <Dn>

**Double-precision to 64-bit (sf == 1 && ftype == 01)**

FCVTNU <Xd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;
FPRounding rounding;

case ftype of
  when '00'
    fltsize = 32;
  when '01'
    fltsize = 64;
  when '10'
    UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      fltsize = 16;
    else
      UNDEFINED;

rounding = FPDecodeRounding(rmode);
```

**Assembler Symbols**

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Hn>	Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Dn>	Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.



## Operation

```
CheckFPAdvSIMDEnabled64();  
  
bits(fltsize) fltval;  
bits(intsize) intval;  
  
fltval = V[n];  
intval = FPToFixed(fltval, 0, TRUE, FPCR, rounding);  
X[d] = intval;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FCVTPS (vector)

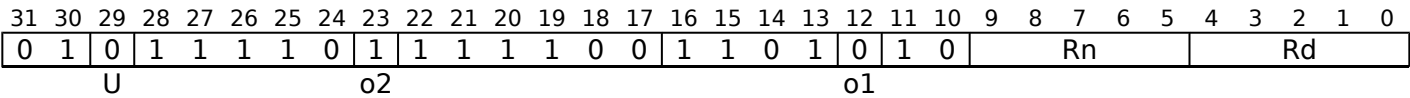
Floating-point Convert to Signed integer, rounding toward Plus infinity (vector). This instruction converts a scalar or each element in a vector from a floating-point value to a signed integer value using the Round towards Plus Infinity rounding mode, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (Armv8.2)



## Scalar half precision

```
FCVTPS <Hd>, <Hn>

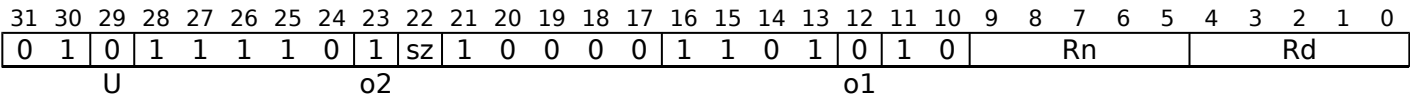
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

## Scalar single-precision and double-precision



## Scalar single-precision and double-precision

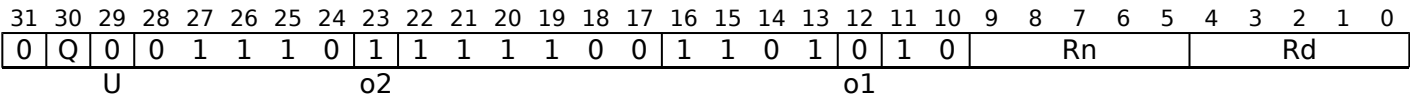
```
FCVTPS <V><d>, <V><n>

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

Vector half precision  
(Armv8.2)



Vector half precision

```
FCVTPS <Vd>.<T>, <Vn>.<T>

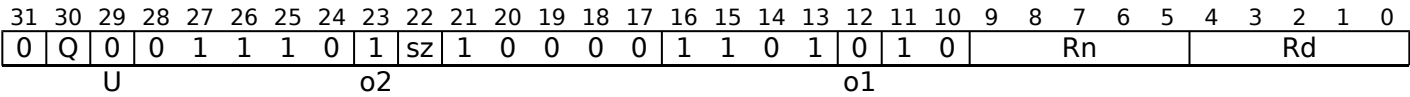
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

Vector single-precision and double-precision



Vector single-precision and double-precision

```
FCVTPS <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the vector half precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the vector single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPToFixed(element, 0, unsigned, FPCR, rounding);
V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

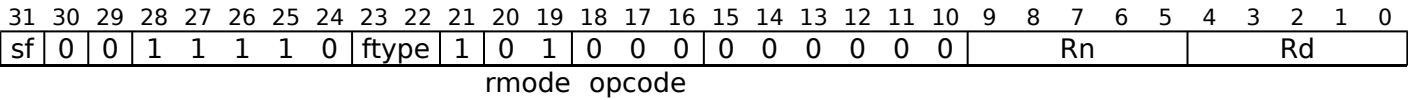
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FCVTPS (scalar)

Floating-point Convert to Signed integer, rounding toward Plus infinity (scalar). This instruction converts the floating-point value in the SIMD&FP source register to a 32-bit or 64-bit signed integer using the Round towards Plus Infinity rounding mode, and writes the result to the general-purpose destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



**Half-precision to 32-bit (sf == 0 && ftype == 11)**  
(Armv8.2)

FCVTPS <Wd>, <Hn>

**Half-precision to 64-bit (sf == 1 && ftype == 11)**  
(Armv8.2)

FCVTPS <Xd>, <Hn>

**Single-precision to 32-bit (sf == 0 && ftype == 00)**

FCVTPS <Wd>, <Sn>

**Single-precision to 64-bit (sf == 1 && ftype == 00)**

FCVTPS <Xd>, <Sn>

**Double-precision to 32-bit (sf == 0 && ftype == 01)**

FCVTPS <Wd>, <Dn>

**Double-precision to 64-bit (sf == 1 && ftype == 01)**

FCVTPS <Xd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;
FPRounding rounding;

case ftype of
  when '00'
    fltsize = 32;
  when '01'
    fltsize = 64;
  when '10'
    UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      fltsize = 16;
    else
      UNDEFINED;

rounding = FPDecodeRounding(rmode);
```

**Assembler Symbols**

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Hn>	Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Dn>	Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
bits(fltsize) fltval;  
bits(intsize) intval;  
  
fltval = V[n];  
intval = FPToFixed(fltval, 0, FALSE, FPCR, rounding);  
X[d] = intval;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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## FCVTPU (vector)

Floating-point Convert to Unsigned integer, rounding toward Plus infinity (vector). This instruction converts a scalar or each element in a vector from a floating-point value to an unsigned integer value using the Round towards Plus Infinity rounding mode, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

### Scalar half precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	1	1	1	1	1	0	0	1	1	0	1	0	1	0	Rn				Rd					
U								o2				o1																			

### Scalar half precision

FCVTPU <Hd>, <Hn>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

### Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	1	sz	1	0	0	0	0	1	1	0	1	0	1	0	Rn				Rd					
U								o2				o1																			

### Scalar single-precision and double-precision

FCVTPU <V><d>, <V><n>

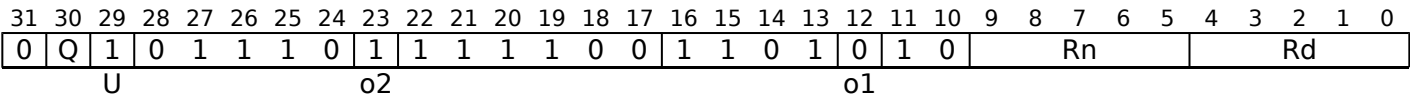
```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```



Vector half precision  
(Armv8.2)



Vector half precision

```
FCVTPU <Vd>.<T>, <Vn>.<T>

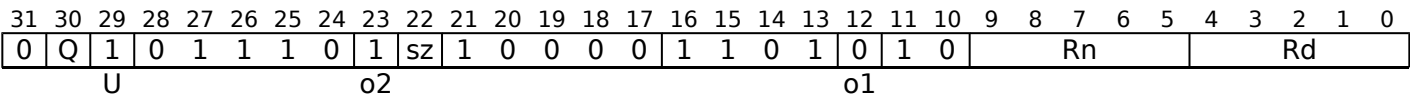
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

Vector single-precision and double-precision



Vector single-precision and double-precision

```
FCVTPU <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the vector half precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the vector single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPToFixed(element, 0, unsigned, FPCR, rounding);
V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

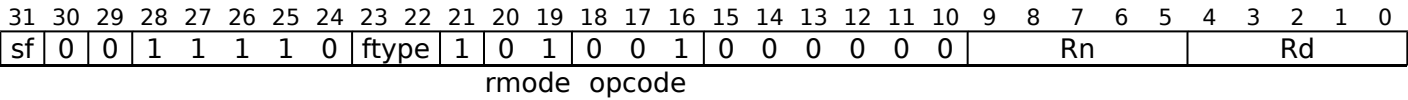
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## FCVTPU (scalar)

Floating-point Convert to Unsigned integer, rounding toward Plus infinity (scalar). This instruction converts the floating-point value in the SIMD&FP source register to a 32-bit or 64-bit unsigned integer using the Round towards Plus Infinity rounding mode, and writes the result to the general-purpose destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



**Half-precision to 32-bit (sf == 0 && ftype == 11)**  
(Armv8.2)

FCVTPU <Wd>, <Hn>

**Half-precision to 64-bit (sf == 1 && ftype == 11)**  
(Armv8.2)

FCVTPU <Xd>, <Hn>

**Single-precision to 32-bit (sf == 0 && ftype == 00)**

FCVTPU <Wd>, <Sn>

**Single-precision to 64-bit (sf == 1 && ftype == 00)**

FCVTPU <Xd>, <Sn>

**Double-precision to 32-bit (sf == 0 && ftype == 01)**

FCVTPU <Wd>, <Dn>

**Double-precision to 64-bit (sf == 1 && ftype == 01)**

FCVTPU <Xd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;
FPRounding rounding;

case ftype of
  when '00'
    fltsize = 32;
  when '01'
    fltsize = 64;
  when '10'
    UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      fltsize = 16;
    else
      UNDEFINED;

rounding = FPDecodeRounding(rmode);
```

**Assembler Symbols**

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Hn>	Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Dn>	Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
bits(fltsize) fltval;  
bits(intsize) intval;  
  
fltval = V[n];  
intval = FPToFixed(fltval, 0, TRUE, FPCR, rounding);  
X[d] = intval;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FCVTXN, FCVTXN2

Floating-point Convert to lower precision Narrow, rounding to odd (vector). This instruction reads each vector element in the source SIMD&FP register, narrows each value to half the precision of the source element using the Round to Odd rounding mode, writes the result to a vector, and writes the vector to the destination SIMD&FP register.

This instruction uses the Round to Odd rounding mode which is not defined by the IEEE 754-2008 standard. This rounding mode ensures that if the result of the conversion is inexact the least significant bit of the mantissa is forced to 1. This rounding mode enables a floating-point value to be converted to a lower precision format via an intermediate precision format while avoiding double rounding errors. For example, a 64-bit floating-point value can be converted to a correctly rounded 16-bit floating-point value by first using this instruction to produce a 32-bit value and then using another instruction with the wanted rounding mode to convert the 32-bit value to the final 16-bit floating-point value.

The FCVTXN instruction writes the vector to the lower half of the destination register and clears the upper half, while the FCVTXN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register.

This instruction can generate a floating-point exception. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#) or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	0	0	sz	1	0	0	0	0	1	0	1	1	0	1	0	Rn				Rd						

## Scalar

```
FCVTXN <Vb><d>, <Va><n>

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz == '0' then UNDEFINED;
integer esize = 32;
integer datasize = esize;
integer elements = 1;
integer part = 0;
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	sz	1	0	0	0	0	1	0	1	1	0	1	0	Rn				Rd					

## Vector

```
FCVTXN{2} <Vd>.<Tb>, <Vn>.<Ta>

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz == '0' then UNDEFINED;
integer esize = 32;
integer datasize = 64;
integer elements = 2;
integer part = UInt(Q);
```

## Assembler Symbols

- 2
- Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Tb> Is an arrangement specifier, encoded in "sz:Q":

sz	Q	<Tb>
0	x	RESERVED
1	0	2S
1	1	4S

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<Ta> Is an arrangement specifier, encoded in "sz":

sz	<Ta>
0	RESERVED
1	2D

<Vb> Is the destination width specifier, encoded in "sz":

sz	<Vb>
0	RESERVED
1	S

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Va> Is the source width specifier, encoded in "sz":

sz	<Va>
0	RESERVED
1	D

<n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(2*datasize) operand = V[n];
bits(datasize) result;

for e = 0 to elements-1
    Elem[result, e, esize] = FPConvert(Elem[operand, e, 2*esize], FPCR, FPRounding_ODD);
Vpart[d, part] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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## FCVTZS (vector, fixed-point)

Floating-point Convert to Signed fixed-point, rounding toward Zero (vector). This instruction converts a scalar or each element in a vector from floating-point to fixed-point signed integer using the Round towards Zero rounding mode, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
0	1	0	1	1	1	1	1	0	!= 0000				immb			1	1	1	1	1	1	Rn				Rd									
U									immh																										

### Scalar

FCVTZS [<V>](#)[<d>](#), [<V>](#)[<n>](#), [#<fbits>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '000x' || (immh == '001x' && !HaveFP16Ext()) then UNDEFINED;
integer esize = if immh == 'lxxx' then 64 else if immh == '0lxx' then 32 else 16;
integer datasize = esize;
integer elements = 1;

integer fracbits = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
FPRounding rounding = FPRounding_ZERO;
```

### Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	0	!= 0000				immb			1	1	1	1	1	1	Rn			Rd						
U									immb																						

### Vector

FCVTZS [<Vd>](#)[.<T>](#), [<Vn>](#)[.<T>](#), [#<fbits>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh == '000x' || (immh == '001x' && !HaveFP16Ext()) then UNDEFINED;
if immh<3>:Q == '10' then UNDEFINED;
integer esize = if immh == 'lxxx' then 64 else if immh == '0lxx' then 32 else 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer fracbits = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
FPRounding rounding = FPRounding_ZERO;
```

## Assembler Symbols

[<V>](#) Is a width specifier, encoded in “immh”:



immh	<V>
000x	RESERVED
001x	H
01xx	S
1xxx	D

<d> Is the number of the SIMD&FP destination register, in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<T>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	x	RESERVED
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<fbits> For the scalar variant: is the number of fractional bits, in the range 1 to the operand width, encoded in "immh:immb":

immh	<fbits>
000x	RESERVED
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

For the vector variant: is the number of fractional bits, in the range 1 to the element width, encoded in "immh:immb":

immh	<fbits>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	RESERVED
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPToFixed(element, fracbits, unsigned, FPCR, rounding);
V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FCVTZS (vector, integer)

Floating-point Convert to Signed integer, rounding toward Zero (vector). This instruction converts a scalar or each element in a vector from a floating-point value to a signed integer value using the Round towards Zero rounding mode, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	1	1	1	1	1	0	0	1	1	0	1	1	1	0	Rn				Rd					
U								o2				o1																			

## Scalar half precision

```
FCVTZS <Hd>, <Hn>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

## Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	1	sz	1	0	0	0	0	1	1	0	1	1	1	0	Rn				Rd					
U								o2				o1																			

## Scalar single-precision and double-precision

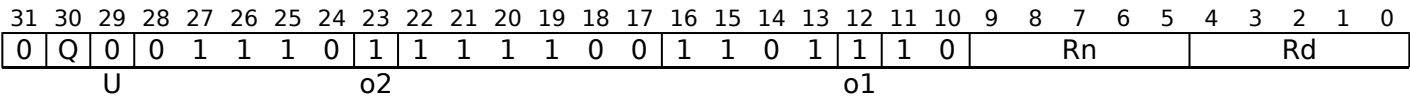
```
FCVTZS <V><d>, <V><n>

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

Vector half precision  
(Armv8.2)



Vector half precision

```
FCVTZS <Vd>.<T>, <Vn>.<T>

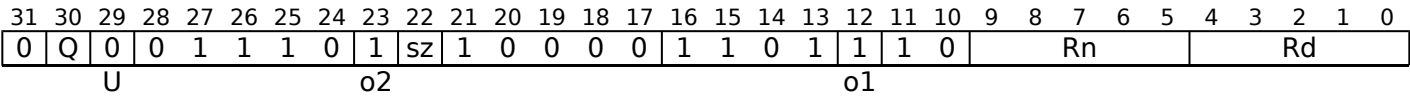
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

Vector single-precision and double-precision



Vector single-precision and double-precision

```
FCVTZS <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the vector half precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the vector single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPToFixed(element, 0, unsigned, FPCR, rounding);

V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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## FCVTZS (scalar, fixed-point)

Floating-point Convert to Signed fixed-point, rounding toward Zero (scalar). This instruction converts the floating-point value in the SIMD&FP source register to a 32-bit or 64-bit fixed-point signed integer using the Round towards Zero rounding mode, and writes the result to the general-purpose destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf		0	0	1	1	1	1	0	ftype		0	1	1	0	0	0	scale					Rn					Rd				
rmode										opcode																					

### Half-precision to 32-bit (sf == 0 && ftype == 11) (Armv8.2)

FCVTZS <Wd>, <Hn>, #<fbits>

### Half-precision to 64-bit (sf == 1 && ftype == 11) (Armv8.2)

FCVTZS <Xd>, <Hn>, #<fbits>

### Single-precision to 32-bit (sf == 0 && ftype == 00)

FCVTZS <Wd>, <Sn>, #<fbits>

### Single-precision to 64-bit (sf == 1 && ftype == 00)

FCVTZS <Xd>, <Sn>, #<fbits>

### Double-precision to 32-bit (sf == 0 && ftype == 01)

FCVTZS <Wd>, <Dn>, #<fbits>

### Double-precision to 64-bit (sf == 1 && ftype == 01)

FCVTZS <Xd>, <Dn>, #<fbits>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;

case ftype of
    when '00' fltsize = 32;
    when '01' fltsize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            fltsize = 16;
        else
            UNDEFINED;

if sf == '0' && scale<5> == '0' then UNDEFINED;
integer fracbits = 64 - UInt(scale);
```

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Hn>	Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Dn>	Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<fbits>	For the double-precision to 32-bit, half-precision to 32-bit and single-precision to 32-bit variant: is the number of bits after the binary point in the fixed-point destination, in the range 1 to 32, encoded as 64 minus "scale".  For the double-precision to 64-bit, half-precision to 64-bit and single-precision to 64-bit variant: is the number of bits after the binary point in the fixed-point destination, in the range 1 to 64, encoded as 64 minus "scale".

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
bits(fltsize) fltval;  
bits(intsize) intval;  
  
fltval = V[n];  
intval = FPToFixed(fltval, fracbits, FALSE, FPCR, FPRounding_ZERO);  
X[d] = intval;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

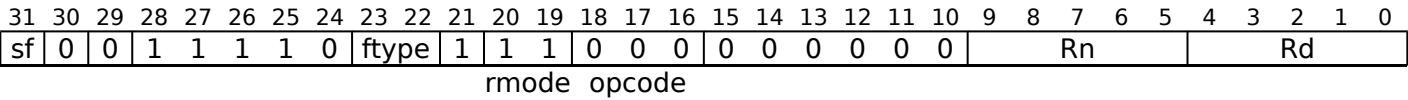
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## FCVTZS (scalar, integer)

Floating-point Convert to Signed integer, rounding toward Zero (scalar). This instruction converts the floating-point value in the SIMD&FP source register to a 32-bit or 64-bit signed integer using the Round towards Zero rounding mode, and writes the result to the general-purpose destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



**Half-precision to 32-bit (sf == 0 && ftype == 11)**  
(Armv8.2)

FCVTZS <Wd>, <Hn>

**Half-precision to 64-bit (sf == 1 && ftype == 11)**  
(Armv8.2)

FCVTZS <Xd>, <Hn>

**Single-precision to 32-bit (sf == 0 && ftype == 00)**

FCVTZS <Wd>, <Sn>

**Single-precision to 64-bit (sf == 1 && ftype == 00)**

FCVTZS <Xd>, <Sn>

**Double-precision to 32-bit (sf == 0 && ftype == 01)**

FCVTZS <Wd>, <Dn>

**Double-precision to 64-bit (sf == 1 && ftype == 01)**

FCVTZS <Xd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;
FPRounding rounding;

case ftype of
  when '00'
    fltsize = 32;
  when '01'
    fltsize = 64;
  when '10'
    UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      fltsize = 16;
    else
      UNDEFINED;

rounding = FPDecodeRounding(rmode);
```

**Assembler Symbols**

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Hn>	Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Dn>	Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.



## Operation

```
CheckFPAdvSIMDEnabled64();  
  
bits(fltsize) fltval;  
bits(intsize) intval;  
  
fltval = V[n];  
intval = FPToFixed(fltval, 0, FALSE, FPCR, rounding);  
X[d] = intval;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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## FCVTZU (vector, fixed-point)

Floating-point Convert to Unsigned fixed-point, rounding toward Zero (vector). This instruction converts a scalar or each element in a vector from floating-point to fixed-point unsigned integer using the Round towards Zero rounding mode, and writes the result to the general-purpose destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
0	1	1	1	1	1	1	1	0	!= 0000				immb			1	1	1	1	1	1	Rn				Rd									
U									immh																										

### Scalar

FCVTZU [<V><d>](#), [<V><n>](#), [#<fbits>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '000x' || (immh == '001x' && !HaveFP16Ext()) then UNDEFINED;
integer esize = if immh == 'lxxx' then 64 else if immh == '0lxx' then 32 else 16;
integer datasize = esize;
integer elements = 1;

integer fracbits = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
FPRounding rounding = FPRounding_ZERO;
```

### Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0					
0	Q	1	0	1	1	1	1	0	!= 0000				immb			1	1	1	1	1	1	Rn			Rd											
U									immb																											

### Vector

FCVTZU [<Vd>.<T>](#), [<Vn>.<T>](#), [#<fbits>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh == '000x' || (immh == '001x' && !HaveFP16Ext()) then UNDEFINED;
if immh<3>:Q == '10' then UNDEFINED;
integer esize = if immh == 'lxxx' then 64 else if immh == '0lxx' then 32 else 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer fracbits = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
FPRounding rounding = FPRounding_ZERO;
```

## Assembler Symbols

[<V>](#) Is a width specifier, encoded in “immh”:

immh	<V>
000x	RESERVED
001x	H
01xx	S
1xxx	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<T>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	x	RESERVED
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.
- <fbits> For the scalar variant: is the number of fractional bits, in the range 1 to the operand width, encoded in "immh:immb":

immh	<fbits>
000x	RESERVED
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

For the vector variant: is the number of fractional bits, in the range 1 to the element width, encoded in "immh:immb":

immh	<fbits>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	RESERVED
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPToFixed(element, fracbits, unsigned, FPCR, rounding);
V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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## FCVTZU (vector, integer)

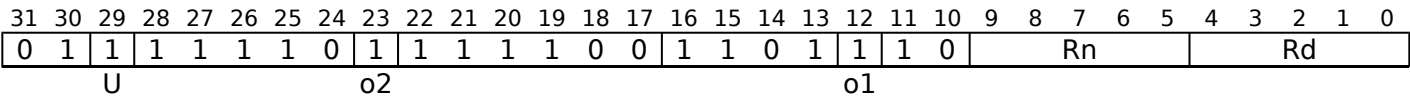
Floating-point Convert to Unsigned integer, rounding toward Zero (vector). This instruction converts a scalar or each element in a vector from a floating-point value to an unsigned integer value using the Round towards Zero rounding mode, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

### Scalar half precision (Armv8.2)



### Scalar half precision

FCVTZU <Hd>, <Hn>

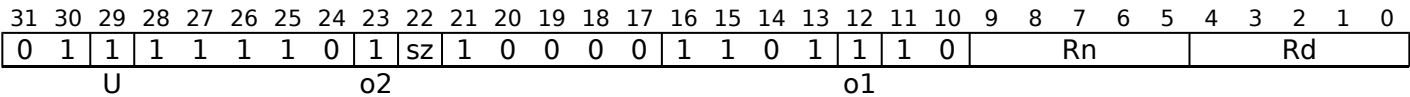
```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

### Scalar single-precision and double-precision



### Scalar single-precision and double-precision

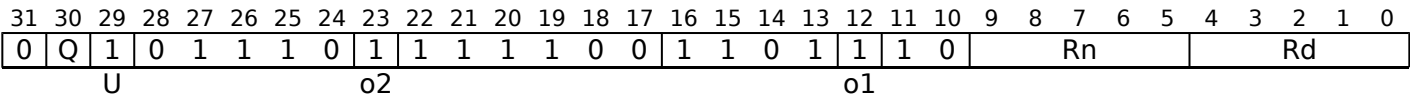
FCVTZU <V><d>, <V><n>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

Vector half precision  
(Armv8.2)



Vector half precision

```
FCVTZU <Vd>.<T>, <Vn>.<T>

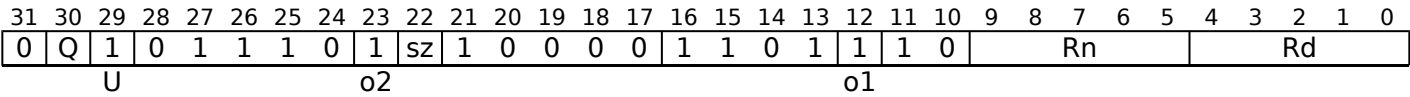
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

Vector single-precision and double-precision



Vector single-precision and double-precision

```
FCVTZU <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

FPRounding rounding = FPDecodeRounding(o1:o2);
boolean unsigned = (U == '1');
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the vector half precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the vector single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPToFixed(element, 0, unsigned, FPCR, rounding);
V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

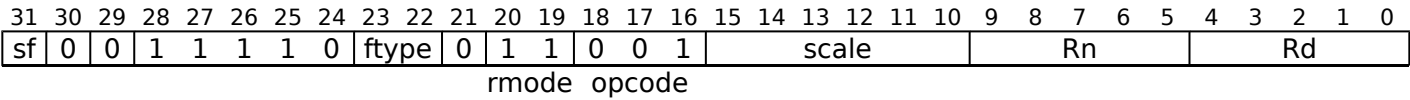
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## FCVTZU (scalar, fixed-point)

Floating-point Convert to Unsigned fixed-point, rounding toward Zero (scalar). This instruction converts the floating-point value in the SIMD&FP source register to a 32-bit or 64-bit fixed-point unsigned integer using the Round towards Zero rounding mode, and writes the result to the general-purpose destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.



### Half-precision to 32-bit (sf == 0 && ftype == 11) (Armv8.2)

FCVTZU <Wd>, <Hn>, #<fbits>

### Half-precision to 64-bit (sf == 1 && ftype == 11) (Armv8.2)

FCVTZU <Xd>, <Hn>, #<fbits>

### Single-precision to 32-bit (sf == 0 && ftype == 00)

FCVTZU <Wd>, <Sn>, #<fbits>

### Single-precision to 64-bit (sf == 1 && ftype == 00)

FCVTZU <Xd>, <Sn>, #<fbits>

### Double-precision to 32-bit (sf == 0 && ftype == 01)

FCVTZU <Wd>, <Dn>, #<fbits>

### Double-precision to 64-bit (sf == 1 && ftype == 01)

FCVTZU <Xd>, <Dn>, #<fbits>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;

case ftype of
  when '00' fltsize = 32;
  when '01' fltsize = 64;
  when '10' UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      fltsize = 16;
    else
      UNDEFINED;

if sf == '0' && scale<5> == '0' then UNDEFINED;
integer fracbits = 64 - UInt(scale);
```

## Assembler Symbols

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Hn>	Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Dn>	Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<fbits>	For the double-precision to 32-bit, half-precision to 32-bit and single-precision to 32-bit variant: is the number of bits after the binary point in the fixed-point destination, in the range 1 to 32, encoded as 64 minus "scale".  For the double-precision to 64-bit, half-precision to 64-bit and single-precision to 64-bit variant: is the number of bits after the binary point in the fixed-point destination, in the range 1 to 64, encoded as 64 minus "scale".

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
bits(fltsize) fltval;  
bits(intsize) intval;  
  
fltval = V[n];  
intval = FPToFixed(fltval, fracbits, TRUE, FPCR, FPRounding_ZERO);  
X[d] = intval;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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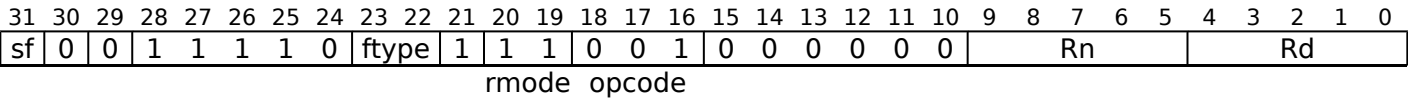


## FCVTZU (scalar, integer)

Floating-point Convert to Unsigned integer, rounding toward Zero (scalar). This instruction converts the floating-point value in the SIMD&FP source register to a 32-bit or 64-bit unsigned integer using the Round towards Zero rounding mode, and writes the result to the general-purpose destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



**Half-precision to 32-bit (sf == 0 && ftype == 11)**  
(Armv8.2)

FCVTZU <Wd>, <Hn>

**Half-precision to 64-bit (sf == 1 && ftype == 11)**  
(Armv8.2)

FCVTZU <Xd>, <Hn>

**Single-precision to 32-bit (sf == 0 && ftype == 00)**

FCVTZU <Wd>, <Sn>

**Single-precision to 64-bit (sf == 1 && ftype == 00)**

FCVTZU <Xd>, <Sn>

**Double-precision to 32-bit (sf == 0 && ftype == 01)**

FCVTZU <Wd>, <Dn>

**Double-precision to 64-bit (sf == 1 && ftype == 01)**

FCVTZU <Xd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;
FPRounding rounding;

case ftype of
  when '00'
    fltsize = 32;
  when '01'
    fltsize = 64;
  when '10'
    UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      fltsize = 16;
    else
      UNDEFINED;

rounding = FPDecodeRounding(rmode);
```

**Assembler Symbols**

<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Hn>	Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Dn>	Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
bits(fltsize) fltval;  
bits(intsize) intval;  
  
fltval = V[n];  
intval = FPToFixed(fltval, 0, TRUE, FPCR, rounding);  
X[d] = intval;
```

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# FDIV (vector)

Floating-point Divide (vector). This instruction divides the floating-point values in the elements in the first source SIMD&FP register, by the floating-point values in the corresponding elements in the second source SIMD&FP register, places the results in a vector, and writes the vector to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	1	0	Rm				0	0	1	1	1	1	Rn				Rd						

### Half-precision

```
FDIV <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

## Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	sz	1	Rm				1	1	1	1	1	1	Rn				Rd						

### Single-precision and double-precision

```
FDIV <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

## Assembler Symbols

- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T>

For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H
- For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = FPDIV(element1, element2, FPCR);

V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FDIV (scalar)

Floating-point Divide (scalar). This instruction divides the floating-point value of the first source SIMD&FP register by the floating-point value of the second source SIMD&FP register, and writes the result to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1	1	1	1	0	ftype		1	Rm				0	0	0	1	1	0	Rn				Rd						

## Half-precision (ftype == 11) (Armv8.2)

FDIV <Hd>, <Hn>, <Hm>

## Single-precision (ftype == 00)

FDIV <Sd>, <Sn>, <Sm>

## Double-precision (ftype == 01)

FDIV <Dd>, <Dn>, <Dm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer datasize;
case ftype of
  when '00' datasize = 32;
  when '01' datasize = 64;
  when '10' UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      datasize = 16;
    else
      UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Dm> Is the 64-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Sm> Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
bits(datasize) result;  
bits(datasize) operand1 = V[n];  
bits(datasize) operand2 = V[m];  
  
result = FPDiv(operand1, operand2, FPCR);  
V[d] = result;
```

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# FJCVTZS

Floating-point Javascript Convert to Signed fixed-point, rounding toward Zero. This instruction converts the double-precision floating-point value in the SIMD&FP source register to a 32-bit signed integer using the Round towards Zero rounding mode, and writes the result to the general-purpose destination register. If the result is too large to be accommodated as a signed 32-bit integer, then the result is the integer modulo  $2^{32}$ , as held in a 32-bit signed integer. This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

## Double-precision to 32-bit (Armv8.3)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1	1	1	1	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	Rn				Rd					
sf			ftype				rmode				opcode																				

## Double-precision to 32-bit

```
FJCVTZS <Wd>, <Dn>

integer d = UInt(Rd);
integer n = UInt(Rn);

if !HaveFJCVTZSExt() then UNDEFINED;
```

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(64) fltval;
bits(32) intval;

bit Z;
fltval = V[n];
(intval, Z) = FPToFixedJS(fltval, FPCR, TRUE);
PSTATE.<N,Z,C,V> = '0':Z:'00';
X[d] = intval;
```

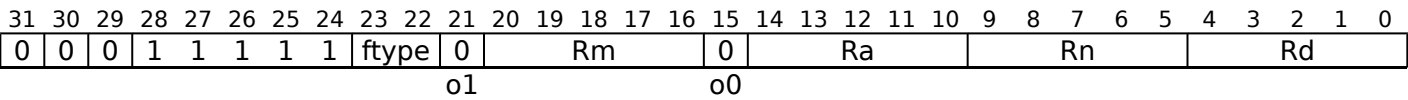


# FMADD

Floating-point fused Multiply-Add (scalar). This instruction multiplies the values of the first two SIMD&FP source registers, adds the product to the value of the third SIMD&FP source register, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (Armv8.2)

FMADD <Hd>, <Hn>, <Hm>, <Ha>

## Single-precision (ftype == 00)

FMADD <Sd>, <Sn>, <Sm>, <Sa>

## Double-precision (ftype == 01)

FMADD <Dd>, <Dn>, <Dm>, <Da>

```
integer d = UInt(Rd);
integer a = UInt(Ra);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer datasize;
case ftype of
  when '00' datasize = 32;
  when '01' datasize = 64;
  when '10' UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      datasize = 16;
    else
      UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the first SIMD&FP source register holding the multiplicand, encoded in the "Rn" field.
- <Dm> Is the 64-bit name of the second SIMD&FP source register holding the multiplier, encoded in the "Rm" field.
- <Da> Is the 64-bit name of the third SIMD&FP source register holding the addend, encoded in the "Ra" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register holding the multiplicand, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register holding the multiplier, encoded in the "Rm" field.
- <Ha> Is the 16-bit name of the third SIMD&FP source register holding the addend, encoded in the "Ra" field.

<Sd>	Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the first SIMD&FP source register holding the multiplicand, encoded in the "Rn" field.
<Sm>	Is the 32-bit name of the second SIMD&FP source register holding the multiplier, encoded in the "Rm" field.
<Sa>	Is the 32-bit name of the third SIMD&FP source register holding the addend, encoded in the "Ra" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) result;
bits(datasize) operanda = V[a];
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];

result = FPMulAdd(operanda, operand1, operand2, FPCR);
V[d] = result;

```

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## FMAX (vector)

Floating-point Maximum (vector). This instruction compares corresponding vector elements in the two source SIMD&FP registers, places the larger of each of the two floating-point values into a vector, and writes the vector to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

### Half-precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	1	0	Rm				0	0	1	1	0	1	Rn				Rd						
U				o1																											

### Half-precision

FMAX [<Vd>.<T>](#), [<Vn>.<T>](#), [<Vm>.<T>](#)

```
if !HaveFP16Ext\(\) then UNDEFINED;
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
boolean minimum = (o1 == '1');
```

### Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	sz	1	Rm				1	1	1	1	0	1	Rn				Rd						
U				o1																											

### Single-precision and double-precision

FMAX [<Vd>.<T>](#), [<Vn>.<T>](#), [<Vm>.<T>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
boolean minimum = (o1 == '1');
```

## Assembler Symbols

- [<Vd>](#) Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- [<T>](#) For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(2*datasize) concat = operand2:operand1;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    if pair then
        element1 = Elem[concat, 2*e, esize];
        element2 = Elem[concat, (2*e)+1, esize];
    else
        element1 = Elem[operand1, e, esize];
        element2 = Elem[operand2, e, esize];

    if minimum then
        Elem[result, e, esize] = FPMin(element1, element2, FPCR);
    else
        Elem[result, e, esize] = FPMax(element1, element2, FPCR);

V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

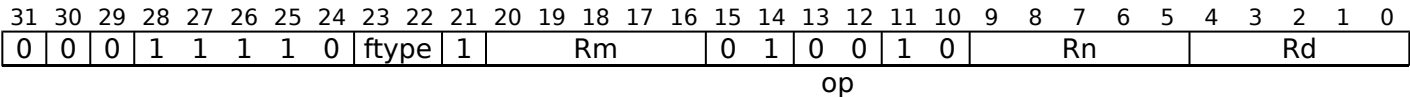
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# FMAX (scalar)

Floating-point Maximum (scalar). This instruction compares the two source SIMD&FP registers, and writes the larger of the two floating-point values to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (Armv8.2)

FMAX <Hd>, <Hn>, <Hm>

## Single-precision (ftype == 00)

FMAX <Sd>, <Sn>, <Sm>

## Double-precision (ftype == 01)

FMAX <Dd>, <Dn>, <Dm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer datasize;
case ftype of
    when '00' datasize = 32;
    when '01' datasize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            datasize = 16;
        else
            UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Dm> Is the 64-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Sm> Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
bits(datasize) result;  
bits(datasize) operand1 = V[n];  
bits(datasize) operand2 = V[m];  
  
result = FPMax(operand1, operand2, FPCR);  
V[d] = result;
```

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# FMAXNM (vector)

Floating-point Maximum Number (vector). This instruction compares corresponding vector elements in the two source SIMD&FP registers, writes the larger of the two floating-point values into a vector, and writes the vector to the destination SIMD&FP register.

NaNs are handled according to the IEEE 754-2008 standard. If one vector element is numeric and the other is a quiet NaN, the result placed in the vector is the numerical value, otherwise the result is identical to *FMAX (scalar)*.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	1	0	Rm				0	0	0	0	0	1	Rn				Rd						
U								a																							

## Half-precision

```

FMAXNM <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
boolean minimum = (a == '1');
```

## Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
0	Q	0	0	1	1	1	0	0	sz	1	Rm					1	1	0	0	0	1	Rn					Rd								
U								o1																											

## Single-precision and double-precision

```

FMAXNM <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
boolean minimum = (o1 == '1');
```

## Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in “Q”:

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in “sz:Q”:

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(2*datasize) concat = operand2:operand1;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    if pair then
        element1 = Elem[concat, 2*e, esize];
        element2 = Elem[concat, (2*e)+1, esize];
    else
        element1 = Elem[operand1, e, esize];
        element2 = Elem[operand2, e, esize];

    if minimum then
        Elem[result, e, esize] = FPMinNum(element1, element2, FPCR);
    else
        Elem[result, e, esize] = FPMaxNum(element1, element2, FPCR);

V[d] = result;

```

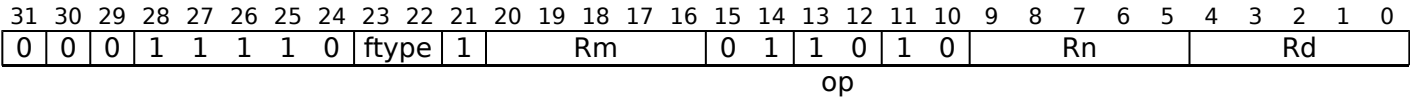
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# FMAXNM (scalar)

Floating-point Maximum Number (scalar). This instruction compares the first and second source SIMD&FP register values, and writes the larger of the two floating-point values to the destination SIMD&FP register. NaNs are handled according to the IEEE 754-2008 standard. If one vector element is numeric and the other is a quiet NaN, the result that is placed in the vector is the numerical value, otherwise the result is identical to *FMAX (scalar)*. This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*. Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Half-precision (ftype == 11)  
(Armv8.2)

FMAXNM <Hd>, <Hn>, <Hm>

Single-precision (ftype == 00)

FMAXNM <Sd>, <Sn>, <Sm>

Double-precision (ftype == 01)

FMAXNM <Dd>, <Dn>, <Dm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer datasize;
case ftype of
    when '00' datasize = 32;
    when '01' datasize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            datasize = 16;
        else
            UNDEFINED;
```

## Assembler Symbols

<Dd>	Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Dn>	Is the 64-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
<Dm>	Is the 64-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
<Hd>	Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Hn>	Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
<Hm>	Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
<Sd>	Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
<Sm>	Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
bits(datasize) result;  
bits(datasize) operand1 = V[n];  
bits(datasize) operand2 = V[m];  
  
result = FPMaXNum(operand1, operand2, FPCR);  
V[d] = result;
```

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# FMAXNMP (scalar)

Floating-point Maximum Number of Pair of elements (scalar). This instruction compares two vector elements in the source SIMD&FP register and writes the largest of the floating-point values as a scalar to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	0	1	1	0	0	0	0	1	1	0	0	1	0	Rn				Rd					
o1 sz																															

## Half-precision

```
FMAXNMP <V><d>, <Vn>.<T>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = 32;
```

## Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	0	sz	1	1	0	0	0	0	1	1	0	0	1	0	Rn				Rd					
o1																															

## Single-precision and double-precision

```
FMAXNMP <V><d>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32;
integer datasize = 64;
```

## Assembler Symbols

- <V>

For the half-precision variant: is the destination width specifier, encoded in "sz":

sz	<V>
0	H
1	RESERVED
- For the single-precision and double-precision variant: is the destination width specifier, encoded in "sz":

sz	<V>
0	S
1	D
- <d>

Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<T> For the half-precision variant: is the source arrangement specifier, encoded in "sz":

sz	<T>
0	2H
1	RESERVED

For the single-precision and double-precision variant: is the source arrangement specifier, encoded in "SZ":

sz	<T>
0	2S
1	2D

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
V[d] = Reduce(ReduceOp_FMAXNUM, operand, esize);
```

## FMAXNMP (vector)

Floating-point Maximum Number Pairwise (vector). This instruction creates a vector by concatenating the vector elements of the first source SIMD&FP register after the vector elements of the second source SIMD&FP register, reads each pair of adjacent vector elements in the two source SIMD&FP registers, writes the largest of each pair of values into a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are floating-point values.

NaNs are handled according to the IEEE 754-2008 standard. If one vector element is numeric and the other is a quiet NaN, the result is the numerical value, otherwise the result is identical to *FMAX (scalar)*.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

### Half-precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	1	0	Rm				0	0	0	0	0	1	Rn				Rd						
U								a																							

### Half-precision

FMAXNMP <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

```
boolean pair = (U == '1');
boolean minimum = (a == '1');
```

### Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	sz	1	Rm				1	1	0	0	0	1	Rn				Rd						
U								o1																							

### Single-precision and double-precision

FMAXNMP <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

```
boolean pair = (U == '1');
boolean minimum = (o1 == '1');
```

## Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(2*datasize) concat = operand2:operand1;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    if pair then
        element1 = Elem[concat, 2*e, esize];
        element2 = Elem[concat, (2*e)+1, esize];
    else
        element1 = Elem[operand1, e, esize];
        element2 = Elem[operand2, e, esize];

    if minimum then
        Elem[result, e, esize] = FPMinNum(element1, element2, FPCR);
    else
        Elem[result, e, esize] = FPMaxNum(element1, element2, FPCR);

V[d] = result;

```

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FMAXNMV

Floating-point Maximum Number across Vector. This instruction compares all the vector elements in the source SIMD&FP register, and writes the largest of the values as a scalar to the destination SIMD&FP register. All the values in this instruction are floating-point values.

NaNs are handled according to the IEEE 754-2008 standard. If one vector element is numeric and the other is a quiet NaN, the result of the comparison is the numerical value, otherwise the result is identical to *FMAX (scalar)*.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

Half-precision  
(Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	0	1	1	0	0	0	0	1	1	0	0	1	0	Rn				Rd					
o1																															

Half-precision

```
FMAXNMV <V><d>, <Vn>.<T>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
```

Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	sz	1	1	0	0	0	0	1	1	0	0	1	0	Rn				Rd					
o1																															

Single-precision and double-precision

```
FMAXNMV <V><d>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q != '01' then UNDEFINED;    // .4S only

integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
```

Assembler Symbols

- <V>

For the half-precision variant: is the destination width specifier, H.  
For the single-precision and double-precision variant: is the destination width specifier, encoded in “sz”:

sz	<V>
0	S
1	RESERVED
- <d>

Is the number of the SIMD&FP destination register, encoded in the “Rd” field.

<Vn>	Is the name of the SIMD&FP source register, encoded in the "Rn" field.	
<T>	For the half-precision variant: is an arrangement specifier, encoded in "Q":	
Q	<T>	
0	4H	
1	8H	

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "Q:sz":

Q	sz	<T>
0	x	RESERVED
1	0	4S
1	1	RESERVED

### Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
V[d] = Reduce(ReduceOp_FMAXNUM, operand, esize);

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FMAXP (scalar)

Floating-point Maximum of Pair of elements (scalar). This instruction compares two vector elements in the source SIMD&FP register and writes the largest of the floating-point values as a scalar to the destination SIMD&FP register. This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	0	1	1	0	0	0	0	1	1	1	1	1	0	Rn				Rd					
ol sz																															

## Half-precision

```
FMAXP <V><d>, <Vn>.<T>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = 32;
```

## Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	0	sz	1	1	0	0	0	0	1	1	1	1	1	0	Rn				Rd					
ol																															

## Single-precision and double-precision

```
FMAXP <V><d>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32;
integer datasize = 64;
```

## Assembler Symbols

- <V>

For the half-precision variant: is the destination width specifier, encoded in "sz":

sz		<V>
0		H
1		RESERVED
- For the single-precision and double-precision variant: is the destination width specifier, encoded in "sz":

sz		<V>
0		S
1		D
- <d>

Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <Vn>

Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<T> For the half-precision variant: is the source arrangement specifier, encoded in “sz”:

sz	<T>
0	2H
1	RESERVED

For the single-precision and double-precision variant: is the source arrangement specifier, encoded in “SZ”:

sz	<T>
0	2S
1	2D

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
V[d] = Reduce(ReduceOp_FMAX, operand, esize);
```

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# FMAXP (vector)

Floating-point Maximum Pairwise (vector). This instruction creates a vector by concatenating the vector elements of the first source SIMD&FP register after the vector elements of the second source SIMD&FP register, reads each pair of adjacent vector elements from the concatenated vector, writes the larger of each pair of values into a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are floating-point values. This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*. Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	1	0	Rm				0	0	1	1	0	1	Rn				Rd						
U								o1																							

## Half-precision

```
FMAXP <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
boolean minimum = (o1 == '1');
```

## Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	sz	1	Rm				1	1	1	1	0	1	Rn				Rd						
U								o1																							

## Single-precision and double-precision

```
FMAXP <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
boolean minimum = (o1 == '1');
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(2*datasize) concat = operand2:operand1;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    if pair then
        element1 = Elem[concat, 2*e, esize];
        element2 = Elem[concat, (2*e)+1, esize];
    else
        element1 = Elem[operand1, e, esize];
        element2 = Elem[operand2, e, esize];

    if minimum then
        Elem[result, e, esize] = FPMin(element1, element2, FPCR);
    else
        Elem[result, e, esize] = FPMax(element1, element2, FPCR);

V[d] = result;

```

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**FMAXV**

Floating-point Maximum across Vector. This instruction compares all the vector elements in the source SIMD&FP register, and writes the largest of the values as a scalar to the destination SIMD&FP register. All the values in this instruction are floating-point values.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

**Half-precision**  
**(Armv8.2)**

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	0	1	1	0	0	0	0	1	1	1	1	1	0	Rn				Rd					
o1																															

**Half-precision**

```

FMAXV <V><d>, <Vn>.<T>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
    
```

**Single-precision and double-precision**

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	sz	1	1	0	0	0	0	1	1	1	1	1	0	Rn				Rd					
o1																															

**Single-precision and double-precision**

```

FMAXV <V><d>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q != '01' then UNDEFINED;

integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
    
```

**Assembler Symbols**

- <V>

For the half-precision variant: is the destination width specifier, H.  
 For the single-precision and double-precision variant: is the destination width specifier, encoded in “sz”:
 

sz	<V>
0	S
1	RESERVED
- <d>

Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <Vn>

Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in “Q”:

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in “Q:sz”:

Q	sz	<T>
0	x	RESERVED
1	0	4S
1	1	RESERVED

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
V[d] = Reduce(ReduceOp_FMAX, operand, esize);
```

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# FMIN (vector)

Floating-point minimum (vector). This instruction compares corresponding elements in the vectors in the two source SIMD&FP registers, places the smaller of each of the two floating-point values into a vector, and writes the vector to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR EL1*, *CPTR EL2*, and *CPTR EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	1	0	Rm				0	0	1	1	0	1	Rn				Rd						
U								o1																							

## Half-precision

```
FMIN <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
boolean minimum = (o1 == '1');
```

## Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	sz	1	Rm				1	1	1	1	0	1	Rn				Rd						
U								o1																							

## Single-precision and double-precision

```
FMIN <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
boolean minimum = (o1 == '1');
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(2*datasize) concat = operand2:operand1;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    if pair then
        element1 = Elem[concat, 2*e, esize];
        element2 = Elem[concat, (2*e)+1, esize];
    else
        element1 = Elem[operand1, e, esize];
        element2 = Elem[operand2, e, esize];

    if minimum then
        Elem[result, e, esize] = FPMin(element1, element2, FPCR);
    else
        Elem[result, e, esize] = FPMax(element1, element2, FPCR);

V[d] = result;

```

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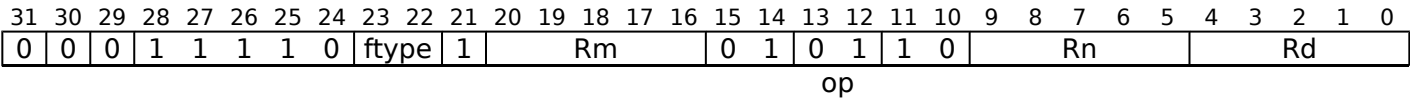


# FMIN (scalar)

Floating-point Minimum (scalar). This instruction compares the first and second source SIMD&FP register values, and writes the smaller of the two floating-point values to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (Armv8.2)

FMIN <Hd>, <Hn>, <Hm>

## Single-precision (ftype == 00)

FMIN <Sd>, <Sn>, <Sm>

## Double-precision (ftype == 01)

FMIN <Dd>, <Dn>, <Dm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer datasize;
case ftype of
    when '00' datasize = 32;
    when '01' datasize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            datasize = 16;
        else
            UNDEFINED;
```

## Assembler Symbols

- <Dd>

Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn>

Is the 64-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Dm>

Is the 64-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Hd>

Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn>

Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm>

Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Sd>

Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn>

Is the 32-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Sm>

Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
bits(datasize) result;  
bits(datasize) operand1 = V[n];  
bits(datasize) operand2 = V[m];  
  
result = FPMIn(operand1, operand2, FPCR);  
V[d] = result;
```

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# FMINNM (vector)

Floating-point Minimum Number (vector). This instruction compares corresponding vector elements in the two source SIMD&FP registers, writes the smaller of the two floating-point values into a vector, and writes the vector to the destination SIMD&FP register.

NaNs are handled according to the IEEE 754-2008 standard. If one vector element is numeric and the other is a quiet NaN, the result placed in the vector is the numerical value, otherwise the result is identical to *FMIN (scalar)*.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	1	0	Rm				0	0	0	0	0	1	Rn				Rd						
U								a																							

## Half-precision

```
FMINNM <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
boolean minimum = (a == '1');
```

## Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
0	Q	0	0	1	1	1	0	1	sz	1	Rm					1	1	0	0	0	1	Rn					Rd								
U								o1																											

## Single-precision and double-precision

```
FMINNM <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
boolean minimum = (o1 == '1');
```

## Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in “Q”:

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in “sz:Q”:

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(2*datasize) concat = operand2:operand1;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    if pair then
        element1 = Elem[concat, 2*e, esize];
        element2 = Elem[concat, (2*e)+1, esize];
    else
        element1 = Elem[operand1, e, esize];
        element2 = Elem[operand2, e, esize];

    if minimum then
        Elem[result, e, esize] = FPMinNum(element1, element2, FPCR);
    else
        Elem[result, e, esize] = FPMaxNum(element1, element2, FPCR);

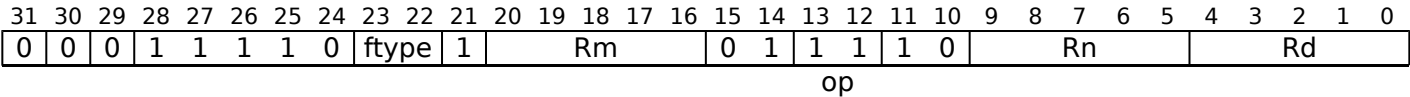
V[d] = result;
```

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# FMINNM (scalar)

Floating-point Minimum Number (scalar). This instruction compares the first and second source SIMD&FP register values, and writes the smaller of the two floating-point values to the destination SIMD&FP register. NaNs are handled according to the IEEE 754-2008 standard. If one vector element is numeric and the other is a quiet NaN, the result that is placed in the vector is the numerical value, otherwise the result is identical to *FMIN (scalar)*. This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*. Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Half-precision (ftype == 11)  
(Armv8.2)

```
FMINNM <Hd>, <Hn>, <Hm>
```

Single-precision (ftype == 00)

```
FMINNM <Sd>, <Sn>, <Sm>
```

Double-precision (ftype == 01)

```
FMINNM <Dd>, <Dn>, <Dm>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer datasize;
case ftype of
    when '00' datasize = 32;
    when '01' datasize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            datasize = 16;
        else
            UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Dm> Is the 64-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Sm> Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
bits(datasize) result;  
bits(datasize) operand1 = V[n];  
bits(datasize) operand2 = V[m];  
  
result = FPMinNum(operand1, operand2, FPCR);  
  
V[d] = result;
```

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# FMINNMP (scalar)

Floating-point Minimum Number of Pair of elements (scalar). This instruction compares two vector elements in the source SIMD&FP register and writes the smallest of the floating-point values as a scalar to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR EL1*, *CPTR EL2*, and *CPTR EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	1	0	1	1	1	1	0	1	0	1	1	0	0	0	0	1	1	0	0	1	0	Rn						Rd					
o1 sz																																	

## Half-precision

```
FMINNMP <V><d>, <Vn>.<T>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = 32;
```

## Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	1	sz	1	1	0	0	0	0	1	1	0	0	1	0	Rn				Rd					
o1																															

## Single-precision and double-precision

```
FMINNMP <V><d>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32;
integer datasize = 64;
```

## Assembler Symbols

- <V>

For the half-precision variant: is the destination width specifier, encoded in "sz":

sz	<V>
0	H
1	RESERVED
- For the single-precision and double-precision variant: is the destination width specifier, encoded in "sz":

sz	<V>
0	S
1	D
- <d>

Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Vn>	Is the name of the SIMD&FP source register, encoded in the "Rn" field.	
<T>	For the half-precision variant: is the source arrangement specifier, encoded in "sz":	
	<b>sz</b>	<b>&lt;T&gt;</b>
	0	2H
	1	RESERVED
	For the single-precision and double-precision variant: is the source arrangement specifier, encoded in "SZ":	
	<b>sz</b>	<b>&lt;T&gt;</b>
	0	2S
	1	2D

Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
V[d] = Reduce(ReduceOp_FMINNUM, operand, esize);

```



# FMINNMP (vector)

Floating-point Minimum Number Pairwise (vector). This instruction creates a vector by concatenating the vector elements of the first source SIMD&FP register after the vector elements of the second source SIMD&FP register, reads each pair of adjacent vector elements in the two source SIMD&FP registers, writes the smallest of each pair of floating-point values into a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are floating-point values.

NaNs are handled according to the IEEE 754-2008 standard. If one vector element is numeric and the other is a quiet NaN, the result is the numerical value, otherwise the result is identical to *FMIN (scalar)*.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	1	0	Rm				0	0	0	0	0	1	Rn				Rd						
U								a																							

## Half-precision

```
FMINNMP <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
boolean minimum = (a == '1');
```

## Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
0	Q	1	0	1	1	1	0	1	sz	1	Rm					1	1	0	0	0	1	Rn					Rd								
U								o1																											

## Single-precision and double-precision

```
FMINNMP <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
boolean minimum = (o1 == '1');
```

## Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(2*datasize) concat = operand2:operand1;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    if pair then
        element1 = Elem[concat, 2*e, esize];
        element2 = Elem[concat, (2*e)+1, esize];
    else
        element1 = Elem[operand1, e, esize];
        element2 = Elem[operand2, e, esize];

    if minimum then
        Elem[result, e, esize] = FPMinNum(element1, element2, FPCR);
    else
        Elem[result, e, esize] = FPMaxNum(element1, element2, FPCR);

V[d] = result;
```

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FMINNMV

Floating-point Minimum Number across Vector. This instruction compares all the vector elements in the source SIMD&FP register, and writes the smallest of the values as a scalar to the destination SIMD&FP register. All the values in this instruction are floating-point values.

NaNs are handled according to the IEEE 754-2008 standard. If one vector element is numeric and the other is a quiet NaN, the result of the comparison is the numerical value, otherwise the result is identical to *FMIN (scalar)*.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

Half-precision  
(Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	0	1	1	0	0	0	0	1	1	0	0	1	0	Rn				Rd					
o1																															

Half-precision

```
FMINNMV <V><d>, <Vn>.<T>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
```

Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	sz	1	1	0	0	0	0	1	1	0	0	1	0	Rn				Rd					
o1																															

Single-precision and double-precision

```
FMINNMV <V><d>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q != '01' then UNDEFINED;    // .4S only

integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
```

Assembler Symbols

- <V>

For the half-precision variant: is the destination width specifier, H.  
For the single-precision and double-precision variant: is the destination width specifier, encoded in “sz”:

sz	<V>
0	S
1	RESERVED
- <d>

Is the number of the SIMD&FP destination register, encoded in the “Rd” field.

<Vn>	Is the name of the SIMD&FP source register, encoded in the "Rn" field.	
<T>	For the half-precision variant: is an arrangement specifier, encoded in "Q":	
Q	<T>	
0	4H	
1	8H	

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "Q:sz":

Q	sz	<T>
0	x	RESERVED
1	0	4S
1	1	RESERVED

### Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
V[d] = Reduce(ReduceOp_FMINNUM, operand, esize);

```

# FMINP (scalar)

Floating-point Minimum of Pair of elements (scalar). This instruction compares two vector elements in the source SIMD&FP register and writes the smallest of the floating-point values as a scalar to the destination SIMD&FP register. This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	1	0	1	1	0	0	0	0	1	1	1	1	1	1	0	Rn				Rd				
ol sz																															

## Half-precision

```
FMINP <V><d>, <Vn>.<T>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = 32;
```

## Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	1	sz	1	1	0	0	0	0	1	1	1	1	1	0	Rn					Rd				
ol																															

## Single-precision and double-precision

```
FMINP <V><d>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32;
integer datasize = 64;
```

## Assembler Symbols

- <V>

For the half-precision variant: is the destination width specifier, encoded in "sz":

sz		<V>
0		H
1		RESERVED
- For the single-precision and double-precision variant: is the destination width specifier, encoded in "sz":

sz		<V>
0		S
1		D
- <d>

Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <Vn>

Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<T> For the half-precision variant: is the source arrangement specifier, encoded in “sz”:

sz	<T>
0	2H
1	RESERVED

For the single-precision and double-precision variant: is the source arrangement specifier, encoded in “SZ”:

sz	<T>
0	2S
1	2D

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
V[d] = Reduce(ReduceOp_FMIN, operand, esize);
```

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# FMINP (vector)

Floating-point Minimum Pairwise (vector). This instruction creates a vector by concatenating the vector elements of the first source SIMD&FP register after the vector elements of the second source SIMD&FP register, reads each pair of adjacent vector elements from the concatenated vector, writes the smaller of each pair of values into a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are floating-point values. This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*. Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	1	0	Rm				0	0	1	1	0	1	Rn				Rd						
U								o1																							

## Half-precision

```
FMINP <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
boolean minimum = (o1 == '1');
```

## Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	sz	1	Rm				1	1	1	1	0	1	Rn				Rd						
U								o1																							

## Single-precision and double-precision

```
FMINP <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean pair = (U == '1');
boolean minimum = (o1 == '1');
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(2*datasize) concat = operand2:operand1;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    if pair then
        element1 = Elem[concat, 2*e, esize];
        element2 = Elem[concat, (2*e)+1, esize];
    else
        element1 = Elem[operand1, e, esize];
        element2 = Elem[operand2, e, esize];

    if minimum then
        Elem[result, e, esize] = FPMin(element1, element2, FPCR);
    else
        Elem[result, e, esize] = FPMax(element1, element2, FPCR);

V[d] = result;

```

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FMINV

Floating-point Minimum across Vector. This instruction compares all the vector elements in the source SIMD&FP register, and writes the smallest of the values as a scalar to the destination SIMD&FP register. All the values in this instruction are floating-point values.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

Half-precision  
(Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	0	1	1	0	0	0	0	1	1	1	1	1	0	Rn				Rd					
o1																															

Half-precision

```
FMINV <V><d>, <Vn>.<T>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
```

Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	sz	1	1	0	0	0	0	1	1	1	1	1	0	Rn				Rd					
o1																															

Single-precision and double-precision

```
FMINV <V><d>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q != '01' then UNDEFINED;

integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
```

Assembler Symbols

- <V>

For the half-precision variant: is the destination width specifier, H.  
For the single-precision and double-precision variant: is the destination width specifier, encoded in “sz”:
- | sz | <V>      |
|----|----------|
| 0  | S        |
| 1  | RESERVED |
- <d>

Is the number of the SIMD&FP destination register, encoded in the “Rd” field.
- <Vn>

Is the name of the SIMD&FP source register, encoded in the “Rn” field.

<T> For the half-precision variant: is an arrangement specifier, encoded in “Q”:

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in “Q:sz”:

Q	sz	<T>
0	x	RESERVED
1	0	4S
1	1	RESERVED

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
V[d] = Reduce(ReduceOp_FMIN, operand, esize);
```

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## FMLA (by element)

Floating-point fused Multiply-Add to accumulator (by element). This instruction multiplies the vector elements in the first source SIMD&FP register by the specified value in the second source SIMD&FP register, and accumulates the results in the vector elements of the destination SIMD&FP register. All the values in this instruction are floating-point values.

This instruction can generate a floating-point exception. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#) or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar, half-precision](#) , [Scalar, single-precision and double-precision](#) , [Vector, half-precision](#) and [Vector, single-precision and double-precision](#)

### Scalar, half-precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	0	0	L	M	Rm				0	0	0	1	H	0	Rn				Rd					
																	o2														

### Scalar, half-precision

```
FMLA <Hd>, <Hn>, <Vm>.H[<index>]

if !HaveFP16Ext() then UNDEFINED;

integer idxdsize = if H == '1' then 128 else 64;
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Rd);
integer index = UInt(H:L:M);

integer esize = 16;
integer datasize = esize;
integer elements = 1;
boolean sub_op = (o2 == '1');
```

### Scalar, single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	1	sz	L	M	Rm			0	0	0	1	H	0	Rn				Rd						
o2																															

Scalar, single-precision and double-precision

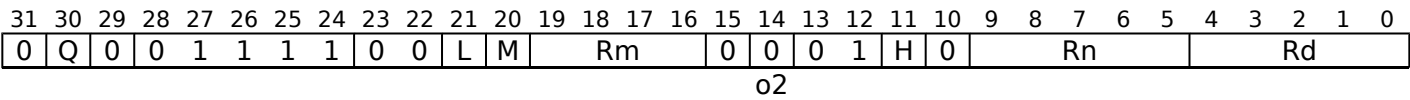
```
FMLA <V><d>, <V><n>, <Vm>.<Ts>[<index>]

integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi = M;
case sz:L of
  when '0x' index = UInt(H:L);
  when '10' index = UInt(H);
  when '11' UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
boolean sub_op = (o2 == '1');
```

Vector, half-precision
(Armv8.2)



Vector, half-precision

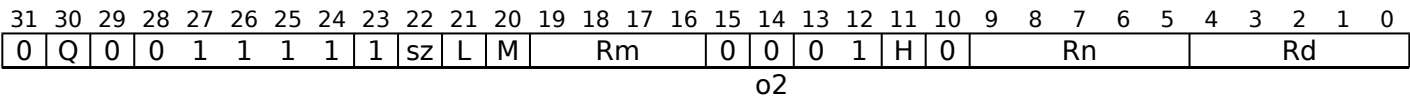
```
FMLA <Vd>.<T>, <Vn>.<T>, <Vm>.H[<index>]

if !HaveFP16Ext() then UNDEFINED;

integer idxdsize = if H == '1' then 128 else 64;
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Rd);
integer index = UInt(H:L:M);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean sub_op = (o2 == '1');
```

Vector, single-precision and double-precision



Vector, single-precision and double-precision

FMLA <Vd>.<T>, <Vn>.<T>, <Vm>.<Ts>[<index>]

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi = M;
case sz:L of
  when '0x' index = UInt(H:L);
  when '10' index = UInt(H);
  when '11' UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean sub_op = (o2 == '1');
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the vector, half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the vector, single-precision and double-precision variant: is an arrangement specifier, encoded in "Q:sz":

Q	sz	<T>
0	0	2S
0	1	RESERVED
1	0	4S
1	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> For the half-precision variant: is the name of the second SIMD&FP source register, in the range V0 to V15, encoded in the "Rm" field.  
For the single-precision and double-precision variant: is the name of the second SIMD&FP source register, encoded in the "M:Rm" fields.
- <Ts> Is an element size specifier, encoded in "sz":

sz	<Ts>
0	S
1	D

- <index> For the half-precision variant: is the element index, in the range 0 to 7, encoded in the "H:L:M" fields.  
For the single-precision and double-precision variant: is the element index, encoded in "sz:L:H":

sz	L	<index>
0	x	H:L
1	0	H
1	1	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(idxdsize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2 = Elem[operand2, index, esize];

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    if sub_op then element1 = FPNeg(element1);
    Elem[result, e, esize] = FPMulAdd(Elem[operand3, e, esize], element1, element2, FPCR);
V[d] = result;

```

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# FMLA (vector)

Floating-point fused Multiply-Add to accumulator (vector). This instruction multiplies corresponding floating-point values in the vectors in the two source SIMD&FP registers, adds the product to the corresponding vector element of the destination SIMD&FP register, and writes the result to the destination SIMD&FP register.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	1	0	Rm				0	0	0	0	1	1	Rn				Rd						
a																															

## Half-precision

```
FMLA <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean sub_op = (a == '1');
```

## Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	sz	1	Rm				1	1	0	0	1	1	Rn				Rd						
op																															

## Single-precision and double-precision

```
FMLA <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean sub_op = (op == '1');
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    if sub_op then element1 = FPNeg(element1);
    Elem[result, e, esize] = FPMulAdd(Elem[operand3, e, esize], element1, element2, FPCR);
V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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## FMLAL, FMLAL2 (by element)

Floating-point fused Multiply-Add Long to accumulator (by element). This instruction multiplies the vector elements in the first source SIMD&FP register by the specified value in the second source SIMD&FP register, and accumulates the product to the corresponding vector element of the destination SIMD&FP register. The instruction does not round the result of the multiply before the accumulation.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

In Armv8.2 and Armv8.3, this is an OPTIONAL instruction. From Armv8.4 it is mandatory for all implementations to support it.

[ID\\_AA64ISAR0\\_EL1](#).FHM indicates whether this instruction is supported.

It has encodings from 2 classes: [FMLAL](#) and [FMLAL2](#)

### FMLAL (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	1	0	L	M				Rm		0	0	0	0	H	0								Rd	
SZ												S																			

### FMLAL

FMLAL <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.H[<index>]

```
if !HaveFP16MulNoRoundingToFP32Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt('0':Rm);    // Vm can only be in bottom 16 registers.
if sz == '1' then UNDEFINED;
integer index = UInt(H:L:M);

integer esize = 32;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean sub_op = (S == '1');
integer part = 0;
```

### FMLAL2 (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	1	0	L	M				Rm		1	0	0	0	H	0								Rd	
SZ												S																			

FMLAL2

```
FMLAL2 <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.H[<index>]

if !HaveFP16MulNoRoundingToFP32Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt('0':Rm);    // Vm can only be in bottom 16 registers.
if sz == '1' then UNDEFINED;
integer index = UInt(H:L:M);

integer esize = 32;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean sub_op = (S == '1');
integer part = 1;
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Ta> Is an arrangement specifier, encoded in "Q":

Q	<Ta>
0	2S
1	4S

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Tb> Is an arrangement specifier, encoded in "Q":

Q	<Tb>
0	2H
1	4H

- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.
- <index> Is the element index, encoded in the "H:L:M" fields.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize DIV 2) operand1 = Vpart[n, part];
bits(128) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;
bits(esize DIV 2) element1;
bits(esize DIV 2) element2 = Elem[operand2, index, esize DIV 2];

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize DIV 2];
    if sub_op then element1 = FPNeg(element1);
    Elem[result, e, esize] = FPMulAddH(Elem[operand3, e, esize], element1, element2, FPCR);
V[d] = result;
```

# FMLAL, FMLAL2 (vector)

Floating-point fused Multiply-Add Long to accumulator (vector). This instruction multiplies corresponding half-precision floating-point values in the vectors in the two source SIMD&FP registers, and accumulates the product to the corresponding vector element of the destination SIMD&FP register. The instruction does not round the result of the multiply before the accumulation.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

In Armv8.2 and Armv8.3, this is an OPTIONAL instruction. From Armv8.4 it is mandatory for all implementations to support it.

[ID\\_AA64ISAR0\\_EL1](#).FHM indicates whether this instruction is supported.

It has encodings from 2 classes: [FMLAL](#) and [FMLAL2](#)

## FMLAL (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	0	1	Rm				1	1	1	0	1	1	Rn				Rd						
								S		sz																					

## FMLAL

```
FMLAL <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

if !HaveFP16MulNoRoundingToFP32Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz == '1' then UNDEFINED;
integer esize = 32;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean sub_op = (S == '1');
integer part = 0;
```

## FMLAL2 (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	0	1	Rm				1	1	0	0	1	1	Rn				Rd						
								S		sz																					

## FMLAL2

```
FMLAL2 <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

if !HaveFP16MulNoRoundingToFP32Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz == '1' then UNDEFINED;
integer esize = 32;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean sub_op = (S == '1');
integer part = 1;
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Ta> Is an arrangement specifier, encoded in "Q":

Q	<Ta>
0	2S
1	4S

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Tb> Is an arrangement specifier, encoded in "Q":

Q	<Tb>
0	2H
1	4H

- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize DIV 2) operand1 = Vpart[n, part];
bits(datasize DIV 2) operand2 = Vpart[m, part];
bits(datasize) operand3 = V[d];
bits(datasize) result;
bits(esize DIV 2) element1;
bits(esize DIV 2) element2;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize DIV 2];
    element2 = Elem[operand2, e, esize DIV 2];
    if sub_op then element1 = FPNeg(element1);
    Elem[result, e, esize] = FPMulAddH(Elem[operand3, e, esize], element1, element2, FPCR);
V[d] = result;
```

## FMLS (by element)

Floating-point fused Multiply-Subtract from accumulator (by element). This instruction multiplies the vector elements in the first source SIMD&FP register by the specified value in the second source SIMD&FP register, and subtracts the results from the vector elements of the destination SIMD&FP register. All the values in this instruction are floating-point values.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar, half-precision](#) , [Scalar, single-precision and double-precision](#) , [Vector, half-precision](#) and [Vector, single-precision and double-precision](#)

### Scalar, half-precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	0	0	L	M	Rm				0	1	0	1	H	0	Rn				Rd					
o2																															

### Scalar, half-precision

FMLS <Hd>, <Hn>, <Vm>.H[<index>]

if !HaveFP16Ext() then UNDEFINED;

```
integer idxdsize = if H == '1' then 128 else 64;
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Rd);
integer index = UInt(H:L:M);

integer esize = 16;
integer datasize = esize;
integer elements = 1;
boolean sub_op = (o2 == '1');
```

### Scalar, single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	1	sz	L	M	Rm				0	1	0	1	H	0	Rn				Rd					
o2																															

Scalar, single-precision and double-precision

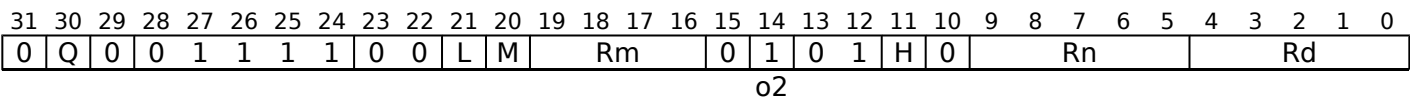
```
FMLS <V><d>, <V><n>, <Vm>.<Ts>[<index>]

integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi = M;
case sz:L of
  when '0x' index = UInt(H:L);
  when '10' index = UInt(H);
  when '11' UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
boolean sub_op = (o2 == '1');
```

Vector, half-precision
(Armv8.2)



Vector, half-precision

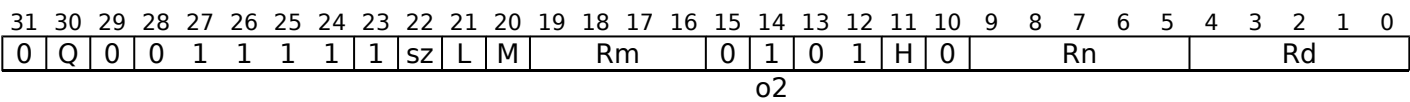
```
FMLS <Vd>.<T>, <Vn>.<T>, <Vm>.H[<index>]

if !HaveFP16Ext() then UNDEFINED;

integer idxdsize = if H == '1' then 128 else 64;
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Rd);
integer index = UInt(H:L:M);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean sub_op = (o2 == '1');
```

Vector, single-precision and double-precision



Vector, single-precision and double-precision

FMLS <Vd>.<T>, <Vn>.<T>, <Vm>.<Ts>[<index>]

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi = M;
case sz:L of
  when '0x' index = UInt(H:L);
  when '10' index = UInt(H);
  when '11' UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean sub_op = (o2 == '1');
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the vector, half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the vector, single-precision and double-precision variant: is an arrangement specifier, encoded in "Q:sz":

Q	sz	<T>
0	0	2S
0	1	RESERVED
1	0	4S
1	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> For the half-precision variant: is the name of the second SIMD&FP source register, in the range V0 to V15, encoded in the "Rm" field.  
For the single-precision and double-precision variant: is the name of the second SIMD&FP source register, encoded in the "M:Rm" fields.
- <Ts> Is an element size specifier, encoded in "sz":

sz	<Ts>
0	S
1	D

- <index> For the half-precision variant: is the element index, in the range 0 to 7, encoded in the "H:L:M" fields.  
For the single-precision and double-precision variant: is the element index, encoded in "sz:L:H":

sz	L	<index>
0	x	H:L
1	0	H
1	1	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(idxdsize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2 = Elem[operand2, index, esize];

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    if sub_op then element1 = FPNeg(element1);
    Elem[result, e, esize] = FPMulAdd(Elem[operand3, e, esize], element1, element2, FPCR);
V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FMLS (vector)

Floating-point fused Multiply-Subtract from accumulator (vector). This instruction multiplies corresponding floating-point values in the vectors in the two source SIMD&FP registers, negates the product, adds the result to the corresponding vector element of the destination SIMD&FP register, and writes the result to the destination SIMD&FP register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	1	0	Rm				0	0	0	0	1	1	Rn				Rd						
a																															

## Half-precision

```
FMLS <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean sub_op = (a == '1');
```

## Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	sz	1	Rm				1	1	0	0	1	1	Rn				Rd						
op																															

## Single-precision and double-precision

```
FMLS <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean sub_op = (op == '1');
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    if sub_op then element1 = FPNeg(element1);
    Elem[result, e, esize] = FPMulAdd(Elem[operand3, e, esize], element1, element2, FPCR);
V[d] = result;

```

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## FMLSL, FMLSL2 (by element)

Floating-point fused Multiply-Subtract Long from accumulator (by element). This instruction multiplies the negated vector elements in the first source SIMD&FP register by the specified value in the second source SIMD&FP register, and accumulates the product to the corresponding vector element of the destination SIMD&FP register. The instruction does not round the result of the multiply before the accumulation.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

In Armv8.2 and Armv8.3, this is an OPTIONAL instruction. From Armv8.4 it is mandatory for all implementations to support it.

*ID\_AA64ISAR0\_EL1*.FHM indicates whether this instruction is supported.

It has encodings from 2 classes: *FMLSL* and *FMLSL2*

### FMLSL (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	1	0	L	M	Rm				0	1	0	0	H	0	Rn				Rd					
SZ																S															

### FMLSL

FMLSL <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.H[<index>]

```
if !HaveFP16MulNoRoundingToFP32Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt('0':Rm); // Vm can only be in bottom 16 registers.
if sz == '1' then UNDEFINED;
integer index = UInt(H:L:M);

integer esize = 32;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean sub_op = (S == '1');
integer part = 0;
```

### FMLSL2 (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	1	0	L	M	Rm				1	1	0	0	H	0	Rn				Rd					
SZ																S															

FMLSL2

```
FMLSL2 <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.H[<index>]

if !HaveFP16MulNoRoundingToFP32Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt('0':Rm);    // Vm can only be in bottom 16 registers.
if sz == '1' then UNDEFINED;
integer index = UInt(H:L:M);

integer esize = 32;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean sub_op = (S == '1');
integer part = 1;
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Ta> Is an arrangement specifier, encoded in "Q":

Q	<Ta>
0	2S
1	4S

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Tb> Is an arrangement specifier, encoded in "Q":

Q	<Tb>
0	2H
1	4H

- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.
- <index> Is the element index, encoded in the "H:L:M" fields.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize DIV 2) operand1 = Vpart[n, part];
bits(128) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;
bits(esize DIV 2) element1;
bits(esize DIV 2) element2 = Elem[operand2, index, esize DIV 2];

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize DIV 2];
    if sub_op then element1 = FPNeg(element1);
    Elem[result, e, esize] = FPMulAddH(Elem[operand3, e, esize], element1, element2, FPCR);
V[d] = result;
```

# FMLSL, FMLSL2 (vector)

Floating-point fused Multiply-Subtract Long from accumulator (vector). This instruction negates the values in the vector of one SIMD&FP register, multiplies these with the corresponding values in another vector, and accumulates the product to the corresponding vector element of the destination SIMD&FP register. The instruction does not round the result of the multiply before the accumulation.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

In Armv8.2 and Armv8.3, this is an OPTIONAL instruction. From Armv8.4 it is mandatory for all implementations to support it.

[ID\\_AA64ISAR0\\_EL1](#).FHM indicates whether this instruction is supported.

It has encodings from 2 classes: [FMLSL](#) and [FMLSL2](#)

## FMLSL (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	0	1	Rm				1	1	1	0	1	1	Rn				Rd						
								S		sz																					

## FMLSL

```
FMLSL <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

if !HaveFP16MulNoRoundingToFP32Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz == '1' then UNDEFINED;
integer esize = 32;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean sub_op = (S == '1');
integer part = 0;
```

## FMLSL2 (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	0	1	Rm				1	1	0	0	1	1	Rn				Rd						
S sz																															

## FMLSL2

```
FMLSL2 <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

if !HaveFP16MulNoRoundingToFP32Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz == '1' then UNDEFINED;
integer esize = 32;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean sub_op = (S == '1');
integer part = 1;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.  
<Ta> Is an arrangement specifier, encoded in "Q":

Q	<Ta>
0	2S
1	4S

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.  
<Tb> Is an arrangement specifier, encoded in "Q":

Q	<Tb>
0	2H
1	4H

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize DIV 2) operand1 = Vpart[n, part];
bits(datasize DIV 2) operand2 = Vpart[m, part];
bits(datasize) operand3 = V[d];
bits(datasize) result;
bits(esize DIV 2) element1;
bits(esize DIV 2) element2;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize DIV 2];
    element2 = Elem[operand2, e, esize DIV 2];
    if sub_op then element1 = FPNeg(element1);
    Elem[result, e, esize] = FPMulAddH(Elem[operand3, e, esize], element1, element2, FPCR);
V[d] = result;
```

# FMOV (vector, immediate)

Floating-point move immediate (vector). This instruction copies an immediate floating-point constant into every element of the SIMD&FP destination register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	0	0	0	0	a	b	c	1	1	1	1	1	1	d	e	f	g	h	Rd					

## Half-precision

```
FMov <Vd>.<T>, #<imm>

if !HaveFP16Ext() then UNDEFINED;

integer rd = UInt(Rd);

integer datasize = if Q == '1' then 128 else 64;
bits(datasize) imm;

imm8 = a:b:c:d:e:f:g:h;
imm16 = imm8<7>:NOT(imm8<6>):Replicate(imm8<6>, 2):imm8<5:0>:Zeros(6);

imm = Replicate(imm16, datasize DIV 16);
```

## Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	op	0	1	1	1	1	0	0	0	0	0	a	b	c	1	1	1	1	0	1	d	e	f	g	h	Rd				
																cmode															

## Single-precision (op == 0)

```
FMov <Vd>.<T>, #<imm>
```

## Double-precision (Q == 1 && op == 1)

```
FMov <Vd>.2D, #<imm>

integer rd = UInt(Rd);

integer datasize = if Q == '1' then 128 else 64;
bits(datasize) imm;
bits(64) imm64;

if cmode:op == '11111' then
    // FMov Dn,#imm is in main FP instruction set
    if Q == '0' then UNDEFINED;

imm64 = AdvSIMDExpandImm(op, cmode, a:b:c:d:e:f:g:h);
imm = Replicate(imm64, datasize DIV 64);
```

## Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in “Q”:

Q	<T>
0	4H
1	8H

For the single-precision variant: is an arrangement specifier, encoded in “Q”:

Q	<T>
0	2S
1	4S

<imm> Is a signed floating-point constant with 3-bit exponent and normalized 4 bits of precision, encoded in "a:b:c:d:e:f:g:h". For details of the range of constants available and the encoding of <imm>, see *Modified immediate constants in A64 floating-point instructions*.

Operation

```
CheckFPAdvSIMDEnabled64();  
V[rd] = imm;
```



# FMOV (register)

Floating-point Move register without conversion. This instruction copies the floating-point value in the SIMD&FP source register to the SIMD&FP destination register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (Armv8.2)

FMOV <Hd>, <Hn>

## Single-precision (ftype == 00)

FMOV <Sd>, <Sn>

## Double-precision (ftype == 01)

FMOV <Dd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer datasize;
case ftype of
  when '00' datasize = 32;
  when '01' datasize = 64;
  when '10' UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      datasize = 16;
    else
      UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();

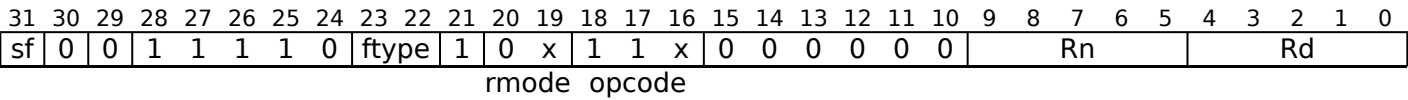
bits(datasize) operand = V[n];

V[d] = operand;
```

FMOV (general)

Floating-point Move to or from general-purpose register without conversion. This instruction transfers the contents of a SIMD&FP register to a general-purpose register, or the contents of a general-purpose register to a SIMD&FP register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



**Half-precision to 32-bit (sf == 0 && ftype == 11 && rmode == 00 && opcode == 110)**  
(Armv8.2)

FMOV <Wd>, <Hn>

**Half-precision to 64-bit (sf == 1 && ftype == 11 && rmode == 00 && opcode == 110)**  
(Armv8.2)

FMOV <Xd>, <Hn>

**32-bit to half-precision (sf == 0 && ftype == 11 && rmode == 00 && opcode == 111)**  
(Armv8.2)

FMOV <Hd>, <Wn>

**32-bit to single-precision (sf == 0 && ftype == 00 && rmode == 00 && opcode == 111)**

FMOV <Sd>, <Wn>

**Single-precision to 32-bit (sf == 0 && ftype == 00 && rmode == 00 && opcode == 110)**

FMOV <Wd>, <Sn>

**64-bit to half-precision (sf == 1 && ftype == 11 && rmode == 00 && opcode == 111)**  
(Armv8.2)

FMOV <Hd>, <Xn>

**64-bit to double-precision (sf == 1 && ftype == 01 && rmode == 00 && opcode == 111)**

FMOV <Dd>, <Xn>

**64-bit to top half of 128-bit (sf == 1 && ftype == 10 && rmode == 01 && opcode == 111)**

FMOV <Vd>.D[1], <Xn>

**Double-precision to 64-bit (sf == 1 && ftype == 01 && rmode == 00 && opcode == 110)**

FMOV <Xd>, <Dn>

**Top half of 128-bit to 64-bit (sf == 1 && ftype == 10 && rmode == 01 && opcode == 110)**

FMOV <Xd>, <Vn>.D[1]

```

integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;
FPConvOp op;
FPRounding rounding;
boolean unsigned;
integer part;

case ftype of
  when '00'
    fltsize = 32;
  when '01'
    fltsize = 64;
  when '10'
    if opcode<2:1>:rmode != '11 01' then UNDEFINED;
    fltsize = 128;
  when '11'
    if HaveFP16Ext() then
      fltsize = 16;
    else
      UNDEFINED;

case opcode<2:1>:rmode of
  when '00 xx' // FCVT[NPMZ][US]
    rounding = FPDecodeRounding(rmode);
    unsigned = (opcode<0> == '1');
    op = FPConvOp_CVT_FtoI;
  when '01 00' // [US]CVTF
    rounding = FPRoundingMode(FPCR);
    unsigned = (opcode<0> == '1');
    op = FPConvOp_CVT_ItoF;
  when '10 00' // FCVTA[US]
    rounding = FPRounding_TIEAWAY;
    unsigned = (opcode<0> == '1');
    op = FPConvOp_CVT_FtoI;
  when '11 00' // FMOV
    if fltsize != 16 && fltsize != intsize then UNDEFINED;
    op = if opcode<0> == '1' then FPConvOp_MOV_ItoF else FPConvOp_MOV_FtoI;
    part = 0;
  when '11 01' // FMOV D[1]
    if intsize != 64 || fltsize != 128 then UNDEFINED;
    op = if opcode<0> == '1' then FPConvOp_MOV_ItoF else FPConvOp_MOV_FtoI;
    part = 1;
    fltsize = 64; // size of D[1] is 64
  when '11 11' // FJCVTZS
    if !HaveFJCVTZSExt() then UNDEFINED;
    rounding = FPRounding_ZERO;
    unsigned = (opcode<0> == '1');
    op = FPConvOp_CVT_FtoI_JS;
  otherwise
    UNDEFINED;

```

## Assembler Symbols

<Dd>	Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Hd>	Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Sd>	Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
<Vd>	Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
<Wd>	Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

<Xd>	Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
<Vn>	Is the name of the SIMD&FP source register, encoded in the "Rn" field.
<Hn>	Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
<Dn>	Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();

bits(fltsize) fltval;
bits(intsize) intval;

case op of
  when FPConvOp_CVT_FtoI
    fltval = V[n];
    intval = FPToFixed(fltval, 0, unsigned, FPCR, rounding);
    X[d] = intval;
  when FPConvOp_CVT_ItoF
    intval = X[n];
    fltval = FixedToFP(intval, 0, unsigned, FPCR, rounding);
    V[d] = fltval;
  when FPConvOp_MOV_FtoI
    fltval = Vpart[n, part];
    intval = ZeroExtend(fltval, intsize);
    X[d] = intval;
  when FPConvOp_MOV_ItoF
    intval = X[n];
    fltval = intval<fltsize-1:0>;
    Vpart[d, part] = fltval;
  when FPConvOp_CVT_FtoI_JS
    bit Z;
    fltval = V[n];
    (intval, Z) = FPToFixedJS(fltval, FPCR, TRUE);
    PSTATE.<N,Z,C,V> = '0':Z:'00';
    X[d] = intval;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FMOV (scalar, immediate)

Floating-point move immediate (scalar). This instruction copies a floating-point immediate constant into the SIMD&FP destination register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1	1	1	1	0	f	t	y	p	e	1	imm8						1	0	0	0	0	0	0	0	Rd			

## Half-precision (ftype == 11) (Armv8.2)

```
FMOV <Hd>, #<imm>
```

## Single-precision (ftype == 00)

```
FMOV <Sd>, #<imm>
```

## Double-precision (ftype == 01)

```
FMOV <Dd>, #<imm>
```

```
integer d = UInt(Rd);
integer datasize;
case ftype of
  when '00' datasize = 32;
  when '01' datasize = 64;
  when '10' UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      datasize = 16;
    else
      UNDEFINED;

bits(datasize) imm = VFPEExpandImm(imm8);
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <imm> Is a signed floating-point constant with 3-bit exponent and normalized 4 bits of precision, encoded in the "imm8" field. For details of the range of constants available and the encoding of <imm>, see [Modified immediate constants in A64 floating-point instructions](#).

## Operation

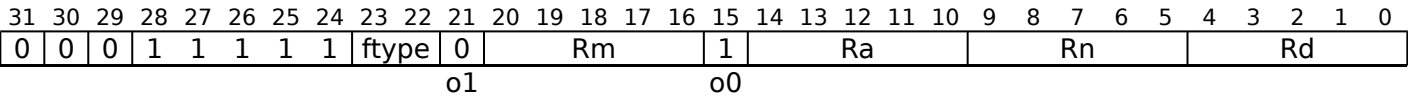
```
CheckFPAdvSIMDEnabled64();
V[d] = imm;
```

# FMSUB

Floating-point Fused Multiply-Subtract (scalar). This instruction multiplies the values of the first two SIMD&FP source registers, negates the product, adds that to the value of the third SIMD&FP source register, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (Armv8.2)

FMSUB <Hd>, <Hn>, <Hm>, <Ha>

## Single-precision (ftype == 00)

FMSUB <Sd>, <Sn>, <Sm>, <Sa>

## Double-precision (ftype == 01)

FMSUB <Dd>, <Dn>, <Dm>, <Da>

```
integer d = UInt(Rd);
integer a = UInt(Ra);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer datasize;
case ftype of
  when '00' datasize = 32;
  when '01' datasize = 64;
  when '10' UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      datasize = 16;
    else
      UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the first SIMD&FP source register holding the multiplicand, encoded in the "Rn" field.
- <Dm> Is the 64-bit name of the second SIMD&FP source register holding the multiplier, encoded in the "Rm" field.
- <Da> Is the 64-bit name of the third SIMD&FP source register holding the minuend, encoded in the "Ra" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register holding the multiplicand, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register holding the multiplier, encoded in the "Rm" field.

<Ha>	Is the 16-bit name of the third SIMD&FP source register holding the minuend, encoded in the "Ra" field.
<Sd>	Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the first SIMD&FP source register holding the multiplicand, encoded in the "Rn" field.
<Sm>	Is the 32-bit name of the second SIMD&FP source register holding the multiplier, encoded in the "Rm" field.
<Sa>	Is the 32-bit name of the third SIMD&FP source register holding the minuend, encoded in the "Ra" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) result;
bits(datasize) operanda = V[a];
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];

operand1 = FPNeg(operand1);
result = FPMuLAdd(operanda, operand1, operand2, FPCR);

V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FMUL (by element)

Floating-point Multiply (by element). This instruction multiplies the vector elements in the first source SIMD&FP register by the specified value in the second source SIMD&FP register, places the results in a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are floating-point values.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar, half-precision](#) , [Scalar, single-precision and double-precision](#) , [Vector, half-precision](#) and [Vector, single-precision and double-precision](#)

## Scalar, half-precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	0	0	L	M	Rm				1	0	0	1	H	0	Rn				Rd					
U																															

## Scalar, half-precision

```
FMUL <Hd>, <Hn>, <Vm>.H[<index>]

if !HaveFP16Ext() then UNDEFINED;

integer idxdsize = if H == '1' then 128 else 64;
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Rd);
integer index = UInt(H:L:M);

integer esize = 16;
integer datasize = esize;
integer elements = 1;
boolean mulx_op = (U == '1');
```

## Scalar, single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	1	sz	L	M	Rm				1	0	0	1	H	0	Rn				Rd					
U																															

Scalar, single-precision and double-precision

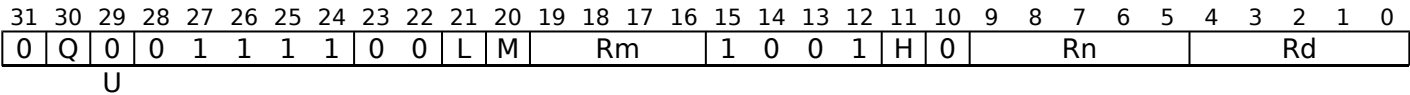
```
FMUL <V><d>, <V><n>, <Vm>.<Ts>[<index>]

integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi = M;
case sz:L of
  when '0x' index = UInt(H:L);
  when '10' index = UInt(H);
  when '11' UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
boolean mulx_op = (U == '1');
```

Vector, half-precision
(Armv8.2)



Vector, half-precision

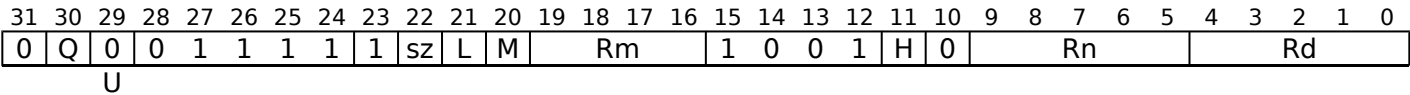
```
FMUL <Vd>.<T>, <Vn>.<T>, <Vm>.H[<index>]

if !HaveFP16Ext() then UNDEFINED;

integer idxdsize = if H == '1' then 128 else 64;
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Rd);
integer index = UInt(H:L:M);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean mulx_op = (U == '1');
```

Vector, single-precision and double-precision



Vector, single-precision and double-precision

FMUL <Vd>.<T>, <Vn>.<T>, <Vm>.<Ts>[<index>]

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi = M;
case sz:L of
  when '0x' index = UInt(H:L);
  when '10' index = UInt(H);
  when '11' UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean mulx_op = (U == '1');
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the vector, half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the vector, single-precision and double-precision variant: is an arrangement specifier, encoded in "Q:sz":

Q	sz	<T>
0	0	2S
0	1	RESERVED
1	0	4S
1	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> For the half-precision variant: is the name of the second SIMD&FP source register, in the range V0 to V15, encoded in the "Rm" field.  
For the single-precision and double-precision variant: is the name of the second SIMD&FP source register, encoded in the "M:Rm" fields.
- <Ts> Is an element size specifier, encoded in "sz":

sz	<Ts>
0	S
1	D

- <index> For the half-precision variant: is the element index, in the range 0 to 7, encoded in the "H:L:M" fields.  
For the single-precision and double-precision variant: is the element index, encoded in "sz:L:H":

sz	L	<index>
0	x	H:L
1	0	H
1	1	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(idxdsize) operand2 = V[m];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2 = Elem[operand2, index, esize];

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    if mulx_op then
        Elem[result, e, esize] = FPMuLX(element1, element2, FPCR);
    else
        Elem[result, e, esize] = FPMuL(element1, element2, FPCR);
V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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FMUL (vector)

Floating-point Multiply (vector). This instruction multiplies corresponding floating-point values in the vectors in the two source SIMD&FP registers, places the result in a vector, and writes the vector to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

Half-precision  
(Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	1	0	Rm				0	0	0	1	1	1	Rn				Rd						

Half-precision

```
FMUL <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	sz	1	Rm				1	1	0	1	1	1	Rn				Rd						

Single-precision and double-precision

```
FMUL <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T>

For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H
- For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = FPMul(element1, element2, FPCR);

V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

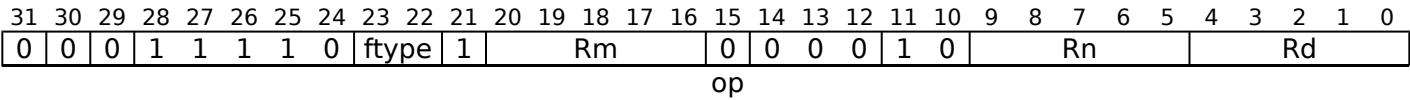
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# FMUL (scalar)

Floating-point Multiply (scalar). This instruction multiplies the floating-point values of the two source SIMD&FP registers, and writes the result to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (Armv8.2)

FMUL <Hd>, <Hn>, <Hm>

## Single-precision (ftype == 00)

FMUL <Sd>, <Sn>, <Sm>

## Double-precision (ftype == 01)

FMUL <Dd>, <Dn>, <Dm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer datasize;
case ftype of
    when '00' datasize = 32;
    when '01' datasize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            datasize = 16;
        else
            UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Dm> Is the 64-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Sm> Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
bits(datasize) result;  
bits(datasize) operand1 = V[n];  
bits(datasize) operand2 = V[m];  
  
result = FPMul(operand1, operand2, FPCR);  
V[d] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FMULX (by element)

Floating-point Multiply extended (by element). This instruction multiplies the floating-point values in the vector elements in the first source SIMD&FP register by the specified floating-point value in the second source SIMD&FP register, places the results in a vector, and writes the vector to the destination SIMD&FP register.

If one value is zero and the other value is infinite, the result is 2.0. In this case, the result is negative if only one of the values is negative, otherwise the result is positive.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar, half-precision](#) , [Scalar, single-precision and double-precision](#) , [Vector, half-precision](#) and [Vector, single-precision and double-precision](#)

## Scalar, half-precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	1	0	0	L	M	Rm				1	0	0	1	H	0	Rn				Rd					
U																															

## Scalar, half-precision

```
FMULX <Hd>, <Hn>, <Vm>.H[<index>]

if !HaveFP16Ext() then UNDEFINED;

integer idxdsize = if H == '1' then 128 else 64;
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Rd);
integer index = UInt(H:L:M);

integer esize = 16;
integer datasize = esize;
integer elements = 1;
boolean mulx_op = (U == '1');
```

## Scalar, single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	1	1	sz	L	M	Rm				1	0	0	1	H	0	Rn				Rd					
U																															

Scalar, single-precision and double-precision

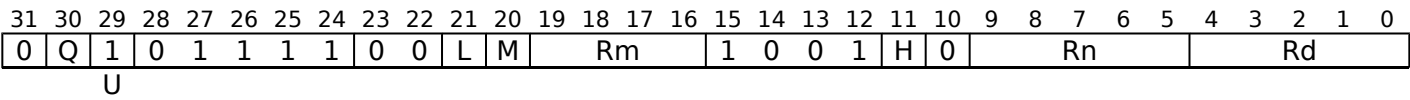
```
FMULX <V><d>, <V><n>, <Vm>.<Ts>[<index>]
```

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi = M;
case sz:L of
  when '0x' index = UInt(H:L);
  when '10' index = UInt(H);
  when '11' UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
boolean mulx_op = (U == '1');
```

Vector, half-precision
(Armv8.2)



Vector, half-precision

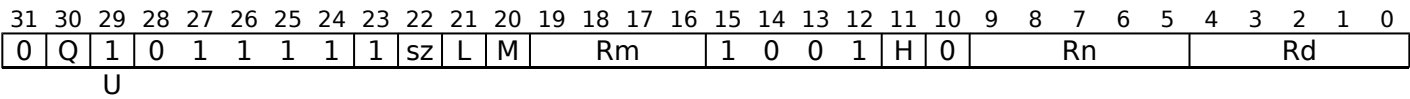
```
FMULX <Vd>.<T>, <Vn>.<T>, <Vm>.H[<index>]
```

```
if !HaveFP16Ext() then UNDEFINED;

integer idxdsize = if H == '1' then 128 else 64;
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Rd);
integer index = UInt(H:L:M);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean mulx_op = (U == '1');
```

Vector, single-precision and double-precision



## Vector, single-precision and double-precision

FMULX <Vd>.<T>, <Vn>.<T>, <Vm>.<Ts>[<index>]

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi = M;
case sz:L of
  when '0x' index = UInt(H:L);
  when '10' index = UInt(H);
  when '11' UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean mulx_op = (U == '1');
```

## Assembler Symbols

<Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.

<Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.

<V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the vector, half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the vector, single-precision and double-precision variant: is an arrangement specifier, encoded in "Q:sz":

Q	sz	<T>
0	0	2S
0	1	RESERVED
1	0	4S
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> For the half-precision variant: is the name of the second SIMD&FP source register, in the range V0 to V15, encoded in the "Rm" field.

For the single-precision and double-precision variant: is the name of the second SIMD&FP source register, encoded in the "M:Rm" fields.

<Ts> Is an element size specifier, encoded in "sz":

sz	<Ts>
0	S
1	D

<index> For the half-precision variant: is the element index, in the range 0 to 7, encoded in the "H:L:M" fields.

For the single-precision and double-precision variant: is the element index, encoded in "sz:L:H":

sz	L	<index>
0	x	H:L
1	0	H
1	1	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(idxdsize) operand2 = V[m];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2 = Elem[operand2, index, esize];

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    if mulx_op then
        Elem[result, e, esize] = FPMuLX(element1, element2, FPCR);
    else
        Elem[result, e, esize] = FPMuL(element1, element2, FPCR);
V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FMULX

Floating-point Multiply extended. This instruction multiplies corresponding floating-point values in the vectors of the two source SIMD&FP registers, places the resulting floating-point values in a vector, and writes the vector to the destination SIMD&FP register.

If one value is zero and the other value is infinite, the result is 2.0. In this case, the result is negative if only one of the values is negative, otherwise the result is positive.

This instruction can generate a floating-point exception. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	1	0	Rm				0	0	0	1	1	1	Rn				Rd						

## Scalar half precision

FMULX <Hd>, <Hn>, <Hm>

```
if !HaveFP16Ext() then UNDEFINED;
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = esize;
integer elements = 1;
```

## Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	sz	1	Rm				1	1	0	1	1	1	Rn				Rd						

## Scalar single-precision and double-precision

FMULX <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
```

## Vector half precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	1	0	Rm				0	0	0	1	1	1	Rn				Rd						

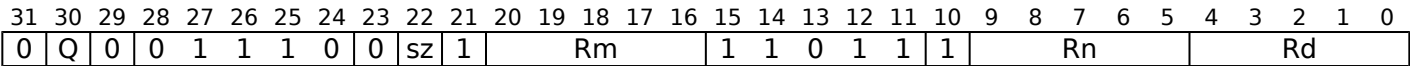
Vector half precision

```
FMULX <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Vector single-precision and double-precision



Vector single-precision and double-precision

```
FMULX <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the vector half precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the vector single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = FPMuLX(element1, element2, FPCR);
V[d] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

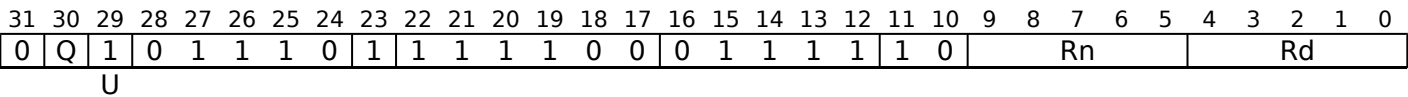
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FNEG (vector)

Floating-point Negate (vector). This instruction negates the value of each vector element in the source SIMD&FP register, writes the result to a vector, and writes the vector to the destination SIMD&FP register.  
Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

Half-precision  
(Armv8.2)



Half-precision

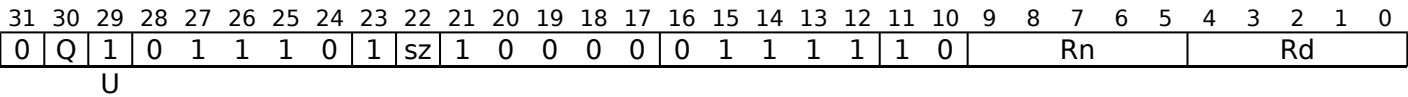
```
FNEG <Vd>.<T>, <Vn>.<T>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean neg = (U == '1');
```

Single-precision and double-precision



Single-precision and double-precision

```
FNEG <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean neg = (U == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":



sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    if neg then
        element = FPNeg(element);
    else
        element = FPAbs(element);
    Elem[result, e, esize] = element;

V[d] = result;

```

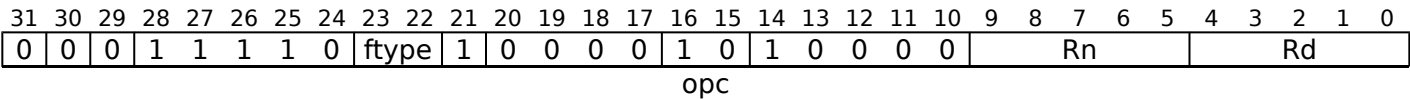
Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FNEG (scalar)

Floating-point Negate (scalar). This instruction negates the value in the SIMD&FP source register and writes the result to the SIMD&FP destination register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (Armv8.2)

FNEG <Hd>, <Hn>

## Single-precision (ftype == 00)

FNEG <Sd>, <Sn>

## Double-precision (ftype == 01)

FNEG <Dd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer datasize;
case ftype of
  when '00' datasize = 32;
  when '01' datasize = 64;
  when '10' UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      datasize = 16;
    else
      UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(datasize) result;
bits(datasize) operand = V[n];

result = FPNeg(operand);
V[d] = result;
```

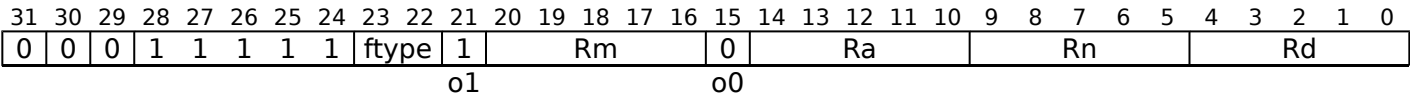


# FNMADD

Floating-point Negated fused Multiply-Add (scalar). This instruction multiplies the values of the first two SIMD&FP source registers, negates the product, subtracts the value of the third SIMD&FP source register, and writes the result to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (Armv8.2)

FNMADD <Hd>, <Hn>, <Hm>, <Ha>

## Single-precision (ftype == 00)

FNMADD <Sd>, <Sn>, <Sm>, <Sa>

## Double-precision (ftype == 01)

FNMADD <Dd>, <Dn>, <Dm>, <Da>

```
integer d = UInt(Rd);
integer a = UInt(Ra);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer datasize;
case ftype of
  when '00' datasize = 32;
  when '01' datasize = 64;
  when '10' UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      datasize = 16;
    else
      UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the first SIMD&FP source register holding the multiplicand, encoded in the "Rn" field.
- <Dm> Is the 64-bit name of the second SIMD&FP source register holding the multiplier, encoded in the "Rm" field.
- <Da> Is the 64-bit name of the third SIMD&FP source register holding the addend, encoded in the "Ra" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register holding the multiplicand, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register holding the multiplier, encoded in the "Rm" field.
- <Ha> Is the 16-bit name of the third SIMD&FP source register holding the addend, encoded in the "Ra" field.

<Sd>	Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the first SIMD&FP source register holding the multiplicand, encoded in the "Rn" field.
<Sm>	Is the 32-bit name of the second SIMD&FP source register holding the multiplier, encoded in the "Rm" field.
<Sa>	Is the 32-bit name of the third SIMD&FP source register holding the addend, encoded in the "Ra" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) result;
bits(datasize) operanda = V[a];
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];

operanda = FPNeg(operanda);
operand1 = FPNeg(operand1);
result = FPMulAdd(operanda, operand1, operand2, FPCR);

V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

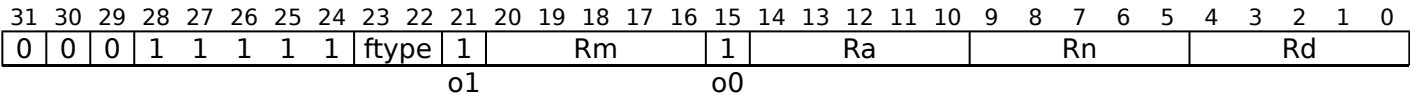
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# FNMSUB

Floating-point Negated fused Multiply-Subtract (scalar). This instruction multiplies the values of the first two SIMD&FP source registers, subtracts the value of the third SIMD&FP source register, and writes the result to the destination SIMD&FP register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (Armv8.2)

FNMSUB <Hd>, <Hn>, <Hm>, <Ha>

## Single-precision (ftype == 00)

FNMSUB <Sd>, <Sn>, <Sm>, <Sa>

## Double-precision (ftype == 01)

FNMSUB <Dd>, <Dn>, <Dm>, <Da>

```
integer d = UInt(Rd);
integer a = UInt(Ra);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer datasize;
case ftype of
  when '00' datasize = 32;
  when '01' datasize = 64;
  when '10' UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      datasize = 16;
    else
      UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the first SIMD&FP source register holding the multiplicand, encoded in the "Rn" field.
- <Dm> Is the 64-bit name of the second SIMD&FP source register holding the multiplier, encoded in the "Rm" field.
- <Da> Is the 64-bit name of the third SIMD&FP source register holding the minuend, encoded in the "Ra" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register holding the multiplicand, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register holding the multiplier, encoded in the "Rm" field.

<Ha>	Is the 16-bit name of the third SIMD&FP source register holding the minuend, encoded in the "Ra" field.
<Sd>	Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Sn>	Is the 32-bit name of the first SIMD&FP source register holding the multiplicand, encoded in the "Rn" field.
<Sm>	Is the 32-bit name of the second SIMD&FP source register holding the multiplier, encoded in the "Rm" field.
<Sa>	Is the 32-bit name of the third SIMD&FP source register holding the minuend, encoded in the "Ra" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) result;
bits(datasize) operanda = V[a];
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];

operanda = FPNeg(operanda);
result = FPMuLAdd(operanda, operand1, operand2, FPCR);

V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

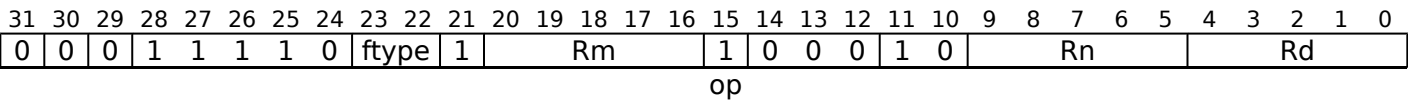
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# FNMUL (scalar)

Floating-point Multiply-Negate (scalar). This instruction multiplies the floating-point values of the two source SIMD&FP registers, and writes the negation of the result to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (Armv8.2)

FNMUL <Hd>, <Hn>, <Hm>

## Single-precision (ftype == 00)

FNMUL <Sd>, <Sn>, <Sm>

## Double-precision (ftype == 01)

FNMUL <Dd>, <Dn>, <Dm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer datasize;
case ftype of
    when '00' datasize = 32;
    when '01' datasize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            datasize = 16;
        else
            UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Dm> Is the 64-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Sm> Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rm" field.



## Operation

```
CheckFPAdvSIMDEnabled64();  
bits(datasize) result;  
bits(datasize) operand1 = V[n];  
bits(datasize) operand2 = V[m];  
  
result = FPMul(operand1, operand2, FPCR);  
  
result = FPNeg(result);  
  
V[d] = result;
```

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# FRECPE

Floating-point Reciprocal Estimate. This instruction finds an approximate reciprocal estimate for each vector element in the source SIMD&FP register, places the result in a vector, and writes the vector to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	1	1	1	1	1	0	0	1	1	1	0	1	1	0	Rn				Rd					

## Scalar half precision

```
FRECPE <Hd>, <Hn>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = esize;
integer elements = 1;
```

## Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	1	sz	1	0	0	0	0	1	1	1	0	1	1	0	Rn				Rd					

## Scalar single-precision and double-precision

```
FRECPE <V><d>, <V><n>

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
```

## Vector half precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	1	1	1	1	0	0	1	1	1	0	1	1	0	Rn				Rd					

Vector half precision

```
FRECPE <Vd>.<T>, <Vn>.<T>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Vector single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	sz	1	0	0	0	0	1	1	1	0	1	1	0	Rn				Rd					

Vector single-precision and double-precision

```
FRECPE <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the vector half precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the vector single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
bits(datasize) operand = V[n];  
bits(datasize) result;  
bits(esize) element;  
  
for e = 0 to elements-1  
    element = Elem[operand, e, esize];  
    Elem[result, e, esize] = FPrecipEstimate(element, FPCR);  
  
V[d] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FRECPS

Floating-point Reciprocal Step. This instruction multiplies the corresponding floating-point values in the vectors of the two source SIMD&FP registers, subtracts each of the products from 2.0, places the resulting floating-point values in a vector, and writes the vector to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	1	0	Rm				0	0	1	1	1	1	Rn				Rd						

## Scalar half precision

```
FRECPS <Hd>, <Hn>, <Hm>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = esize;
integer elements = 1;
```

## Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	sz	1	Rm				1	1	1	1	1	1	Rn				Rd						

## Scalar single-precision and double-precision

```
FRECPS <V><d>, <V><n>, <V><m>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
```

## Vector half precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	1	0	Rm				0	0	1	1	1	1	Rn				Rd						

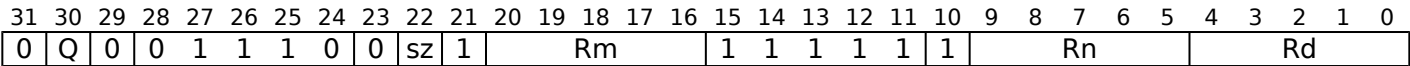
Vector half precision

```
FRECPS <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Vector single-precision and double-precision



Vector single-precision and double-precision

```
FRECPS <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the vector half precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the vector single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = FPRecipStepFused(element1, element2);

V[d] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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FRECPX

Floating-point Reciprocal exponent (scalar). This instruction finds an approximate reciprocal exponent for each vector element in the source SIMD&FP register, places the result in a vector, and writes the vector to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

Half-precision  
(Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	1	1	1	1	1	0	0	1	1	1	1	1	1	0										
																Rn								Rd							

Half-precision

FRECPX <Hd>, <Hn>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = esize;
integer elements = 1;
```

Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	1	sz	1	0	0	0	0	1	1	1	1	1	1	0										
																Rn								Rd							

Single-precision and double-precision

FRECPX <V><d>, <V><n>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
```

Assembler Symbols

- <Hd>

Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn>

Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <V>

Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D
- <d>

Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n>

Is the number of the SIMD&FP source register, encoded in the "Rn" field.



## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPRecpX(element, FPCR);

V[d] = result;
```

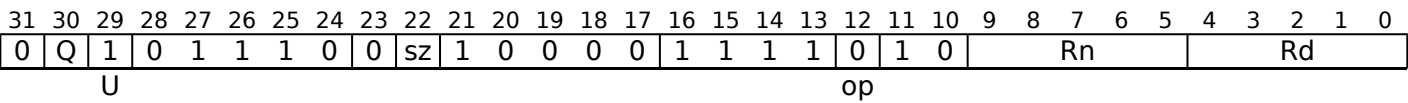
Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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FRINT32X (vector)

Floating-point Round to 32-bit Integer, using current rounding mode (vector). This instruction rounds a vector of floating-point values in the SIMD&FP source register to integral floating-point values that fit into a 32-bit integer size using the rounding mode that is determined by the *FPCR*, and writes the result to the SIMD&FP destination register. A zero input returns a zero result with the same sign. When one of the result values is not numerically equal to the corresponding input value, an Inexact exception is raised. When an input is infinite, NaN or out-of-range, the instruction returns for the corresponding result value the most negative integer representable in the destination size, and an Invalid Operation floating-point exception is raised. A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*. Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

Vector single-precision and double-precision (Armv8.5)



Vector single-precision and double-precision

```
FRINT32X <Vd>.<T>, <Vn>.<T>

if !HaveFrintExt() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
integer intsize = if op == '0' then 32 else 64;
FPRounding rounding = if U == '0' then FPRounding_ZERO else FPRoundingMode(FPCR);
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPRoundIntN(element, FPCR, rounding, intsize);

V[d] = result;
```



# FRINT32X (scalar)

Floating-point Round to 32-bit Integer, using current rounding mode (scalar). This instruction rounds a floating-point value in the SIMD&FP source register to an integral floating-point value that fits into a 32-bit integer size using the rounding mode that is determined by the [FPCR](#), and writes the result to the SIMD&FP destination register.

A zero input returns a zero result with the same sign. When the result value is not numerically equal to the input value, an Inexact exception is raised. When the input is infinite, NaN or out-of-range, the instruction returns {for the corresponding result value} the most negative integer representable in the destination size, and an Invalid Operation floating-point exception is raised.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

## Floating-point (Armv8.5)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1	1	1	1	0	0	x	1	0	1	0	0	0	1	1	0	0	0	0	Rn				Rd					
ftype										op																					

### Single-precision (ftype == 00)

FRINT32X <Sd>, <Sn>

### Double-precision (ftype == 01)

FRINT32X <Dd>, <Dn>

```
if !HaveFrintExt() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);

integer datasize;
case ftype of
    when '00' datasize = 32;
    when '01' datasize = 64;
    when '1x' UNDEFINED;

FPRounding rounding = FPRoundingMode(FPCR);
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(datasize) result;
bits(datasize) operand = V[n];

result = FPRoundIntN(operand, FPCR, rounding, 32);

V[d] = result;
```



FRINT32Z (vector)

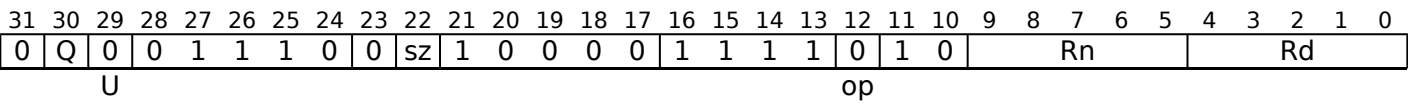
Floating-point Round to 32-bit Integer toward Zero (vector). This instruction rounds a vector of floating-point values in the SIMD&FP source register to integral floating-point values that fit into a 32-bit integer size using the Round towards Zero rounding mode, and writes the result to the SIMD&FP destination register.

A zero input returns a zero result with the same sign. When one of the result values is not numerically equal to the corresponding input value, an Inexact exception is raised. When an input is infinite, NaN or out-of-range, the instruction returns for the corresponding result value the most negative integer representable in the destination size, and an Invalid Operation floating-point exception is raised.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

Vector single-precision and double-precision (Armv8.5)



Vector single-precision and double-precision

```
FRINT32Z <Vd>.<T>, <Vn>.<T>

if !HaveFrintExt() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
integer intsize = if op == '0' then 32 else 64;
FPRounding rounding = if U == '0' then FPRounding_ZERO else FPRoundingMode(FPCR);
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPRoundIntN(element, FPCR, rounding, intsize);

V[d] = result;
```



# FRINT32Z (scalar)

Floating-point Round to 32-bit Integer toward Zero (scalar). This instruction rounds a floating-point value in the SIMD&FP source register to an integral floating-point value that fits into a 32-bit integer size using the Round towards Zero rounding mode, and writes the result to the SIMD&FP destination register.

A zero input returns a zero result with the same sign. When the result value is not numerically equal to the {corresponding} input value, an Inexact exception is raised. When the input is infinite, NaN or out-of-range, the instruction returns {for the corresponding result value} the most negative integer representable in the destination size, and an Invalid Operation floating-point exception is raised.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

## Floating-point (Armv8.5)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1	1	1	1	0	0	x	1	0	1	0	0	0	0	1	0	0	0	0	Rn				Rd					
ftype										op																					

### Single-precision (ftype == 00)

FRINT32Z <Sd>, <Sn>

### Double-precision (ftype == 01)

FRINT32Z <Dd>, <Dn>

```
if !HaveFrintExt() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);

integer datasize;
case ftype of
    when '00' datasize = 32;
    when '01' datasize = 64;
    when '1x' UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(datasize) result;
bits(datasize) operand = V[n];

result = FPRoundIntN(operand, FPCR, FPRounding_ZERO, 32);

V[d] = result;
```

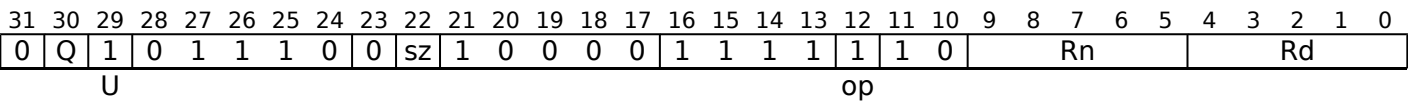




FRINT64X (vector)

Floating-point Round to 64-bit Integer, using current rounding mode (vector). This instruction rounds a vector of floating-point values in the SIMD&FP source register to integral floating-point values that fit into a 64-bit integer size using the rounding mode that is determined by the *FPCR*, and writes the result to the SIMD&FP destination register. A zero input returns a zero result with the same sign. When one of the result values is not numerically equal to the corresponding input value, an Inexact exception is raised. When an input is infinite, NaN or out-of-range, the instruction returns for the corresponding result value the most negative integer representable in the destination size, and an Invalid Operation floating-point exception is raised. A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*. Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

Vector single-precision and double-precision (Armv8.5)



Vector single-precision and double-precision

```
FRINT64X <Vd>.<T>, <Vn>.<T>

if !HaveFrintExt() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
integer intsize = if op == '0' then 32 else 64;
FPRounding rounding = if U == '0' then FPRounding_ZERO else FPRoundingMode(FPCR);
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPRoundIntN(element, FPCR, rounding, intsize);

V[d] = result;
```



# FRINT64X (scalar)

Floating-point Round to 64-bit Integer, using current rounding mode (scalar). This instruction rounds a floating-point value in the SIMD&FP source register to an integral floating-point value that fits into a 64-bit integer size using the rounding mode that is determined by the [FPCR](#), and writes the result to the SIMD&FP destination register.

A zero input returns a zero result with the same sign. When the result value is not numerically equal to the input value, an Inexact exception is raised. When the input is infinite, NaN or out-of-range, the instruction returns {for the corresponding result value} the most negative integer representable in the destination size, and an Invalid Operation floating-point exception is raised.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

## Floating-point (Armv8.5)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1	1	1	1	0	0	x	1	0	1	0	0	1	1	1	0	0	0	0	Rn				Rd					
ftype										op																					

### Single-precision (ftype == 00)

FRINT64X <Sd>, <Sn>

### Double-precision (ftype == 01)

FRINT64X <Dd>, <Dn>

```
if !HaveFrintExt() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);

integer datasize;
case ftype of
  when '00' datasize = 32;
  when '01' datasize = 64;
  when '1x' UNDEFINED;

FPRounding rounding = FPRoundingMode(FPCR);
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(datasize) result;
bits(datasize) operand = V[n];

result = FPRoundIntN(operand, FPCR, rounding, 64);

V[d] = result;
```



FRINT64Z (vector)

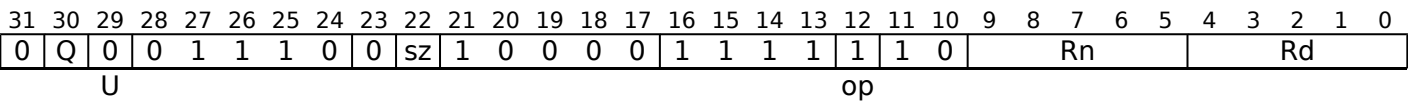
Floating-point Round to 64-bit Integer toward Zero (vector). This instruction rounds a vector of floating-point values in the SIMD&FP source register to integral floating-point values that fit into a 64-bit integer size using the Round towards Zero rounding mode, and writes the result to the SIMD&FP destination register.

A zero input returns a zero result with the same sign. When one of the result values is not numerically equal to the corresponding input value, an Inexact exception is raised. When an input is infinite, NaN or out-of-range, the instruction returns for the corresponding result value the most negative integer representable in the destination size, and an Invalid Operation floating-point exception is raised.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

Vector single-precision and double-precision (Armv8.5)



Vector single-precision and double-precision

```
FRINT64Z <Vd>.<T>, <Vn>.<T>

if !HaveFrintExt() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
integer intsize = if op == '0' then 32 else 64;
FPRounding rounding = if U == '0' then FPRounding_ZERO else FPRoundingMode(FPCR);
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPRoundIntN(element, FPCR, rounding, intsize);

V[d] = result;
```



# FRINT64Z (scalar)

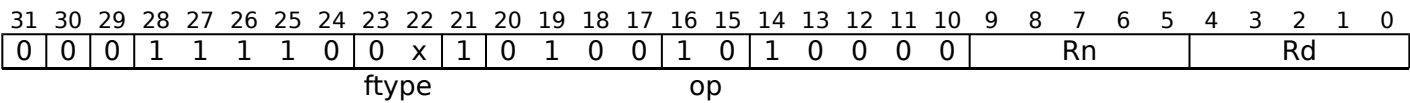
Floating-point Round to 64-bit Integer toward Zero (scalar). This instruction rounds a floating-point value in the SIMD&FP source register to an integral floating-point value that fits into a 64-bit integer size using the Round towards Zero rounding mode, and writes the result to the SIMD&FP destination register.

A zero input returns a zero result with the same sign. When the result value is not numerically equal to the {corresponding} input value, an Inexact exception is raised. When the input is infinite, NaN or out-of-range, the instruction returns {for the corresponding result value} the most negative integer representable in the destination size, and an Invalid Operation floating-point exception is raised.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

## Floating-point (Armv8.5)



### Single-precision (ftype == 00)

FRINT64Z <Sd>, <Sn>

### Double-precision (ftype == 01)

FRINT64Z <Dd>, <Dn>

```
if !HaveFrintExt() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);

integer datasize;
case ftype of
  when '00' datasize = 32;
  when '01' datasize = 64;
  when '1x' UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(datasize) result;
bits(datasize) operand = V[n];

result = FPRoundIntN(operand, FPCR, FPRounding_ZERO, 64);

V[d] = result;
```





# FRINTA (vector)

Floating-point Round to Integral, to nearest with ties to Away (vector). This instruction rounds a vector of floating-point values in the SIMD&FP source register to integral floating-point values of the same size using the Round to Nearest with Ties to Away rounding mode, and writes the result to the SIMD&FP destination register.

A zero input gives a zero result with the same sign, an infinite input gives an infinite result with the same sign, and a NaN is propagated as for normal arithmetic.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	1	1	1	1	0	0	1	1	0	0	0	1	0	Rn				Rd					
U								o2				o1																			

## Half-precision

```
FRINTA <Vd>.<T>, <Vn>.<T>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean exact = FALSE;
FPRounding rounding;
case U:o1:o2 of
  when '0xx' rounding = FPDecodeRounding(o1:o2);
  when '100' rounding = FPRounding_TIEAWAY;
  when '101' UNDEFINED;
  when '110' rounding = FPRoundingMode(FPCR); exact = TRUE;
  when '111' rounding = FPRoundingMode(FPCR);
```

## Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	sz	1	0	0	0	0	1	1	0	0	0	1	0	Rn				Rd					
U								o2				o1																			

Single-precision and double-precision

```
FRINTA <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean exact = FALSE;
FPRounding rounding;
case U:o1:o2 of
  when '0xx' rounding = FPDecodeRounding(o1:o2);
  when '100' rounding = FPRounding_TIEAWAY;
  when '101' UNDEFINED;
  when '110' rounding = FPRoundingMode(FPCR); exact = TRUE;
  when '111' rounding = FPRoundingMode(FPCR);
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
  element = Elem[operand, e, esize];
  Elem[result, e, esize] = FPRoundInt(element, FPCR, rounding, exact);

V[d] = result;
```

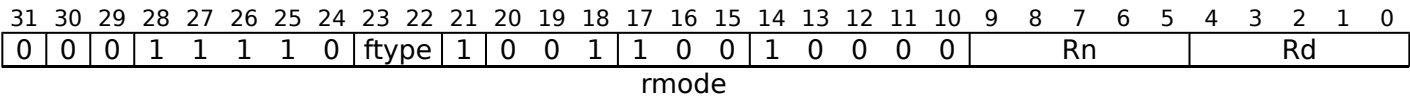
# FRINTA (scalar)

Floating-point Round to Integral, to nearest with ties to Away (scalar). This instruction rounds a floating-point value in the SIMD&FP source register to an integral floating-point value of the same size using the Round to Nearest with Ties to Away rounding mode, and writes the result to the SIMD&FP destination register.

A zero input gives a zero result with the same sign, an infinite input gives an infinite result with the same sign, and a NaN is propagated as for normal arithmetic.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (Armv8.2)

FRINTA <Hd>, <Hn>

## Single-precision (ftype == 00)

FRINTA <Sd>, <Sn>

## Double-precision (ftype == 01)

FRINTA <Dd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer datasize;
case ftype of
    when '00' datasize = 32;
    when '01' datasize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            datasize = 16;
        else
            UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
bits(datasize) result;  
bits(datasize) operand = V[n];  
  
result = FPRoundInt(operand, FPCR, FPRounding_TIEAWAY, FALSE);  
  
V[d] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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FRINTI (vector)

Floating-point Round to Integral, using current rounding mode (vector). This instruction rounds a vector of floating-point values in the SIMD&FP source register to integral floating-point values of the same size using the rounding mode that is determined by the *FPCR*, and writes the result to the SIMD&FP destination register.

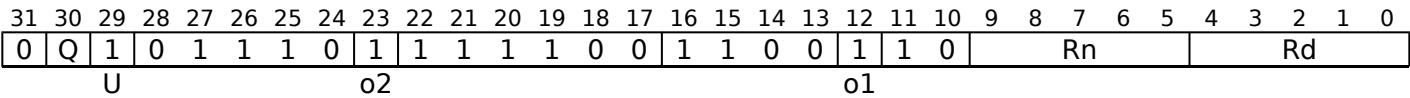
A zero input gives a zero result with the same sign, an infinite input gives an infinite result with the same sign, and a NaN is propagated as for normal arithmetic.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

Half-precision  
(Armv8.2)



Half-precision

FRINTI <Vd>.<T>, <Vn>.<T>

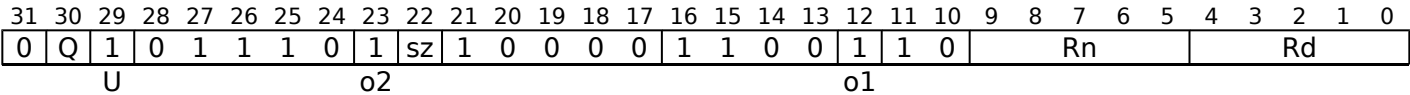
```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean exact = FALSE;
FPRounding rounding;
case U:o1:o2 of
  when '0xx' rounding = FPDecodeRounding(o1:o2);
  when '100' rounding = FPRounding_TIEAWAY;
  when '101' UNDEFINED;
  when '110' rounding = FPRoundingMode(FPCR); exact = TRUE;
  when '111' rounding = FPRoundingMode(FPCR);
```

Single-precision and double-precision



Single-precision and double-precision

```
FRINTI <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean exact = FALSE;
FPRounding rounding;
case U:o1:o2 of
  when '0xx' rounding = FPDecodeRounding(o1:o2);
  when '100' rounding = FPRounding_TIEAWAY;
  when '101' UNDEFINED;
  when '110' rounding = FPRoundingMode(FPCR); exact = TRUE;
  when '111' rounding = FPRoundingMode(FPCR);
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
  element = Elem[operand, e, esize];
  Elem[result, e, esize] = FPRoundInt(element, FPCR, rounding, exact);

V[d] = result;
```

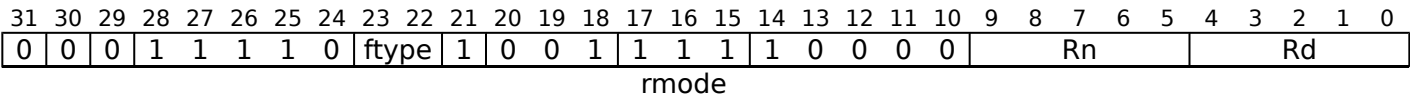
# FRINTI (scalar)

Floating-point Round to Integral, using current rounding mode (scalar). This instruction rounds a floating-point value in the SIMD&FP source register to an integral floating-point value of the same size using the rounding mode that is determined by the [FPCR](#), and writes the result to the SIMD&FP destination register.

A zero input gives a zero result with the same sign, an infinite input gives an infinite result with the same sign, and a NaN is propagated as for normal arithmetic.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (Armv8.2)

FRINTI <Hd>, <Hn>

## Single-precision (ftype == 00)

FRINTI <Sd>, <Sn>

## Double-precision (ftype == 01)

FRINTI <Dd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer datasize;
case ftype of
    when '00' datasize = 32;
    when '01' datasize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            datasize = 16;
        else
            UNDEFINED;

FPRounding rounding;
rounding = FPRoundingMode(FPCR);
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.



## Operation

```
CheckFPAdvSIMDEnabled64();  
  
bits(datasize) result;  
bits(datasize) operand = V[n];  
  
result = FPRoundInt(operand, FPCR, rounding, FALSE);  
  
V[d] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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FRINTM (vector)

Floating-point Round to Integral, toward Minus infinity (vector). This instruction rounds a vector of floating-point values in the SIMD&FP source register to integral floating-point values of the same size using the Round towards Minus Infinity rounding mode, and writes the result to the SIMD&FP destination register.

A zero input gives a zero result with the same sign, an infinite input gives an infinite result with the same sign, and a NaN is propagated as for normal arithmetic.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

Half-precision  
(Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	1	1	1	1	0	0	1	1	0	0	1	1	0	Rn				Rd					
U								o2				o1																			

Half-precision

FRINTM <Vd>.<T>, <Vn>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean exact = FALSE;
FPRounding rounding;
case U:o1:o2 of
  when '0xx' rounding = FPDecodeRounding(o1:o2);
  when '100' rounding = FPRounding_TIEAWAY;
  when '101' UNDEFINED;
  when '110' rounding = FPRoundingMode(FPCR); exact = TRUE;
  when '111' rounding = FPRoundingMode(FPCR);
```

Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	sz	1	0	0	0	0	1	1	0	0	1	1	0	Rn				Rd					
U								o2				o1																			

Single-precision and double-precision

```
FRINTM <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean exact = FALSE;
FPRounding rounding;
case U:o1:o2 of
  when '0xx' rounding = FPDecodeRounding(o1:o2);
  when '100' rounding = FPRounding_TIEAWAY;
  when '101' UNDEFINED;
  when '110' rounding = FPRoundingMode(FPCR); exact = TRUE;
  when '111' rounding = FPRoundingMode(FPCR);
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
  element = Elem[operand, e, esize];
  Elem[result, e, esize] = FPRoundInt(element, FPCR, rounding, exact);

V[d] = result;
```

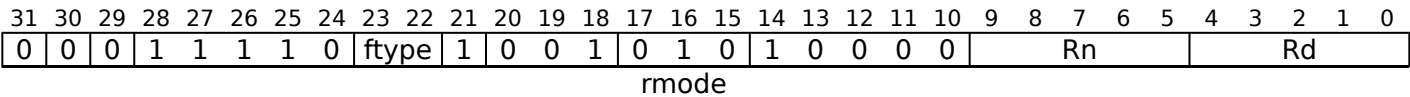
# FRINTM (scalar)

Floating-point Round to Integral, toward Minus infinity (scalar). This instruction rounds a floating-point value in the SIMD&FP source register to an integral floating-point value of the same size using the Round towards Minus Infinity rounding mode, and writes the result to the SIMD&FP destination register.

A zero input gives a zero result with the same sign, an infinite input gives an infinite result with the same sign, and a NaN is propagated as for normal arithmetic.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (Armv8.2)

FRINTM <Hd>, <Hn>

## Single-precision (ftype == 00)

FRINTM <Sd>, <Sn>

## Double-precision (ftype == 01)

FRINTM <Dd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer datasize;
case ftype of
    when '00' datasize = 32;
    when '01' datasize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            datasize = 16;
        else
            UNDEFINED;

FPRounding rounding;
rounding = FPDecodeRounding('10');
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
bits(datasize) result;  
bits(datasize) operand = V[n];  
  
result = FPRoundInt(operand, FPCR, rounding, FALSE);  
  
V[d] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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FRINTN (vector)

Floating-point Round to Integral, to nearest with ties to even (vector). This instruction rounds a vector of floating-point values in the SIMD&FP source register to integral floating-point values of the same size using the Round to Nearest rounding mode, and writes the result to the SIMD&FP destination register.

A zero input gives a zero result with the same sign, an infinite input gives an infinite result with the same sign, and a NaN is propagated as for normal arithmetic.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

Half-precision  
(Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	1	1	1	1	0	0	1	1	0	0	0	1	0	Rn				Rd					
U								o2				o1																			

Half-precision

FRINTN <Vd>.<T>, <Vn>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean exact = FALSE;
FPRounding rounding;
case U:o1:o2 of
  when '0xx' rounding = FPDecodeRounding(o1:o2);
  when '100' rounding = FPRounding_TIEAWAY;
  when '101' UNDEFINED;
  when '110' rounding = FPRoundingMode(FPCR); exact = TRUE;
  when '111' rounding = FPRoundingMode(FPCR);
```

Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	sz	1	0	0	0	0	1	1	0	0	0	1	0	Rn				Rd					
U								o2				o1																			

Single-precision and double-precision

```
FRINTN <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean exact = FALSE;
FPRounding rounding;
case U:o1:o2 of
  when '0xx' rounding = FPDecodeRounding(o1:o2);
  when '100' rounding = FPRounding_TIEAWAY;
  when '101' UNDEFINED;
  when '110' rounding = FPRoundingMode(FPCR); exact = TRUE;
  when '111' rounding = FPRoundingMode(FPCR);
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
  element = Elem[operand, e, esize];
  Elem[result, e, esize] = FPRoundInt(element, FPCR, rounding, exact);

V[d] = result;
```

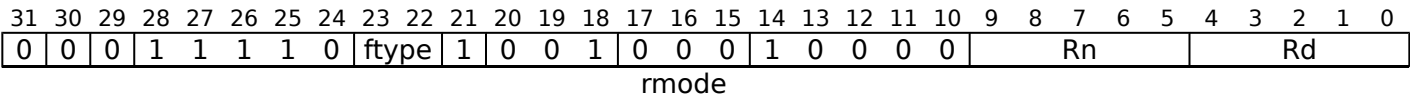
# FRINTN (scalar)

Floating-point Round to Integral, to nearest with ties to even (scalar). This instruction rounds a floating-point value in the SIMD&FP source register to an integral floating-point value of the same size using the Round to Nearest rounding mode, and writes the result to the SIMD&FP destination register.

A zero input gives a zero result with the same sign, an infinite input gives an infinite result with the same sign, and a NaN is propagated as for normal arithmetic.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (Armv8.2)

FRINTN <Hd>, <Hn>

## Single-precision (ftype == 00)

FRINTN <Sd>, <Sn>

## Double-precision (ftype == 01)

FRINTN <Dd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer datasize;
case ftype of
    when '00' datasize = 32;
    when '01' datasize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            datasize = 16;
        else
            UNDEFINED;

FPRounding rounding;
rounding = FPDecodeRounding('00');
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.



## Operation

```
CheckFPAdvSIMDEnabled64();  
  
bits(datasize) result;  
bits(datasize) operand = V[n];  
  
result = FPRoundInt(operand, FPCR, rounding, FALSE);  
  
V[d] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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FRINTP (vector)

Floating-point Round to Integral, toward Plus infinity (vector). This instruction rounds a vector of floating-point values in the SIMD&FP source register to integral floating-point values of the same size using the Round towards Plus Infinity rounding mode, and writes the result to the SIMD&FP destination register.

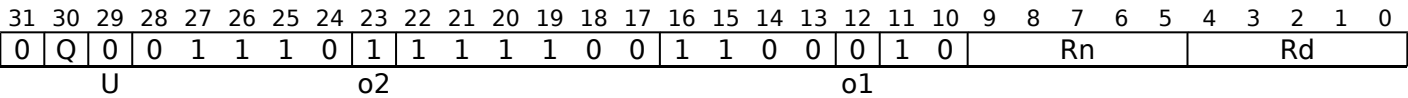
A zero input gives a zero result with the same sign, an infinite input gives an infinite result with the same sign, and a NaN is propagated as for normal arithmetic.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

Half-precision  
(Armv8.2)



Half-precision

FRINTP <Vd>.<T>, <Vn>.<T>

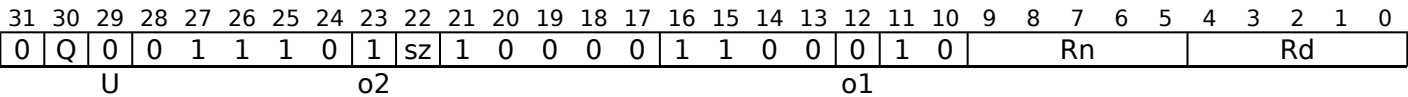
```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean exact = FALSE;
FPRounding rounding;
case U:o1:o2 of
  when '0xx' rounding = FPDecodeRounding(o1:o2);
  when '100' rounding = FPRounding_TIEAWAY;
  when '101' UNDEFINED;
  when '110' rounding = FPRoundingMode(FPCR); exact = TRUE;
  when '111' rounding = FPRoundingMode(FPCR);
```

Single-precision and double-precision



Single-precision and double-precision

```
FRINTP <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean exact = FALSE;
FPRounding rounding;
case U:o1:o2 of
  when '0xx' rounding = FPDecodeRounding(o1:o2);
  when '100' rounding = FPRounding_TIEAWAY;
  when '101' UNDEFINED;
  when '110' rounding = FPRoundingMode(FPCR); exact = TRUE;
  when '111' rounding = FPRoundingMode(FPCR);
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
  element = Elem[operand, e, esize];
  Elem[result, e, esize] = FPRoundInt(element, FPCR, rounding, exact);

V[d] = result;
```

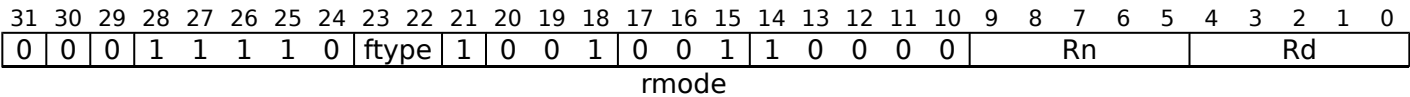
# FRINTP (scalar)

Floating-point Round to Integral, toward Plus infinity (scalar). This instruction rounds a floating-point value in the SIMD&FP source register to an integral floating-point value of the same size using the Round towards Plus Infinity rounding mode, and writes the result to the SIMD&FP destination register.

A zero input gives a zero result with the same sign, an infinite input gives an infinite result with the same sign, and a NaN is propagated as for normal arithmetic.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (Armv8.2)

FRINTP <Hd>, <Hn>

## Single-precision (ftype == 00)

FRINTP <Sd>, <Sn>

## Double-precision (ftype == 01)

FRINTP <Dd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer datasize;
case ftype of
    when '00' datasize = 32;
    when '01' datasize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            datasize = 16;
        else
            UNDEFINED;

FPRounding rounding;
rounding = FPDecodeRounding('01');
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
bits(datasize) result;  
bits(datasize) operand = V[n];  
  
result = FPRoundInt(operand, FPCR, rounding, FALSE);  
  
V[d] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FRINTX (vector)

Floating-point Round to Integral exact, using current rounding mode (vector). This instruction rounds a vector of floating-point values in the SIMD&FP source register to integral floating-point values of the same size using the rounding mode that is determined by the [FPCR](#), and writes the result to the SIMD&FP destination register.

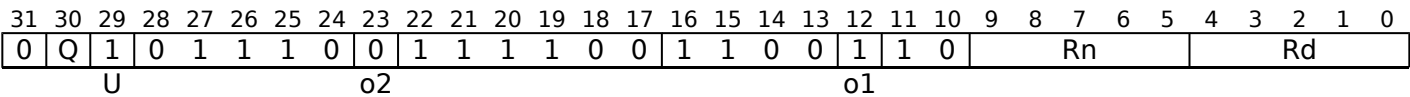
When a result value is not numerically equal to the corresponding input value, an Inexact exception is raised. A zero input gives a zero result with the same sign, an infinite input gives an infinite result with the same sign, and a NaN is propagated as for normal arithmetic.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (Armv8.2)



## Half-precision

```
FRINTX <Vd>.<T>, <Vn>.<T>

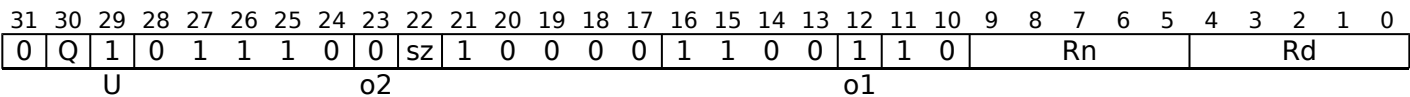
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean exact = FALSE;
FPRounding rounding;
case U:o1:o2 of
    when '0xx' rounding = FPDecodeRounding(o1:o2);
    when '100' rounding = FPRounding_TIEAWAY;
    when '101' UNDEFINED;
    when '110' rounding = FPRoundingMode(FPCR); exact = TRUE;
    when '111' rounding = FPRoundingMode(FPCR);
```

## Single-precision and double-precision



Single-precision and double-precision

```
FRINTX <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean exact = FALSE;
FPRounding rounding;
case U:o1:o2 of
  when '0xx' rounding = FPDecodeRounding(o1:o2);
  when '100' rounding = FPRounding_TIEAWAY;
  when '101' UNDEFINED;
  when '110' rounding = FPRoundingMode(FPCR); exact = TRUE;
  when '111' rounding = FPRoundingMode(FPCR);
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
  element = Elem[operand, e, esize];
  Elem[result, e, esize] = FPRoundInt(element, FPCR, rounding, exact);

V[d] = result;
```

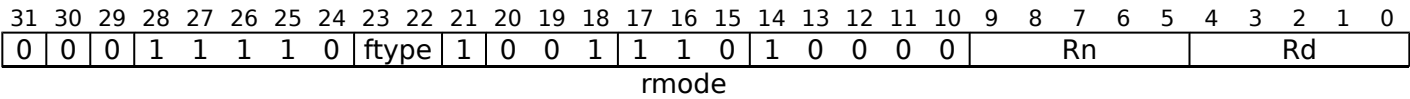
# FRINTX (scalar)

Floating-point Round to Integral exact, using current rounding mode (scalar). This instruction rounds a floating-point value in the SIMD&FP source register to an integral floating-point value of the same size using the rounding mode that is determined by the [FPCR](#), and writes the result to the SIMD&FP destination register.

When the result value is not numerically equal to the input value, an Inexact exception is raised. A zero input gives a zero result with the same sign, an infinite input gives an infinite result with the same sign, and a NaN is propagated as for normal arithmetic.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (Armv8.2)

FRINTX <Hd>, <Hn>

## Single-precision (ftype == 00)

FRINTX <Sd>, <Sn>

## Double-precision (ftype == 01)

FRINTX <Dd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer datasize;
case ftype of
    when '00' datasize = 32;
    when '01' datasize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            datasize = 16;
        else
            UNDEFINED;

FPRounding rounding;
rounding = FPRoundingMode(FPCR);
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.



## Operation

```
CheckFPAdvSIMDEnabled64();  
  
bits(datasize) result;  
bits(datasize) operand = V[n];  
  
result = FPRoundInt(operand, FPCR, rounding, TRUE);  
  
V[d] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FRINTZ (vector)

Floating-point Round to Integral, toward Zero (vector). This instruction rounds a vector of floating-point values in the SIMD&FP source register to integral floating-point values of the same size using the Round towards Zero rounding mode, and writes the result to the SIMD&FP destination register.

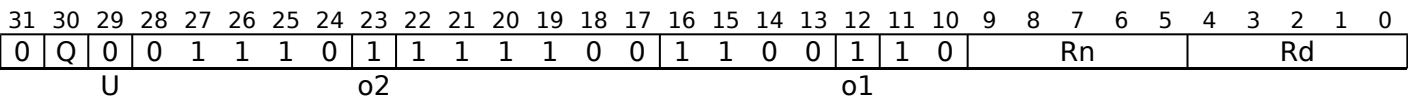
A zero input gives a zero result with the same sign, an infinite input gives an infinite result with the same sign, and a NaN is propagated as for normal arithmetic.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

## Half-precision (Armv8.2)



## Half-precision

FRINTZ <Vd>.<T>, <Vn>.<T>

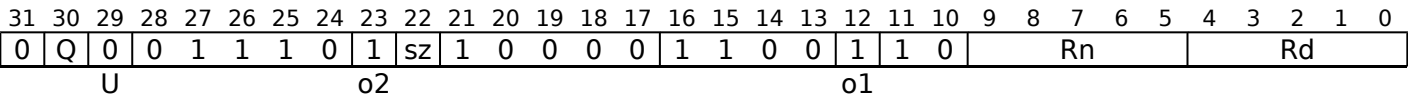
```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean exact = FALSE;
FPRounding rounding;
case U:o1:o2 of
  when '0xx' rounding = FPDecodeRounding(o1:o2);
  when '100' rounding = FPRounding_TIEAWAY;
  when '101' UNDEFINED;
  when '110' rounding = FPRoundingMode(FPCR); exact = TRUE;
  when '111' rounding = FPRoundingMode(FPCR);
```

## Single-precision and double-precision



Single-precision and double-precision

```
FRINTZ <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean exact = FALSE;
FPRounding rounding;
case U:o1:o2 of
  when '0xx' rounding = FPDecodeRounding(o1:o2);
  when '100' rounding = FPRounding_TIEAWAY;
  when '101' UNDEFINED;
  when '110' rounding = FPRoundingMode(FPCR); exact = TRUE;
  when '111' rounding = FPRoundingMode(FPCR);
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
  element = Elem[operand, e, esize];
  Elem[result, e, esize] = FPRoundInt(element, FPCR, rounding, exact);

V[d] = result;
```

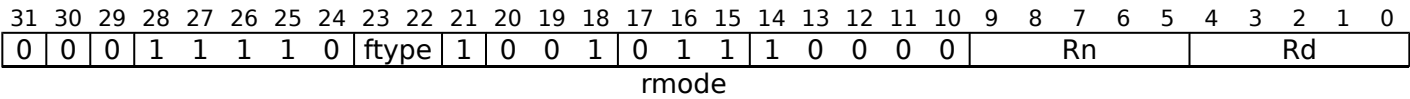
# FRINTZ (scalar)

Floating-point Round to Integral, toward Zero (scalar). This instruction rounds a floating-point value in the SIMD&FP source register to an integral floating-point value of the same size using the Round towards Zero rounding mode, and writes the result to the SIMD&FP destination register.

A zero input gives a zero result with the same sign, an infinite input gives an infinite result with the same sign, and a NaN is propagated as for normal arithmetic.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (Armv8.2)

FRINTZ <Hd>, <Hn>

## Single-precision (ftype == 00)

FRINTZ <Sd>, <Sn>

## Double-precision (ftype == 01)

FRINTZ <Dd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer datasize;
case ftype of
    when '00' datasize = 32;
    when '01' datasize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            datasize = 16;
        else
            UNDEFINED;

FPRounding rounding;
rounding = FPDecodeRounding('11');
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
bits(datasize) result;  
bits(datasize) operand = V[n];  
  
result = FPRoundInt(operand, FPCR, rounding, FALSE);  
  
V[d] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FRSQRTE

Floating-point Reciprocal Square Root Estimate. This instruction calculates an approximate square root for each vector element in the source SIMD&FP register, places the result in a vector, and writes the vector to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	1	1	1	1	1	0	0	1	1	1	0	1	1	0	Rn				Rd					

## Scalar half precision

```
FRSQRTE <Hd>, <Hn>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = esize;
integer elements = 1;
```

## Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	1	sz	1	0	0	0	0	1	1	1	0	1	1	0	Rn				Rd					

## Scalar single-precision and double-precision

```
FRSQRTE <V><d>, <V><n>

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
```

## Vector half precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	1	1	1	1	0	0	1	1	1	0	1	1	0	Rn				Rd					

Vector half precision

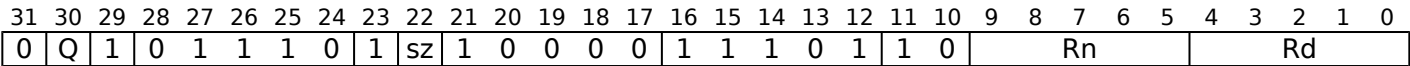
```
FRSQRTTE <Vd>.<T>, <Vn>.<T>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Vector single-precision and double-precision



Vector single-precision and double-precision

```
FRSQRTTE <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the vector half precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the vector single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPRSqrtEstimate(element, FPCR);

V[d] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FRSQRTS

Floating-point Reciprocal Square Root Step. This instruction multiplies corresponding floating-point values in the vectors of the two source SIMD&FP registers, subtracts each of the products from 3.0, divides these results by 2.0, places the results into a vector, and writes the vector to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	1	1	0	Rm				0	0	1	1	1	1	Rn				Rd						

## Scalar half precision

```
FRSQRTS <Hd>, <Hn>, <Hm>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = esize;
integer elements = 1;
```

## Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	1	sz	1	Rm				1	1	1	1	1	1	Rn				Rd						

## Scalar single-precision and double-precision

```
FRSQRTS <V><d>, <V><n>, <V><m>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
```

## Vector half precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	1	0	Rm				0	0	1	1	1	1	Rn				Rd						

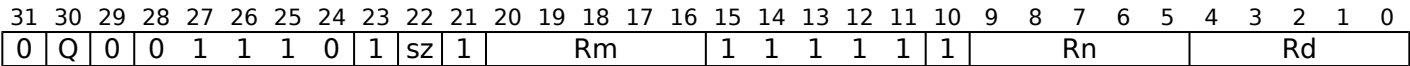
Vector half precision

```
FRSQRTS <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Vector single-precision and double-precision



Vector single-precision and double-precision

```
FRSQRTS <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the vector half precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the vector single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = FPRSqrtStepFused(element1, element2);

V[d] = result;
```

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FSQRT (vector)

Floating-point Square Root (vector). This instruction calculates the square root for each vector element in the source SIMD&FP register, places the result in a vector, and writes the vector to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR* or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

Half-precision  
(Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	1	1	1	1	0	0	1	1	1	1	1	1	0	Rn				Rd					

Half-precision

```
FSQRT <Vd>.<T>, <Vn>.<T>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	sz	1	0	0	0	0	1	1	1	1	1	1	0	Rn				Rd					

Single-precision and double-precision

```
FSQRT <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPSqrt(element, FPCR);

V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

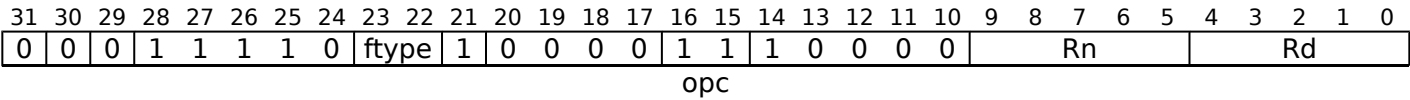
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# FSQRT (scalar)

Floating-point Square Root (scalar). This instruction calculates the square root of the value in the SIMD&FP source register and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (Armv8.2)

FSQRT <Hd>, <Hn>

## Single-precision (ftype == 00)

FSQRT <Sd>, <Sn>

## Double-precision (ftype == 01)

FSQRT <Dd>, <Dn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer datasize;
case ftype of
    when '00' datasize = 32;
    when '01' datasize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            datasize = 16;
        else
            UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
bits(datasize) result;  
bits(datasize) operand = V[n];  
  
result = FPSqrt(operand, FPCR);  
  
V[d] = result;
```

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FSUB (vector)

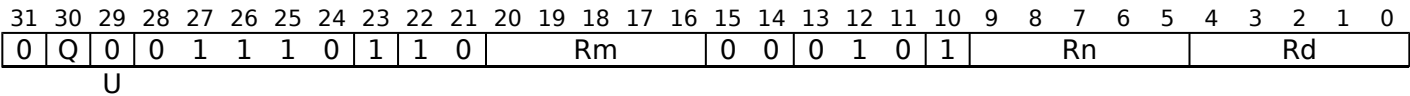
Floating-point Subtract (vector). This instruction subtracts the elements in the vector in the second source SIMD&FP register, from the corresponding elements in the vector in the first source SIMD&FP register, places each result into elements of a vector, and writes the vector to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR EL1*, *CPTR EL2*, and *CPTR EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision and double-precision](#)

Half-precision  
(Armv8.2)



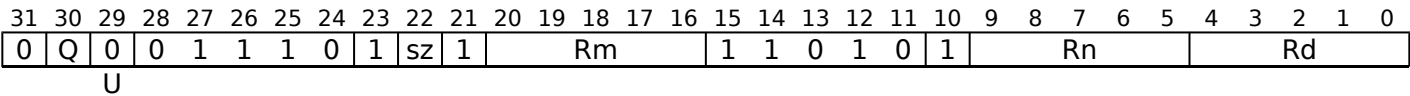
Half-precision

FSUB <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean abs = (U == '1');
```

Single-precision and double-precision



Single-precision and double-precision

FSUB <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean abs = (U == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the half-precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":



sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;
bits(esize) diff;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    diff = FPSub(element1, element2, FPCR);
    Elem[result, e, esize] = if abs then FPAbs(diff) else diff;

V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

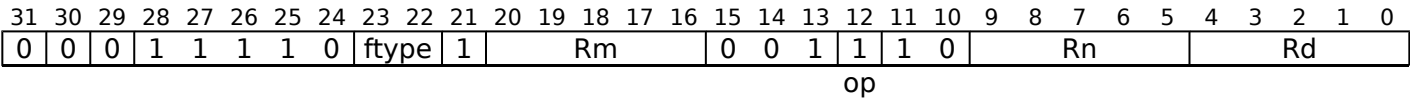
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# FSUB (scalar)

Floating-point Subtract (scalar). This instruction subtracts the floating-point value of the second source SIMD&FP register from the floating-point value of the first source SIMD&FP register, and writes the result to the destination SIMD&FP register.

This instruction can generate a floating-point exception. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Half-precision (ftype == 11) (Armv8.2)

FSUB <Hd>, <Hn>, <Hm>

## Single-precision (ftype == 00)

FSUB <Sd>, <Sn>, <Sm>

## Double-precision (ftype == 01)

FSUB <Dd>, <Dn>, <Dm>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer datasize;
case ftype of
    when '00' datasize = 32;
    when '01' datasize = 64;
    when '10' UNDEFINED;
    when '11'
        if HaveFP16Ext() then
            datasize = 16;
        else
            UNDEFINED;
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Dn> Is the 64-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Dm> Is the 64-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Hm> Is the 16-bit name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Sm> Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
bits(datasize) result;  
bits(datasize) operand1 = V[n];  
bits(datasize) operand2 = V[m];  
  
result = FPSub(operand1, operand2, FPCR);  
V[d] = result;
```

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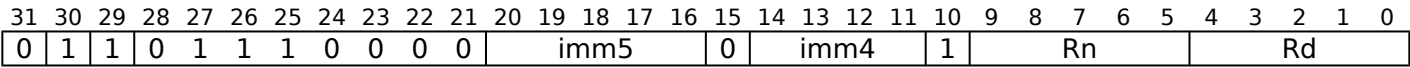
INS (element)

Insert vector element from another vector element. This instruction copies the vector element of the source SIMD&FP register to the specified vector element of the destination SIMD&FP register.

This instruction can insert data into individual elements within a SIMD&FP register without clearing the remaining bits to zero.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This instruction is used by the alias MOV (element).



Advanced SIMD

INS <Vd>.<Ts>[<index1>], <Vn>.<Ts>[<index2>]

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer size = LowestSetBit(imm5);
if size > 3 then UNDEFINED;

integer dst_index = UInt(imm5<4:size+1>);
integer src_index = UInt(imm4<3:size>);
integer idxdsize = if imm4<3> == '1' then 128 else 64;
// imm4<size-1:0> is IGNORED

integer esize = 8 << size;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ts> Is an element size specifier, encoded in "imm5":

imm5	<Ts>
x0000	RESERVED
xxxx1	B
xxx10	H
xx100	S
x1000	D

<index1> Is the destination element index encoded in "imm5":

imm5	<index1>
x0000	RESERVED
xxxx1	imm5<4:1>
xxx10	imm5<4:2>
xx100	imm5<4:3>
x1000	imm5<4>

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<index2> Is the source element index encoded in "imm5:imm4":

imm5	<index2>
x0000	RESERVED
xxxx1	imm4<3:0>
xxx10	imm4<3:1>
xx100	imm4<3:2>
x1000	imm4<3>

Unspecified bits in "imm4" are ignored but should be set to zero by an assembler.

## Operation

```
CheckFPAdvSIMDEnabled64();  
bits(idxdsize) operand = V[n];  
bits(128) result;  
  
result = V[d];  
Elem[result, dst_index, esize] = Elem[operand, src_index, esize];  
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# INS (general)

Insert vector element from general-purpose register. This instruction copies the contents of the source general-purpose register to the specified vector element in the destination SIMD&FP register.

This instruction can insert data into individual elements within a SIMD&FP register without clearing the remaining bits to zero.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This instruction is used by the alias [MOV \(from general\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	1	1	1	0	0	0	0	imm5					0	0	0	1	1	1	Rn					Rd				

## Advanced SIMD

```
INS <Vd>.<Ts>[<index>], <R><n>

integer d = UInt(Rd);
integer n = UInt(Rn);

integer size = LowestSetBit(imm5);

if size > 3 then UNDEFINED;
integer index = UInt(imm5<4:size+1>);

integer esize = 8 << size;
```

## Assembler Symbols

- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Ts>

Is an element size specifier, encoded in "imm5":

imm5	<Ts>
x0000	RESERVED
xxx1	B
xx10	H
xx100	S
x1000	D
- <index>

Is the element index encoded in "imm5":

imm5	<index>
x0000	RESERVED
xxx1	imm5<4:1>
xx10	imm5<4:2>
xx100	imm5<4:3>
x1000	imm5<4>
- <R>

Is the width specifier for the general-purpose source register, encoded in "imm5":

imm5	<R>
x0000	RESERVED
xxx1	W
xx10	W
xx100	W
x1000	X
- <n>

Is the number [0-30] of the general-purpose source register or ZR (31), encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
bits(esize) element = X[n];  
bits(128) result;  
  
result = V[d];  
Elem[result, index, esize] = element;  
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# LD1 (multiple structures)

Load multiple single-element structures to one, two, three, or four registers. This instruction loads multiple single-element structures from memory and writes the result to one, two, three, or four SIMD&FP registers. Depending on the settings in the `CPACR_EL1`, `CPTR_EL2`, and `CPTR_EL3` registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

## No offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	0	0	1	0	0	0	0	0	0	x	x	1	x	size		Rn				Rt					
L										opcode																					

## One register (opcode == 0111)

LD1 { <Vt>.<T> }, [<Xn|SP>]

## Two registers (opcode == 1010)

LD1 { <Vt>.<T>, <Vt2>.<T> }, [<Xn|SP>]

## Three registers (opcode == 0110)

LD1 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T> }, [<Xn|SP>]

## Four registers (opcode == 0010)

LD1 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T>, <Vt4>.<T> }, [<Xn|SP>]

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

## Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	0	1	1	0	Rm				x	x	1	x	size			Rn				Rt					
L										opcode																					



One register, immediate offset (Rm == 11111 && opcode == 0111)

```
LD1 { <Vt>.<T> }, [<Xn|SP>], <imm>
```

One register, register offset (Rm != 11111 && opcode == 0111)

```
LD1 { <Vt>.<T> }, [<Xn|SP>], <Xm>
```

Two registers, immediate offset (Rm == 11111 && opcode == 1010)

```
LD1 { <Vt>.<T>, <Vt2>.<T> }, [<Xn|SP>], <imm>
```

Two registers, register offset (Rm != 11111 && opcode == 1010)

```
LD1 { <Vt>.<T>, <Vt2>.<T> }, [<Xn|SP>], <Xm>
```

Three registers, immediate offset (Rm == 11111 && opcode == 0110)

```
LD1 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T> }, [<Xn|SP>], <imm>
```

Three registers, register offset (Rm != 11111 && opcode == 0110)

```
LD1 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T> }, [<Xn|SP>], <Xm>
```

Four registers, immediate offset (Rm == 11111 && opcode == 0010)

```
LD1 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T>, <Vt4>.<T> }, [<Xn|SP>], <imm>
```

Four registers, register offset (Rm != 11111 && opcode == 0010)

```
LD1 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T>, <Vt4>.<T> }, [<Xn|SP>], <Xm>
```

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

Assembler Symbols

- <Vt> Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	1D
11	1	2D

- <Vt2> Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.
- <Vt3> Is the name of the third SIMD&FP register to be transferred, encoded as "Rt" plus 2 modulo 32.
- <Vt4> Is the name of the fourth SIMD&FP register to be transferred, encoded as "Rt" plus 3 modulo 32.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> For the one register, immediate offset variant: is the post-index immediate offset, encoded in "Q":

Q	<imm>
0	#8
1	#16

For the two registers, immediate offset variant: is the post-index immediate offset, encoded in “Q”:

Q	<imm>
0	#16
1	#32

For the three registers, immediate offset variant: is the post-index immediate offset, encoded in “Q”:

Q	<imm>
0	#24
1	#48

For the four registers, immediate offset variant: is the post-index immediate offset, encoded in “Q”:

Q	<imm>
0	#32
1	#64

<Xm> Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the “Rm” field.

## Shared Decode

```
MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << UInt(size);
integer elements = datasize DIV esize;

integer rpt;    // number of iterations
integer selem;  // structure elements

case opcode of
  when '0000' rpt = 1; selem = 4;    // LD/ST4 (4 registers)
  when '0010' rpt = 4; selem = 1;    // LD/ST1 (4 registers)
  when '0100' rpt = 1; selem = 3;    // LD/ST3 (3 registers)
  when '0110' rpt = 3; selem = 1;    // LD/ST1 (3 registers)
  when '0111' rpt = 1; selem = 1;    // LD/ST1 (1 register)
  when '1000' rpt = 1; selem = 2;    // LD/ST2 (2 registers)
  when '1010' rpt = 2; selem = 1;    // LD/ST1 (2 registers)
  otherwise UNDEFINED;

// .LD format only permitted with LD1 & ST1
if size:Q == '110' && selem != 1 then UNDEFINED;
```

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(datasize) rval;
integer tt;
constant integer ebytes = esize DIV 8;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
for r = 0 to rpt-1
    for e = 0 to elements-1
        tt = (t + r) MOD 32;
        for s = 0 to selem-1
            rval = V[tt];
            if memop == MemOp_LOAD then
                Elem[rval, e, esize] = Mem[address+offs, ebytes, AccType_VEC];
                V[tt] = rval;
            else // memop == MemOp_STORE
                Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, e, esize];
                offs = offs + ebytes;
                tt = (tt + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# LD1 (single structure)

Load one single-element structure to one lane of one register. This instruction loads a single-element structure from memory and writes the result to the specified lane of the SIMD&FP register without affecting the other bits of the register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

## No offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	0	1	0	0	0	0	0	0	x	x	0	S	size	Rn				Rt						
L										R	opcode																				

## 8-bit (opcode == 000)

LD1 { <Vt>.B }[<index>], [<Xn|SP>]

## 16-bit (opcode == 010 && size == x0)

LD1 { <Vt>.H }[<index>], [<Xn|SP>]

## 32-bit (opcode == 100 && size == 00)

LD1 { <Vt>.S }[<index>], [<Xn|SP>]

## 64-bit (opcode == 100 && S == 0 && size == 01)

LD1 { <Vt>.D }[<index>], [<Xn|SP>]

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

## Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	1	1	0	Rm					x	x	0	S	size	Rn				Rt						
L										R	opcode																				

**8-bit, immediate offset (Rm == 11111 && opcode == 000)**

```
LD1 { <Vt>.B }[<index>], [<Xn|SP>], #1
```

**8-bit, register offset (Rm != 11111 && opcode == 000)**

```
LD1 { <Vt>.B }[<index>], [<Xn|SP>], <Xm>
```

**16-bit, immediate offset (Rm == 11111 && opcode == 010 && size == x0)**

```
LD1 { <Vt>.H }[<index>], [<Xn|SP>], #2
```

**16-bit, register offset (Rm != 11111 && opcode == 010 && size == x0)**

```
LD1 { <Vt>.H }[<index>], [<Xn|SP>], <Xm>
```

**32-bit, immediate offset (Rm == 11111 && opcode == 100 && size == 00)**

```
LD1 { <Vt>.S }[<index>], [<Xn|SP>], #4
```

**32-bit, register offset (Rm != 11111 && opcode == 100 && size == 00)**

```
LD1 { <Vt>.S }[<index>], [<Xn|SP>], <Xm>
```

**64-bit, immediate offset (Rm == 11111 && opcode == 100 && S == 0 && size == 01)**

```
LD1 { <Vt>.D }[<index>], [<Xn|SP>], #8
```

**64-bit, register offset (Rm != 11111 && opcode == 100 && S == 0 && size == 01)**

```
LD1 { <Vt>.D }[<index>], [<Xn|SP>], <Xm>
```

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

**Assembler Symbols**

<Vt>	Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
<index>	For the 8-bit variant: is the element index, encoded in "Q:S:size". For the 16-bit variant: is the element index, encoded in "Q:S:size<1>". For the 32-bit variant: is the element index, encoded in "Q:S". For the 64-bit variant: is the element index, encoded in "Q".
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

## Shared Decode

```
integer scale = UInt(opcode<2:1>);
integer selem = UInt(opcode<0>:R) + 1;
boolean replicate = FALSE;
integer index;

case scale of
  when 3
    // load and replicate
    if L == '0' || S == '1' then UNDEFINED;
    scale = UInt(size);
    replicate = TRUE;
  when 0
    index = UInt(Q:S:size);    // B[0-15]
  when 1
    if size<0> == '1' then UNDEFINED;
    index = UInt(Q:S:size<1>); // H[0-7]
  when 2
    if size<1> == '1' then UNDEFINED;
    if size<0> == '0' then
      index = UInt(Q:S);    // S[0-3]
    else
      if S == '1' then UNDEFINED;
      index = UInt(Q);    // D[0-1]
      scale = 3;

MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << scale;
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(128) rval;
bits(esize) element;
constant integer ebytes = esize DIV 8;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
if replicate then
    // load and replicate to all elements
    for s = 0 to selem-1
        element = Mem[address+offs, ebytes, AccType_VEC];
        // replicate to fill 128- or 64-bit register
        V[t] = Replicate(element, datasize DIV esize);
        offs = offs + ebytes;
        t = (t + 1) MOD 32;
else
    // load/store one element per register
    for s = 0 to selem-1
        rval = V[t];
        if memop == MemOp_LOAD then
            // insert into one lane of 128-bit register
            Elem[rval, index, esize] = Mem[address+offs, ebytes, AccType_VEC];
            V[t] = rval;
        else // memop == MemOp_STORE
            // extract from one lane of 128-bit register
            Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, index, esize];
            offs = offs + ebytes;
            t = (t + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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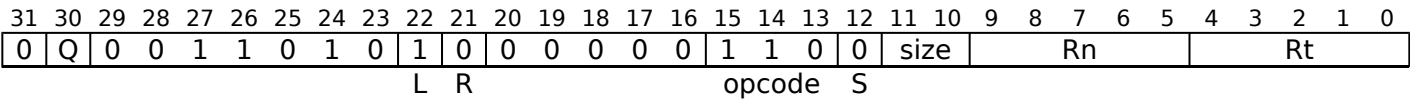
LD1R

Load one single-element structure and Replicate to all lanes (of one register). This instruction loads a single-element structure from memory and replicates the structure to all the lanes of the SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

No offset

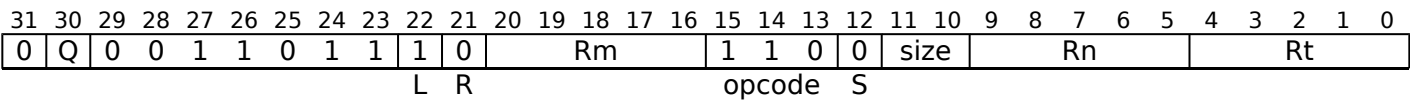


No offset

```
LD1R { <Vt>.<T> }, [<Xn|SP>]

integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

Post-index



Immediate offset (Rm == 11111)

```
LD1R { <Vt>.<T> }, [<Xn|SP>], <imm>
```

Register offset (Rm != 11111)

```
LD1R { <Vt>.<T> }, [<Xn|SP>], <Xm>

integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

Assembler Symbols

<Vt>

Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.

<T>

Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	1D
11	1	2D

<Xn|SP>

Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.



<imm> Is the post-index immediate offset, encoded in "size":

size	<imm>
00	#1
01	#2
10	#4
11	#8

<Xm> Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

## Shared Decode

```
integer scale = UInt(opcode<2:1>);
integer selem = UInt(opcode<0>:R) + 1;
boolean replicate = FALSE;
integer index;

case scale of
  when 3
    // load and replicate
    if L == '0' || S == '1' then UNDEFINED;
    scale = UInt(size);
    replicate = TRUE;
  when 0
    index = UInt(Q:S:size);    // B[0-15]
  when 1
    if size<0> == '1' then UNDEFINED;
    index = UInt(Q:S:size<1>); // H[0-7]
  when 2
    if size<1> == '1' then UNDEFINED;
    if size<0> == '0' then
      index = UInt(Q:S);    // S[0-3]
    else
      if S == '1' then UNDEFINED;
      index = UInt(Q);    // D[0-1]
      scale = 3;
MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << scale;
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(128) rval;
bits(esize) element;
constant integer ebytes = esize DIV 8;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
if replicate then
    // load and replicate to all elements
    for s = 0 to selem-1
        element = Mem[address+offs, ebytes, AccType_VEC];
        // replicate to fill 128- or 64-bit register
        V[t] = Replicate(element, datasize DIV esize);
        offs = offs + ebytes;
        t = (t + 1) MOD 32;
else
    // load/store one element per register
    for s = 0 to selem-1
        rval = V[t];
        if memop == MemOp_LOAD then
            // insert into one lane of 128-bit register
            Elem[rval, index, esize] = Mem[address+offs, ebytes, AccType_VEC];
            V[t] = rval;
        else // memop == MemOp_STORE
            // extract from one lane of 128-bit register
            Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, index, esize];
            offs = offs + ebytes;
            t = (t + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

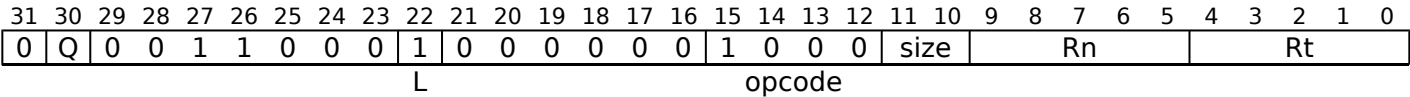
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LD2 (multiple structures)

Load multiple 2-element structures to two registers. This instruction loads multiple 2-element structures from memory and writes the result to the two SIMD&FP registers, with de-interleaving.  
For an example of de-interleaving, see LD3 (multiple structures).  
Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: No offset and Post-index

No offset

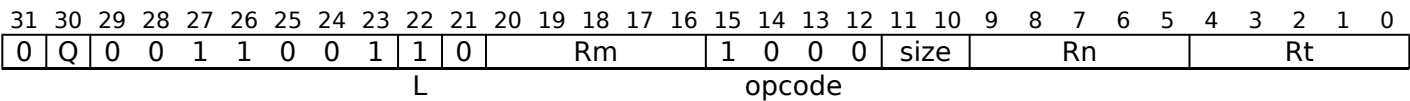


No offset

```
LD2 { <Vt>.<T>, <Vt2>.<T> }, [<Xn|SP>]

integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

Post-index



Immediate offset (Rm == 11111)

```
LD2 { <Vt>.<T>, <Vt2>.<T> }, [<Xn|SP>], <imm>
```

Register offset (Rm != 11111)

```
LD2 { <Vt>.<T>, <Vt2>.<T> }, [<Xn|SP>], <Xm>

integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

Assembler Symbols

- <Vt> Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vt2> Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the post-index immediate offset, encoded in "Q":
 

Q	<imm>
0	#16
1	#32
- <Xm> Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

### Shared Decode

```

MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << UInt(size);
integer elements = datasize DIV esize;

integer rpt;    // number of iterations
integer selem;  // structure elements

case opcode of
  when '0000' rpt = 1; selem = 4;    // LD/ST4 (4 registers)
  when '0010' rpt = 4; selem = 1;    // LD/ST1 (4 registers)
  when '0100' rpt = 1; selem = 3;    // LD/ST3 (3 registers)
  when '0110' rpt = 3; selem = 1;    // LD/ST1 (3 registers)
  when '0111' rpt = 1; selem = 1;    // LD/ST1 (1 register)
  when '1000' rpt = 1; selem = 2;    // LD/ST2 (2 registers)
  when '1010' rpt = 2; selem = 1;    // LD/ST1 (2 registers)
  otherwise UNDEFINED;

// .1D format only permitted with LD1 & ST1
if size:Q == '110' && selem != 1 then UNDEFINED;

```

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(datasize) rval;
integer tt;
constant integer ebytes = esize DIV 8;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
for r = 0 to rpt-1
    for e = 0 to elements-1
        tt = (t + r) MOD 32;
        for s = 0 to selem-1
            rval = V[tt];
            if memop == MemOp_LOAD then
                Elem[rval, e, esize] = Mem[address+offs, ebytes, AccType_VEC];
                V[tt] = rval;
            else // memop == MemOp_STORE
                Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, e, esize];
                offs = offs + ebytes;
                tt = (tt + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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## LD2 (single structure)

Load single 2-element structure to one lane of two registers. This instruction loads a 2-element structure from memory and writes the result to the corresponding elements of the two SIMD&FP registers without affecting the other bits of the registers.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

### No offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	0	1	1	0	0	0	0	0	x	x	0	S	size	Rn				Rt						
L										R	opcode																				

### 8-bit (opcode == 000)

LD2 { <Vt>.B, <Vt2>.B }[<index>], [<Xn|SP>]

### 16-bit (opcode == 010 && size == x0)

LD2 { <Vt>.H, <Vt2>.H }[<index>], [<Xn|SP>]

### 32-bit (opcode == 100 && size == 00)

LD2 { <Vt>.S, <Vt2>.S }[<index>], [<Xn|SP>]

### 64-bit (opcode == 100 && S == 0 && size == 01)

LD2 { <Vt>.D, <Vt2>.D }[<index>], [<Xn|SP>]

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

### Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	1	1	1	Rm				x	x	0	S	size	Rn				Rt							
L										R	opcode																				

**8-bit, immediate offset (Rm == 11111 && opcode == 000)**

```
LD2 { <Vt>.B, <Vt2>.B }[<index>], [<Xn|SP>], #2
```

**8-bit, register offset (Rm != 11111 && opcode == 000)**

```
LD2 { <Vt>.B, <Vt2>.B }[<index>], [<Xn|SP>], <Xm>
```

**16-bit, immediate offset (Rm == 11111 && opcode == 010 && size == x0)**

```
LD2 { <Vt>.H, <Vt2>.H }[<index>], [<Xn|SP>], #4
```

**16-bit, register offset (Rm != 11111 && opcode == 010 && size == x0)**

```
LD2 { <Vt>.H, <Vt2>.H }[<index>], [<Xn|SP>], <Xm>
```

**32-bit, immediate offset (Rm == 11111 && opcode == 100 && size == 00)**

```
LD2 { <Vt>.S, <Vt2>.S }[<index>], [<Xn|SP>], #8
```

**32-bit, register offset (Rm != 11111 && opcode == 100 && size == 00)**

```
LD2 { <Vt>.S, <Vt2>.S }[<index>], [<Xn|SP>], <Xm>
```

**64-bit, immediate offset (Rm == 11111 && opcode == 100 && S == 0 && size == 01)**

```
LD2 { <Vt>.D, <Vt2>.D }[<index>], [<Xn|SP>], #16
```

**64-bit, register offset (Rm != 11111 && opcode == 100 && S == 0 && size == 01)**

```
LD2 { <Vt>.D, <Vt2>.D }[<index>], [<Xn|SP>], <Xm>
```

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

**Assembler Symbols**

<Vt>	Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
<Vt2>	Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.
<index>	For the 8-bit variant: is the element index, encoded in "Q:S:size". For the 16-bit variant: is the element index, encoded in "Q:S:size<1>". For the 32-bit variant: is the element index, encoded in "Q:S". For the 64-bit variant: is the element index, encoded in "Q".
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

## Shared Decode

```
integer scale = UInt(opcode<2:1>);
integer selem = UInt(opcode<0>:R) + 1;
boolean replicate = FALSE;
integer index;

case scale of
  when 3
    // load and replicate
    if L == '0' || S == '1' then UNDEFINED;
    scale = UInt(size);
    replicate = TRUE;
  when 0
    index = UInt(Q:S:size);    // B[0-15]
  when 1
    if size<0> == '1' then UNDEFINED;
    index = UInt(Q:S:size<1>); // H[0-7]
  when 2
    if size<1> == '1' then UNDEFINED;
    if size<0> == '0' then
      index = UInt(Q:S);    // S[0-3]
    else
      if S == '1' then UNDEFINED;
      index = UInt(Q);    // D[0-1]
      scale = 3;

MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << scale;
```



## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(128) rval;
bits(esize) element;
constant integer ebytes = esize DIV 8;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
if replicate then
    // load and replicate to all elements
    for s = 0 to selem-1
        element = Mem[address+offs, ebytes, AccType_VEC];
        // replicate to fill 128- or 64-bit register
        V[t] = Replicate(element, datasize DIV esize);
        offs = offs + ebytes;
        t = (t + 1) MOD 32;
else
    // load/store one element per register
    for s = 0 to selem-1
        rval = V[t];
        if memop == MemOp_LOAD then
            // insert into one lane of 128-bit register
            Elem[rval, index, esize] = Mem[address+offs, ebytes, AccType_VEC];
            V[t] = rval;
        else // memop == MemOp_STORE
            // extract from one lane of 128-bit register
            Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, index, esize];
            offs = offs + ebytes;
            t = (t + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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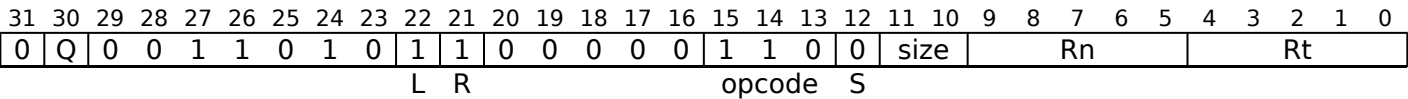
LD2R

Load single 2-element structure and Replicate to all lanes of two registers. This instruction loads a 2-element structure from memory and replicates the structure to all the lanes of the two SIMD&FP registers.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: No offset and Post-index

No offset

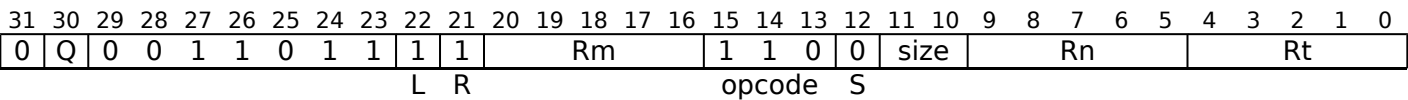


No offset

```
LD2R { <Vt>.<T>, <Vt2>.<T> }, [<Xn|SP>]

integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

Post-index



Immediate offset (Rm == 11111)

```
LD2R { <Vt>.<T>, <Vt2>.<T> }, [<Xn|SP>], <imm>
```

Register offset (Rm != 11111)

```
LD2R { <Vt>.<T>, <Vt2>.<T> }, [<Xn|SP>], <Xm>

integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

Assembler Symbols

- <Vt>

Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
- <T>

Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	1D
11	1	2D
- <Vt2>

Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.

- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the post-index immediate offset, encoded in "size":
- | size | <imm> |
|------|-------|
| 00   | #2    |
| 01   | #4    |
| 10   | #8    |
| 11   | #16   |
- <Xm> Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

### Shared Decode

```

integer scale = UInt(opcode<2:1>);
integer selem = UInt(opcode<0>:R) + 1;
boolean replicate = FALSE;
integer index;

case scale of
  when 3
    // load and replicate
    if L == '0' || S == '1' then UNDEFINED;
    scale = UInt(size);
    replicate = TRUE;
  when 0
    index = UInt(Q:S:size);    // B[0-15]
  when 1
    if size<0> == '1' then UNDEFINED;
    index = UInt(Q:S:size<1>); // H[0-7]
  when 2
    if size<1> == '1' then UNDEFINED;
    if size<0> == '0' then
      index = UInt(Q:S);    // S[0-3]
    else
      if S == '1' then UNDEFINED;
      index = UInt(Q);    // D[0-1]
      scale = 3;
MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << scale;

```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(128) rval;
bits(esize) element;
constant integer ebytes = esize DIV 8;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
if replicate then
    // load and replicate to all elements
    for s = 0 to selem-1
        element = Mem[address+offs, ebytes, AccType_VEC];
        // replicate to fill 128- or 64-bit register
        V[t] = Replicate(element, datasize DIV esize);
        offs = offs + ebytes;
        t = (t + 1) MOD 32;
else
    // load/store one element per register
    for s = 0 to selem-1
        rval = V[t];
        if memop == MemOp_LOAD then
            // insert into one lane of 128-bit register
            Elem[rval, index, esize] = Mem[address+offs, ebytes, AccType_VEC];
            V[t] = rval;
        else // memop == MemOp_STORE
            // extract from one lane of 128-bit register
            Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, index, esize];
            offs = offs + ebytes;
            t = (t + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

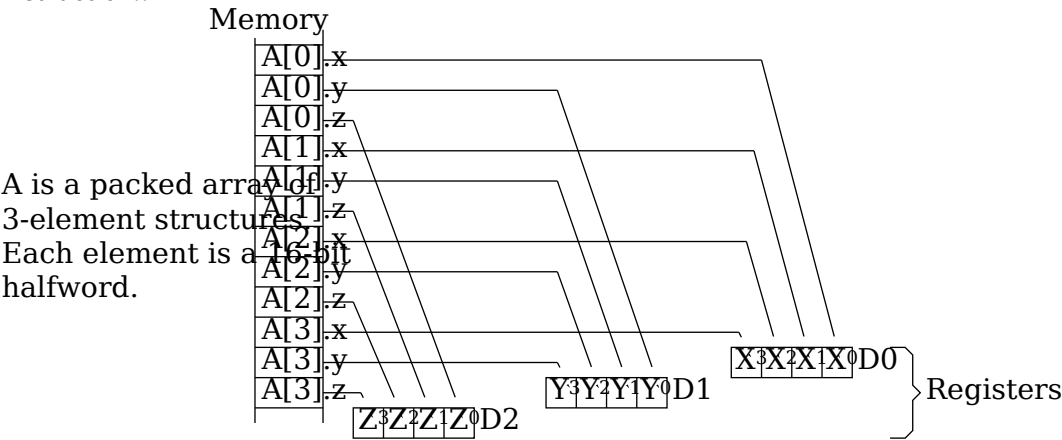
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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## LD3 (multiple structures)

Load multiple 3-element structures to three registers. This instruction loads multiple 3-element structures from memory and writes the result to the three SIMD&FP registers, with de-interleaving. The following figure shows an example of the operation of de-interleaving of a LD3.16 (multiple 3-element structures) instruction:.



Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

### No offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	size	Rn			Rt							
L										opcode																					

### No offset

LD3 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T> }, [<Xn|SP>]

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

### Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	0	1	1	0	Rm					0	1	0	0	size	Rn					Rt					
L										opcode																					

### Immediate offset (Rm == 11111)

LD3 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T> }, [<Xn|SP>], <imm>

### Register offset (Rm != 11111)

LD3 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T> }, [<Xn|SP>], <Xm>

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

Assembler Symbols

- <Vt>

Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
- <T>

Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D
- <Vt2>

Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.
- <Vt3>

Is the name of the third SIMD&FP register to be transferred, encoded as "Rt" plus 2 modulo 32.
- <Xn|SP>

Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm>

Is the post-index immediate offset, encoded in "Q":

Q	<imm>
0	#24
1	#48
- <Xm>

Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

Shared Decode

```
MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << UInt(size);
integer elements = datasize DIV esize;

integer rpt;    // number of iterations
integer selem;  // structure elements

case opcode of
  when '0000' rpt = 1; selem = 4;    // LD/ST4 (4 registers)
  when '0010' rpt = 4; selem = 1;    // LD/ST1 (4 registers)
  when '0100' rpt = 1; selem = 3;    // LD/ST3 (3 registers)
  when '0110' rpt = 3; selem = 1;    // LD/ST1 (3 registers)
  when '0111' rpt = 1; selem = 1;    // LD/ST1 (1 register)
  when '1000' rpt = 1; selem = 2;    // LD/ST2 (2 registers)
  when '1010' rpt = 2; selem = 1;    // LD/ST1 (2 registers)
  otherwise UNDEFINED;

// .LD format only permitted with LD1 & ST1
if size:Q == '110' && selem != 1 then UNDEFINED;
```

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(datasize) rval;
integer tt;
constant integer ebytes = esize DIV 8;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
for r = 0 to rpt-1
    for e = 0 to elements-1
        tt = (t + r) MOD 32;
        for s = 0 to selem-1
            rval = V[tt];
            if memop == MemOp_LOAD then
                Elem[rval, e, esize] = Mem[address+offs, ebytes, AccType_VEC];
                V[tt] = rval;
            else // memop == MemOp_STORE
                Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, e, esize];
                offs = offs + ebytes;
                tt = (tt + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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## LD3 (single structure)

Load single 3-element structure to one lane of three registers). This instruction loads a 3-element structure from memory and writes the result to the corresponding elements of the three SIMD&FP registers without affecting the other bits of the registers.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

### No offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	0	1	0	0	0	0	0	0	x	x	1	S	size	Rn			Rt							
L										R	opcode																				

### 8-bit (opcode == 001)

LD3 { <Vt>.B, <Vt2>.B, <Vt3>.B }[<index>], [<Xn|SP>]

### 16-bit (opcode == 011 && size == x0)

LD3 { <Vt>.H, <Vt2>.H, <Vt3>.H }[<index>], [<Xn|SP>]

### 32-bit (opcode == 101 && size == 00)

LD3 { <Vt>.S, <Vt2>.S, <Vt3>.S }[<index>], [<Xn|SP>]

### 64-bit (opcode == 101 && S == 0 && size == 01)

LD3 { <Vt>.D, <Vt2>.D, <Vt3>.D }[<index>], [<Xn|SP>]

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

### Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	1	1	0	Rm					x	x	1	S	size	Rn			Rt							
L										R	opcode																				



**8-bit, immediate offset (Rm == 11111 && opcode == 001)**

```
LD3 { <Vt>.B, <Vt2>.B, <Vt3>.B }[<index>], [<Xn|SP>], #3
```

**8-bit, register offset (Rm != 11111 && opcode == 001)**

```
LD3 { <Vt>.B, <Vt2>.B, <Vt3>.B }[<index>], [<Xn|SP>], <Xm>
```

**16-bit, immediate offset (Rm == 11111 && opcode == 011 && size == x0)**

```
LD3 { <Vt>.H, <Vt2>.H, <Vt3>.H }[<index>], [<Xn|SP>], #6
```

**16-bit, register offset (Rm != 11111 && opcode == 011 && size == x0)**

```
LD3 { <Vt>.H, <Vt2>.H, <Vt3>.H }[<index>], [<Xn|SP>], <Xm>
```

**32-bit, immediate offset (Rm == 11111 && opcode == 101 && size == 00)**

```
LD3 { <Vt>.S, <Vt2>.S, <Vt3>.S }[<index>], [<Xn|SP>], #12
```

**32-bit, register offset (Rm != 11111 && opcode == 101 && size == 00)**

```
LD3 { <Vt>.S, <Vt2>.S, <Vt3>.S }[<index>], [<Xn|SP>], <Xm>
```

**64-bit, immediate offset (Rm == 11111 && opcode == 101 && S == 0 && size == 01)**

```
LD3 { <Vt>.D, <Vt2>.D, <Vt3>.D }[<index>], [<Xn|SP>], #24
```

**64-bit, register offset (Rm != 11111 && opcode == 101 && S == 0 && size == 01)**

```
LD3 { <Vt>.D, <Vt2>.D, <Vt3>.D }[<index>], [<Xn|SP>], <Xm>
```

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

**Assembler Symbols**

<Vt>	Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
<Vt2>	Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.
<Vt3>	Is the name of the third SIMD&FP register to be transferred, encoded as "Rt" plus 2 modulo 32.
<index>	For the 8-bit variant: is the element index, encoded in "Q:S:size". For the 16-bit variant: is the element index, encoded in "Q:S:size<1>". For the 32-bit variant: is the element index, encoded in "Q:S". For the 64-bit variant: is the element index, encoded in "Q".
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

## Shared Decode

```
integer scale = UInt(opcode<2:1>);
integer selem = UInt(opcode<0>:R) + 1;
boolean replicate = FALSE;
integer index;

case scale of
  when 3
    // load and replicate
    if L == '0' || S == '1' then UNDEFINED;
    scale = UInt(size);
    replicate = TRUE;
  when 0
    index = UInt(Q:S:size);    // B[0-15]
  when 1
    if size<0> == '1' then UNDEFINED;
    index = UInt(Q:S:size<1>); // H[0-7]
  when 2
    if size<1> == '1' then UNDEFINED;
    if size<0> == '0' then
      index = UInt(Q:S);    // S[0-3]
    else
      if S == '1' then UNDEFINED;
      index = UInt(Q);    // D[0-1]
      scale = 3;

MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << scale;
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(128) rval;
bits(esize) element;
constant integer ebytes = esize DIV 8;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
if replicate then
    // load and replicate to all elements
    for s = 0 to selem-1
        element = Mem[address+offs, ebytes, AccType_VEC];
        // replicate to fill 128- or 64-bit register
        V[t] = Replicate(element, datasize DIV esize);
        offs = offs + ebytes;
        t = (t + 1) MOD 32;
else
    // load/store one element per register
    for s = 0 to selem-1
        rval = V[t];
        if memop == MemOp_LOAD then
            // insert into one lane of 128-bit register
            Elem[rval, index, esize] = Mem[address+offs, ebytes, AccType_VEC];
            V[t] = rval;
        else // memop == MemOp_STORE
            // extract from one lane of 128-bit register
            Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, index, esize];
            offs = offs + ebytes;
            t = (t + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

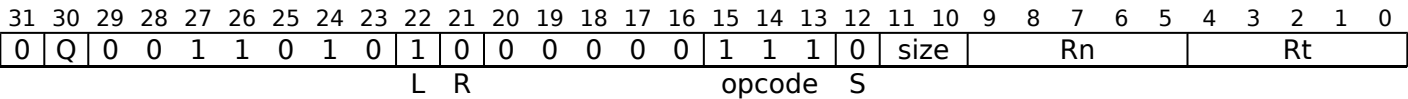
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LD3R

Load single 3-element structure and Replicate to all lanes of three registers. This instruction loads a 3-element structure from memory and replicates the structure to all the lanes of the three SIMD&FP registers. Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

No offset

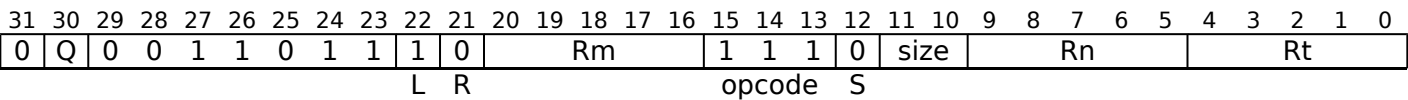


No offset

```
LD3R { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T> }, [<Xn|SP>]

integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

Post-index



Immediate offset (Rm == 11111)

```
LD3R { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T> }, [<Xn|SP>], <imm>
```

Register offset (Rm != 11111)

```
LD3R { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T> }, [<Xn|SP>], <Xm>

integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

Assembler Symbols

- <Vt>

Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
- <T>

Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	1D
11	1	2D
- <Vt2>

Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.

- <Vt3> Is the name of the third SIMD&FP register to be transferred, encoded as "Rt" plus 2 modulo 32.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the post-index immediate offset, encoded in "size":
 

size	<imm>
00	#3
01	#6
10	#12
11	#24
- <Xm> Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

### Shared Decode

```

integer scale = UInt(opcode<2:1>);
integer selem = UInt(opcode<0>:R) + 1;
boolean replicate = FALSE;
integer index;

case scale of
  when 3
    // load and replicate
    if L == '0' || S == '1' then UNDEFINED;
    scale = UInt(size);
    replicate = TRUE;
  when 0
    index = UInt(Q:S:size);    // B[0-15]
  when 1
    if size<0> == '1' then UNDEFINED;
    index = UInt(Q:S:size<1>); // H[0-7]
  when 2
    if size<1> == '1' then UNDEFINED;
    if size<0> == '0' then
      index = UInt(Q:S);    // S[0-3]
    else
      if S == '1' then UNDEFINED;
      index = UInt(Q);      // D[0-1]
      scale = 3;

MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << scale;

```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(128) rval;
bits(esize) element;
constant integer ebytes = esize DIV 8;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
if replicate then
    // load and replicate to all elements
    for s = 0 to selem-1
        element = Mem[address+offs, ebytes, AccType_VEC];
        // replicate to fill 128- or 64-bit register
        V[t] = Replicate(element, datasize DIV esize);
        offs = offs + ebytes;
        t = (t + 1) MOD 32;
else
    // load/store one element per register
    for s = 0 to selem-1
        rval = V[t];
        if memop == MemOp_LOAD then
            // insert into one lane of 128-bit register
            Elem[rval, index, esize] = Mem[address+offs, ebytes, AccType_VEC];
            V[t] = rval;
        else // memop == MemOp_STORE
            // extract from one lane of 128-bit register
            Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, index, esize];
            offs = offs + ebytes;
            t = (t + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

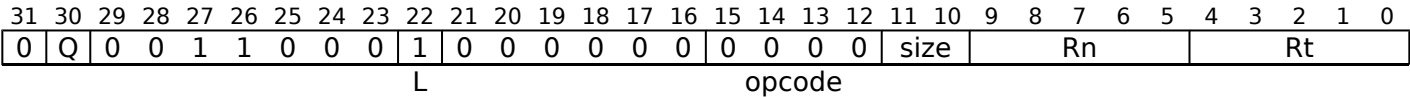
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LD4 (multiple structures)

Load multiple 4-element structures to four registers. This instruction loads multiple 4-element structures from memory and writes the result to the four SIMD&FP registers, with de-interleaving.  
For an example of de-interleaving, see LD3 (multiple structures).  
Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: No offset and Post-index

No offset

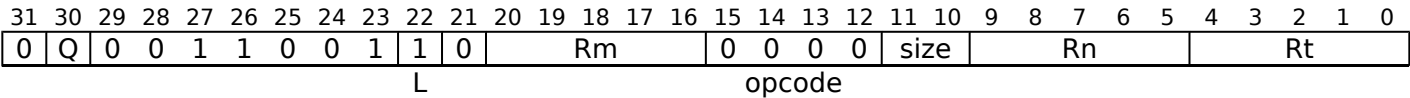


No offset

```
LD4 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T>, <Vt4>.<T> }, [<Xn|SP>]

integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

Post-index



Immediate offset (Rm == 11111)

```
LD4 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T>, <Vt4>.<T> }, [<Xn|SP>], <imm>
```

Register offset (Rm != 11111)

```
LD4 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T>, <Vt4>.<T> }, [<Xn|SP>], <Xm>

integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

Assembler Symbols

- <Vt> Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vt2> Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.
- <Vt3> Is the name of the third SIMD&FP register to be transferred, encoded as "Rt" plus 2 modulo 32.
- <Vt4> Is the name of the fourth SIMD&FP register to be transferred, encoded as "Rt" plus 3 modulo 32.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the post-index immediate offset, encoded in "Q":
 

Q	<imm>
0	#32
1	#64
- <Xm> Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

### Shared Decode

```

MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << UInt(size);
integer elements = datasize DIV esize;

integer rpt;    // number of iterations
integer selem;  // structure elements

case opcode of
  when '0000' rpt = 1; selem = 4;    // LD/ST4 (4 registers)
  when '0010' rpt = 4; selem = 1;    // LD/ST1 (4 registers)
  when '0100' rpt = 1; selem = 3;    // LD/ST3 (3 registers)
  when '0110' rpt = 3; selem = 1;    // LD/ST1 (3 registers)
  when '0111' rpt = 1; selem = 1;    // LD/ST1 (1 register)
  when '1000' rpt = 1; selem = 2;    // LD/ST2 (2 registers)
  when '1010' rpt = 2; selem = 1;    // LD/ST1 (2 registers)
  otherwise UNDEFINED;

// .LD format only permitted with LD1 & ST1
if size:Q == '110' && selem != 1 then UNDEFINED;

```



## Operation

```
CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(datasize) rval;
integer tt;
constant integer ebytes = esize DIV 8;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
for r = 0 to rpt-1
    for e = 0 to elements-1
        tt = (t + r) MOD 32;
        for s = 0 to selem-1
            rval = V[tt];
            if memop == MemOp_LOAD then
                Elem[rval, e, esize] = Mem[address+offs, ebytes, AccType_VEC];
                V[tt] = rval;
            else // memop == MemOp_STORE
                Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, e, esize];
                offs = offs + ebytes;
                tt = (tt + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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## LD4 (single structure)

Load single 4-element structure to one lane of four registers. This instruction loads a 4-element structure from memory and writes the result to the corresponding elements of the four SIMD&FP registers without affecting the other bits of the registers.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

### No offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	0	1	1	0	0	0	0	0	x	x	1	S	size	Rn				Rt						
L										R										opcode											

### 8-bit (opcode == 001)

LD4 { <Vt>.B, <Vt2>.B, <Vt3>.B, <Vt4>.B }[<index>], [<Xn|SP>]

### 16-bit (opcode == 011 && size == x0)

LD4 { <Vt>.H, <Vt2>.H, <Vt3>.H, <Vt4>.H }[<index>], [<Xn|SP>]

### 32-bit (opcode == 101 && size == 00)

LD4 { <Vt>.S, <Vt2>.S, <Vt3>.S, <Vt4>.S }[<index>], [<Xn|SP>]

### 64-bit (opcode == 101 && S == 0 && size == 01)

LD4 { <Vt>.D, <Vt2>.D, <Vt3>.D, <Vt4>.D }[<index>], [<Xn|SP>]

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

### Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	1	1	1	Rm					x	x	1	S	size	Rn				Rt						
L										R	opcode																				

### 8-bit, immediate offset (Rm == 11111 && opcode == 001)

```
LD4 { <Vt>.B, <Vt2>.B, <Vt3>.B, <Vt4>.B }[<index>], [<Xn|SP>], #4
```

### 8-bit, register offset (Rm != 11111 && opcode == 001)

```
LD4 { <Vt>.B, <Vt2>.B, <Vt3>.B, <Vt4>.B }[<index>], [<Xn|SP>], <Xm>
```

### 16-bit, immediate offset (Rm == 11111 && opcode == 011 && size == x0)

```
LD4 { <Vt>.H, <Vt2>.H, <Vt3>.H, <Vt4>.H }[<index>], [<Xn|SP>], #8
```

### 16-bit, register offset (Rm != 11111 && opcode == 011 && size == x0)

```
LD4 { <Vt>.H, <Vt2>.H, <Vt3>.H, <Vt4>.H }[<index>], [<Xn|SP>], <Xm>
```

### 32-bit, immediate offset (Rm == 11111 && opcode == 101 && size == 00)

```
LD4 { <Vt>.S, <Vt2>.S, <Vt3>.S, <Vt4>.S }[<index>], [<Xn|SP>], #16
```

### 32-bit, register offset (Rm != 11111 && opcode == 101 && size == 00)

```
LD4 { <Vt>.S, <Vt2>.S, <Vt3>.S, <Vt4>.S }[<index>], [<Xn|SP>], <Xm>
```

### 64-bit, immediate offset (Rm == 11111 && opcode == 101 && S == 0 && size == 01)

```
LD4 { <Vt>.D, <Vt2>.D, <Vt3>.D, <Vt4>.D }[<index>], [<Xn|SP>], #32
```

### 64-bit, register offset (Rm != 11111 && opcode == 101 && S == 0 && size == 01)

```
LD4 { <Vt>.D, <Vt2>.D, <Vt3>.D, <Vt4>.D }[<index>], [<Xn|SP>], <Xm>
```

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

## Assembler Symbols

<Vt>	Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
<Vt2>	Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.
<Vt3>	Is the name of the third SIMD&FP register to be transferred, encoded as "Rt" plus 2 modulo 32.
<Vt4>	Is the name of the fourth SIMD&FP register to be transferred, encoded as "Rt" plus 3 modulo 32.
<index>	For the 8-bit variant: is the element index, encoded in "Q:S:size". For the 16-bit variant: is the element index, encoded in "Q:S:size<1>". For the 32-bit variant: is the element index, encoded in "Q:S". For the 64-bit variant: is the element index, encoded in "Q".
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

## Shared Decode

```
integer scale = UInt(opcode<2:1>);
integer selem = UInt(opcode<0>:R) + 1;
boolean replicate = FALSE;
integer index;

case scale of
  when 3
    // load and replicate
    if L == '0' || S == '1' then UNDEFINED;
    scale = UInt(size);
    replicate = TRUE;
  when 0
    index = UInt(Q:S:size);    // B[0-15]
  when 1
    if size<0> == '1' then UNDEFINED;
    index = UInt(Q:S:size<1>); // H[0-7]
  when 2
    if size<1> == '1' then UNDEFINED;
    if size<0> == '0' then
      index = UInt(Q:S);    // S[0-3]
    else
      if S == '1' then UNDEFINED;
      index = UInt(Q);    // D[0-1]
      scale = 3;

MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << scale;
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(128) rval;
bits(esize) element;
constant integer ebytes = esize DIV 8;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
if replicate then
    // load and replicate to all elements
    for s = 0 to selem-1
        element = Mem[address+offs, ebytes, AccType_VEC];
        // replicate to fill 128- or 64-bit register
        V[t] = Replicate(element, datasize DIV esize);
        offs = offs + ebytes;
        t = (t + 1) MOD 32;
else
    // load/store one element per register
    for s = 0 to selem-1
        rval = V[t];
        if memop == MemOp_LOAD then
            // insert into one lane of 128-bit register
            Elem[rval, index, esize] = Mem[address+offs, ebytes, AccType_VEC];
            V[t] = rval;
        else // memop == MemOp_STORE
            // extract from one lane of 128-bit register
            Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, index, esize];
            offs = offs + ebytes;
            t = (t + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

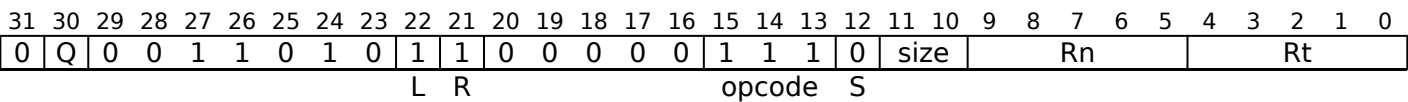
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LD4R

Load single 4-element structure and Replicate to all lanes of four registers. This instruction loads a 4-element structure from memory and replicates the structure to all the lanes of the four SIMD&FP registers. Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

No offset

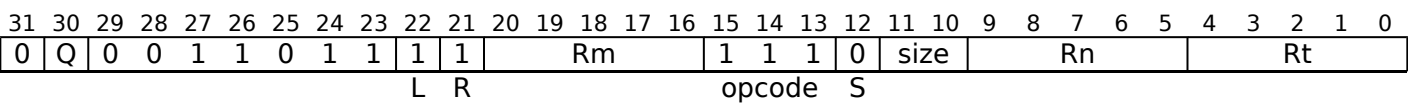


No offset

```
LD4R { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T>, <Vt4>.<T> }, [<Xn|SP>]

integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

Post-index



Immediate offset (Rm == 11111)

```
LD4R { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T>, <Vt4>.<T> }, [<Xn|SP>], <imm>
```

Register offset (Rm != 11111)

```
LD4R { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T>, <Vt4>.<T> }, [<Xn|SP>], <Xm>

integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

Assembler Symbols

- <Vt>

Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
- <T>

Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	1D
11	1	2D
- <Vt2>

Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.

- <Vt3> Is the name of the third SIMD&FP register to be transferred, encoded as "Rt" plus 2 modulo 32.
- <Vt4> Is the name of the fourth SIMD&FP register to be transferred, encoded as "Rt" plus 3 modulo 32.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the post-index immediate offset, encoded in "size":

size	<imm>
00	#4
01	#8
10	#16
11	#32

- <Xm> Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

## Shared Decode

```

integer scale = UInt(opcode<2:1>);
integer selem = UInt(opcode<0>:R) + 1;
boolean replicate = FALSE;
integer index;

case scale of
  when 3
    // load and replicate
    if L == '0' || S == '1' then UNDEFINED;
    scale = UInt(size);
    replicate = TRUE;
  when 0
    index = UInt(Q:S:size);    // B[0-15]
  when 1
    if size<0> == '1' then UNDEFINED;
    index = UInt(Q:S:size<1>); // H[0-7]
  when 2
    if size<1> == '1' then UNDEFINED;
    if size<0> == '0' then
      index = UInt(Q:S);    // S[0-3]
    else
      if S == '1' then UNDEFINED;
      index = UInt(Q);    // D[0-1]
      scale = 3;

MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << scale;

```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(128) rval;
bits(esize) element;
constant integer ebytes = esize DIV 8;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
if replicate then
    // load and replicate to all elements
    for s = 0 to selem-1
        element = Mem[address+offs, ebytes, AccType_VEC];
        // replicate to fill 128- or 64-bit register
        V[t] = Replicate(element, datasize DIV esize);
        offs = offs + ebytes;
        t = (t + 1) MOD 32;
else
    // load/store one element per register
    for s = 0 to selem-1
        rval = V[t];
        if memop == MemOp_LOAD then
            // insert into one lane of 128-bit register
            Elem[rval, index, esize] = Mem[address+offs, ebytes, AccType_VEC];
            V[t] = rval;
        else // memop == MemOp_STORE
            // extract from one lane of 128-bit register
            Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, index, esize];
            offs = offs + ebytes;
            t = (t + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

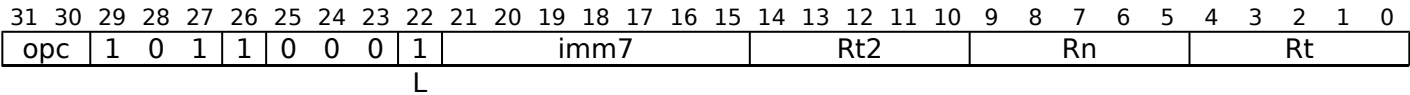
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# LDNP (SIMD&FP)

Load Pair of SIMD&FP registers, with Non-temporal hint. This instruction loads a pair of SIMD&FP registers from memory, issuing a hint to the memory system that the access is non-temporal. The address that is used for the load is calculated from a base register value and an optional immediate offset.

For information about non-temporal pair instructions, see [Load/Store SIMD and Floating-point Non-temporal pair](#). Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## 32-bit (opc == 00)

LDNP <St1>, <St2>, [<Xn|SP>{, #<imm>}]

## 64-bit (opc == 01)

LDNP <Dt1>, <Dt2>, [<Xn|SP>{, #<imm>}]

## 128-bit (opc == 10)

LDNP <Qt1>, <Qt2>, [<Xn|SP>{, #<imm>}]

// Empty.

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [LDNP \(SIMD&FP\)](#).

## Assembler Symbols

- <Dt1> Is the 64-bit name of the first SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Dt2> Is the 64-bit name of the second SIMD&FP register to be transferred, encoded in the "Rt2" field.
- <Qt1> Is the 128-bit name of the first SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Qt2> Is the 128-bit name of the second SIMD&FP register to be transferred, encoded in the "Rt2" field.
- <St1> Is the 32-bit name of the first SIMD&FP register to be transferred, encoded in the "Rt" field.
- <St2> Is the 32-bit name of the second SIMD&FP register to be transferred, encoded in the "Rt2" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> For the 32-bit variant: is the optional signed immediate byte offset, a multiple of 4 in the range -256 to 252, defaulting to 0 and encoded in the "imm7" field as <imm>/4.  
For the 64-bit variant: is the optional signed immediate byte offset, a multiple of 8 in the range -512 to 504, defaulting to 0 and encoded in the "imm7" field as <imm>/8.  
For the 128-bit variant: is the optional signed immediate byte offset, a multiple of 16 in the range -1024 to 1008, defaulting to 0 and encoded in the "imm7" field as <imm>/16.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer t2 = UInt(Rt2);
if opc == '11' then UNDEFINED;
integer scale = 2 + UInt(opc);
integer datasize = 8 << scale;
bits(64) offset = LSL(SignExtend(imm7, 64), scale);
boolean tag_checked = n != 31;
```

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(datasize) data1;
bits(datasize) data2;
constant integer dbytes = datasize DIV 8;
boolean rt_unknown = FALSE;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if t == t2 then
    Constraint c = ConstrainUnpredictable(Unpredictable_LDPOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rt_unknown = TRUE;    // result is UNKNOWN
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data1 = Mem[address, dbytes, AccType_VECSTREAM];
data2 = Mem[address+dbytes, dbytes, AccType_VECSTREAM];
if rt_unknown then
    data1 = bits(datasize) UNKNOWN;
    data2 = bits(datasize) UNKNOWN;
V[t] = data1;
V[t2] = data2;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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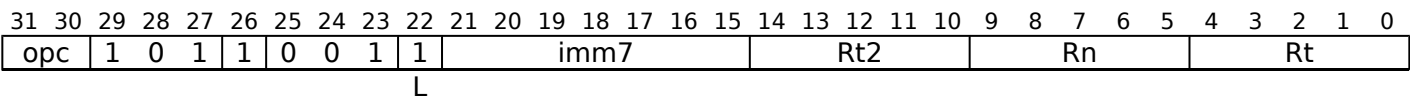
# LDP (SIMD&FP)

Load Pair of SIMD&FP registers. This instruction loads a pair of SIMD&FP registers from memory. The address that is used for the load is calculated from a base register value and an optional immediate offset.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Signed offset](#)

## Post-index



### 32-bit (opc == 00)

LDP <St1>, <St2>, [<Xn|SP>], #<imm>

### 64-bit (opc == 01)

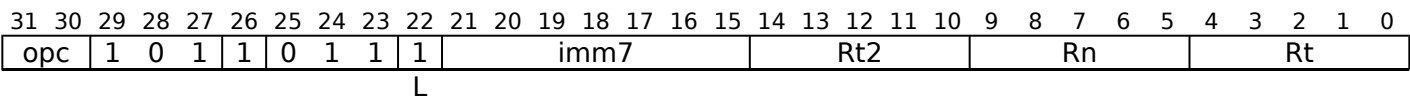
LDP <Dt1>, <Dt2>, [<Xn|SP>], #<imm>

### 128-bit (opc == 10)

LDP <Qt1>, <Qt2>, [<Xn|SP>], #<imm>

boolean wback = TRUE;  
boolean postindex = TRUE;

## Pre-index



### 32-bit (opc == 00)

LDP <St1>, <St2>, [<Xn|SP>, #<imm>]!

### 64-bit (opc == 01)

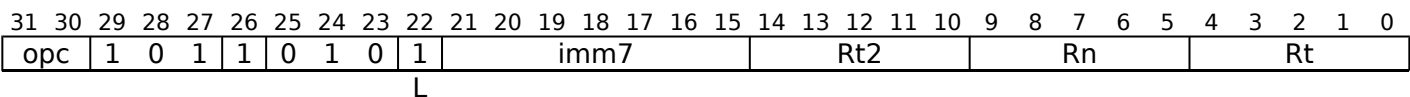
LDP <Dt1>, <Dt2>, [<Xn|SP>, #<imm>]!

### 128-bit (opc == 10)

LDP <Qt1>, <Qt2>, [<Xn|SP>, #<imm>]!

boolean wback = TRUE;  
boolean postindex = FALSE;

## Signed offset



### 32-bit (opc == 00)

```
LDP <St1>, <St2>, [<Xn|SP>{, #<imm>}]
```

### 64-bit (opc == 01)

```
LDP <Dt1>, <Dt2>, [<Xn|SP>{, #<imm>}]
```

### 128-bit (opc == 10)

```
LDP <Qt1>, <Qt2>, [<Xn|SP>{, #<imm>}]
```

```
boolean wback = FALSE;  
boolean postindex = FALSE;
```

For information about the CONSTRAINED UNPREDICTABLE behavior of this instruction, see [Architectural Constraints on UNPREDICTABLE behaviors](#), and particularly [LDP \(SIMD&FP\)](#).

## Assembler Symbols

<Dt1>	Is the 64-bit name of the first SIMD&FP register to be transferred, encoded in the "Rt" field.
<Dt2>	Is the 64-bit name of the second SIMD&FP register to be transferred, encoded in the "Rt2" field.
<Qt1>	Is the 128-bit name of the first SIMD&FP register to be transferred, encoded in the "Rt" field.
<Qt2>	Is the 128-bit name of the second SIMD&FP register to be transferred, encoded in the "Rt2" field.
<St1>	Is the 32-bit name of the first SIMD&FP register to be transferred, encoded in the "Rt" field.
<St2>	Is the 32-bit name of the second SIMD&FP register to be transferred, encoded in the "Rt2" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<imm>	For the 32-bit post-index and 32-bit pre-index variant: is the signed immediate byte offset, a multiple of 4 in the range -256 to 252, encoded in the "imm7" field as <imm>/4.  For the 32-bit signed offset variant: is the optional signed immediate byte offset, a multiple of 4 in the range -256 to 252, defaulting to 0 and encoded in the "imm7" field as <imm>/4.  For the 64-bit post-index and 64-bit pre-index variant: is the signed immediate byte offset, a multiple of 8 in the range -512 to 504, encoded in the "imm7" field as <imm>/8.  For the 64-bit signed offset variant: is the optional signed immediate byte offset, a multiple of 8 in the range -512 to 504, defaulting to 0 and encoded in the "imm7" field as <imm>/8.  For the 128-bit post-index and 128-bit pre-index variant: is the signed immediate byte offset, a multiple of 16 in the range -1024 to 1008, encoded in the "imm7" field as <imm>/16.  For the 128-bit signed offset variant: is the optional signed immediate byte offset, a multiple of 16 in the range -1024 to 1008, defaulting to 0 and encoded in the "imm7" field as <imm>/16.

## Shared Decode

```
integer n = UInt(Rn);  
integer t = UInt(Rt);  
integer t2 = UInt(Rt2);  
if opc == '11' then UNDEFINED;  
integer scale = 2 + UInt(opc);  
integer datasize = 8 << scale;  
bits(64) offset = LSL(SignExtend(imm7, 64), scale);  
boolean tag_checked = wback || n != 31;
```

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(datasize) data1;
bits(datasize) data2;
constant integer dbytes = datasize DIV 8;
boolean rt_unknown = FALSE;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if t == t2 then
    Constraint c = ConstrainUnpredictable(Unpredictable_LDPOVERLAP);
    assert c IN {Constraint_UNKNOWN, Constraint_UNDEF, Constraint_NOP};
    case c of
        when Constraint_UNKNOWN rt_unknown = TRUE;    // result is UNKNOWN
        when Constraint_UNDEF    UNDEFINED;
        when Constraint_NOP      EndOfInstruction();

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

data1 = Mem[address, dbytes, AccType_VEC];
data2 = Mem[address+dbytes, dbytes, AccType_VEC];
if rt_unknown then
    data1 = bits(datasize) UNKNOWN;
    data2 = bits(datasize) UNKNOWN;
V[t] = data1;
V[t2] = data2;

if wback then
    if postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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## LDR (immediate, SIMD&FP)

Load SIMD&FP Register (immediate offset). This instruction loads an element from memory, and writes the result as a scalar to the SIMD&FP register. The address that is used for the load is calculated from a base register value, a signed immediate offset, and an optional offset that is a multiple of the element size.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Unsigned offset](#)

### Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size	1	1	1	1	0	0	x	1	0	imm9										0	1	Rn				Rt					
opc																															

#### 8-bit (size == 00 && opc == 01)

LDR <Bt>, [<Xn|SP>], #<sim>

#### 16-bit (size == 01 && opc == 01)

LDR <Ht>, [<Xn|SP>], #<sim>

#### 32-bit (size == 10 && opc == 01)

LDR <St>, [<Xn|SP>], #<sim>

#### 64-bit (size == 11 && opc == 01)

LDR <Dt>, [<Xn|SP>], #<sim>

#### 128-bit (size == 00 && opc == 11)

LDR <Qt>, [<Xn|SP>], #<sim>

```
boolean wback = TRUE;
boolean postindex = TRUE;
integer scale = UInt(opc<1>:size);
if scale > 4 then UNDEFINED;
bits(64) offset = SignExtend(imm9, 64);
```

### Pre-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size		1	1	1	1	0	0	x	1	0	imm9									1	1	Rn				Rt					
opc																															

8-bit (size == 00 && opc == 01)

```
LDR <Bt>, [<Xn|SP>, #<sim>]!
```

16-bit (size == 01 && opc == 01)

```
LDR <Ht>, [<Xn|SP>, #<sim>]!
```

32-bit (size == 10 && opc == 01)

```
LDR <St>, [<Xn|SP>, #<sim>]!
```

64-bit (size == 11 && opc == 01)

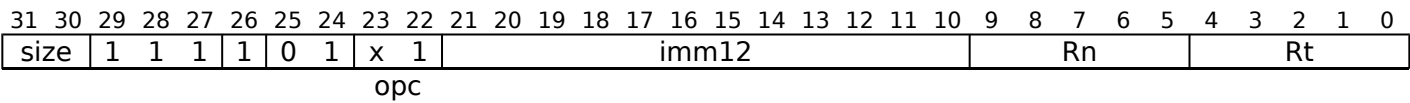
```
LDR <Dt>, [<Xn|SP>, #<sim>]!
```

128-bit (size == 00 && opc == 11)

```
LDR <Qt>, [<Xn|SP>, #<sim>]!
```

```
boolean wback = TRUE;
boolean postindex = FALSE;
integer scale = UInt(opc<l>:size);
if scale > 4 then UNDEFINED;
bits(64) offset = SignExtend(imm9, 64);
```

Unsigned offset



8-bit (size == 00 && opc == 01)

```
LDR <Bt>, [<Xn|SP>{, #<pimm>}]
```

16-bit (size == 01 && opc == 01)

```
LDR <Ht>, [<Xn|SP>{, #<pimm>}]
```

32-bit (size == 10 && opc == 01)

```
LDR <St>, [<Xn|SP>{, #<pimm>}]
```

64-bit (size == 11 && opc == 01)

```
LDR <Dt>, [<Xn|SP>{, #<pimm>}]
```

128-bit (size == 00 && opc == 11)

```
LDR <Qt>, [<Xn|SP>{, #<pimm>}]
```

```
boolean wback = FALSE;
boolean postindex = FALSE;
integer scale = UInt(opc<l>:size);
if scale > 4 then UNDEFINED;
bits(64) offset = LSL(ZeroExtend(imm12, 64), scale);
```

## Assembler Symbols

<Bt>	Is the 8-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
<Dt>	Is the 64-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
<Ht>	Is the 16-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
<Qt>	Is the 128-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
<St>	Is the 32-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<sim>	Is the signed immediate byte offset, in the range -256 to 255, encoded in the "imm9" field.
<pimm>	For the 8-bit variant: is the optional positive immediate byte offset, in the range 0 to 4095, defaulting to 0 and encoded in the "imm12" field.  For the 16-bit variant: is the optional positive immediate byte offset, a multiple of 2 in the range 0 to 8190, defaulting to 0 and encoded in the "imm12" field as <pimm>/2.  For the 32-bit variant: is the optional positive immediate byte offset, a multiple of 4 in the range 0 to 16380, defaulting to 0 and encoded in the "imm12" field as <pimm>/4.  For the 64-bit variant: is the optional positive immediate byte offset, a multiple of 8 in the range 0 to 32760, defaulting to 0 and encoded in the "imm12" field as <pimm>/8.  For the 128-bit variant: is the optional positive immediate byte offset, a multiple of 16 in the range 0 to 65520, defaulting to 0 and encoded in the "imm12" field as <pimm>/16.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
MemOp memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = 8 << scale;
boolean tag_checked = memop != MemOp_PREFETCH && (wback || n != 31);
```



## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();
bits(64) address;
bits(datasize) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

case memop of
    when MemOp_STORE
        data = V[t];
        Mem[address, datasize DIV 8, AccType_VEC] = data;

    when MemOp_LOAD
        data = Mem[address, datasize DIV 8, AccType_VEC];
        V[t] = data;

if wback then
    if postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# LDR (literal, SIMD&FP)

Load SIMD&FP Register (PC-relative literal). This instruction loads a SIMD&FP register from memory. The address that is used for the load is calculated from the PC value and an immediate offset.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
opc		0	1	1	1	0	0	imm19																	Rt						

## 32-bit (opc == 00)

LDR <St>, <label>

## 64-bit (opc == 01)

LDR <Dt>, <label>

## 128-bit (opc == 10)

LDR <Qt>, <label>

```
integer t = UInt(Rt);
integer size;
bits(64) offset;

case opc of
  when '00'
    size = 4;
  when '01'
    size = 8;
  when '10'
    size = 16;
  when '11'
    UNDEFINED;

offset = SignExtend(imm19:'00', 64);
```

## Assembler Symbols

- <Dt> Is the 64-bit name of the SIMD&FP register to be loaded, encoded in the "Rt" field.
- <Qt> Is the 128-bit name of the SIMD&FP register to be loaded, encoded in the "Rt" field.
- <St> Is the 32-bit name of the SIMD&FP register to be loaded, encoded in the "Rt" field.
- <label> Is the program label from which the data is to be loaded. Its offset from the address of this instruction, in the range +/-1MB, is encoded as "imm19" times 4.

## Operation

```
bits(64) address = PC[] + offset;
bits(size*8) data;

if HaveMTEExt() then
  SetTagCheckedInstruction(FALSE);

CheckFPAdvSIMDEnabled64();

data = Mem[address, size, AccType_VEC];
V[t] = data;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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## LDR (register, SIMD&FP)

Load SIMD&FP Register (register offset). This instruction loads a SIMD&FP register from memory. The address that is used for the load is calculated from a base register value and an offset register value. The offset can be optionally shifted and extended.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0										
size		1		1		1		0		0		x		1		1		Rm						option		S		1		0		Rn						Rt			
opc																																									

### 8-fsreg,LDR-8-fsreg (size == 00 && opc == 01 && option != 011)

LDR <Bt>, [<Xn|SP>, (<Wm>|<Xm>), <extend> {<amount>}]

### 8-fsreg,LDR-8-fsreg (size == 00 && opc == 01 && option == 011)

LDR <Bt>, [<Xn|SP>, <Xm>{, LSL <amount>}]

### 16-fsreg,LDR-16-fsreg (size == 01 && opc == 01)

LDR <Ht>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]

### 32-fsreg,LDR-32-fsreg (size == 10 && opc == 01)

LDR <St>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]

### 64-fsreg,LDR-64-fsreg (size == 11 && opc == 01)

LDR <Dt>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]

### 128-fsreg,LDR-128-fsreg (size == 00 && opc == 11)

LDR <Qt>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]

```
integer scale = UInt(opc<1>:size);
if scale > 4 then UNDEFINED;
if option<1> == '0' then UNDEFINED;    // sub-word index
ExtendType extend_type = DecodeRegExtend(option);
integer shift = if S == '1' then scale else 0;
```

## Assembler Symbols

<Bt>	Is the 8-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
<Dt>	Is the 64-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
<Ht>	Is the 16-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
<Qt>	Is the 128-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
<St>	Is the 32-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<Wm>	When option<0> is set to 0, is the 32-bit name of the general-purpose index register, encoded in the "Rm" field.
<Xm>	When option<0> is set to 1, is the 64-bit name of the general-purpose index register, encoded in the "Rm" field.
<extend>	For the 8-bit variant: is the index extend specifier, encoded in "option":

option	<extend>
010	UXTW
110	SXTW
111	SCTX

For the 128-bit, 16-bit, 32-bit and 64-bit variant: is the index extend/shift specifier, defaulting to LSL, and which must be omitted for the LSL option when <amount> is omitted. encoded in “option”:

option	<extend>
010	UXTW
011	LSL
110	SXTW
111	SCTX

<amount> For the 8-bit variant: is the index shift amount, it must be #0, encoded in “S” as 0 if omitted, or as 1 if present.

For the 16-bit variant: is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in “S”:

S	<amount>
0	#0
1	#1

For the 32-bit variant: is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in “S”:

S	<amount>
0	#0
1	#2

For the 64-bit variant: is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in “S”:

S	<amount>
0	#0
1	#3

For the 128-bit variant: is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in “S”:

S	<amount>
0	#0
1	#4

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer m = UInt(Rm);
MemOp memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = 8 << scale;
boolean tag_checked = memop != MemOp_PREFETCH;
```

## Operation

```
bits(64) offset = ExtendReg(m, extend_type, shift);
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();
bits(64) address;
bits(datasize) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

case memop of
    when MemOp_STORE
        data = V[t];
        Mem[address, datasize DIV 8, AccType_VEC] = data;

    when MemOp_LOAD
        data = Mem[address, datasize DIV 8, AccType_VEC];
        V[t] = data;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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# LDUR (SIMD&FP)

Load SIMD&FP Register (unscaled offset). This instruction loads a SIMD&FP register from memory. The address that is used for the load is calculated from a base register value and an optional immediate offset.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size		1	1	1	1	0	0	x	1	0	imm9									0	0	Rn				Rt					
opc																															

## 8-bit (size == 00 && opc == 01)

LDUR <Bt>, [<Xn|SP>{, #<sim>}]

## 16-bit (size == 01 && opc == 01)

LDUR <Ht>, [<Xn|SP>{, #<sim>}]

## 32-bit (size == 10 && opc == 01)

LDUR <St>, [<Xn|SP>{, #<sim>}]

## 64-bit (size == 11 && opc == 01)

LDUR <Dt>, [<Xn|SP>{, #<sim>}]

## 128-bit (size == 00 && opc == 11)

LDUR <Qt>, [<Xn|SP>{, #<sim>}]

```
integer scale = UInt(opc<1>:size);
if scale > 4 then UNDEFINED;
bits(64) offset = SignExtend(imm9, 64);
```

## Assembler Symbols

- <Bt> Is the 8-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Dt> Is the 64-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Ht> Is the 16-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Qt> Is the 128-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
- <St> Is the 32-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
MemOp memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = 8 << scale;
boolean tag_checked = memop != MemOp_PREFETCH && (n != 31);
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();
bits(64) address;
bits(datasize) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

case memop of
    when MemOp_STORE
        data = V[t];
        Mem[address, datasize DIV 8, AccType_VEC] = data;

    when MemOp_LOAD
        data = Mem[address, datasize DIV 8, AccType_VEC];
        V[t] = data;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

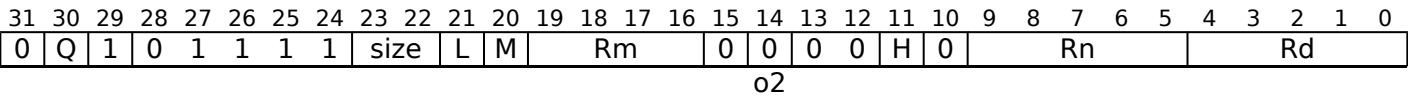
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MLA (by element)

Multiply-Add to accumulator (vector, by element). This instruction multiplies the vector elements in the first source SIMD&FP register by the specified value in the second source SIMD&FP register, and accumulates the results with the vector elements of the destination SIMD&FP register. All the values in this instruction are unsigned integer values. Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Vector

```
MLA <Vd>.<T>, <Vn>.<T>, <Vm>.<Ts>[<index>]

integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean sub_op = (o2 == '1');
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in "size:M:Rm":

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

Restricted to V0-V15 when element size <Ts> is H.

<Ts> Is an element size specifier, encoded in "size":

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in "size:L:H:M":

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(idxdsize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;
integer element1;
integer element2;
bits(esize) product;

element2 = UInt(Elem[operand2, index, esize]);
for e = 0 to elements-1
    element1 = UInt(Elem[operand1, e, esize]);
    product = (element1*element2)<esize-1:0>;
    if sub_op then
        Elem[result, e, esize] = Elem[operand3, e, esize] - product;
    else
        Elem[result, e, esize] = Elem[operand3, e, esize] + product;
V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

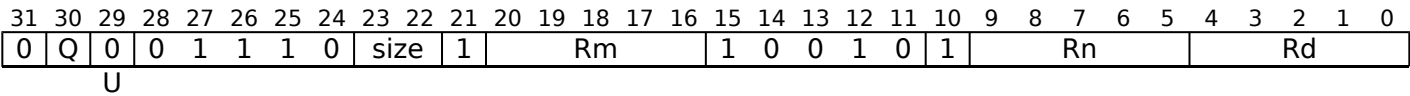
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MLA (vector)

Multiply-Add to accumulator (vector). This instruction multiplies corresponding elements in the vectors of the two source SIMD&FP registers, and accumulates the results with the vector elements of the destination SIMD&FP register.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers of the same type

```
MLA <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean sub_op = (U == '1');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":
- | size | Q | <T>      |
|------|---|----------|
| 00   | 0 | 8B       |
| 00   | 1 | 16B      |
| 01   | 0 | 4H       |
| 01   | 1 | 8H       |
| 10   | 0 | 2S       |
| 10   | 1 | 4S       |
| 11   | x | RESERVED |
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;
bits(esize) product;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    product = (UInt(element1)*UInt(element2))<esize-1:0>;
    if sub_op then
        Elem[result, e, esize] = Elem[operand3, e, esize] - product;
    else
        Elem[result, e, esize] = Elem[operand3, e, esize] + product;
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

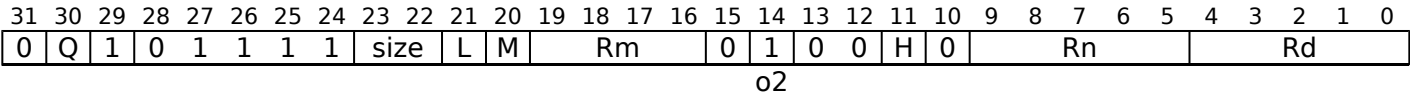
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MLS (by element)

Multiply-Subtract from accumulator (vector, by element). This instruction multiplies the vector elements in the first source SIMD&FP register by the specified value in the second source SIMD&FP register, and subtracts the results from the vector elements of the destination SIMD&FP register. All the values in this instruction are unsigned integer values.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Vector

```
MLS <Vd>.<T>, <Vn>.<T>, <Vm>.<Ts>[<index>]

integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean sub_op = (o2 == '1');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in "size:M:Rm":

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

- Restricted to V0-V15 when element size <Ts> is H.
- <Ts> Is an element size specifier, encoded in "size":

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in “size:L:H:M”:

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(idxdsize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;
integer element1;
integer element2;
bits(esize) product;

element2 = UInt(Elem[operand2, index, esize]);
for e = 0 to elements-1
    element1 = UInt(Elem[operand1, e, esize]);
    product = (element1*element2)<esize-1:0>;
    if sub_op then
        Elem[result, e, esize] = Elem[operand3, e, esize] - product;
    else
        Elem[result, e, esize] = Elem[operand3, e, esize] + product;
V[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

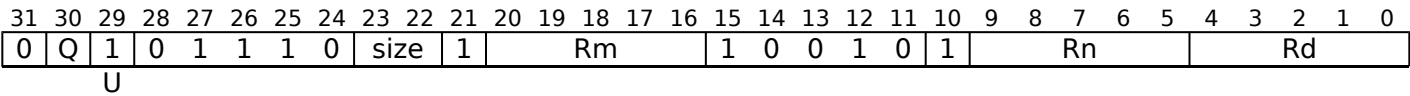
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MLS (vector)

Multiply-Subtract from accumulator (vector). This instruction multiplies corresponding elements in the vectors of the two source SIMD&FP registers, and subtracts the results from the vector elements of the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers of the same type

```
MLS <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean sub_op = (U == '1');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":
- | size | Q | <T>      |
|------|---|----------|
| 00   | 0 | 8B       |
| 00   | 1 | 16B      |
| 01   | 0 | 4H       |
| 01   | 1 | 8H       |
| 10   | 0 | 2S       |
| 10   | 1 | 4S       |
| 11   | x | RESERVED |
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;
bits(esize) product;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    product = (UInt(element1)*UInt(element2))<esize-1:0>;
    if sub_op then
        Elem[result, e, esize] = Elem[operand3, e, esize] - product;
    else
        Elem[result, e, esize] = Elem[operand3, e, esize] + product;
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# MOV (scalar)

Move vector element to scalar. This instruction duplicates the specified vector element in the SIMD&FP source register into a scalar, and writes the result to the SIMD&FP destination register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This is an alias of [DUP \(element\)](#). This means:

- The encodings in this description are named to match the encodings of [DUP \(element\)](#).
- The description of [DUP \(element\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	0	0	imm5					0	0	0	0	0	1	Rn					Rd				

## Scalar

MOV <V><d>, <Vn>.<T>[<index>]

is equivalent to

DUP <V><d>, <Vn>.<T>[<index>]

and is always the preferred disassembly.

## Assembler Symbols

<V> Is the destination width specifier, encoded in “imm5”:

imm5	<V>
x0000	RESERVED
xxx1	B
xx10	H
xx100	S
x1000	D

<d> Is the number of the SIMD&FP destination register, encoded in the “Rd” field.

<Vn> Is the name of the SIMD&FP source register, encoded in the “Rn” field.

<T> Is the element width specifier, encoded in “imm5”:

imm5	<T>
x0000	RESERVED
xxx1	B
xx10	H
xx100	S
x1000	D

<index> Is the element index encoded in “imm5”:

imm5	<index>
x0000	RESERVED
xxx1	imm5<4:1>
xx10	imm5<4:2>
xx100	imm5<4:3>
x1000	imm5<4>

## Operation

The description of [DUP \(element\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:

- The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# MOV (element)

Move vector element to another vector element. This instruction copies the vector element of the source SIMD&FP register to the specified vector element of the destination SIMD&FP register.

This instruction can insert data into individual elements within a SIMD&FP register without clearing the remaining bits to zero.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This is an alias of [INS \(element\)](#). This means:

- The encodings in this description are named to match the encodings of [INS \(element\)](#).
- The description of [INS \(element\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	1	1	0	0	0	0	imm5					0	imm4				1	Rn				Rd					

## Advanced SIMD

MOV <Vd>.<Ts>[<index1>], <Vn>.<Ts>[<index2>]

is equivalent to

[INS](#) <Vd>.<Ts>[<index1>], <Vn>.<Ts>[<index2>]

and is always the preferred disassembly.

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Ts> Is an element size specifier, encoded in "imm5":

imm5	<Ts>
x0000	RESERVED
xxxx1	B
xxx10	H
xx100	S
x1000	D

- <index1> Is the destination element index encoded in "imm5":

imm5	<index1>
x0000	RESERVED
xxxx1	imm5<4:1>
xxx10	imm5<4:2>
xx100	imm5<4:3>
x1000	imm5<4>

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.
- <index2> Is the source element index encoded in "imm5:imm4":

imm5	<index2>
x0000	RESERVED
xxxx1	imm4<3:0>
xxx10	imm4<3:1>
xx100	imm4<3:2>
x1000	imm4<3>

Unspecified bits in "imm4" are ignored but should be set to zero by an assembler.

## Operation

The description of [INS \(element\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# MOV (from general)

Move general-purpose register to a vector element. This instruction copies the contents of the source general-purpose register to the specified vector element in the destination SIMD&FP register.

This instruction can insert data into individual elements within a SIMD&FP register without clearing the remaining bits to zero.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This is an alias of [INS \(general\)](#). This means:

- The encodings in this description are named to match the encodings of [INS \(general\)](#).
- The description of [INS \(general\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	1	1	1	0	0	0	0	imm5					0	0	0	1	1	1	Rn					Rd				

## Advanced SIMD

MOV <Vd>.<Ts>[<index>], <R><n>

is equivalent to

INS <Vd>.<Ts>[<index>], <R><n>

and is always the preferred disassembly.

## Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ts> Is an element size specifier, encoded in "imm5":

imm5	<Ts>
x0000	RESERVED
xxxx1	B
xxx10	H
xx100	S
x1000	D

<index> Is the element index encoded in "imm5":

imm5	<index>
x0000	RESERVED
xxxx1	imm5<4:1>
xxx10	imm5<4:2>
xx100	imm5<4:3>
x1000	imm5<4>

<R> Is the width specifier for the general-purpose source register, encoded in "imm5":

imm5	<R>
x0000	RESERVED
xxxx1	W
xxx10	W
xx100	W
x1000	X

<n> Is the number [0-30] of the general-purpose source register or ZR (31), encoded in the "Rn" field.

## Operation

The description of [INS \(general\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# MOV (vector)

Move vector. This instruction copies the vector in the source SIMD&FP register into the destination SIMD&FP register.  
Depending on the settings in the `CPACR_EL1`, `CPTR_EL2`, and `CPTR_EL3` registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This is an alias of [ORR \(vector, register\)](#). This means:

- The encodings in this description are named to match the encodings of [ORR \(vector, register\)](#).
  - The description of [ORR \(vector, register\)](#) gives the operational pseudocode for this instruction.
- |      |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |   |   |   |    |   |   |   |   |
|------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|---|---|---|---|----|---|---|---|---|
| 31   | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9  | 8 | 7 | 6 | 5 | 4  | 3 | 2 | 1 | 0 |
| 0    | Q  | 0  | 0  | 1  | 1  | 1  | 0  | 1  | 0  | 1  | Rm |    |    |    |    | 0  | 0  | 0  | 1  | 1  | 1  | Rn |   |   |   |   | Rd |   |   |   |   |
| size |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |   |   |   |    |   |   |   |   |

## Three registers of the same type

MOV `<Vd>.<T>`, `<Vn>.<T>`

is equivalent to

`ORR <Vd>.<T>`, `<Vn>.<T>`, `<Vn>.<T>`

and is the preferred disassembly when `Rm == Rn`.

## Assembler Symbols

`<Vd>` Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

`<T>` Is an arrangement specifier, encoded in "Q":

Q	<T>
0	8B
1	16B

`<Vn>` Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

## Operation

The description of [ORR \(vector, register\)](#) gives the operational pseudocode for this instruction.

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# MOV (to general)

Move vector element to general-purpose register. This instruction reads the unsigned integer from the source SIMD&FP register, zero-extends it to form a 32-bit or 64-bit value, and writes the result to the destination general-purpose register.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This is an alias of *UMOV*. This means:

- The encodings in this description are named to match the encodings of *UMOV*.
  - The description of *UMOV* gives the operational pseudocode for this instruction.
- |      |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |   |   |   |    |   |   |   |   |
|------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|---|---|---|---|----|---|---|---|---|
| 31   | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9  | 8 | 7 | 6 | 5 | 4  | 3 | 2 | 1 | 0 |
| 0    | Q  | 0  | 0  | 1  | 1  | 1  | 0  | 0  | 0  | 0  | x  | x  | x  | 0  | 0  | 0  | 0  | 1  | 1  | 1  | 1  | Rn |   |   |   |   | Rd |   |   |   |   |
| imm5 |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |   |   |   |    |   |   |   |   |

## 32-bit (Q == 0 && imm5 == xx100)

MOV <Wd>, <Vn>.S[<index>]

is equivalent to

*UMOV* <Wd>, <Vn>.S[<index>]

and is always the preferred disassembly.

## 64-reg,UMOV-64-reg (Q == 1 && imm5 == x1000)

MOV <Xd>, <Vn>.D[<index>]

is equivalent to

*UMOV* <Xd>, <Vn>.D[<index>]

and is always the preferred disassembly.

## Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.
- <index> For the 32-bit variant: is the element index encoded in "imm5<4:3>".  
For the 64-reg,UMOV-64-reg variant: is the element index encoded in "imm5<4>".

## Operation

The description of *UMOV* gives the operational pseudocode for this instruction.

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.





## MOVI

Move Immediate (vector). This instruction places an immediate constant into every vector element of the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	op	0	1	1	1	1	0	0	0	0	0	a	b	c	cmode			0	1	d	e	f	g	h	Rd					

### 8-bit (op == 0 && cmode == 1110)

```
MOVI <Vd>.<T>, #<imm8>{, LSL #0}
```

### 16-bit shifted immediate (op == 0 && cmode == 10x0)

```
MOVI <Vd>.<T>, #<imm8>{, LSL #<amount>}
```

### 32-bit shifted immediate (op == 0 && cmode == 0xx0)

```
MOVI <Vd>.<T>, #<imm8>{, LSL #<amount>}
```

### 32-bit shifting ones (op == 0 && cmode == 110x)

```
MOVI <Vd>.<T>, #<imm8>, MSL #<amount>
```

### 64-bit scalar (Q == 0 && op == 1 && cmode == 1110)

```
MOVI <Dd>, #<imm>
```

### 64-bit vector (Q == 1 && op == 1 && cmode == 1110)

```
MOVI <Vd>.2D, #<imm>
```

```
integer rd = UInt(Rd);
```

```
integer datasize = if Q == '1' then 128 else 64;
bits(datasize) imm;
bits(64) imm64;
```

```
ImmediateOp operation;
```

```
case cmode:op of
```

```
  when '0xx00' operation = ImmediateOp\_MOVI;
  when '0xx01' operation = ImmediateOp\_MVNI;
  when '0xx10' operation = ImmediateOp\_ORR;
  when '0xx11' operation = ImmediateOp\_BIC;
  when '10x00' operation = ImmediateOp\_MOVI;
  when '10x01' operation = ImmediateOp\_MVNI;
  when '10x10' operation = ImmediateOp\_ORR;
  when '10x11' operation = ImmediateOp\_BIC;
  when '110x0' operation = ImmediateOp\_MOVI;
  when '110x1' operation = ImmediateOp\_MVNI;
  when '1110x' operation = ImmediateOp\_MOVI;
  when '11110' operation = ImmediateOp\_MOVI;
  when '11111'
```

```
    // FMOV Dn,#imm is in main FP instruction set
    if Q == '0' then UNDEFINED;
    operation = ImmediateOp\_MOVI;
```

```
imm64 = AdvSIMDExpandImm(op, cmode, a:b:c:d:e:f:g:h);
imm = Replicate(imm64, datasize DIV 64);
```

## Assembler Symbols

- <Dd> Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <imm> Is a 64-bit immediate 'aaaaaaaabbbbbbbccccccddddddeeeeeefffffffgggggggghhhhhhh', encoded in "a:b:c:d:e:f:g:h".
- <T> For the 8-bit variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	8B
1	16B

For the 16-bit variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the 32-bit variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	2S
1	4S

- <imm8> Is an 8-bit immediate encoded in "a:b:c:d:e:f:g:h".
- <amount> For the 16-bit shifted immediate variant: is the shift amount encoded in "cmode<1>":

cmode<1>	<amount>
0	0
1	8

defaulting to 0 if LSL is omitted.

For the 32-bit shifted immediate variant: is the shift amount encoded in "cmode<2:1>":

cmode<2:1>	<amount>
00	0
01	8
10	16
11	24

defaulting to 0 if LSL is omitted.

For the 32-bit shifting ones variant: is the shift amount encoded in "cmode<0>":

cmode<0>	<amount>
0	8
1	16

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand;
bits(datasize) result;

case operation of
    when ImmediateOp_MOVI
        result = imm;
    when ImmediateOp_MVNI
        result = NOT(imm);
    when ImmediateOp_ORR
        operand = V[rd];
        result = operand OR imm;
    when ImmediateOp_BIC
        operand = V[rd];
        result = operand AND NOT(imm);

V[rd] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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MUL (by element)

Multiply (vector, by element). This instruction multiplies the vector elements in the first source SIMD&FP register by the specified value in the second source SIMD&FP register, places the results in a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are unsigned integer values.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	size	L	M	Rm				1	0	0	0	H	0	Rn				Rd						

Vector

```
MUL <Vd>.<T>, <Vn>.<T>, <Vm>.<Ts>[<index>]

integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in "size:M:Rm":

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

- Restricted to V0-V15 when element size <Ts> is H.
- <Ts> Is an element size specifier, encoded in "size":

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

- <index> Is the element index, encoded in "size:L:H:M":

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(idxdsize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
bits(esize) product;

element2 = UInt(Elem[operand2, index, esize]);
for e = 0 to elements-1
    element1 = UInt(Elem[operand1, e, esize]);
    product = (element1*element2)<esize-1:0>;
    Elem[result, e, esize] = product;

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

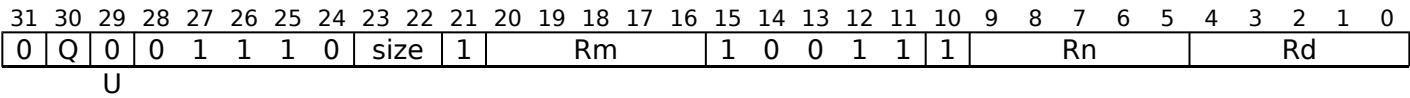
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MUL (vector)

Multiply (vector). This instruction multiplies corresponding elements in the vectors of the two source SIMD&FP registers, places the results in a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers of the same type

```
MUL <Vd>.<T>, <Vn>.<T>, <Vm>.<T>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if U == '1' && size != '00' then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean poly = (U == '1');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;
bits(esize) product;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    if poly then
        product = PolynomialMult(element1, element2)<esize-1:0>;
    else
        product = (UInt(element1)*UInt(element2))<esize-1:0>;
    Elem[result, e, esize] = product;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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MVN

Bitwise NOT (vector). This instruction reads each vector element from the source SIMD&FP register, places the inverse of each value into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This is an alias of NOT. This means:

- The encodings in this description are named to match the encodings of NOT.
- The description of NOT gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	0	1	0	0	0	0	0	0	1	0	1	1	0	Rn				Rd					

Vector

MVN <Vd>.<T>, <Vn>.<T>

is equivalent to

NOT <Vd>.<T>, <Vn>.<T>

and is always the preferred disassembly.

Assembler Symbols

- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T>

Is an arrangement specifier, encoded in "Q":

Q	<T>
0	8B
1	16B

- <Vn>

Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

The description of NOT gives the operational pseudocode for this instruction.

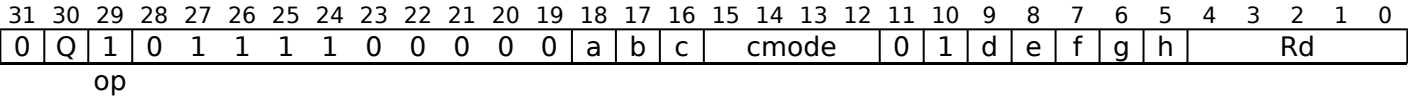
Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

MVNI

Move inverted Immediate (vector). This instruction places the inverse of an immediate constant into every vector element of the destination SIMD&FP register.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



16-bit shifted immediate (cmode == 10x0)

```
MVNI <Vd>.<T>, #<imm8>{, LSL #<amount>}
```

32-bit shifted immediate (cmode == 0xx0)

```
MVNI <Vd>.<T>, #<imm8>{, LSL #<amount>}
```

32-bit shifting ones (cmode == 110x)

```
MVNI <Vd>.<T>, #<imm8>, MSL #<amount>
```

```
integer rd = UInt(Rd);

integer datasize = if Q == '1' then 128 else 64;
bits(datasize) imm;
bits(64) imm64;

ImmediateOp operation;
case cmode:op of
  when '0xx01' operation = ImmediateOp_MVNI;
  when '0xx11' operation = ImmediateOp_BIC;
  when '10x01' operation = ImmediateOp_MVNI;
  when '10x11' operation = ImmediateOp_BIC;
  when '110x1' operation = ImmediateOp_MVNI;
  when '1110x' operation = ImmediateOp_MOVI;
  when '11111'
    // FMOV Dn,#imm is in main FP instruction set
    if Q == '0' then UNDEFINED;
    operation = ImmediateOp_MOVI;

imm64 = AdvSIMDExpandImm(op, cmode, a:b:c:d:e:f:g:h);
imm = Replicate(imm64, datasize DIV 64);
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> For the 16-bit variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the 32-bit variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	2S
1	4S

<imm8> Is an 8-bit immediate encoded in "a:b:c:d:e:f:g:h".

<amount> For the 16-bit shifted immediate variant: is the shift amount encoded in "cmode<1>":

<b>cmode&lt;1&gt;</b>	<b>&lt;amount&gt;</b>
0	0
1	8

defaulting to 0 if LSL is omitted.

For the 32-bit shifted immediate variant: is the shift amount encoded in “cmode<2:1>”:

<b>cmode&lt;2:1&gt;</b>	<b>&lt;amount&gt;</b>
00	0
01	8
10	16
11	24

defaulting to 0 if LSL is omitted.

For the 32-bit shifting ones variant: is the shift amount encoded in “cmode<0>”:

<b>cmode&lt;0&gt;</b>	<b>&lt;amount&gt;</b>
0	8
1	16

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand;
bits(datasize) result;

case operation of
  when ImmediateOp_MOVI
    result = imm;
  when ImmediateOp_MVNI
    result = NOT(imm);
  when ImmediateOp_ORR
    operand = V[rd];
    result = operand OR imm;
  when ImmediateOp_BIC
    operand = V[rd];
    result = operand AND NOT(imm);

V[rd] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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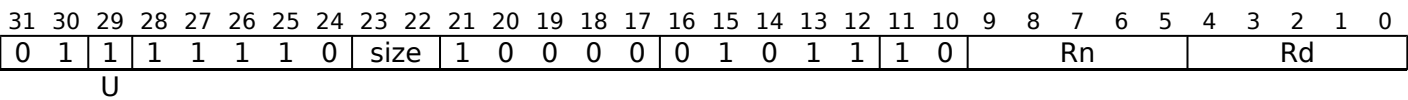
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# NEG (vector)

Negate (vector). This instruction reads each vector element from the source SIMD&FP register, negates each value, puts the result into a vector, and writes the vector to the destination SIMD&FP register.  
Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar



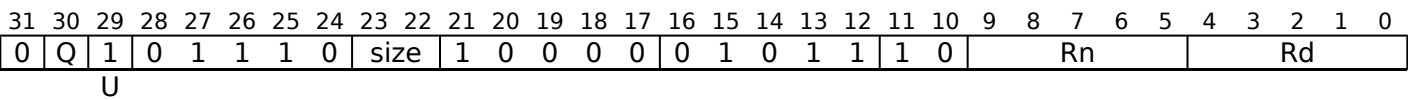
## Scalar

```
NEG <V><d>, <V><n>

integer d = UInt(Rd);
integer n = UInt(Rn);

if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean neg = (U == '1');
```

## Vector



## Vector

```
NEG <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean neg = (U == '1');
```

## Assembler Symbols

- <V>

Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D
- <d>

Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n>

Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T>

Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
integer element;

for e = 0 to elements-1
    element = SInt(Elem[operand, e, esize]);
    if neg then
        element = -element;
    else
        element = Abs(element);
    Elem[result, e, esize] = element<esize-1:0>;

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# NOT

Bitwise NOT (vector). This instruction reads each vector element from the source SIMD&FP register, places the inverse of each value into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This instruction is used by the alias [MVN](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	0	1	0	0	0	0	0	0	1	0	1	1	0	Rn				Rd					

## Vector

```
NOT <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 8;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV 8;
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "Q":
- | Q | <T> |
|---|-----|
| 0 | 8B  |
| 1 | 16B |
- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = NOT(element);

V[d] = result;
```

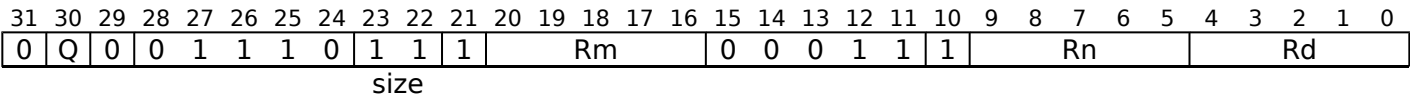
## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

ORN (vector)

Bitwise inclusive OR NOT (vector). This instruction performs a bitwise OR NOT between the two source SIMD&FP registers, and writes the result to the destination SIMD&FP register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers of the same type

```
ORN <Vd>.<T>, <Vn>.<T>, <Vm>.<T>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if Q == '1' then 128 else 64;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "Q":

Q	<T>
0	8B
1	16B

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

operand2 = NOT(operand2);

result = operand1 OR operand2;

V[d] = result;
```

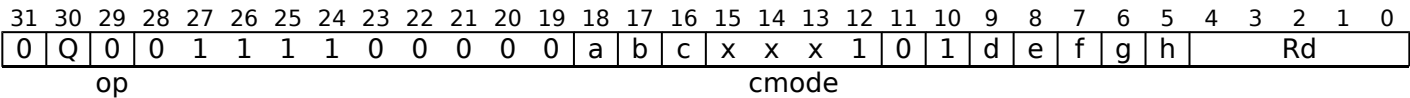
Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

ORR (vector, immediate)

Bitwise inclusive OR (vector, immediate). This instruction reads each vector element from the destination SIMD&FP register, performs a bitwise OR between each result and an immediate constant, places the result into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



16-bit (cmode == 10x1)

```
ORR <Vd>.<T>, #<imm8>{, LSL #<amount>}
```

32-bit (cmode == 0xx1)

```
ORR <Vd>.<T>, #<imm8>{, LSL #<amount>}
```

```
integer rd = UInt(Rd);

integer datasize = if Q == '1' then 128 else 64;
bits(datasize) imm;
bits(64) imm64;

ImmediateOp operation;
case cmode:op of
  when '0xx00' operation = ImmediateOp_MOVI;
  when '0xx10' operation = ImmediateOp_ORR;
  when '10x00' operation = ImmediateOp_MOVI;
  when '10x10' operation = ImmediateOp_ORR;
  when '110x0' operation = ImmediateOp_MOVI;
  when '1110x' operation = ImmediateOp_MOVI;
  when '11110' operation = ImmediateOp_MOVI;
imm64 = AdvSIMDExpandImm(op, cmode, a:b:c:d:e:f:g:h);
imm = Replicate(imm64, datasize DIV 64);
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP register, encoded in the "Rd" field.
- <T> For the 16-bit variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the 32-bit variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	2S
1	4S

- <imm8> Is an 8-bit immediate encoded in "a:b:c:d:e:f:g:h".
- <amount> For the 16-bit variant: is the shift amount encoded in "cmode<1>":

cmode<1>	<amount>
0	0
1	8

defaulting to 0 if LSL is omitted.

For the 32-bit variant: is the shift amount encoded in "cmode<2:1>":



<b>cmode&lt;2:1&gt;</b>	<b>&lt;amount&gt;</b>
00	0
01	8
10	16
11	24

defaulting to 0 if LSL is omitted.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand;
bits(datasize) result;

case operation of
  when ImmediateOp_MOVI
    result = imm;
  when ImmediateOp_MVNI
    result = NOT(imm);
  when ImmediateOp_ORR
    operand = V[rd];
    result = operand OR imm;
  when ImmediateOp_BIC
    operand = V[rd];
    result = operand AND NOT(imm);

V[rd] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

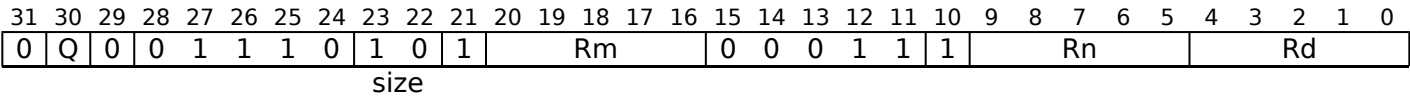
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## ORR (vector, register)

Bitwise inclusive OR (vector, register). This instruction performs a bitwise OR between the two source SIMD&FP registers, and writes the result to the destination SIMD&FP register.  
Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This instruction is used by the alias [MOV \(vector\)](#).



### Three registers of the same type

ORR <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer datasize = if Q == '1' then 128 else 64;
```

### Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "Q":

Q	<T>
0	8B
1	16B
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

### Alias Conditions

Alias	Is preferred when
<a href="#">MOV (vector)</a>	Rm == Rn

### Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

result = operand1 OR operand2;

V[d] = result;
```

### Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

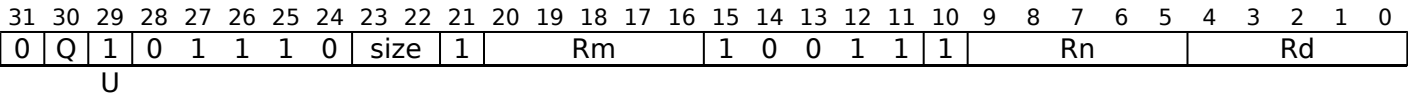


PMUL

Polynomial Multiply. This instruction multiplies corresponding elements in the vectors of the two source SIMD&FP registers, places the results in a vector, and writes the vector to the destination SIMD&FP register.

For information about multiplying polynomials see *Polynomial arithmetic over {0, 1}*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers of the same type

```
PMUL <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if U == '1' && size != '00' then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean poly = (U == '1');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":
- | size | Q | <T>      |
|------|---|----------|
| 00   | 0 | 8B       |
| 00   | 1 | 16B      |
| 01   | x | RESERVED |
| 1x   | x | RESERVED |
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;
bits(esize) product;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    if poly then
        product = PolynomialMult(element1, element2)<esize-1:0>;
    else
        product = (UInt(element1)*UInt(element2))<esize-1:0>;
    Elem[result, e, esize] = product;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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PMULL, PMULL2

Polynomial Multiply Long. This instruction multiplies corresponding elements in the lower or upper half of the vectors of the two source SIMD&FP registers, places the results in a vector, and writes the vector to the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied.

For information about multiplying polynomials see *Polynomial arithmetic over {0, 1}*.

The PMULL instruction extracts each source vector from the lower half of each source register, while the PMULL2 instruction extracts each source vector from the upper half of each source register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	Q	0	0	1	1	1	0	size	1	Rm						1	1	1	0	0	0	Rn						Rd					

Three registers, not all the same type

PMULL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '01' || size == '10' then UNDEFINED;
if size == '11' && !HaveBit128PMULLExt() then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the “Rd” field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	RESERVED
10	RESERVED
11	1Q

The ‘1Q’ arrangement is only allocated in an implementation that includes the Cryptographic Extension, and is otherwise RESERVED.

<Vn> Is the name of the first SIMD&FP source register, encoded in the “Rn” field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	x	RESERVED
10	x	RESERVED
11	0	1D
11	1	2D

<Vm> Is the name of the second SIMD&FP source register, encoded in the “Rm” field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    Elem[result, e, 2*esize] = PolynomialMult(element1, element2);

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

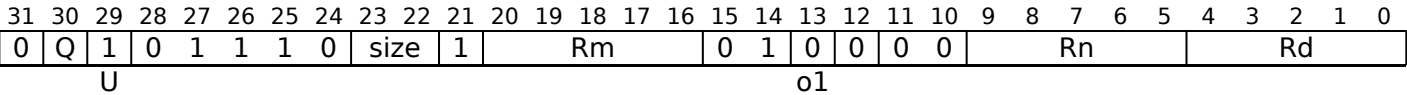
- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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RADDHN, RADDHN2

Rounding Add returning High Narrow. This instruction adds each vector element in the first source SIMD&FP register to the corresponding vector element in the second source SIMD&FP register, places the most significant half of the result into a vector, and writes the vector to the lower or upper half of the destination SIMD&FP register. The results are rounded. For truncated results, see [ADDHN](#). The RADDHN instruction writes the vector to the lower half of the destination register and clears the upper half, while the RADDHN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register. Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers, not all the same type

RADDHN{2} <Vd>.<Tb>, <Vn>.<Ta>, <Vm>.<Ta>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(0);
integer elements = datasize DIV esize;

boolean sub_op = (o1 == '1');
boolean round = (U == '1');
```

Assembler Symbols

- 2

Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Tb>

Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED
- <Vn>

Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Ta>

Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED
- <Vm>

Is the name of the second SIMD&FP source register, encoded in the "Rm" field.



## Operation

```
CheckFPAdvSIMDEnabled64();
bits(2*datasize) operand1 = V[n];
bits(2*datasize) operand2 = V[m];
bits(datasize) result;
integer round_const = if round then 1 << (esize - 1) else 0;
bits(2*esize) element1;
bits(2*esize) element2;
bits(2*esize) sum;

for e = 0 to elements-1
    element1 = Elem[operand1, e, 2*esize];
    element2 = Elem[operand2, e, 2*esize];
    if sub_op then
        sum = element1 - element2;
    else
        sum = element1 + element2;
    sum = sum + round_const;
    Elem[result, e, esize] = sum<2*esize-1:esize>;

Vpart[d, part] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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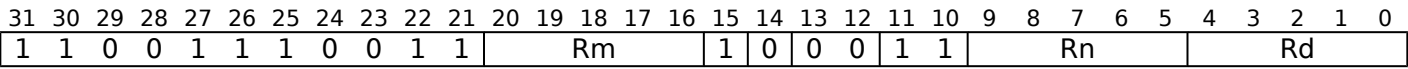
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RAX1

Rotate and Exclusive OR rotates each 64-bit element of the 128-bit vector in a source SIMD&FP register left by 1, performs a bitwise exclusive OR of the resulting 128-bit vector and the vector in another source SIMD&FP register, and writes the result to the destination SIMD&FP register.

This instruction is implemented only when [ARMv8.2-SHA](#) is implemented.

Advanced SIMD  
(Armv8.2)



Advanced SIMD

```
RAX1 <Vd>.2D, <Vn>.2D, <Vm>.2D
```

```
if !HaveSHA3Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) Vm = V[m];
bits(128) Vn = V[n];
V[d] = Vn EOR (ROL(Vm<127:64>, 1):ROL(Vm<63:0>, 1));
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# RBIT (vector)

Reverse Bit order (vector). This instruction reads each vector element from the source SIMD&FP register, reverses the bits of the element, places the results into a vector, and writes the vector to the destination SIMD&FP register. Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	1	1	0	0	0	0	0	0	1	0	1	1	0	Rn				Rd					

## Vector

```
RBIT <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 8;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV 8;
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "Q":

Q	<T>
0	8B
1	16B

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;
bits(esize) rev;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    for i = 0 to esize-1
        rev<esize-1-i> = element<i>;
        Elem[result, e, esize] = rev;

V[d] = result;
```

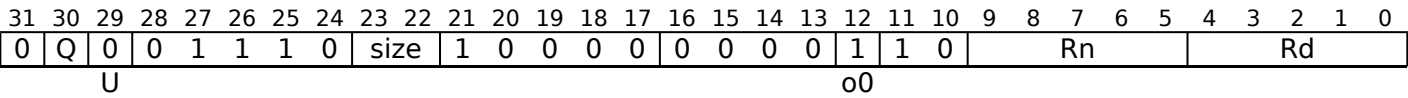
## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

REV16 (vector)

Reverse elements in 16-bit halfwords (vector). This instruction reverses the order of 8-bit elements in each halfword of the vector in the source SIMD&FP register, places the results into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Vector

REV16 <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

// size=esize:  B(0),  H(1),  S(1),  D(S)
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;

// op=REVx:  64(0), 32(1), 16(2)
bits(2) op = o0:U;

// => op+size:
//   64+B = 0, 64+H = 1, 64+S = 2, 64+D = X
//   32+B = 1, 32+H = 2, 32+S = X, 32+D = X
//   16+B = 2, 16+H = X, 16+S = X, 16+D = X
//   8+B = X, 8+H = X, 8+S = X, 8+D = X
// => 3-(op+size) (index bits in group)
//   64/B = 3, 64+H = 2, 64+S = 1, 64+D = X
//   32+B = 2, 32+H = 1, 32+S = X, 32+D = X
//   16+B = 1, 16+H = X, 16+S = X, 16+D = X
//   8+B = X, 8+H = X, 8+S = X, 8+D = X

// index bits within group: 1, 2, 3
if UInt(op) + UInt(size) >= 3 then UNDEFINED;

integer container_size;
case op of
  when '10' container_size = 16;
  when '01' container_size = 32;
  when '00' container_size = 64;

integer containers = datasize DIV container_size;
integer elements_per_container = container_size DIV esize;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	x	RESERVED
1x	x	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
integer element = 0;
integer rev_element;
for c = 0 to containers-1
    rev_element = element + elements_per_container - 1;
    for e = 0 to elements_per_container-1
        Elem[result, rev_element, esize] = Elem[operand, element, esize];
        element = element + 1;
        rev_element = rev_element - 1;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

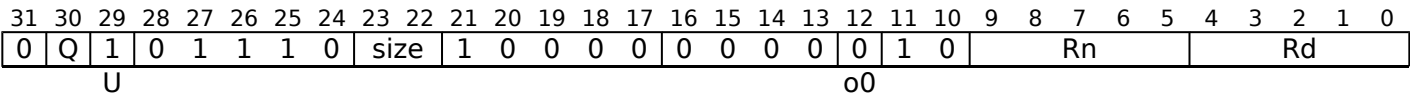
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REV32 (vector)

Reverse elements in 32-bit words (vector). This instruction reverses the order of 8-bit or 16-bit elements in each word of the vector in the source SIMD&FP register, places the results into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Vector

```
REV32 <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

// size=esize:  B(0),  H(1),  S(1),  D(S)
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;

// op=REVx:  64(0), 32(1), 16(2)
bits(2) op = o0:U;

// => op+size:
//   64+B = 0, 64+H = 1, 64+S = 2, 64+D = X
//   32+B = 1, 32+H = 2, 32+S = X, 32+D = X
//   16+B = 2, 16+H = X, 16+S = X, 16+D = X
//   8+B = X, 8+H = X, 8+S = X, 8+D = X
// => 3-(op+size) (index bits in group)
//   64/B = 3, 64+H = 2, 64+S = 1, 64+D = X
//   32+B = 2, 32+H = 1, 32+S = X, 32+D = X
//   16+B = 1, 16+H = X, 16+S = X, 16+D = X
//   8+B = X, 8+H = X, 8+S = X, 8+D = X

// index bits within group: 1, 2, 3
if UInt(op) + UInt(size) >= 3 then UNDEFINED;

integer container_size;
case op of
  when '10' container_size = 16;
  when '01' container_size = 32;
  when '00' container_size = 64;

integer containers = datasize DIV container_size;
integer elements_per_container = container_size DIV esize;
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
1x	x	RESERVED

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
integer element = 0;
integer rev_element;
for c = 0 to containers-1
    rev_element = element + elements_per_container - 1;
    for e = 0 to elements_per_container-1
        Elem[result, rev_element, esize] = Elem[operand, element, esize];
        element = element + 1;
        rev_element = rev_element - 1;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

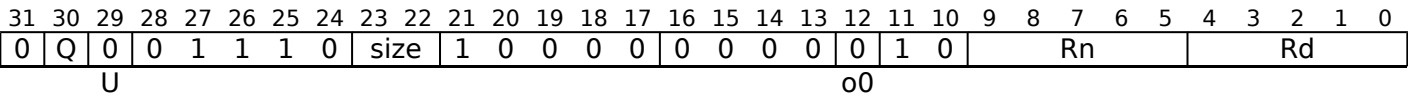
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REV64

Reverse elements in 64-bit doublewords (vector). This instruction reverses the order of 8-bit, 16-bit, or 32-bit elements in each doubleword of the vector in the source SIMD&FP register, places the results into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Vector

```
REV64 <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

// size=esize:  B(0),  H(1),  S(1),  D(S)
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;

// op=REVx:  64(0), 32(1), 16(2)
bits(2) op = o0:U;

// => op+size:
//   64+B = 0, 64+H = 1, 64+S = 2, 64+D = X
//   32+B = 1, 32+H = 2, 32+S = X, 32+D = X
//   16+B = 2, 16+H = X, 16+S = X, 16+D = X
//   8+B = X, 8+H = X, 8+S = X, 8+D = X
// => 3-(op+size) (index bits in group)
//   64/B = 3, 64+H = 2, 64+S = 1, 64+D = X
//   32+B = 2, 32+H = 1, 32+S = X, 32+D = X
//   16+B = 1, 16+H = X, 16+S = X, 16+D = X
//   8+B = X, 8+H = X, 8+S = X, 8+D = X

// index bits within group: 1, 2, 3
if UInt(op) + UInt(size) >= 3 then UNDEFINED;

integer container_size;
case op of
  when '10' container_size = 16;
  when '01' container_size = 32;
  when '00' container_size = 64;

integer containers = datasize DIV container_size;
integer elements_per_container = container_size DIV esize;
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.



## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
integer element = 0;
integer rev_element;
for c = 0 to containers-1
    rev_element = element + elements_per_container - 1;
    for e = 0 to elements_per_container-1
        Elem[result, rev_element, esize] = Elem[operand, element, esize];
        element = element + 1;
        rev_element = rev_element - 1;
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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RSHRN, RSHRN2

Rounding Shift Right Narrow (immediate). This instruction reads each unsigned integer value from the vector in the source SIMD&FP register, right shifts each result by an immediate value, writes the final result to a vector, and writes the vector to the lower or upper half of the destination SIMD&FP register. The destination vector elements are half as long as the source vector elements. The results are rounded. For truncated results, see [SHRN](#).

The RSHRN instruction writes the vector to the lower half of the destination register and clears the upper half, while the RSHRN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	0	!= 0000				immb			1	0	0	0	1	1	Rn				Rd					
immh										op																					

Vector

```
RSHRN{2} <Vd>.<Tb>, <Vn>.<Ta>, #<shift>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

integer shift = (2 * esize) - UInt(immh:immb);
boolean round = (op == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Tb> Is an arrangement specifier, encoded in “immh:Q”:

immh	Q	<Tb>
0000	x	SEE Advanced SIMD modified immediate
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	x	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<Ta> Is an arrangement specifier, encoded in “immh”:

immh	<Ta>
0000	SEE Advanced SIMD modified immediate
0001	8H
001x	4S
01xx	2D
1xxx	RESERVED

<shift> Is the right shift amount, in the range 1 to the destination element width in bits, encoded in “immh:immb”:

immh	<shift>
0000	SEE Advanced SIMD modified immediate
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	RESERVED

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize*2) operand = V[n];
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;

for e = 0 to elements-1
    element = (UInt(Elem[operand, e, 2*esize]) + round_const) >> shift;
    Elem[result, e, esize] = element<esize-1:0>;

Vpart[d, part] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

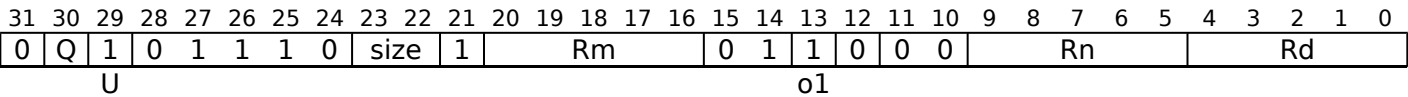
RSUBHN, RSUBHN2

Rounding Subtract returning High Narrow. This instruction subtracts each vector element of the second source SIMD&FP register from the corresponding vector element of the first source SIMD&FP register, places the most significant half of the result into a vector, and writes the vector to the lower or upper half of the destination SIMD&FP register.

The results are rounded. For truncated results, see [SUBHN](#).

The RSUBHN instruction writes the vector to the lower half of the destination register and clears the upper half, while the RSUBHN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers, not all the same type

```
RSUBHN{2} <Vd>.<Tb>, <Vn>.<Ta>, <Vm>.<Ta>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean sub_op = (o1 == '1');
boolean round = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q 2	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(2*datasize) operand1 = V[n];
bits(2*datasize) operand2 = V[m];
bits(datasize) result;
integer round_const = if round then 1 << (esize - 1) else 0;
bits(2*esize) element1;
bits(2*esize) element2;
bits(2*esize) sum;

for e = 0 to elements-1
    element1 = Elem[operand1, e, 2*esize];
    element2 = Elem[operand2, e, 2*esize];
    if sub_op then
        sum = element1 - element2;
    else
        sum = element1 + element2;
    sum = sum + round_const;
    Elem[result, e, esize] = sum<2*esize-1:esize>;

Vpart[d, part] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

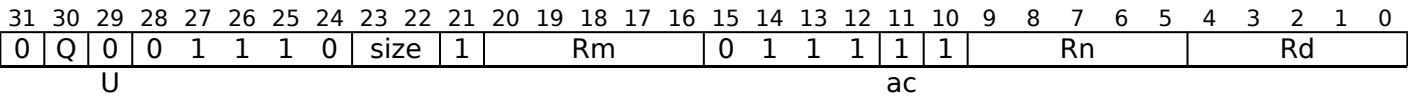
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SABA

Signed Absolute difference and Accumulate. This instruction subtracts the elements of the vector of the second source SIMD&FP register from the corresponding elements of the first source SIMD&FP register, and accumulates the absolute values of the results into the elements of the vector of the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers of the same type

```
SABA <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean accumulate = (ac == '1');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
bits(esize) absdiff;

result = if accumulate then V[d] else Zeros();
for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    absdiff = Abs(element1-element2)<esize-1:0>;
    Elem[result, e, esize] = Elem[result, e, esize] + absdiff;
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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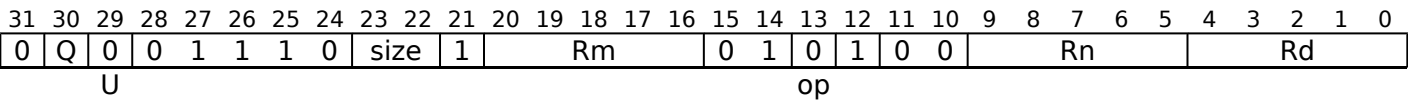
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SABAL, SABAL2

Signed Absolute difference and Accumulate Long. This instruction subtracts the vector elements in the lower or upper half of the second source SIMD&FP register from the corresponding vector elements of the first source SIMD&FP register, and accumulates the absolute values of the results into the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the source vector elements.

The SABAL instruction extracts each source vector from the lower half of each source register, while the SABAL2 instruction extracts each source vector from the upper half of each source register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers, not all the same type

```
SABAL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(0);
integer elements = datasize DIV esize;

boolean accumulate = (op == '0');
boolean unsigned = (U == '1');
```

Assembler Symbols

- 2

Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Ta>

Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED
- <Vn>

Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Tb>

Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED
- <Vm>

Is the name of the second SIMD&FP source register, encoded in the "Rm" field.



## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) absdiff;

result = if accumulate then V[d] else Zeros();
for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    absdiff = Abs(element1-element2)<2*esize-1:0>;
    Elem[result, e, 2*esize] = Elem[result, e, 2*esize] + absdiff;
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

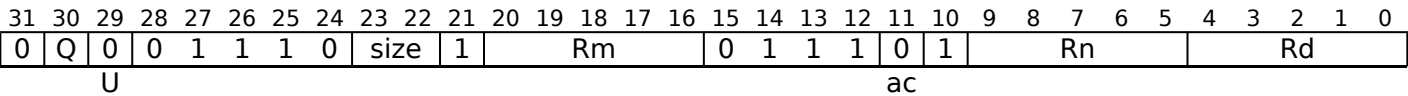
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SABD

Signed Absolute Difference. This instruction subtracts the elements of the vector of the second source SIMD&FP register from the corresponding elements of the first source SIMD&FP register, places the the absolute values of the results into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers of the same type

```
SABD <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean accumulate = (ac == '1');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
bits(esize) absdiff;

result = if accumulate then V[d] else Zeros();
for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    absdiff = Abs(element1-element2)<esize-1:0>;
    Elem[result, e, esize] = Elem[result, e, esize] + absdiff;
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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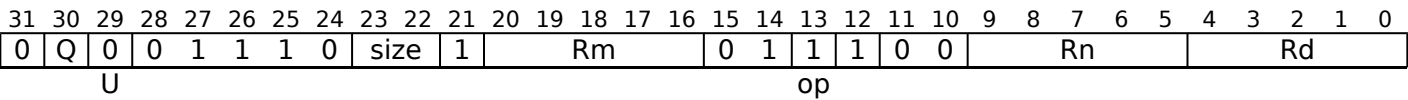
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SABDL, SABDL2

Signed Absolute Difference Long. This instruction subtracts the vector elements of the second source SIMD&FP register from the corresponding vector elements of the first source SIMD&FP register, places the absolute value of the results into a vector, and writes the vector to the lower or upper half of the destination SIMD&FP register. The destination vector elements are twice as long as the source vector elements.

The SABDL instruction writes the vector to the lower half of the destination register and clears the upper half, while the SABDL2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers, not all the same type

SABDL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean accumulate = (op == '0');
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q 2	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) absdiff;

result = if accumulate then V[d] else Zeros();
for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    absdiff = Abs(element1-element2)<2*esize-1:0>;
    Elem[result, e, 2*esize] = Elem[result, e, 2*esize] + absdiff;
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

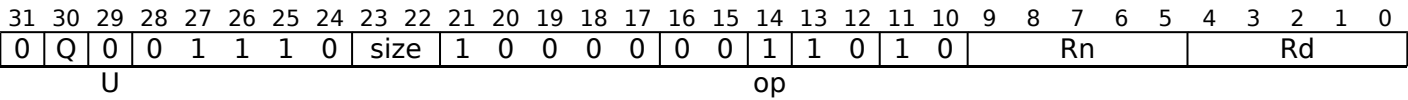
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SADALP

Signed Add and Accumulate Long Pairwise. This instruction adds pairs of adjacent signed integer values from the vector in the source SIMD&FP register and accumulates the results into the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the source vector elements.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Vector

SADALP <Vd>.<Ta>, <Vn>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV (2 * esize);
boolean acc = (op == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Ta> Is an arrangement specifier, encoded in "size:Q":

size	Q	<Ta>
00	0	4H
00	1	8H
01	0	2S
01	1	4S
10	0	1D
10	1	2D
11	x	RESERVED

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.
- <Tb> Is an arrangement specifier, encoded in "size:Q":

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;

bits(2*esize) sum;
integer op1;
integer op2;

if acc then result = V[d];
for e = 0 to elements-1
    op1 = Int(Elem[operand, 2*e+0, esize], unsigned);
    op2 = Int(Elem[operand, 2*e+1, esize], unsigned);
    sum = (op1+op2)<2*esize-1:0>;
    if acc then
        Elem[result, e, 2*esize] = Elem[result, e, 2*esize] + sum;
    else
        Elem[result, e, 2*esize] = sum;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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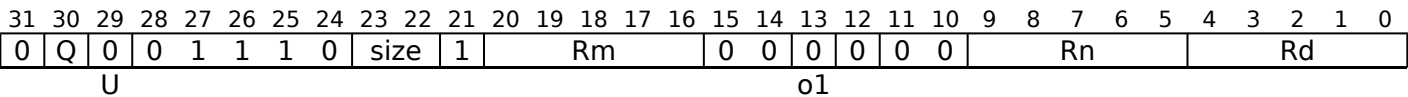
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SADDL, SADDL2

Signed Add Long (vector). This instruction adds each vector element in the lower or upper half of the first source SIMD&FP register to the corresponding vector element of the second source SIMD&FP register, places the results into a vector, and writes the vector to the destination SIMD&FP register. The destination vector elements are twice as long as the source vector elements. All the values in this instruction are signed integer values.

The SADDL instruction extracts each source vector from the lower half of each source register, while the SADDL2 instruction extracts each source vector from the upper half of each source register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers, not all the same type

```
SADDL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(0);
integer elements = datasize DIV esize;

boolean sub_op = (o1 == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

- 2

Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Ta>

Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED
- <Vn>

Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Tb>

Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED
- <Vm>

Is the name of the second SIMD&FP source register, encoded in the "Rm" field.



## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
integer element1;
integer element2;
integer sum;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    if sub_op then
        sum = element1 - element2;
    else
        sum = element1 + element2;
    Elem[result, e, 2*esize] = sum<2*esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

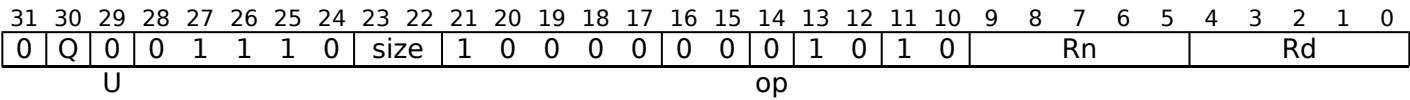
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SADDLP

Signed Add Long Pairwise. This instruction adds pairs of adjacent signed integer values from the vector in the source SIMD&FP register, places the result into a vector, and writes the vector to the destination SIMD&FP register. The destination vector elements are twice as long as the source vector elements.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Vector

SADDLP <Vd>.<Ta>, <Vn>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV (2 * esize);
boolean acc = (op == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Ta> Is an arrangement specifier, encoded in "size:Q":

size	Q	<Ta>
00	0	4H
00	1	8H
01	0	2S
01	1	4S
10	0	1D
10	1	2D
11	x	RESERVED

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.
- <Tb> Is an arrangement specifier, encoded in "size:Q":

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;

bits(2*esize) sum;
integer op1;
integer op2;

if acc then result = V[d];
for e = 0 to elements-1
    op1 = Int(Elem[operand, 2*e+0, esize], unsigned);
    op2 = Int(Elem[operand, 2*e+1, esize], unsigned);
    sum = (op1+op2)<2*esize-1:0>;
    if acc then
        Elem[result, e, 2*esize] = Elem[result, e, 2*esize] + sum;
    else
        Elem[result, e, 2*esize] = sum;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

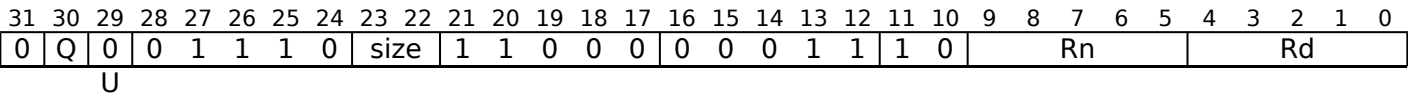
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SADDLV

Signed Add Long across Vector. This instruction adds every vector element in the source SIMD&FP register together, and writes the scalar result to the destination SIMD&FP register. The destination scalar is twice as long as the source vector elements. All the values in this instruction are signed integer values.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Advanced SIMD

```
SADDLV <V><d>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '100' then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
```

Assembler Symbols

<V> Is the destination width specifier, encoded in “size”:

size	<V>
00	H
01	S
10	D
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<T> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	RESERVED
10	1	4S
11	x	RESERVED

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
integer sum;

sum = Int(Elem[operand, 0, esize], unsigned);
for e = 1 to elements-1
    sum = sum + Int(Elem[operand, e, esize], unsigned);

V[d] = sum<2*esize-1:0>;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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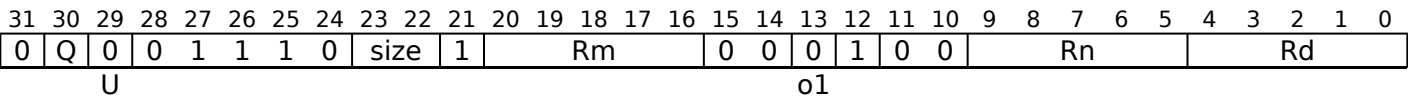
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SADDW, SADDW2

Signed Add Wide. This instruction adds vector elements of the first source SIMD&FP register to the corresponding vector elements in the lower or upper half of the second source SIMD&FP register, places the results in a vector, and writes the vector to the SIMD&FP destination register.

The SADDW instruction extracts the second source vector from the lower half of the second source register, while the SADDW2 instruction extracts the second source vector from the upper half of the second source register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers, not all the same type

SADDW{2} <Vd>.<Ta>, <Vn>.<Ta>, <Vm>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean sub_op = (o1 == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q		2
0		[absent]
1		[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(2*datasize) operand1 = V[n];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
integer element1;
integer element2;
integer sum;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, 2*esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    if sub_op then
        sum = element1 - element2;
    else
        sum = element1 + element2;
    Elem[result, e, 2*esize] = sum<2*esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# SCVTF (vector, fixed-point)

Signed fixed-point Convert to Floating-point (vector). This instruction converts each element in a vector from fixed-point to floating-point using the rounding mode that is specified by the [FPCR](#), and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	0	!= 0000				immb			1	1	1	0	0	1	Rn				Rd					
U									immh																						

## Scalar

```
SCVTF <V><d>, <V><n>, #<fbits>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '000x' || (immh == '001x' && !HaveFP16Ext()) then UNDEFINED;
integer esize = if immh == 'lxxx' then 64 else if immh == '0lxx' then 32 else 16;
integer datasize = esize;
integer elements = 1;

integer fracbits = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
FPRounding rounding = FPRoundingMode(FPCR);
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	0	!= 0000				immb			1	1	1	0	0	1	Rn				Rd					
U									immh																						

## Vector

```
SCVTF <Vd>.<T>, <Vn>.<T>, #<fbits>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh == '000x' || (immh == '001x' && !HaveFP16Ext()) then UNDEFINED;
if immh<3>:Q == '10' then UNDEFINED;
integer esize = if immh == 'lxxx' then 64 else if immh == '0lxx' then 32 else 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer fracbits = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
FPRounding rounding = FPRoundingMode(FPCR);
```

## Assembler Symbols

<V> Is a width specifier, encoded in “immh”:



immh	<V>
000x	RESERVED
001x	H
01xx	S
1xxx	D

<d> Is the number of the SIMD&FP destination register, in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<T>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	x	RESERVED
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<fbits> For the scalar variant: is the number of fractional bits, in the range 1 to the operand width, encoded in "immh:immb":

immh	<fbits>
000x	RESERVED
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

For the vector variant: is the number of fractional bits, in the range 1 to the element width, encoded in "immh:immb":

immh	<fbits>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	RESERVED
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FixedToFP(element, fracbits, unsigned, FPCR, rounding);
V[d] = result;

```

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# SCVTF (vector, integer)

Signed integer Convert to Floating-point (vector). This instruction converts each element in a vector from signed integer to floating-point using the rounding mode that is specified by the *FPCR*, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	1	1	1	1	0	0	1	1	1	0	1	1	0	Rn				Rd					
U																															

## Scalar half precision

```
SCVTF <Hd>, <Hn>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
```

## Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	sz	1	0	0	0	0	1	1	1	0	1	1	0	Rn				Rd					
U																															

## Scalar single-precision and double-precision

```
SCVTF <V><d>, <V><n>

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
```

## Vector half precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	0	1	1	1	1	0	0	1	1	1	0	1	1	0	Rn				Rd					
U																															

Vector half precision

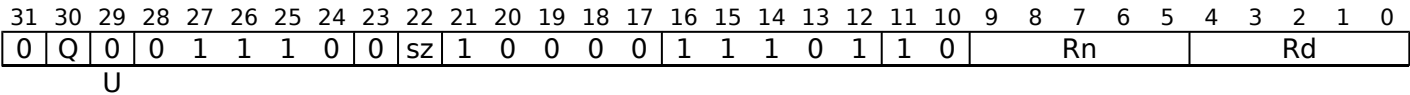
```
SCVTF <Vd>.<T>, <Vn>.<T>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
```

Vector single-precision and double-precision



Vector single-precision and double-precision

```
SCVTF <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
```

Assembler Symbols

- <Hd>

Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn>

Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <V>

Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D
- <d>

Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n>

Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T>

For the vector half precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

  
For the vector single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D
- <Vn>

Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
FPRounding rounding = FPRoundingMode(FPCR);
bits(esize) element;
for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FixedToFP(element, 0, unsigned, FPCR, rounding);
V[d] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

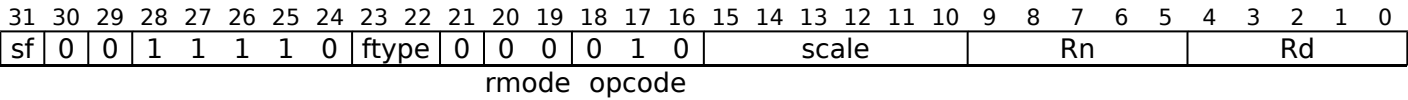
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SCVTF (scalar, fixed-point)

Signed fixed-point Convert to Floating-point (scalar). This instruction converts the signed value in the 32-bit or 64-bit general-purpose source register to a floating-point value using the rounding mode that is specified by the *FPCR*, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.



**32-bit to half-precision (sf == 0 && ftype == 11)**  
(Armv8.2)

SCVTF <Hd>, <Wn>, #<fbits>

**32-bit to single-precision (sf == 0 && ftype == 00)**

SCVTF <Sd>, <Wn>, #<fbits>

**32-bit to double-precision (sf == 0 && ftype == 01)**

SCVTF <Dd>, <Wn>, #<fbits>

**64-bit to half-precision (sf == 1 && ftype == 11)**  
(Armv8.2)

SCVTF <Hd>, <Xn>, #<fbits>

**64-bit to single-precision (sf == 1 && ftype == 00)**

SCVTF <Sd>, <Xn>, #<fbits>

**64-bit to double-precision (sf == 1 && ftype == 01)**

SCVTF <Dd>, <Xn>, #<fbits>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;
FPRounding rounding;

case ftype of
  when '00' fltsize = 32;
  when '01' fltsize = 64;
  when '10' UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      fltsize = 16;
    else
      UNDEFINED;

if sf == '0' && scale<5> == '0' then UNDEFINED;
integer fracbits = 64 - UInt(scale);

rounding = FPRoundingMode(FPCR);
```

**Assembler Symbols**

<Dd>	Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Hd>	Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Sd>	Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
<fbits>	For the 32-bit to double-precision, 32-bit to half-precision and 32-bit to single-precision variant: is the number of bits after the binary point in the fixed-point source, in the range 1 to 32, encoded as 64 minus "scale".

For the 64-bit to double-precision, 64-bit to half-precision and 64-bit to single-precision variant: is the number of bits after the binary point in the fixed-point source, in the range 1 to 64, encoded as 64 minus "scale".

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
bits(fltsize) fltval;  
bits(intsize) intval;  
  
intval = X[n];  
fltval = FixedToFP(intval, fracbits, FALSE, FPCR, rounding);  
V[d] = fltval;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

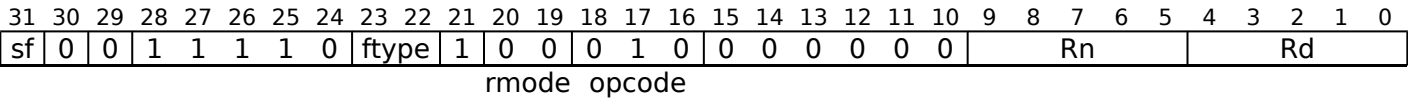
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SCVTF (scalar, integer)

Signed integer Convert to Floating-point (scalar). This instruction converts the signed integer value in the general-purpose source register to a floating-point value using the rounding mode that is specified by the *FPCR*, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.





**32-bit to half-precision (sf == 0 && ftype == 11)**  
(Armv8.2)

SCVTF <Hd>, <Wn>

**32-bit to single-precision (sf == 0 && ftype == 00)**

SCVTF <Sd>, <Wn>

**32-bit to double-precision (sf == 0 && ftype == 01)**

SCVTF <Dd>, <Wn>

**64-bit to half-precision (sf == 1 && ftype == 11)**  
(Armv8.2)

SCVTF <Hd>, <Xn>

**64-bit to single-precision (sf == 1 && ftype == 00)**

SCVTF <Sd>, <Xn>

**64-bit to double-precision (sf == 1 && ftype == 01)**

SCVTF <Dd>, <Xn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;
FPRounding rounding;

case ftype of
  when '00'
    fltsize = 32;
  when '01'
    fltsize = 64;
  when '10'
    UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      fltsize = 16;
    else
      UNDEFINED;

rounding = FPRoundingMode(FPCR);
```

**Assembler Symbols**

<Dd>	Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Hd>	Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Sd>	Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
bits(fltsize) fltval;  
bits(intsize) intval;  
  
intval = X[n];  
fltval = FixedToFP(intval, 0, FALSE, FPCR, rounding);  
V[d] = fltval;
```

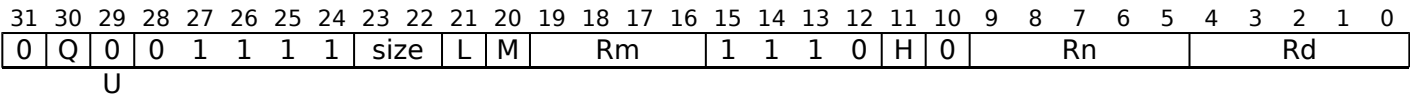
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SDOT (by element)

Dot Product signed arithmetic (vector, by element). This instruction performs the dot product of the four 8-bit elements in each 32-bit element of the first source register with the four 8-bit elements of an indexed 32-bit element in the second source register, accumulating the result into the corresponding 32-bit element of the destination register. Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped. In Armv8.2 and Armv8.3, this is an OPTIONAL instruction. From Armv8.4 it is mandatory for all implementations to support it. ID\_AA64ISAR0\_EL1.DP indicates whether this instruction is supported.

Vector (Armv8.2)



Vector

SDOT <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.4B[<index>]

```
if !HaveD0TPExt() then UNDEFINED;
if size != '10' then UNDEFINED;
boolean signed = (U == '0');

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(M:Rm);
integer index = UInt(H:L);

integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

- <Vd>

Is the name of the SIMD&FP third source and destination register, encoded in the "Rd" field.
- <Ta>

Is an arrangement specifier, encoded in "Q":

Q	<Ta>
0	2S
1	4S
- <Vn>

Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Tb>

Is an arrangement specifier, encoded in "Q":

Q	<Tb>
0	8B
1	16B
- <Vm>

Is the name of the second SIMD&FP source register, encoded in the "M:Rm" fields.
- <index>

Is the element index, encoded in the "H:L" fields.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(128) operand2 = V[m];
bits(datasize) result = V[d];
for e = 0 to elements-1
    integer res = 0;
    integer element1, element2;
    for i = 0 to 3
        if signed then
            element1 = SInt(Elem[operand1, 4*e+i, esize DIV 4]);
            element2 = SInt(Elem[operand2, 4*index+i, esize DIV 4]);
        else
            element1 = UInt(Elem[operand1, 4*e+i, esize DIV 4]);
            element2 = UInt(Elem[operand2, 4*index+i, esize DIV 4]);
        res = res + element1 * element2;
    Elem[result, e, esize] = Elem[result, e, esize] + res;
V[d] = result;
```

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SDOT (vector)

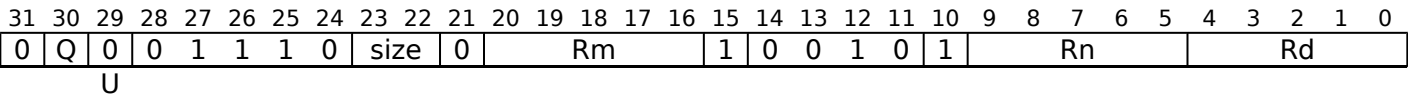
Dot Product signed arithmetic (vector). This instruction performs the dot product of the four signed 8-bit elements in each 32-bit element of the first source register with the four signed 8-bit elements of the corresponding 32-bit element in the second source register, accumulating the result into the corresponding 32-bit element of the destination register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

In Armv8.2 and Armv8.3, this is an OPTIONAL instruction. From Armv8.4 it is mandatory for all implementations to support it.

ID\_AA64ISAR0\_EL1.DP indicates whether this instruction is supported.

Vector (Armv8.2)



Vector

SDOT <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
if !HaveDOTPExt() then UNDEFINED;
if size != '10' then UNDEFINED;
boolean signed = (U == '0');
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP third source and destination register, encoded in the "Rd" field.
- <Ta> Is an arrangement specifier, encoded in "Q":

Q	<Ta>
0	2S
1	4S
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Tb> Is an arrangement specifier, encoded in "Q":

Q	<Tb>
0	8B
1	16B
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

result = V[d];
for e = 0 to elements-1
    integer res = 0;
    integer element1, element2;
    for i = 0 to 3
        if signed then
            element1 = SInt(Elem[operand1, 4*e+i, esize DIV 4]);
            element2 = SInt(Elem[operand2, 4*e+i, esize DIV 4]);
        else
            element1 = UInt(Elem[operand1, 4*e+i, esize DIV 4]);
            element2 = UInt(Elem[operand2, 4*e+i, esize DIV 4]);
        res = res + element1 * element2;
    Elem[result, e, esize] = Elem[result, e, esize] + res;
V[d] = result;
```

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# SHA1C

SHA1 hash update (choose).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	0	0	Rm				0	0	0	0	0	0	Rn				Rd						

## Advanced SIMD

SHA1C <Qd>, <Sn>, <Vm>.4S

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if !HaveSHA1Ext() then UNDEFINED;
```

## Assembler Symbols

- <Qd> Is the 128-bit name of the SIMD&FP source and destination, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the third SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) X = V[d];
bits(32) Y = V[n]; // Note: 32 not 128 bits wide
bits(128) W = V[m];
bits(32) t;

for e = 0 to 3
    t = SHAchoose(X<63:32>, X<95:64>, X<127:96>);
    Y = Y + ROL(X<31:0>, 5) + t + Elem[W, e, 32];
    X<63:32> = ROL(X<63:32>, 30);
    <Y, X> = ROL(Y:X, 32);
V[d] = X;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# SHA1H

SHA1 fixed rotate.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	Rn				Rd					

## Advanced SIMD

```
SHA1H <Sd>, <Sn>

integer d = UInt(Rd);
integer n = UInt(Rn);
if !HaveSHA1Ext() then UNDEFINED;
```

## Assembler Symbols

- <Sd> Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(32) operand = V[n]; // read element [0] only, [1-3] zeroed
V[d] = ROL(operand, 30);
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.



# SHA1M

SHA1 hash update (majority).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	0	0			Rm			0	0	1	0	0	0			Rn					Rd		

## Advanced SIMD

SHA1M <Qd>, <Sn>, <Vm>.4S

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if !HaveSHA1Ext() then UNDEFINED;
```

## Assembler Symbols

- <Qd> Is the 128-bit name of the SIMD&FP source and destination, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the third SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) X = V[d];
bits(32) Y = V[n]; // Note: 32 not 128 bits wide
bits(128) W = V[m];
bits(32) t;

for e = 0 to 3
    t = SHAmajority(X<63:32>, X<95:64>, X<127:96>);
    Y = Y + ROL(X<31:0>, 5) + t + Elem[W, e, 32];
    X<63:32> = ROL(X<63:32>, 30);
    <Y, X> = ROL(Y:X, 32);
V[d] = X;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# SHA1P

SHA1 hash update (parity).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	0	0	Rm					0	0	0	1	0	0	Rn					Rd				

## Advanced SIMD

SHA1P <Qd>, <Sn>, <Vm>.4S

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if !HaveSHA1Ext() then UNDEFINED;
```

## Assembler Symbols

- <Qd> Is the 128-bit name of the SIMD&FP source and destination, encoded in the "Rd" field.
- <Sn> Is the 32-bit name of the second SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the third SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) X = V[d];
bits(32) Y = V[n]; // Note: 32 not 128 bits wide
bits(128) W = V[m];
bits(32) t;

for e = 0 to 3
    t = SHAparity(X<63:32>, X<95:64>, X<127:96>);
    Y = Y + ROL(X<31:0>, 5) + t + Elem[W, e, 32];
    X<63:32> = ROL(X<63:32>, 30);
    <Y, X> = ROL(Y:X, 32);
V[d] = X;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# SHA1SU0

SHA1 schedule update 0.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	0	0	Rm				0	0	1	1	0	0	Rn				Rd						

## Advanced SIMD

SHA1SU0 <Vd>.4S, <Vn>.4S, <Vm>.4S

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if !HaveSHA1Ext() then UNDEFINED;
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the second SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the third SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) operand1 = V[d];
bits(128) operand2 = V[n];
bits(128) operand3 = V[m];
bits(128) result;

result = operand2<63:0>:operand1<127:64>;
result = result EOR operand1 EOR operand3;
V[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# SHA1SU1

SHA1 schedule update 1.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	0	1	0	1	0	0	0	0	0	0	1	1	0	Rn				Rd					

## Advanced SIMD

SHA1SU1 <Vd>.4S, <Vn>.4S

```
integer d = UInt(Rd);
integer n = UInt(Rn);
if !HaveSHA1Ext() then UNDEFINED;
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the second SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

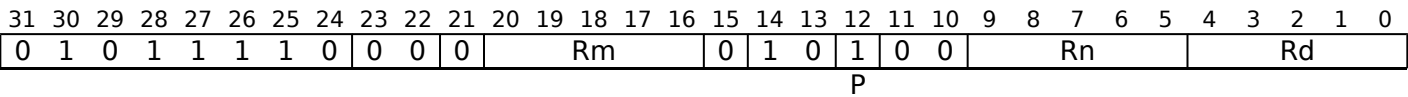
bits(128) operand1 = V[d];
bits(128) operand2 = V[n];
bits(128) result;
bits(128) T = operand1 EOR LSR(operand2, 32);
result<31:0> = ROL(T<31:0>, 1);
result<63:32> = ROL(T<63:32>, 1);
result<95:64> = ROL(T<95:64>, 1);
result<127:96> = ROL(T<127:96>, 1) EOR ROL(T<31:0>, 2);
V[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# SHA256H2

SHA256 hash update (part 2).



## Advanced SIMD

SHA256H2 <Qd>, <Qn>, <Vm>.4S

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if !HaveSHA256Ext() then UNDEFINED;
```

## Assembler Symbols

- <Qd> Is the 128-bit name of the SIMD&FP source and destination, encoded in the "Rd" field.
- <Qn> Is the 128-bit name of the second SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the third SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();
bits(128) result;
result = SHA256hash(V[n], V[d], V[m], FALSE);
V[d] = result;
```

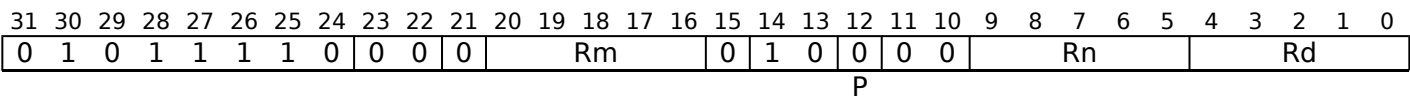
## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

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# SHA256H

SHA256 hash update (part 1).



## Advanced SIMD

SHA256H <Qd>, <Qn>, <Vm>.4S

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if !HaveSHA256Ext() then UNDEFINED;
```

## Assembler Symbols

- <Qd> Is the 128-bit name of the SIMD&FP source and destination, encoded in the "Rd" field.
- <Qn> Is the 128-bit name of the second SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the third SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();
bits(128) result;
result = SHA256hash(V[d], V[n], V[m], TRUE);
V[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

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# SHA256SU0

SHA256 schedule update 0.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	0	1	0	1	0	0	0	0	0	1	0	1	0	Rn				Rd					

## Advanced SIMD

SHA256SU0 <Vd>.4S, <Vn>.4S

```
integer d = UInt(Rd);
integer n = UInt(Rn);
if !HaveSHA256Ext() then UNDEFINED;
```

## Assembler Symbols

- <Vd>
- Is the name of the SIMD&FP source and destination register, encoded in the "Rd" field.
- <Vn>
- Is the name of the second SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) operand1 = V[d];
bits(128) operand2 = V[n];
bits(128) result;
bits(128) T = operand2<31:0>:operand1<127:32>;
bits(32) elt;

for e = 0 to 3
    elt = Elem[T, e, 32];
    elt = ROR(elt, 7) EOR ROR(elt, 18) EOR LSR(elt, 3);
    Elem[result, e, 32] = elt + Elem[operand1, e, 32];
V[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# SHA256SU1

SHA256 schedule update 1.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	0	0	0	Rm				0	1	1	0	0	0	Rn				Rd						

## Advanced SIMD

SHA256SU1 <Vd>.4S, <Vn>.4S, <Vm>.4S

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if !HaveSHA256Ext() then UNDEFINED;
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the second SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the third SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) operand1 = V[d];
bits(128) operand2 = V[n];
bits(128) operand3 = V[m];
bits(128) result;
bits(128) T0 = operand3<31:0>:operand2<127:32>;
bits(64) T1;
bits(32) elt;

T1 = operand3<127:64>;
for e = 0 to 1
    elt = Elem[T1, e, 32];
    elt = ROR(elt, 17) EOR ROR(elt, 19) EOR LSR(elt, 10);
    elt = elt + Elem[operand1, e, 32] + Elem[T0, e, 32];
    Elem[result, e, 32] = elt;

T1 = result<63:0>;
for e = 2 to 3
    elt = Elem[T1, e-2, 32];
    elt = ROR(elt, 17) EOR ROR(elt, 19) EOR LSR(elt, 10);
    elt = elt + Elem[operand1, e, 32] + Elem[T0, e, 32];
    Elem[result, e, 32] = elt;

V[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.



# SHA512H2

SHA512 Hash update part 2 takes the values from the three 128-bit source SIMD&FP registers and produces a 128-bit output value that combines the sigma0 and majority functions of two iterations of the SHA512 computation. It returns this value to the destination SIMD&FP register.

This instruction is implemented only when [ARMv8.2-SHA](#) is implemented.

## Advanced SIMD (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	0	1	1	Rm				1	0	0	0	0	1	Rn				Rd						

## Advanced SIMD

SHA512H2 <Qd>, <Qn>, <Vm>.2D

```
if !HaveSHA512Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
```

## Assembler Symbols

- <Qd> Is the 128-bit name of the SIMD&FP source and destination register, encoded in the "Rd" field.
- <Qn> Is the 128-bit name of the second SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the third SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) Vtmp;
bits(64) NSigma0;
bits(128) X = V[n];
bits(128) Y = V[m];
bits(128) W = V[d];

NSigma0 = ROR(Y<63:0>, 28) EOR ROR(Y<63:0>, 34) EOR ROR(Y<63:0>, 39);
Vtmp<127:64> = (X<63:0> AND Y<127:64>) EOR (X<63:0> AND Y<63:0>) EOR (Y<127:64> AND Y<63:0>);
Vtmp<127:64> = (Vtmp<127:64> + NSigma0 + W<127:64>);
NSigma0 = ROR(Vtmp<127:64>, 28) EOR ROR(Vtmp<127:64>, 34) EOR ROR(Vtmp<127:64>, 39);
Vtmp<63:0> = (Vtmp<127:64> AND Y<63:0>) EOR (Vtmp<127:64> AND Y<127:64>) EOR (Y<127:64> AND Y<63:0>);
Vtmp<63:0> = (Vtmp<63:0> + NSigma0 + W<63:0>);

V[d] = Vtmp;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# SHA512H

SHA512 Hash update part 1 takes the values from the three 128-bit source SIMD&FP registers and produces a 128-bit output value that combines the sigma1 and chi functions of two iterations of the SHA512 computation. It returns this value to the destination SIMD&FP register.

This instruction is implemented only when *ARMv8.2-SHA* is implemented.

## Advanced SIMD (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	0	1	1	Rm				1	0	0	0	0	0	Rn				Rd						

## Advanced SIMD

SHA512H <Qd>, <Qn>, <Vm>.2D

```
if !HaveSHA512Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
```

## Assembler Symbols

- <Qd> Is the 128-bit name of the SIMD&FP source and destination register, encoded in the "Rd" field.
- <Qn> Is the 128-bit name of the second SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the third SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) Vtmp;
bits(64) MSigma1;
bits(64) tmp;
bits(128) X = V[n];
bits(128) Y = V[m];
bits(128) W = V[d];

MSigma1 = ROR(Y<127:64>, 14) EOR ROR(Y<127:64>, 18) EOR ROR(Y<127:64>, 41);
Vtmp<127:64> = (Y<127:64> AND X<63:0>) EOR (NOT(Y<127:64>) AND X<127:64>);
Vtmp<127:64> = (Vtmp<127:64> + MSigma1 + W<127:64>);
tmp = Vtmp<127:64> + Y<63:0>;
MSigma1 = ROR(tmp, 14) EOR ROR(tmp, 18) EOR ROR(tmp, 41);
Vtmp<63:0> = (tmp AND Y<127:64>) EOR (NOT(tmp) AND X<63:0>);
Vtmp<63:0> = (Vtmp<63:0> + MSigma1 + W<63:0>);
V[d] = Vtmp;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# SHA512SU0

SHA512 Schedule Update 0 takes the values from the two 128-bit source SIMD&FP registers and produces a 128-bit output value that combines the gamma0 functions of two iterations of the SHA512 schedule update that are performed after the first 16 iterations within a block. It returns this value to the destination SIMD&FP register.

This instruction is implemented only when [ARMv8.2-SHA](#) is implemented.

## Advanced SIMD (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	Rn				Rd					

## Advanced SIMD

SHA512SU0 <Vd>.2D, <Vn>.2D

```
if !HaveSHA512Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the second SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(64) sig0;
bits(128) Vtmp;
bits(128) X = V[n];
bits(128) W = V[d];
sig0 = ROR(W<127:64>, 1) EOR ROR(W<127:64>, 8) EOR ('0000000':W<127:71>);
Vtmp<63:0> = W<63:0> + sig0;
sig0 = ROR(X<63:0>, 1) EOR ROR(X<63:0>, 8) EOR ('0000000':X<63:7>);
Vtmp<127:64> = W<127:64> + sig0;
V[d] = Vtmp;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

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# SHA512SU1

SHA512 Schedule Update 1 takes the values from the three source SIMD&FP registers and produces a 128-bit output value that combines the gamma1 functions of two iterations of the SHA512 schedule update that are performed after the first 16 iterations within a block. It returns this value to the destination SIMD&FP register.

This instruction is implemented only when **ARMv8.2-SHA** is implemented.

## Advanced SIMD (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	0	1	1	Rm				1	0	0	0	1	0	Rn				Rd						

## Advanced SIMD

SHA512SU1 <Vd>.2D, <Vn>.2D, <Vm>.2D

```
if !HaveSHA512Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the second SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the third SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(64) sig1;
bits(128) Vtmp;
bits(128) X = V[n];
bits(128) Y = V[m];
bits(128) W = V[d];

sig1 = ROR(X<127:64>, 19) EOR ROR(X<127:64>, 61) EOR ('000000':X<127:70>);
Vtmp<127:64> = W<127:64> + sig1 + Y<127:64>;
sig1 = ROR(X<63:0>, 19) EOR ROR(X<63:0>, 61) EOR ('000000':X<63:6>);
Vtmp<63:0> = W<63:0> + sig1 + Y<63:0>;
V[d] = Vtmp;
```

## Operational information

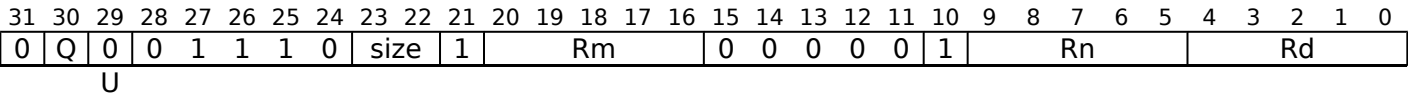
- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

SHADD

Signed Halving Add. This instruction adds corresponding signed integer values from the two source SIMD&FP registers, shifts each result right one bit, places the results into a vector, and writes the vector to the destination SIMD&FP register.

The results are truncated. For rounded results, see [SRHADD](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers of the same type

```
SHADD <Vd>.<T>, <Vn>.<T>, <Vm>.<T>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
integer sum;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    sum = element1 + element2;
    Elem[result, e, esize] = sum<esize:1>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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SHL

Shift Left (immediate). This instruction reads each value from a vector, left shifts each result by an immediate value, writes the final result to a vector, and writes the vector to the destination SIMD&FP register.  
Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	0	!= 0000				immb			0	1	0	1	0	1	Rn				Rd					
immh																															

Scalar

```
SHL <V><d>, <V><n>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh<3> != '1' then UNDEFINED;
integer esize = 8 << 3;
integer datasize = esize;
integer elements = 1;

integer shift = UInt(immh:immb) - esize;
```

Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	0	!= 0000				immb			0	1	0	1	0	1	Rn				Rd					
immh																															

Vector

```
SHL <Vd>.<T>, <Vn>.<T>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3>:Q == '10' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer shift = UInt(immh:immb) - esize;
```

Assembler Symbols

- <V>

Is a width specifier, encoded in “immh”:

immh		<V>
0xxx		RESERVED
1xxx		D
- <d>

Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n>

Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in “immh:Q”:

immh	Q	<T>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<shift> For the scalar variant: is the left shift amount, in the range 0 to 63, encoded in “immh:immb”:

immh	<shift>
0xxx	RESERVED
1xxx	(UInt(immh:immb) - 64)

For the vector variant: is the left shift amount, in the range 0 to the element width in bits minus 1, encoded in “immh:immb”:

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(UInt(immh:immb) - 8)
001x	(UInt(immh:immb) - 16)
01xx	(UInt(immh:immb) - 32)
1xxx	(UInt(immh:immb) - 64)

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;

for e = 0 to elements-1
    Elem[result, e, esize] = LSL(Elem[operand, e, esize], shift);

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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SHLL, SHLL2

Shift Left Long (by element size). This instruction reads each vector element in the lower or upper half of the source SIMD&FP register, left shifts each result by the element size, writes the final result to a vector, and writes the vector to the destination SIMD&FP register. The destination vector elements are twice as long as the source vector elements. The SHLL instruction extracts vector elements from the lower half of the source register, while the SHLL2 instruction extracts vector elements from the upper half of the source register. Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	size			1	0	0	0	0	1	0	0	1	1	1	0	Rn				Rd				

Vector

```
SHLL{2} <Vd>.<Ta>, <Vn>.<Tb>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

integer shift = esize;
boolean unsigned = FALSE;    // Or TRUE without change of functionality
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q		2
0		[absent]
1		[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<shift> Is the left shift amount, which must be equal to the source element width in bits, encoded in “size”:

size	<shift>
00	8
01	16
10	32
11	RESERVED

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = Vpart[n, part];
bits(2*datasize) result;
integer element;

for e = 0 to elements-1
    element = Int(Elem[operand, e, esize], unsigned) << shift;
    Elem[result, e, 2*esize] = element<2*esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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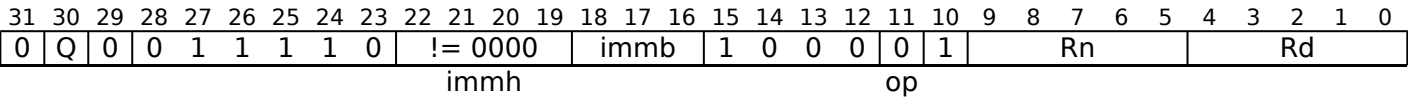
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SHRN, SHRN2

Shift Right Narrow (immediate). This instruction reads each unsigned integer value from the source SIMD&FP register, right shifts each result by an immediate value, puts the final result into a vector, and writes the vector to the lower or upper half of the destination SIMD&FP register. The destination vector elements are half as long as the source vector elements. The results are truncated. For rounded results, see [RSHRN](#).

The RSHRN instruction writes the vector to the lower half of the destination register and clears the upper half, while the RSHRN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Vector

```
SHRN{2} <Vd>.<Tb>, <Vn>.<Ta>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

integer shift = (2 * esize) - UInt(immh:immb);
boolean round = (op == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Tb> Is an arrangement specifier, encoded in “immh:Q”:

immh	Q	<Tb>
0000	x	SEE Advanced SIMD modified immediate
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	x	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<Ta> Is an arrangement specifier, encoded in “immh”:

immh	<Ta>
0000	SEE Advanced SIMD modified immediate
0001	8H
001x	4S
01xx	2D
1xxx	RESERVED

<shift> Is the right shift amount, in the range 1 to the destination element width in bits, encoded in “immh:immb”:

immh	<shift>
0000	SEE Advanced SIMD modified immediate
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	RESERVED

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize*2) operand = V[n];
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;

for e = 0 to elements-1
    element = (UInt(Elem[operand, e, 2*esize]) + round_const) >> shift;
    Elem[result, e, esize] = element<esize-1:0>;

Vpart[d, part] = result;
```

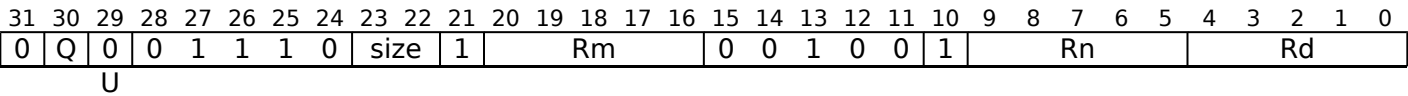
Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

SHSUB

Signed Halving Subtract. This instruction subtracts the elements in the vector in the second source SIMD&FP register from the corresponding elements in the vector in the first source SIMD&FP register, shifts each result right one bit, places each result into elements of a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers of the same type

```
SHSUB <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
integer diff;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    diff = element1 - element2;
    Elem[result, e, esize] = diff<esize:1>;

V[d] = result;
```

Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

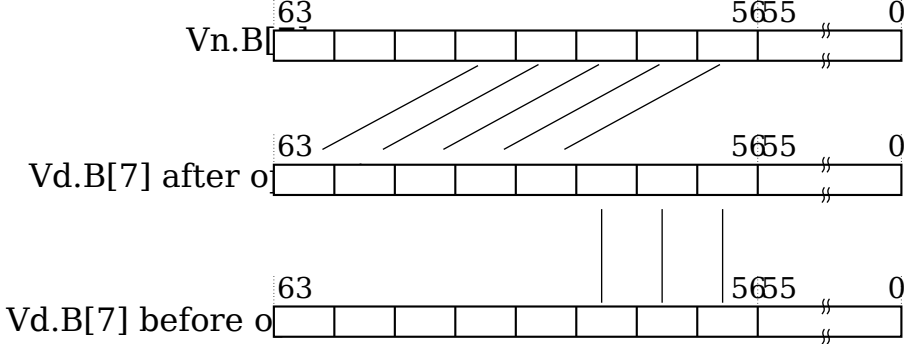
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SLI

Shift Left and Insert (immediate). This instruction reads each vector element in the source SIMD&FP register, left shifts each vector element by an immediate value, and inserts the result into the corresponding vector element in the destination SIMD&FP register such that the new zero bits created by the shift are not inserted but retain their existing value. Bits shifted out of the left of each vector element in the source register are lost.

The following figure shows an example of the operation of shift left by 3 for an 8-bit vector element.



Depending on the settings in the [CPACR EL1](#), [CPTR EL2](#), and [CPTR EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	1	1	1	1	1	1	1	0	!= 0000				immb			0	1	0	1	0	1	1	Rn					Rd				
immh																																

Scalar

SLI [<V><d>](#), [<V><n>](#), [#<shift>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh<3> != '1' then UNDEFINED;
integer esize = 8 << 3;
integer datasize = esize;
integer elements = 1;

integer shift = UInt(immh:immb) - esize;
```

Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	Q	1	0	1	1	1	1	0	!= 0000				immb			0	1	0	1	0	1	1	Rn					Rd				
immh																																

Vector

```
SLI <Vd>.<T>, <Vn>.<T>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3>:Q == '10' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer shift = UInt(immh:immb) - esize;
```

Assembler Symbols

<V> Is a width specifier, encoded in “immh”:

immh	<V>
0xxx	RESERVED
1xxx	D

<d> Is the number of the SIMD&FP destination register, in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in “immh:Q”:

immh	Q	<T>
0000	x	SEE Advanced SIMD modified immediate
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<shift> For the scalar variant: is the left shift amount, in the range 0 to 63, encoded in “immh:immb”:

immh	<shift>
0xxx	RESERVED
1xxx	(UInt(immh:immb) - 64)

For the vector variant: is the left shift amount, in the range 0 to the element width in bits minus 1, encoded in “immh:immb”:

immh	<shift>
0000	SEE Advanced SIMD modified immediate
0001	(UInt(immh:immb) - 8)
001x	(UInt(immh:immb) - 16)
01xx	(UInt(immh:immb) - 32)
1xxx	(UInt(immh:immb) - 64)



## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) operand2 = V[d];
bits(datasize) result;
bits(esize) mask = LSL(Ones(esize), shift);
bits(esize) shifted;

for e = 0 to elements-1
    shifted = LSL(Elem[operand, e, esize], shift);
    Elem[result, e, esize] = (Elem[operand2, e, esize] AND NOT(mask)) OR shifted;
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# SM3PARTW1

SM3PARTW1 takes three 128-bit vectors from the three source SIMD&FP registers and returns a 128-bit result in the destination SIMD&FP register. The result is obtained by a three-way exclusive OR of the elements within the input vectors with some fixed rotations, see the Operation pseudocode for more information.

This instruction is implemented only when [ARMv8.2-SM](#) is implemented.

## Advanced SIMD (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	0	1	1	Rm				1	1	0	0	0	0	Rn				Rd						

## Advanced SIMD

SM3PARTW1 <Vd>.4S, <Vn>.4S, <Vm>.4S

```
if !HaveSM3Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the second SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the third SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) Vm = V[m];
bits(128) Vn = V[n];
bits(128) Vd = V[d];
bits(128) result;

result<95:0> = (Vd EOR Vn)<95:0> EOR (ROL(Vm<127:96>, 15):ROL(Vm<95:64>, 15):ROL(Vm<63:32>, 15));

for i = 0 to 3
    if i == 3 then
        result<127:96> = (Vd EOR Vn)<127:96> EOR (ROL(result<31:0>, 15));
        result<(32*i)+31:(32*i)> = result<(32*i)+31:(32*i)> EOR ROL(result<(32*i)+31:(32*i)>, 15) EOR ROL(result<(32*i)+31:(32*i)>, 15);
    V[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# SM3PARTW2

SM3PARTW2 takes three 128-bit vectors from three source SIMD&FP registers and returns a 128-bit result in the destination SIMD&FP register. The result is obtained by a three-way exclusive OR of the elements within the input vectors with some fixed rotations, see the Operation pseudocode for more information.

This instruction is implemented only when [ARMv8.2-SM](#) is implemented.

## Advanced SIMD (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	0	1	1	Rm				1	1	0	0	0	1	Rn				Rd						

## Advanced SIMD

SM3PARTW2 <Vd>.4S, <Vn>.4S, <Vm>.4S

```
if !HaveSM3Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the second SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the third SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) Vm = V[m];
bits(128) Vn = V[n];
bits(128) Vd = V[d];
bits(128) result;
bits(128) tmp;
bits(32) tmp2;
tmp<127:0> = Vn EOR (ROL(Vm<127:96>, 7):ROL(Vm<95:64>, 7):ROL(Vm<63:32>, 7):ROL(Vm<31:0>, 7));
result<127:0> = Vd<127:0> EOR tmp<127:0>;
tmp2 = ROL(tmp<31:0>, 15);
tmp2 = tmp2 EOR ROL(tmp2, 15) EOR ROL(tmp2, 23);
result<127:96> = result<127:96> EOR tmp2;
V[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# SM3SS1

SM3SS1 rotates the top 32 bits of the 128-bit vector in the first source SIMD&FP register by 12, and adds that 32-bit value to the two other 32-bit values held in the top 32 bits of each of the 128-bit vectors in the second and third source SIMD&FP registers, rotating this result left by 7 and writing the final result into the top 32 bits of the vector in the destination SIMD&FP register, with the bottom 96 bits of the vector being written to 0.

This instruction is implemented only when [ARMv8.2-SM](#) is implemented.

## Advanced SIMD (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	0	1	0					Rm	0															Rd

## Advanced SIMD

SM3SS1 <Vd>.4S, <Vn>.4S, <Vm>.4S, <Va>.4S

```
if !HaveSM3Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer a = UInt(Ra);
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Va> Is the name of the third SIMD&FP source register, encoded in the "Ra" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) Vm = V[m];
bits(128) Vn = V[n];
bits(128) Vd = V[d];
bits(128) Va = V[a];
Vd<127:96> = ROL((ROL(Vn<127:96>, 12) + Vm<127:96> + Va<127:96>), 7);
Vd<95:0> = Zeros();
V[d] = Vd;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# SM3TT1A

SM3TT1A takes three 128-bit vectors from three source SIMD&FP registers and a 2-bit immediate index value, and returns a 128-bit result in the destination SIMD&FP register. It performs a three-way exclusive OR of the three 32-bit fields held in the upper three elements of the first source vector, and adds the resulting 32-bit value and the following three other 32-bit values:

- The bottom 32-bit element of the first source vector, Vd, that was used for the three-way exclusive OR.
- The result of the exclusive OR of the top 32-bit element of the second source vector, Vn, with a rotation left by 12 of the top 32-bit element of the first source vector.
- A 32-bit element indexed out of the third source vector, Vm.

The result of this addition is returned as the top element of the result. The other elements of the result are taken from elements of the first source vector, with the element returned in bits<63:32> being rotated left by 9.

This instruction is implemented only when [ARMv8.2-SM](#) is implemented.

## Advanced SIMD

(Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	0	1	0	Rm				1	0	imm2	0	0	Rn				Rd							

## Advanced SIMD

```
SM3TT1A <Vd>.4S, <Vn>.4S, <Vm>.S[<imm2>]

if !HaveSM3Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer i = UInt(imm2);
```

## Assembler Symbols

<Vd>	Is the name of the SIMD&FP source and destination register, encoded in the "Rd" field.
<Vn>	Is the name of the second SIMD&FP source register, encoded in the "Rn" field.
<Vm>	Is the name of the third SIMD&FP source register, encoded in the "Rm" field.
<imm2>	Is a 32-bit element indexed out of <Vm>, encoded in "imm2".

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) Vm = V[m];
bits(128) Vn = V[n];
bits(128) Vd = V[d];
bits(32) WjPrime;
bits(128) result;
bits(32) TT1;
bits(32) SS2;

WjPrime = Elem[Vm, i, 32];
SS2 = Vn<127:96> EOR ROL(Vd<127:96>, 12);
TT1 = Vd<63:32> EOR (Vd<127:96> EOR Vd<95:64>);
TT1 = (TT1+Vd<31:0>+SS2+WjPrime)<31:0>;
result<31:0> = Vd<63:32>;
result<63:32> = ROL(Vd<95:64>, 9);
result<95:64> = Vd<127:96>;
result<127:96> = TT1;
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# SM3TT1B

SM3TT1B takes three 128-bit vectors from three source SIMD&FP registers and a 2-bit immediate index value, and returns a 128-bit result in the destination SIMD&FP register. It performs a 32-bit majority function between the three 32-bit fields held in the upper three elements of the first source vector, and adds the resulting 32-bit value and the following three other 32-bit values:

- The bottom 32-bit element of the first source vector, Vd, that was used for the 32-bit majority function.
  - The result of the exclusive OR of the top 32-bit element of the second source vector, Vn, with a rotation left by 12 of the top 32-bit element of the first source vector.
  - A 32-bit element indexed out of the third source vector, Vm.
- The result of this addition is returned as the top element of the result. The other elements of the result are taken from elements of the first source vector, with the element returned in bits<63:32> being rotated left by 9.
- This instruction is implemented only when **ARMv8.2-SM** is implemented.

## Advanced SIMD (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	0	1	0	Rm				1	0	imm2	0	1	Rn				Rd							

## Advanced SIMD

```
SM3TT1B <Vd>.4S, <Vn>.4S, <Vm>.S[<imm2>]

if !HaveSM3Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer i = UInt(imm2);
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the second SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the third SIMD&FP source register, encoded in the "Rm" field.
- <imm2> Is a 32-bit element indexed out of <Vm>, encoded in "imm2".

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) Vm = V[m];
bits(128) Vn = V[n];
bits(128) Vd = V[d];
bits(32) WjPrime;
bits(128) result;
bits(32) TT1;
bits(32) SS2;

WjPrime = Elem[Vm, i, 32];
SS2 = Vn<127:96> EOR ROL(Vd<127:96>, 12);
TT1 = (Vd<127:96> AND Vd<63:32>) OR (Vd<127:96> AND Vd<95:64>) OR (Vd<63:32> AND Vd<95:64>);
TT1 = (TT1+Vd<31:0>+SS2+WjPrime)<31:0>;
result<31:0> = Vd<63:32>;
result<63:32> = ROL(Vd<95:64>, 9);
result<95:64> = Vd<127:96>;
result<127:96> = TT1;
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# SM3TT2A

SM3TT2A takes three 128-bit vectors from three source SIMD&FP register and a 2-bit immediate index value, and returns a 128-bit result in the destination SIMD&FP register. It performs a three-way exclusive OR of the three 32-bit fields held in the upper three elements of the first source vector, and adds the resulting 32-bit value and the following three other 32-bit values:

- The bottom 32-bit element of the first source vector, Vd, that was used for the three-way exclusive OR.
- The 32-bit element held in the top 32 bits of the second source vector, Vn.
- A 32-bit element indexed out of the third source vector, Vm.

A three-way exclusive OR is performed of the result of this addition, the result of the addition rotated left by 9, and the result of the addition rotated left by 17. The result of this exclusive OR is returned as the top element of the returned result. The other elements of this result are taken from elements of the first source vector, with the element returned in bits<63:32> being rotated left by 19.

This instruction is implemented only when **ARMv8.2-SM** is implemented.

## Advanced SIMD (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	0	1	0	Rm				1	0	imm2		1	0	Rn				Rd						

## Advanced SIMD

SM3TT2A <Vd>.4S, <Vn>.4S, <Vm>.S[<imm2>]

```
if !HaveSM3Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer i = UInt(imm2);
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the second SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the third SIMD&FP source register, encoded in the "Rm" field.
- <imm2> Is a 32-bit element indexed out of <Vm>, encoded in "imm2".

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) Vm = V[m];
bits(128) Vn = V[n];
bits(128) Vd = V[d];
bits(32) Wj;
bits(128) result;
bits(32) TT2;

Wj = Elem[Vm, i, 32];
TT2 = Vd<63:32> EOR (Vd<127:96> EOR Vd<95:64>);
TT2 = (TT2+Vd<31:0>+Vn<127:96>+Wj)<31:0>;

result<31:0> = Vd<63:32>;
result<63:32> = ROL(Vd<95:64>, 19);
result<95:64> = Vd<127:96>;
result<127:96> = TT2 EOR ROL(TT2, 9) EOR ROL(TT2, 17);
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# SM3TT2B

SM3TT2B takes three 128-bit vectors from three source SIMD&FP registers, and a 2-bit immediate index value, and returns a 128-bit result in the destination SIMD&FP register. It performs a 32-bit majority function between the three 32-bit fields held in the upper three elements of the first source vector, and adds the resulting 32-bit value and the following three other 32-bit values:

- The bottom 32-bit element of the first source vector, Vd, that was used for the 32-bit majority function.
- The 32-bit element held in the top 32 bits of the second source vector, Vn.
- A 32-bit element indexed out of the third source vector, Vm.

A three-way exclusive OR is performed of the result of this addition, the result of the addition rotated left by 9, and the result of the addition rotated left by 17. The result of this exclusive OR is returned as the top element of the returned result. The other elements of this result are taken from elements of the first source vector, with the element returned in bits<63:32> being rotated left by 19.

This instruction is implemented only when **ARMv8.2-SM** is implemented.

## Advanced SIMD (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	0	1	0	Rm				1	0	imm2		1	1	Rn				Rd						

## Advanced SIMD

SM3TT2B <Vd>.4S, <Vn>.4S, <Vm>.S[<imm2>]

```
if !HaveSM3Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer i = UInt(imm2);
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the second SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the third SIMD&FP source register, encoded in the "Rm" field.
- <imm2> Is a 32-bit element indexed out of <Vm>, encoded in "imm2".

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) Vm = V[m];
bits(128) Vn = V[n];
bits(128) Vd = V[d];
bits(32) Wj;
bits(128) result;
bits(32) TT2;

Wj = Elem[Vm, i, 32];
TT2 = (Vd<127:96> AND Vd<95:64>) OR (NOT(Vd<127:96>) AND Vd<63:32>);
TT2 = (TT2+Vd<31:0>+Vn<127:96>+Wj)<31:0>;

result<31:0> = Vd<63:32>;
result<63:32> = ROL(Vd<95:64>, 19);
result<95:64> = Vd<127:96>;
result<127:96> = TT2 EOR ROL(TT2, 9) EOR ROL(TT2, 17);
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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SM4E

SM4 Encode takes input data as a 128-bit vector from the first source SIMD&FP register, and four iterations of the round key held as the elements of the 128-bit vector in the second source SIMD&FP register. It encrypts the data by four rounds, in accordance with the SM4 standard, returning the 128-bit result to the destination SIMD&FP register. This instruction is implemented only when [ARMv8.2-SM](#) is implemented.

Advanced SIMD  
(Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	1	1	0	0	0	0	0	0	1	0	0	0	0	1	0	Rn			Rd					

Advanced SIMD

SM4E <Vd>.4S, <Vn>.4S

```
if !HaveSM4Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the second SIMD&FP source register, encoded in the "Rn" field.

Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) Vn = V[n];
bits(32) intval;
bits(8) sboxout;
bits(128) roundresult;
bits(32) roundkey;

roundresult = V[d];
for index = 0 to 3
    roundkey = Elem[Vn, index, 32];

    intval = roundresult<127:96> EOR roundresult<95:64> EOR roundresult<63:32> EOR roundkey;

    for i = 0 to 3
        Elem[intval, i, 8] = Sbox(Elem[intval, i, 8]);

    intval = intval EOR ROL(intval, 2) EOR ROL(intval, 10) EOR ROL(intval, 18) EOR ROL(intval, 24);
    intval = intval EOR roundresult<31:0>;

    roundresult<31:0> = roundresult<63:32>;
    roundresult<63:32> = roundresult<95:64>;
    roundresult<95:64> = roundresult<127:96>;
    roundresult<127:96> = intval;
V[d] = roundresult;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.

- The values of the NZCV flags.

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# SM4EKEY

SM4 Key takes an input as a 128-bit vector from the first source SIMD&FP register and a 128-bit constant from the second SIMD&FP register. It derives four iterations of the output key, in accordance with the SM4 standard, returning the 128-bit result to the destination SIMD&FP register.

This instruction is implemented only when **ARMv8.2-SM** is implemented.

## Advanced SIMD (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	0	1	1	Rm					1	1	0	0	1	0	Rn					Rd				

## Advanced SIMD

SM4EKEY <Vd>.4S, <Vn>.4S, <Vm>.4S

```
if !HaveSM4Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) Vm = V[m];
bits(32) intval;
bits(8) sboxout;
bits(128) result;
bits(32) const;
bits(128) roundresult;

roundresult = V[n];
for index = 0 to 3
    const = Elem[Vm, index, 32];

    intval = roundresult<127:96> EOR roundresult<95:64> EOR roundresult<63:32> EOR const;

    for i = 0 to 3
        Elem[intval, i, 8] = Sbox(Elem[intval, i, 8]);

    intval = intval EOR ROL(intval, 13) EOR ROL(intval, 23);
    intval = intval EOR roundresult<31:0>;

    roundresult<31:0> = roundresult<63:32>;
    roundresult<63:32> = roundresult<95:64>;
    roundresult<95:64> = roundresult<127:96>;
    roundresult<127:96> = intval;
V[d] = roundresult;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:

- The values of the data supplied in any of its registers.
- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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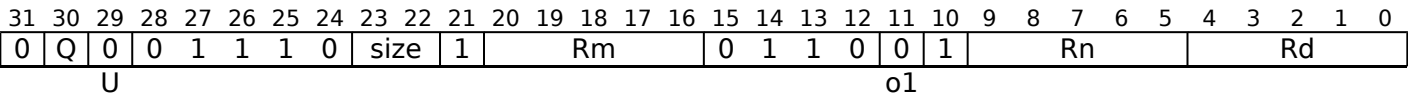
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SMAX

Signed Maximum (vector). This instruction compares corresponding elements in the vectors in the two source SIMD&FP registers, places the larger of each pair of signed integer values into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers of the same type

```
SMAX <Vd>.<T>, <Vn>.<T>, <Vm>.<T>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean minimum = (o1 == '1');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
integer maxmin;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    maxmin = if minimum then Min(element1, element2) else Max(element1, element2);
    Elem[result, e, esize] = maxmin<size-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

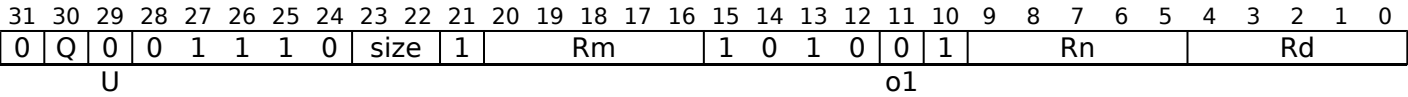
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SMAXP

Signed Maximum Pairwise. This instruction creates a vector by concatenating the vector elements of the first source SIMD&FP register after the vector elements of the second source SIMD&FP register, reads each pair of adjacent vector elements in the two source SIMD&FP registers, writes the largest of each pair of signed integer values into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers of the same type

```
SMAXP <Vd>.<T>, <Vn>.<T>, <Vm>.<T>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean minimum = (o1 == '1');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(2*datasize) concat = operand2:operand1;
integer element1;
integer element2;
integer maxmin;

for e = 0 to elements-1
    element1 = Int(Elem[concat, 2*e, esize], unsigned);
    element2 = Int(Elem[concat, (2*e)+1, esize], unsigned);
    maxmin = if minimum then Min(element1, element2) else Max(element1, element2);
    Elem[result, e, esize] = maxmin<esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

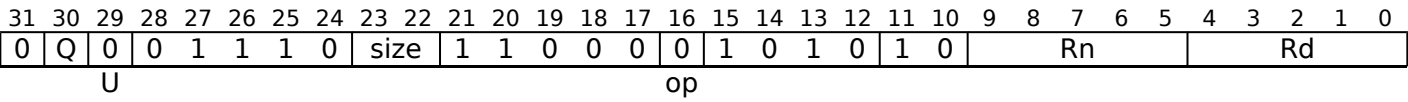
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SMAV

Signed Maximum across Vector. This instruction compares all the vector elements in the source SIMD&FP register, and writes the largest of the values as a scalar to the destination SIMD&FP register. All the values in this instruction are signed integer values.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Advanced SIMD

```
SMAV <V><d>, <Vn>.<T>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '100' then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean min = (op == '1');
```

Assembler Symbols

<V> Is the destination width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<T> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	RESERVED
10	1	4S
11	x	RESERVED

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
integer maxmin;
integer element;

maxmin = Int(Elem[operand, 0, esize], unsigned);
for e = 1 to elements-1
    element = Int(Elem[operand, e, esize], unsigned);
    maxmin = if min then Min(maxmin, element) else Max(maxmin, element);

V[d] = maxmin<esize-1:0>;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

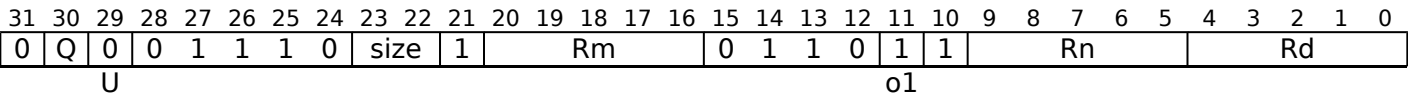
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SMIN

Signed Minimum (vector). This instruction compares corresponding elements in the vectors in the two source SIMD&FP registers, places the smaller of each of the two signed integer values into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers of the same type

SMIN <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean minimum = (o1 == '1');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
integer maxmin;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    maxmin = if minimum then Min(element1, element2) else Max(element1, element2);
    Elem[result, e, esize] = maxmin<esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

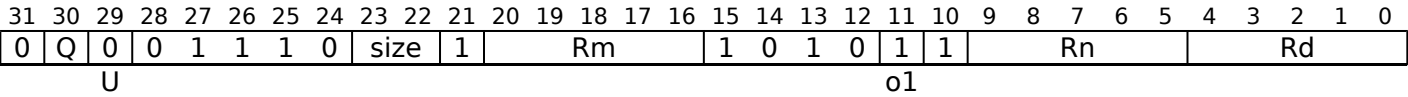
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SMINP

Signed Minimum Pairwise. This instruction creates a vector by concatenating the vector elements of the first source SIMD&FP register after the vector elements of the second source SIMD&FP register, reads each pair of adjacent vector elements in the two source SIMD&FP registers, writes the smallest of each pair of signed integer values into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers of the same type

```
SMINP <Vd>.<T>, <Vn>.<T>, <Vm>.<T>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean minimum = (o1 == '1');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(2*datasize) concat = operand2:operand1;
integer element1;
integer element2;
integer maxmin;

for e = 0 to elements-1
    element1 = Int(Elem[concat, 2*e, esize], unsigned);
    element2 = Int(Elem[concat, (2*e)+1, esize], unsigned);
    maxmin = if minimum then Min(element1, element2) else Max(element1, element2);
    Elem[result, e, esize] = maxmin<esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

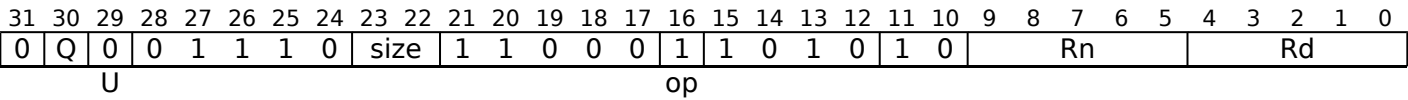
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SMINV

Signed Minimum across Vector. This instruction compares all the vector elements in the source SIMD&FP register, and writes the smallest of the values as a scalar to the destination SIMD&FP register. All the values in this instruction are signed integer values.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Advanced SIMD

SMINV <V><d>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '100' then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean min = (op == '1');
```

Assembler Symbols

- <V> Is the destination width specifier, encoded in “size”:
- | size | <V>      |
|------|----------|
| 00   | B        |
| 01   | H        |
| 10   | S        |
| 11   | RESERVED |
- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.
- <T> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	RESERVED
10	1	4S
11	x	RESERVED

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
integer maxmin;
integer element;

maxmin = Int(Elem[operand, 0, esize], unsigned);
for e = 1 to elements-1
    element = Int(Elem[operand, e, esize], unsigned);
    maxmin = if min then Min(maxmin, element) else Max(maxmin, element);

V[d] = maxmin<esize-1:0>;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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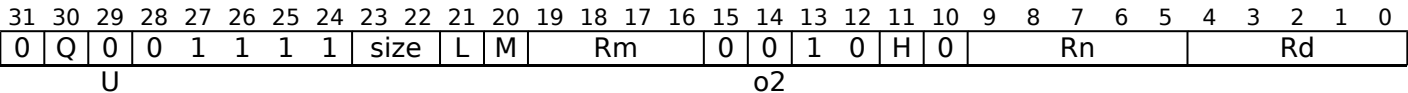
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SMLAL, SMLAL2 (by element)

Signed Multiply-Add Long (vector, by element). This instruction multiplies each vector element in the lower or upper half of the first source SIMD&FP register by the specified vector element in the second source SIMD&FP register, and accumulates the results with the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied. All the values in this instruction are signed integer values.

The SMLAL instruction extracts vector elements from the lower half of the first source register, while the SMLAL2 instruction extracts vector elements from the upper half of the first source register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Vector

```
SMLAL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Ts>[<index>]
```

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
  when '01' index = UInt(H:L:M); Rmhi = '0';
  when '10' index = UInt(H:L); Rmhi = M;
  otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean sub_op = (o2 == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q		2
0		[absent]
1		[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	RESERVED
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in “size:M:Rm”:

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

Restricted to V0-V15 when element size <Ts> is H.

<Ts> Is an element size specifier, encoded in “size”:

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in “size:L:H:M”:

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(idxsizesize) operand2 = V[m];
bits(2*datasize) operand3 = V[d];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;

element2 = Int(Elem[operand2, index, esize], unsigned);
for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    product = (element1*element2)<2*esize-1:0>;
    if sub_op then
        Elem[result, e, 2*esize] = Elem[operand3, e, 2*esize] - product;
    else
        Elem[result, e, 2*esize] = Elem[operand3, e, 2*esize] + product;

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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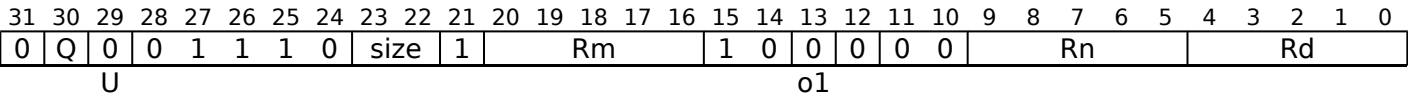
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SMLAL, SMLAL2 (vector)

Signed Multiply-Add Long (vector). This instruction multiplies corresponding signed integer values in the lower or upper half of the vectors of the two source SIMD&FP registers, and accumulates the results with the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied.

The SMLAL instruction extracts each source vector from the lower half of each source register, while the SMLAL2 instruction extracts each source vector from the upper half of each source register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers, not all the same type

```
SMLAL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(0);
integer elements = datasize DIV esize;
boolean sub_op = (o1 == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q 2	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) operand3 = V[d];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;
bits(2*esize) accum;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    product = (element1*element2)<2*esize-1:0>;
    if sub_op then
        accum = Elem[operand3, e, 2*esize] - product;
    else
        accum = Elem[operand3, e, 2*esize] + product;
    Elem[result, e, 2*esize] = accum;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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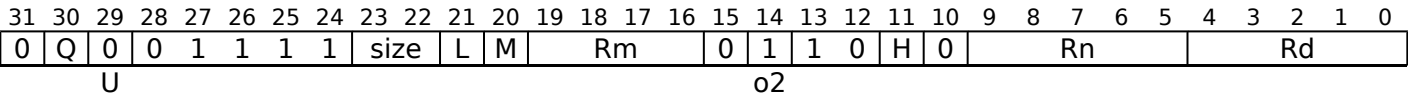


SMLSL, SMLSL2 (by element)

Signed Multiply-Subtract Long (vector, by element). This instruction multiplies each vector element in the lower or upper half of the first source SIMD&FP register by the specified vector element of the second source SIMD&FP register and subtracts the results from the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied.

The SMLSL instruction extracts vector elements from the lower half of the first source register, while the SMLSL2 instruction extracts vector elements from the upper half of the first source register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Vector

SMLSL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Ts>[<index>]

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
  when '01' index = UInt(H:L:M); Rmhi = '0';
  when '10' index = UInt(H:L); Rmhi = M;
  otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean sub_op = (o2 == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the “Rd” field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	RESERVED
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the “Rn” field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in “size:M:Rm”:

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

Restricted to V0-V15 when element size <Ts> is H.

<Ts> Is an element size specifier, encoded in “size”:

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in “size:L:H:M”:

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(idxsizesize) operand2 = V[m];
bits(2*datasize) operand3 = V[d];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;

element2 = Int(Elem[operand2, index, esize], unsigned);
for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    product = (element1*element2)<2*esize-1:0>;
    if sub_op then
        Elem[result, e, 2*esize] = Elem[operand3, e, 2*esize] - product;
    else
        Elem[result, e, 2*esize] = Elem[operand3, e, 2*esize] + product;

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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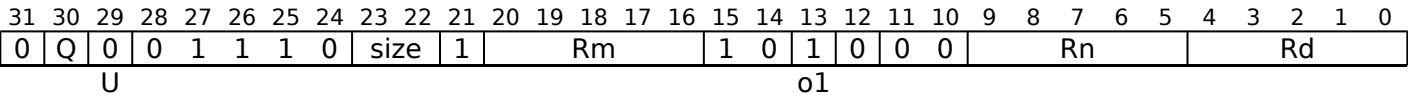
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SMLSL, SMLSL2 (vector)

Signed Multiply-Subtract Long (vector). This instruction multiplies corresponding signed integer values in the lower or upper half of the vectors of the two source SIMD&FP registers, and subtracts the results from the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied.

The SMLSL instruction extracts each source vector from the lower half of each source register, while the SMLSL2 instruction extracts each source vector from the upper half of each source register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers, not all the same type

SMLSL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(0);
integer elements = datasize DIV esize;
boolean sub_op = (o1 == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q		2
0		[absent]
1		[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) operand3 = V[d];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;
bits(2*esize) accum;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    product = (element1*element2)<2*esize-1:0>;
    if sub_op then
        accum = Elem[operand3, e, 2*esize] - product;
    else
        accum = Elem[operand3, e, 2*esize] + product;
    Elem[result, e, 2*esize] = accum;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

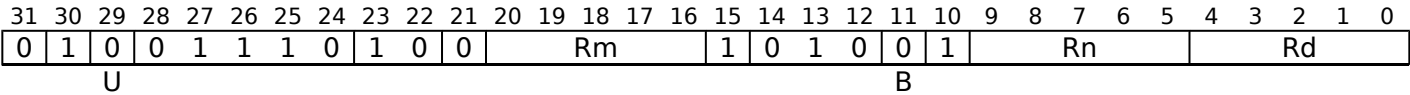
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# SMMLA (vector)

Signed 8-bit integer matrix multiply-accumulate. This instruction multiplies the 2x8 matrix of signed 8-bit integer values in the first source vector by the 8x2 matrix of signed 8-bit integer values in the second source vector. The resulting 2x2 32-bit integer matrix product is destructively added to the 32-bit integer matrix accumulator in the destination vector. This is equivalent to performing an 8-way dot product per destination element. From Armv8.2, this is an OPTIONAL instruction. [ID\\_AA64ISAR0\\_EL1](#).I8MM indicates whether this instruction is supported.

## Vector (Armv8.6)



## Vector

```
SMMLA <Vd>.4S, <Vn>.16B, <Vm>.16B

if !HaveInt8MatMulExt() then UNDEFINED;
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Rd);
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP third source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

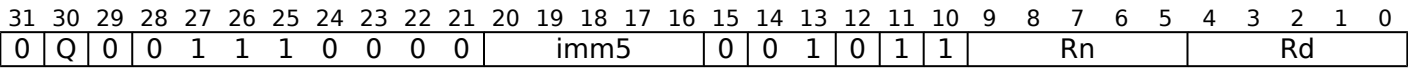
```
CheckFPAdvSIMDEnabled64();
bits(128) operand1 = V[n];
bits(128) operand2 = V[m];
bits(128) addend = V[d];

V[d] = MatMulAdd(addend, operand1, operand2, FALSE, FALSE);
```

SMOV

Signed Move vector element to general-purpose register. This instruction reads the signed integer from the source SIMD&FP register, sign-extends it to form a 32-bit or 64-bit value, and writes the result to destination general-purpose register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



32-bit (Q == 0)

```
SMOV <Wd>, <Vn>.<Ts>[<index>]
```

64-reg,SMOV-64-reg (Q == 1)

```
SMOV <Xd>, <Vn>.<Ts>[<index>]
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer size;
case Q:imm5 of
    when 'xxxxx1' size = 0;    // SMOV [WX]d, Vn.B
    when 'xxxx10' size = 1;    // SMOV [WX]d, Vn.H
    when '1xx100' size = 2;    // SMOV Xd, Vn.S
    otherwise UNDEFINED;

integer idxdsize = if imm5<4> == '1' then 128 else 64;
integer index = UInt(imm5<4:size+1>);
integer esize = 8 << size;
integer datasize = if Q == '1' then 64 else 32;
```

Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.
- <Ts> For the 32-bit variant: is an element size specifier, encoded in "imm5":

imm5	<Ts>
xxx00	RESERVED
xxxx1	B
xxx10	H

For the 64-reg,SMOV-64-reg variant: is an element size specifier, encoded in "imm5":

imm5	<Ts>
xx000	RESERVED
xxxx1	B
xxx10	H
xx100	S

- <index> For the 32-bit variant: is the element index encoded in "imm5":

imm5	<index>
xxx00	RESERVED
xxxx1	imm5<4:1>
xxx10	imm5<4:2>

For the 64-reg,SMOV-64-reg variant: is the element index encoded in "imm5":

<b>imm5</b>	<b>&lt;index&gt;</b>
xx000	RESERVED
xxxx1	imm5<4:1>
xxx10	imm5<4:2>
xx100	imm5<4:3>

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(idxdsize) operand = V[n];

X[d] = SignExtend(Elem[operand, index, esize], datasize);

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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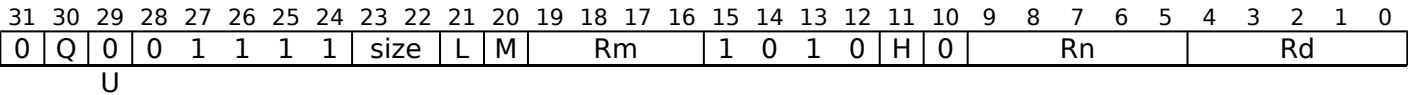
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SMULL, SMULL2 (by element)

Signed Multiply Long (vector, by element). This instruction multiplies each vector element in the lower or upper half of the first source SIMD&FP register by the specified vector element of the second source SIMD&FP register, places the result in a vector, and writes the vector to the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied.

The SMULL instruction extracts vector elements from the lower half of the first source register, while the SMULL2 instruction extracts vector elements from the upper half of the first source register.

Depending on the settings in the CPACR EL1, CPTR EL2, and CPTR EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Vector

```
SMULL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Ts>[<index>]
```

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q 2	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	RESERVED
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED



<Vm> Is the name of the second SIMD&FP source register, encoded in “size:M:Rm”:

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

Restricted to V0-V15 when element size <Ts> is H.

<Ts> Is an element size specifier, encoded in “size”:

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in “size:L:H:M”:

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(idxdsize) operand2 = V[m];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;

element2 = Int(Elem[operand2, index, esize], unsigned);
for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    product = (element1*element2)<2*esize-1:0>;
    Elem[result, e, 2*esize] = product;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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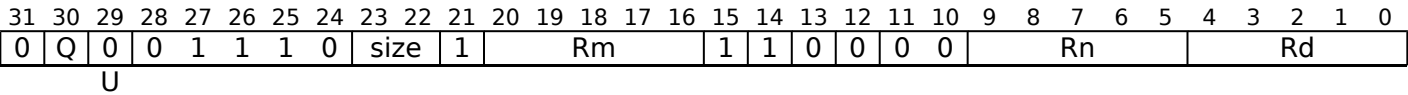
SMULL, SMULL2 (vector)

Signed Multiply Long (vector). This instruction multiplies corresponding signed integer values in the lower or upper half of the vectors of the two source SIMD&FP registers, places the results in a vector, and writes the vector to the destination SIMD&FP register.

The destination vector elements are twice as long as the elements that are multiplied.

The SMULL instruction extracts each source vector from the lower half of each source register, while the SMULL2 instruction extracts each source vector from the upper half of each source register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers, not all the same type

```
SMULL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q		2
0		[absent]
1		[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
integer element1;
integer element2;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    Elem[result, e, 2*esize] = (element1*element2)<2*esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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SQABS

Signed saturating Absolute value. This instruction reads each vector element from the source SIMD&FP register, puts the absolute value of the result into a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are signed integer values.

If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit *FPSR.QC* is set.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	size	1	0	0	0	0	0	0	0	1	1	1	1	0	Rn				Rd					
U																															

Scalar

SQABS <V><d>, <V><n>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean neg = (U == '1');
```

Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	size	1	0	0	0	0	0	0	0	1	1	1	1	0	Rn				Rd					
U																															

Vector

SQABS <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean neg = (U == '1');
```

Assembler Symbols

- <V>

Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D
- <d>

Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n>

Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
integer element;
boolean sat;

for e = 0 to elements-1
    element = SInt(Elem[operand, e, esize]);
    if neg then
        element = -element;
    else
        element = Abs(element);
    (Elem[result, e, esize], sat) = SignedSatQ(element, esize);
    if sat then FPSR.QC = '1';

V[d] = result;
```

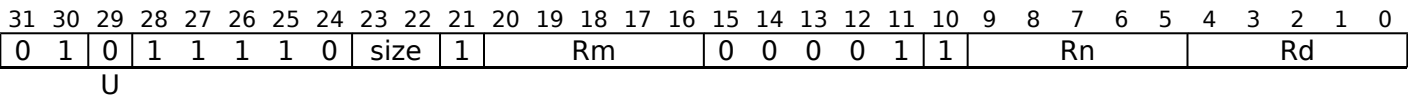
SQADD

Signed saturating Add. This instruction adds the values of corresponding elements of the two source SIMD&FP registers, places the results into a vector, and writes the vector to the destination SIMD&FP register. If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit *FPSR.QC* is set.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar

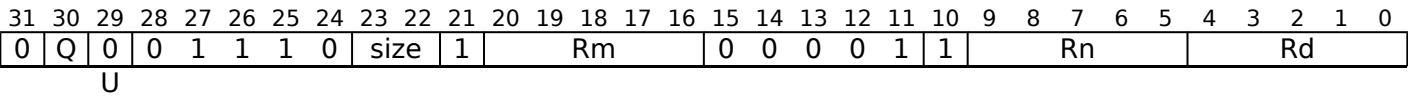


Scalar

```
SQADD <V><d>, <V><n>, <V><m>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
```

Vector



Vector

```
SQADD <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
```

Assembler Symbols

- <V>

Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D
- <d>

Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n>

Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m>

Is the number of the second SIMD&FP source register, encoded in the "Rm" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

### Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
integer sum;
boolean sat;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    sum = element1 + element2;
    (Elem[result, e, esize], sat) = SatQ(sum, esize, unsigned);
    if sat then FPSR.QC = '1';

V[d] = result;

```

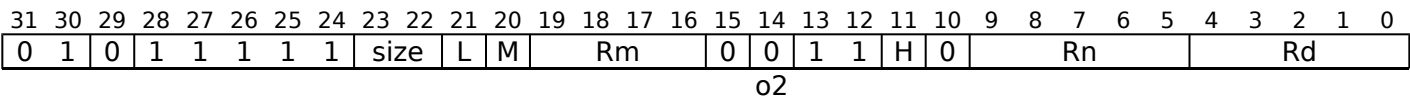
## SQDMLAL, SQDMLAL2 (by element)

Signed saturating Doubling Multiply-Add Long (by element). This instruction multiplies each vector element in the lower or upper half of the first source SIMD&FP register by the specified vector element of the second source SIMD&FP register, doubles the results, and accumulates the final results with the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied. If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit *FPSR.QC* is set.

The SQDMLAL instruction extracts vector elements from the lower half of the first source register, while the SQDMLAL2 instruction extracts vector elements from the upper half of the first source register. Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar



### Scalar

SQDMLAL <Va><d>, <Vb><n>, <Vm>.<Ts>[<index>]

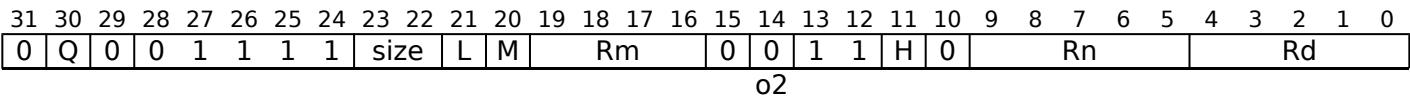
```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
integer part = 0;

boolean sub_op = (o2 == '1');
```

### Vector





Vector

```
SQDMLAL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Ts>[<index>]
```

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean sub_op = (o2 == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	RESERVED
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Va> Is the destination width specifier, encoded in “size”:

size	<Va>
00	RESERVED
01	S
10	D
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Vb> Is the source width specifier, encoded in “size”:

size	<Vb>
00	RESERVED
01	H
10	S
11	RESERVED

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in “size:M:Rm”:

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

Restricted to V0-V15 when element size <Ts> is H.

<Ts> Is an element size specifier, encoded in “size”:

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in “size:L:H:M”:

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(idxdsize) operand2 = V[m];
bits(2*datasize) operand3 = V[d];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;
integer accum;
boolean sat1;
boolean sat2;

element2 = SInt(Elem[operand2, index, esize]);
for e = 0 to elements-1
    element1 = SInt(Elem[operand1, e, esize]);
    (product, sat1) = SignedSatQ(2 * element1 * element2, 2 * esize);
    if sub_op then
        accum = SInt(Elem[operand3, e, 2*esize]) - SInt(product);
    else
        accum = SInt(Elem[operand3, e, 2*esize]) + SInt(product);
    (Elem[result, e, 2*esize], sat2) = SignedSatQ(accum, 2 * esize);
    if sat1 || sat2 then FPSR.QC = '1';

V[d] = result;

```

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## SQDMLAL, SQDMLAL2 (vector)

Signed saturating Doubling Multiply-Add Long. This instruction multiplies corresponding signed integer values in the lower or upper half of the vectors of the two source SIMD&FP registers, doubles the results, and accumulates the final results with the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied.

If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

The SQDMLAL instruction extracts each source vector from the lower half of each source register, while the SQDMLAL2 instruction extracts each source vector from the upper half of each source register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	1	0	1	1	1	1	0	size	1	Rm						1	0	0	1	0	0	Rn						Rd					
o1																																	

### Scalar

SQDMLAL [<Va><d>](#), [<Vb><n>](#), [<Vb><m>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '00' || size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
integer part = 0;

boolean sub_op = (o1 == '1');
```

### Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	Q	0	0	1	1	1	0	size	1	Rm						1	0	0	1	0	0	Rn						Rd					
o1																																	

### Vector

SQDMLAL{2} [<Vd>.<Ta>](#), [<Vn>.<Tb>](#), [<Vm>.<Tb>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '00' || size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean sub_op = (o1 == '1');
```

## Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in "Q":

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in "size":

size	<Ta>
00	RESERVED
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in "size:Q":

size	Q	<Tb>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

<Va> Is the destination width specifier, encoded in "size":

size	<Va>
00	RESERVED
01	S
10	D
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Vb> Is the source width specifier, encoded in "size":

size	<Vb>
00	RESERVED
01	H
10	S
11	RESERVED

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) operand3 = V[d];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;
integer accum;
boolean sat1;
boolean sat2;

for e = 0 to elements-1
    element1 = SInt(Elem[operand1, e, esize]);
    element2 = SInt(Elem[operand2, e, esize]);
    (product, sat1) = SignedSatQ(2 * element1 * element2, 2 * esize);
    if sub_op then
        accum = SInt(Elem[operand3, e, 2*esize]) - SInt(product);
    else
        accum = SInt(Elem[operand3, e, 2*esize]) + SInt(product);
    (Elem[result, e, 2*esize], sat2) = SignedSatQ(accum, 2 * esize);
    if sat1 || sat2 then FPSR.QC = '1';

V[d] = result;
```

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## SQDMLSL, SQDMLSL2 (by element)

Signed saturating Doubling Multiply-Subtract Long (by element). This instruction multiplies each vector element in the lower or upper half of the first source SIMD&FP register by the specified vector element of the second source SIMD&FP register, doubles the results, and subtracts the final results from the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied. All the values in this instruction are signed integer values.

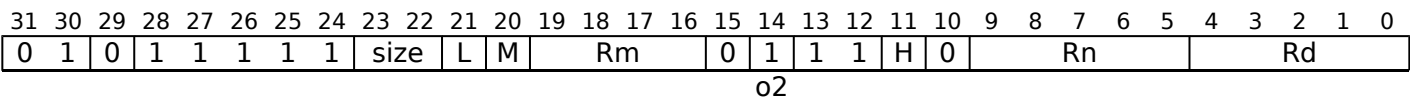
If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit *FPSR.QC* is set.

The SQDMLSL instruction extracts vector elements from the lower half of the first source register, while the SQDMLSL2 instruction extracts vector elements from the upper half of the first source register.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar



### Scalar

SQDMLSL <Va><d>, <Vb><n>, <Vm>.<Ts>[<index>]

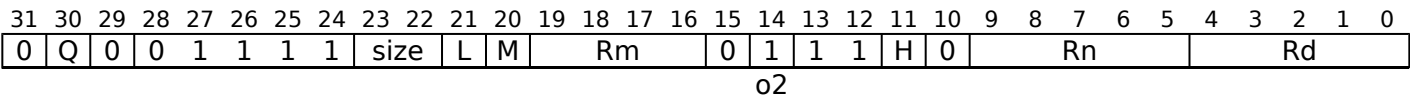
```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
  when '01' index = UInt(H:L:M); Rmhi = '0';
  when '10' index = UInt(H:L); Rmhi = M;
  otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
integer part = 0;

boolean sub_op = (o2 == '1');
```

### Vector



Vector

```
SQDMLSL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Ts>[<index>]
```

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean sub_op = (o2 == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	RESERVED
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Va> Is the destination width specifier, encoded in “size”:

size	<Va>
00	RESERVED
01	S
10	D
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Vb> Is the source width specifier, encoded in “size”:

size	<Vb>
00	RESERVED
01	H
10	S
11	RESERVED

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in “size:M:Rm”:

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

Restricted to V0-V15 when element size <Ts> is H.

<Ts> Is an element size specifier, encoded in “size”:

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in “size:L:H:M”:

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(idxdsize) operand2 = V[m];
bits(2*datasize) operand3 = V[d];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;
integer accum;
boolean sat1;
boolean sat2;

element2 = SInt(Elem[operand2, index, esize]);
for e = 0 to elements-1
    element1 = SInt(Elem[operand1, e, esize]);
    (product, sat1) = SignedSatQ(2 * element1 * element2, 2 * esize);
    if sub_op then
        accum = SInt(Elem[operand3, e, 2*esize]) - SInt(product);
    else
        accum = SInt(Elem[operand3, e, 2*esize]) + SInt(product);
    (Elem[result, e, 2*esize], sat2) = SignedSatQ(accum, 2 * esize);
    if sat1 || sat2 then FPSR.QC = '1';

V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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## SQDMLSL, SQDMLSL2 (vector)

Signed saturating Doubling Multiply-Subtract Long. This instruction multiplies corresponding signed integer values in the lower or upper half of the vectors of the two source SIMD&FP registers, doubles the results, and subtracts the final results from the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied.

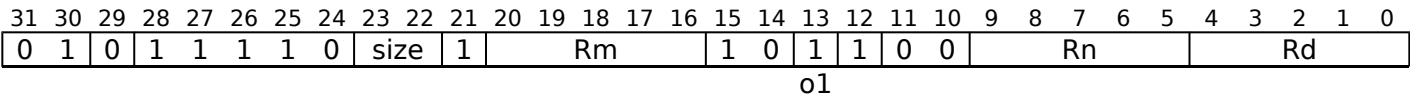
If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

The SQDMLSL instruction extracts each source vector from the lower half of each source register, while the SQDMLSL2 instruction extracts each source vector from the upper half of each source register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar



### Scalar

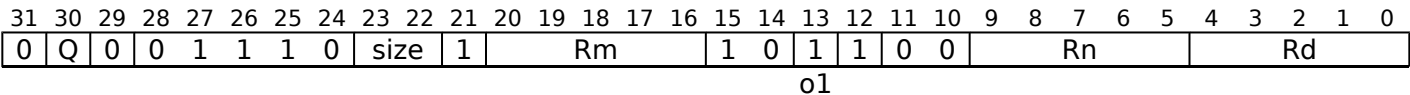
SQDMLSL [<Va><d>](#), [<Vb><n>](#), [<Vb><m>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '00' || size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
integer part = 0;

boolean sub_op = (o1 == '1');
```

### Vector



### Vector

SQDMLSL{2} [<Vd>.<Ta>](#), [<Vn>.<Tb>](#), [<Vm>.<Tb>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '00' || size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean sub_op = (o1 == '1');
```

## Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in "Q":

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in "size":

size	<Ta>
00	RESERVED
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in "size:Q":

size	Q	<Tb>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

<Va> Is the destination width specifier, encoded in "size":

size	<Va>
00	RESERVED
01	S
10	D
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Vb> Is the source width specifier, encoded in "size":

size	<Vb>
00	RESERVED
01	H
10	S
11	RESERVED

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) operand3 = V[d];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;
integer accum;
boolean sat1;
boolean sat2;

for e = 0 to elements-1
    element1 = SInt(Elem[operand1, e, esize]);
    element2 = SInt(Elem[operand2, e, esize]);
    (product, sat1) = SignedSatQ(2 * element1 * element2, 2 * esize);
    if sub_op then
        accum = SInt(Elem[operand3, e, 2*esize]) - SInt(product);
    else
        accum = SInt(Elem[operand3, e, 2*esize]) + SInt(product);
    (Elem[result, e, 2*esize], sat2) = SignedSatQ(accum, 2 * esize);
    if sat1 || sat2 then FPSR.QC = '1';

V[d] = result;
```

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## SQDMULH (by element)

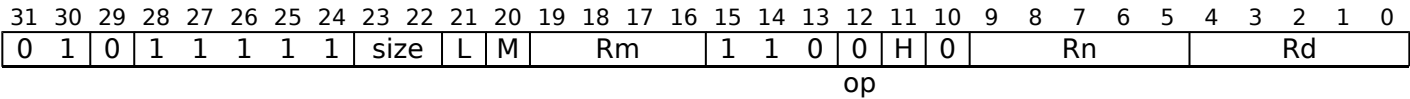
Signed saturating Doubling Multiply returning High half (by element). This instruction multiplies each vector element in the first source SIMD&FP register by the specified vector element of the second source SIMD&FP register, doubles the results, places the most significant half of the final results into a vector, and writes the vector to the destination SIMD&FP register.

The results are truncated. For rounded results, see [SQRDMULH](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar



### Scalar

```
SQDMULH <V><d>, <V><n>, <Vm>.<Ts>[<index>]

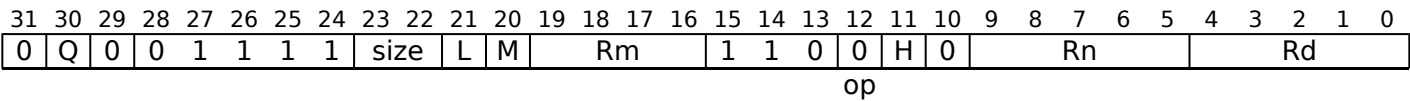
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;

boolean round = (op == '1');
```

### Vector



Vector

```
SQDMULH <Vd>.<T>, <Vn>.<T>, <Vm>.<Ts>[<index>]
```

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean round = (op == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	RESERVED
01	H
10	S
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in “size:M:Rm”:

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

Restricted to V0-V15 when element size <Ts> is H.

<Ts> Is an element size specifier, encoded in “size”:

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in “size:L:H:M”:

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(idxdsize) operand2 = V[m];
bits(datasize) result;
integer round_const = if round then 1 << (esize - 1) else 0;
integer element1;
integer element2;
integer product;
boolean sat;

element2 = SInt(Elem[operand2, index, esize]);
for e = 0 to elements-1
    element1 = SInt(Elem[operand1, e, esize]);
    product = (2 * element1 * element2) + round_const;
    // The following only saturates if element1 and element2 equal -(2^(esize-1))
    (Elem[result, e, esize], sat) = SignedSatQ(product >> esize, esize);
    if sat then FPSR.QC = '1';

V[d] = result;

```

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SQDMULH (vector)

Signed saturating Doubling Multiply returning High half. This instruction multiplies the values of corresponding elements of the two source SIMD&FP registers, doubles the results, places the most significant half of the final results into a vector, and writes the vector to the destination SIMD&FP register.

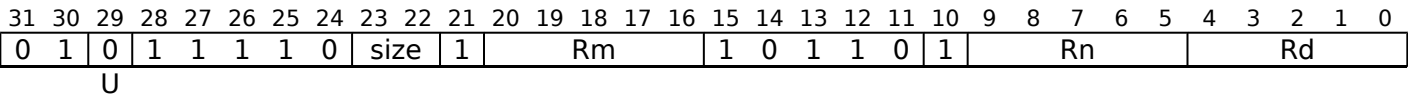
The results are truncated. For rounded results, see [SQRDMULH](#).

If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar

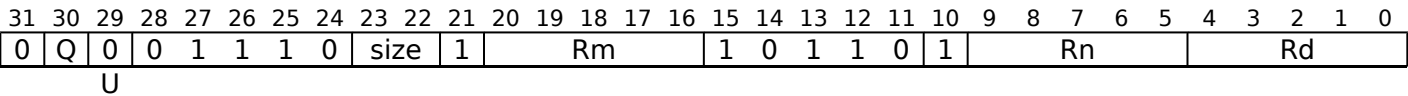


Scalar

SQDMULH <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' || size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean rounding = (U == '1');
```

Vector



Vector

SQDMULH <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' || size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean rounding = (U == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	RESERVED
01	H
10	S
11	RESERVED

<d> Is the number of the SIMD&FP destination register, in the "Rd" field.

- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

### Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer round_const = if rounding then 1 << (esize - 1) else 0;
integer element1;
integer element2;
integer product;
boolean sat;

for e = 0 to elements-1
    element1 = SInt(Elem[operand1, e, esize]);
    element2 = SInt(Elem[operand2, e, esize]);
    product = (2 * element1 * element2) + round_const;
    (Elem[result, e, esize], sat) = SignedSatQ(product >> esize, esize);
    if sat then FPSR.QC = '1';

V[d] = result;

```



## SQDMULL, SQDMULL2 (by element)

Signed saturating Doubling Multiply Long (by element). This instruction multiplies each vector element in the lower or upper half of the first source SIMD&FP register by the specified vector element of the second source SIMD&FP register, doubles the results, places the final results in a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are signed integer values.

If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

The SQDMULL instruction extracts the first source vector from the lower half of the first source register, while the SQDMULL2 instruction extracts the first source vector from the upper half of the first source register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	size	L	M			Rm			1	0	1	1	H	0				Rn				Rd		

### Scalar

SQDMULL <Va><d>, <Vb><n>, <Vm>.<Ts>[<index>]

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
integer part = 0;
```

### Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	size	L	M			Rm			1	0	1	1	H	0				Rn				Rd		

Vector

```
SQDMULL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Ts>[<index>]
```

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q 2	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	RESERVED
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Va> Is the destination width specifier, encoded in “size”:

size	<Va>
00	RESERVED
01	S
10	D
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Vb> Is the source width specifier, encoded in “size”:

size	<Vb>
00	RESERVED
01	H
10	S
11	RESERVED

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in “size:M:Rm”:

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

Restricted to V0-V15 when element size <Ts> is H.

<Ts> Is an element size specifier, encoded in “size”:

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in “size:L:H:M”:

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();

bits(datasize) operand1 = Vpart[n, part];
bits(idxdsize) operand2 = V[m];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;
boolean sat;

element2 = SInt(Elem[operand2, index, esize]);
for e = 0 to elements-1
    element1 = SInt(Elem[operand1, e, esize]);
    (product, sat) = SignedSatQ(2 * element1 * element2, 2 * esize);
    Elem[result, e, 2*esize] = product;
    if sat then FPSR.QC = '1';

V[d] = result;

```

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SQDMULL, SQDMULL2 (vector)

Signed saturating Doubling Multiply Long. This instruction multiplies corresponding vector elements in the lower or upper half of the two source SIMD&FP registers, doubles the results, places the final results in a vector, and writes the vector to the destination SIMD&FP register.

If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit *FPSR.QC* is set.

The SQDMULL instruction extracts each source vector from the lower half of each source register, while the SQDMULL2 instruction extracts each source vector from the upper half of each source register.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	size	1				Rm			1	1	0	1	0	0				Rn				Rd		

Scalar

SQDMULL <Va><d>, <Vb><n>, <Vb><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '00' || size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
integer part = 0;
```

Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	size	1				Rm			1	1	0	1	0	0				Rn				Rd		

Vector

SQDMULL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '00' || size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q		2
0		[absent]
1		[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the “Rd” field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	RESERVED
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in "size:Q":

size	Q	<Tb>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

<Va> Is the destination width specifier, encoded in "size":

size	<Va>
00	RESERVED
01	S
10	D
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Vb> Is the source width specifier, encoded in "size":

size	<Vb>
00	RESERVED
01	H
10	S
11	RESERVED

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;
boolean sat;

for e = 0 to elements-1
    element1 = SInt(Elem[operand1, e, esize]);
    element2 = SInt(Elem[operand2, e, esize]);
    (product, sat) = SignedSatQ(2 * element1 * element2, 2 * esize);
    Elem[result, e, 2*esize] = product;
    if sat then FPSR.QC = '1';

V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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SQNEG

Signed saturating Negate. This instruction reads each vector element from the source SIMD&FP register, negates each value, places the result into a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are signed integer values.

If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit *FPSR.QC* is set.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	size	1	0	0	0	0	0	0	0	1	1	1	1	0	Rn				Rd					
U																															

Scalar

SQNEG <V><d>, <V><n>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean neg = (U == '1');
```

Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	size	1	0	0	0	0	0	0	0	1	1	1	1	0	Rn				Rd					
U																															

Vector

SQNEG <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean neg = (U == '1');
```

Assembler Symbols

- <V>

Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D
- <d>

Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n>

Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
integer element;
boolean sat;

for e = 0 to elements-1
    element = SInt(Elem[operand, e, esize]);
    if neg then
        element = -element;
    else
        element = Abs(element);
    (Elem[result, e, esize], sat) = SignedSatQ(element, esize);
    if sat then FPSR.QC = '1';

V[d] = result;
```

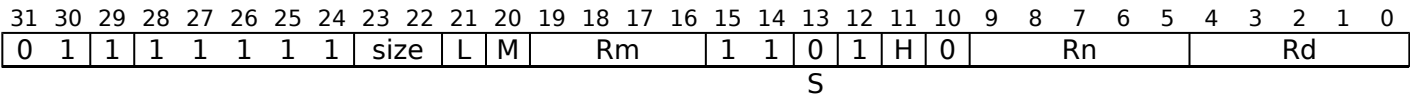
## SQRDMLAH (by element)

Signed Saturating Rounding Doubling Multiply Accumulate returning High Half (by element). This instruction multiplies the vector elements of the first source SIMD&FP register with the value of a vector element of the second source SIMD&FP register without saturating the multiply results, doubles the results, and accumulates the most significant half of the final results with the vector elements of the destination SIMD&FP register. The results are rounded.

If any of the results overflow, they are saturated. The cumulative saturation bit, [FPSR.QC](#), is set if saturation occurs. Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar (Armv8.1)



### Scalar

SQRDMLAH <V><d>, <V><n>, <Vm>.<Ts>[<index>]

```
if !HaveQRDMLAHExt() then UNDEFINED;

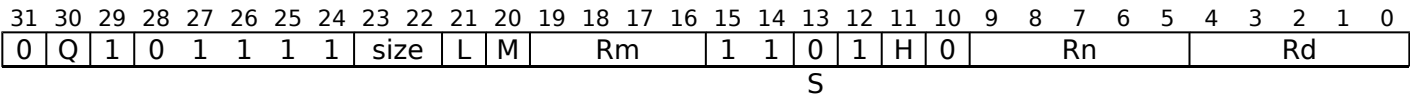
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
  when '01' index = UInt(H:L:M); Rmhi = '0';
  when '10' index = UInt(H:L); Rmhi = M;
  otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;

boolean rounding = TRUE;
boolean sub_op = (S == '1');
```

### Vector (Armv8.1)





Vector

```
SQRDMLAH <Vd>.<T>, <Vn>.<T>, <Vm>.<Ts>[<index>]
```

```
if !HaveQRDMLAHExt() then UNDEFINED;

integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean rounding = TRUE;
boolean sub_op = (S == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	RESERVED
01	H
10	S
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in “size:M:Rm”:

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

Restricted to V0-V15 when element size <Ts> is H.

<Ts> Is an element size specifier, encoded in “size”:

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in “size:L:H:M”:

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(idxdsize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;
integer rounding_const = if rounding then 1 << (esize - 1) else 0;
integer element1;
integer element2;
integer element3;
integer product;
boolean sat;

element2 = SInt(Elem[operand2, index, esize]);
for e = 0 to elements-1
    element1 = SInt(Elem[operand1, e, esize]);
    element3 = SInt(Elem[operand3, e, esize]);
    if sub_op then
        accum = ((element3 << esize) - 2 * (element1 * element2) + rounding_const);
    else
        accum = ((element3 << esize) + 2 * (element1 * element2) + rounding_const);
    (Elem[result, e, esize], sat) = SignedSatQ(accum >> esize, esize);
    if sat then FPSR.QC = '1';

V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# SQRDMLAH (vector)

Signed Saturating Rounding Doubling Multiply Accumulate returning High Half (vector). This instruction multiplies the vector elements of the first source SIMD&FP register with the corresponding vector elements of the second source SIMD&FP register without saturating the multiply results, doubles the results, and accumulates the most significant half of the final results with the vector elements of the destination SIMD&FP register. The results are rounded. If any of the results overflow, they are saturated. The cumulative saturation bit, [FPSR.QC](#), is set if saturation occurs. Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	size	0	Rm				1	0	0	0	0	1	Rn				Rd							
																					S										

## Scalar

```
SQRDMLAH <V><d>, <V><n>, <V><m>

if !HaveQRDMLAHExt() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' || size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean rounding = TRUE;
boolean sub_op = (S == '1');
```

## Vector (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	size	0	Rm				1	0	0	0	0	1	Rn				Rd							
																					S										

## Vector

```
SQRDMLAH <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

if !HaveQRDMLAHExt() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' || size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean rounding = TRUE;
boolean sub_op = (S == '1');
```

## Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	RESERVED
01	H
10	S
11	RESERVED

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;
integer rounding_const = if rounding then 1 << (esize - 1) else 0;
integer element1;
integer element2;
integer element3;
integer product;
boolean sat;

for e = 0 to elements-1
    element1 = SInt(Elem[operand1, e, esize]);
    element2 = SInt(Elem[operand2, e, esize]);
    element3 = SInt(Elem[operand3, e, esize]);
    if sub_op then
        accum = ((element3 << esize) - 2 * (element1 * element2) + rounding_const);
    else
        accum = ((element3 << esize) + 2 * (element1 * element2) + rounding_const);
    (Elem[result, e, esize], sat) = SignedSatQ(accum >> esize, esize);
    if sat then FPSR.QC = '1';

V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

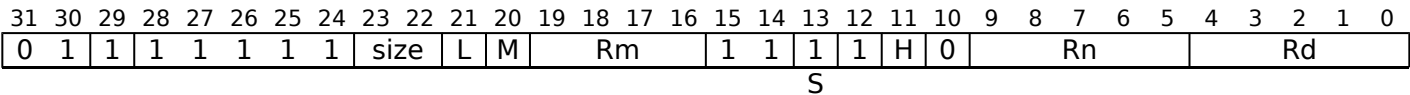
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## SQRDMLSH (by element)

Signed Saturating Rounding Doubling Multiply Subtract returning High Half (by element). This instruction multiplies the vector elements of the first source SIMD&FP register with the value of a vector element of the second source SIMD&FP register without saturating the multiply results, doubles the results, and subtracts the most significant half of the final results from the vector elements of the destination SIMD&FP register. The results are rounded. If any of the results overflow, they are saturated. The cumulative saturation bit, [FPSR.QC](#), is set if saturation occurs. Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar (Armv8.1)



### Scalar

```
SQRDMLSH <V><d>, <V><n>, <Vm>.<Ts>[<index>]

if !HaveQRDMLAExt() then UNDEFINED;

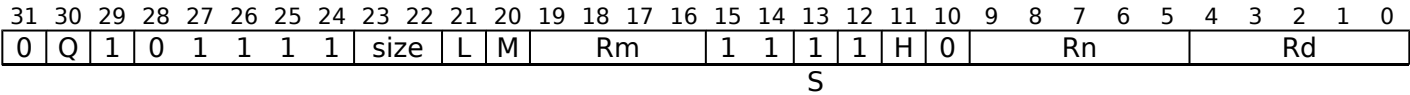
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;

boolean rounding = TRUE;
boolean sub_op = (S == '1');
```

### Vector (Armv8.1)



Vector

```
SQRDMLSH <Vd>.<T>, <Vn>.<T>, <Vm>.<Ts>[<index>]
```

```
if !HaveQRDMLAExt() then UNDEFINED;

integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean rounding = TRUE;
boolean sub_op = (S == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	RESERVED
01	H
10	S
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in “size:M:Rm”:

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

Restricted to V0-V15 when element size <Ts> is H.

<Ts> Is an element size specifier, encoded in “size”:

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in “size:L:H:M”:

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(idxdsize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;
integer rounding_const = if rounding then 1 << (esize - 1) else 0;
integer element1;
integer element2;
integer element3;
integer product;
boolean sat;

element2 = SInt(Elem[operand2, index, esize]);
for e = 0 to elements-1
    element1 = SInt(Elem[operand1, e, esize]);
    element3 = SInt(Elem[operand3, e, esize]);
    if sub_op then
        accum = ((element3 << esize) - 2 * (element1 * element2) + rounding_const);
    else
        accum = ((element3 << esize) + 2 * (element1 * element2) + rounding_const);
    (Elem[result, e, esize], sat) = SignedSatQ(accum >> esize, esize);
    if sat then FPSR.QC = '1';

V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# SQRDMLSH (vector)

Signed Saturating Rounding Doubling Multiply Subtract returning High Half (vector). This instruction multiplies the vector elements of the first source SIMD&FP register with the corresponding vector elements of the second source SIMD&FP register without saturating the multiply results, doubles the results, and subtracts the most significant half of the final results from the vector elements of the destination SIMD&FP register. The results are rounded. If any of the results overflow, they are saturated. The cumulative saturation bit, [FPSR.QC](#), is set if saturation occurs. Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	size	0	Rm				1	0	0	0	1	1	Rn				Rd							
																					S										

## Scalar

```
SQRDMLSH <V><d>, <V><n>, <V><m>

if !HaveQRDMLAHExt() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' || size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean rounding = TRUE;
boolean sub_op = (S == '1');
```

## Vector (Armv8.1)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	size	0	Rm				1	0	0	0	1	1	Rn				Rd							
																					S										

## Vector

```
SQRDMLSH <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

if !HaveQRDMLAHExt() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' || size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean rounding = TRUE;
boolean sub_op = (S == '1');
```

## Assembler Symbols

<V> Is a width specifier, encoded in “size”:



size	<V>
00	RESERVED
01	H
10	S
11	RESERVED

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;
integer rounding_const = if rounding then 1 << (esize - 1) else 0;
integer element1;
integer element2;
integer element3;
integer product;
boolean sat;

for e = 0 to elements-1
    element1 = SInt(Elem[operand1, e, esize]);
    element2 = SInt(Elem[operand2, e, esize]);
    element3 = SInt(Elem[operand3, e, esize]);
    if sub_op then
        accum = ((element3 << esize) - 2 * (element1 * element2) + rounding_const);
    else
        accum = ((element3 << esize) + 2 * (element1 * element2) + rounding_const);
    (Elem[result, e, esize], sat) = SignedSatQ(accum >> esize, esize);
    if sat then FPSR.QC = '1';

V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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## SQRDMULH (by element)

Signed saturating Rounding Doubling Multiply returning High half (by element). This instruction multiplies each vector element in the first source SIMD&FP register by the specified vector element of the second source SIMD&FP register, doubles the results, places the most significant half of the final results into a vector, and writes the vector to the destination SIMD&FP register.

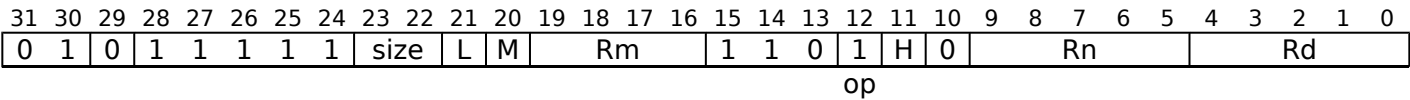
The results are rounded. For truncated results, see [SQDMULH](#).

If any of the results overflows, they are saturated. If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar



### Scalar

SQRDMULH [<V><d>](#), [<V><n>](#), [<Vm>.<Ts>](#)[[<index>](#)]

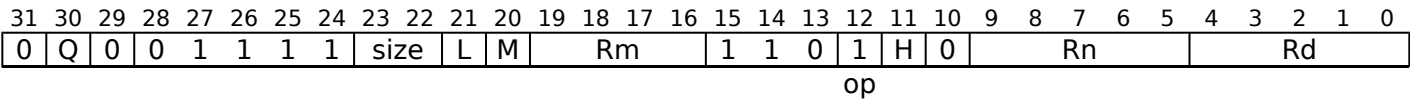
```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;

boolean round = (op == '1');
```

### Vector



Vector

```
SQRDMULH <Vd>.<T>, <Vn>.<T>, <Vm>.<Ts>[<index>]
```

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean round = (op == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	RESERVED
01	H
10	S
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in “size:M:Rm”:

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

Restricted to V0-V15 when element size <Ts> is H.

<Ts> Is an element size specifier, encoded in “size”:

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in “size:L:H:M”:

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(idxdsize) operand2 = V[m];
bits(datasize) result;
integer round_const = if round then 1 << (esize - 1) else 0;
integer element1;
integer element2;
integer product;
boolean sat;

element2 = SInt(Elem[operand2, index, esize]);
for e = 0 to elements-1
    element1 = SInt(Elem[operand1, e, esize]);
    product = (2 * element1 * element2) + round_const;
    // The following only saturates if element1 and element2 equal -(2^(esize-1))
    (Elem[result, e, esize], sat) = SignedSatQ(product >> esize, esize);
    if sat then FPSR.QC = '1';

V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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SQRDMULH (vector)

Signed saturating Rounding Doubling Multiply returning High half. This instruction multiplies the values of corresponding elements of the two source SIMD&FP registers, doubles the results, places the most significant half of the final results into a vector, and writes the vector to the destination SIMD&FP register.

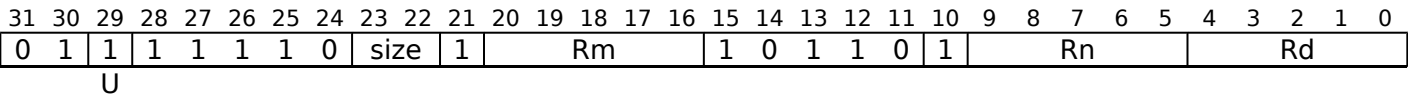
The results are rounded. For truncated results, see [SQDMULH](#).

If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar

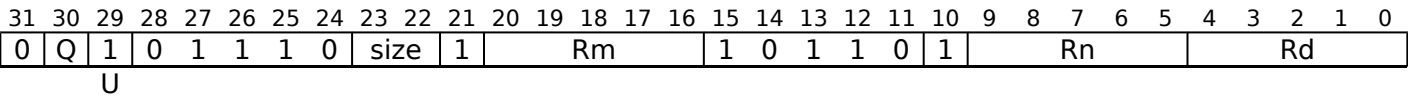


Scalar

SQRDMULH <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' || size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean rounding = (U == '1');
```

Vector



Vector

SQRDMULH <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' || size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean rounding = (U == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	RESERVED
01	H
10	S
11	RESERVED

<d> Is the number of the SIMD&FP destination register, in the "Rd" field.

- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

### Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer round_const = if rounding then 1 << (esize - 1) else 0;
integer element1;
integer element2;
integer product;
boolean sat;

for e = 0 to elements-1
    element1 = SInt(Elem[operand1, e, esize]);
    element2 = SInt(Elem[operand2, e, esize]);
    product = (2 * element1 * element2) + round_const;
    (Elem[result, e, esize], sat) = SignedSatQ(product >> esize, esize);
    if sat then FPSR.QC = '1';

V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# SQRSHL

Signed saturating Rounding Shift Left (register). This instruction takes each vector element in the first source SIMD&FP register, shifts it by a value from the least significant byte of the corresponding vector element of the second source SIMD&FP register, places the results into a vector, and writes the vector to the destination SIMD&FP register.

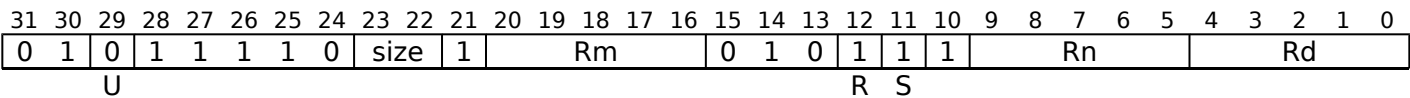
If the shift value is positive, the operation is a left shift. Otherwise, it is a right shift. The results are rounded. For truncated results, see [SQSHL](#).

If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

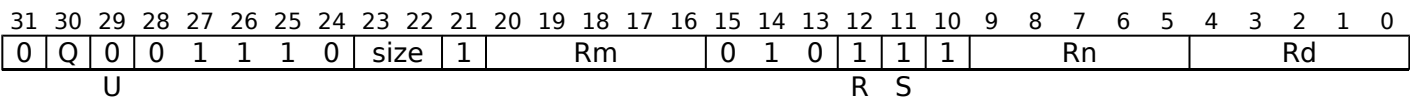


## Scalar

```
SQRSHL <V><d>, <V><n>, <V><m>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
if S == '0' && size != '11' then UNDEFINED;
```

## Vector



## Vector

```
SQRSHL <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
```

## Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

integer round_const = 0;
integer shift;
integer element;
boolean sat;

for e = 0 to elements-1
    shift = SInt(Elem[operand2, e, esize]<7:0>);
    if rounding then
        round_const = 1 << (-shift - 1);    // 0 for left shift, 2^(n-1) for right shift
    element = (Int(Elem[operand1, e, esize], unsigned) + round_const) << shift;
    if saturating then
        (Elem[result, e, esize], sat) = SatQ(element, esize, unsigned);
        if sat then FPSR.QC = '1';
    else
        Elem[result, e, esize] = element<esize-1:0>;

V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# SQRSHRN, SQRSHRN2

Signed saturating Rounded Shift Right Narrow (immediate). This instruction reads each vector element in the source SIMD&FP register, right shifts each result by an immediate value, saturates each shifted result to a value that is half the original width, puts the final result into a vector, and writes the vector to the lower or upper half of the destination SIMD&FP register. All the values in this instruction are signed integer values. The destination vector elements are half as long as the source vector elements. The results are rounded. For truncated results, see [SQSHRN](#).

The SQRSHRN instruction writes the vector to the lower half of the destination register and clears the upper half, while the SQRSHRN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register.

If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	0	!= 0000				immb			1	0	0	1	1	1	Rn				Rd					
U									immh				op																		

## Scalar

```
SQRSHRN <Vb><d>, <Va><n>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then UNDEFINED;
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = esize;
integer elements = 1;
integer part = 0;

integer shift = (2 * esize) - UInt(immh:immb);
boolean round = (op == '1');
boolean unsigned = (U == '1');
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	0	!= 0000				immb			1	0	0	1	1	1	Rn				Rd					
U									immh				op																		

## Vector

```
SQRSHRN{2} <Vd>.<Tb>, <Vn>.<Ta>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

integer shift = (2 * esize) - UInt(immh:immb);
boolean round = (op == '1');
boolean unsigned = (U == '1');
```

## Assembler Symbols

- 2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in "Q":

Q	2
0	[absent]
1	[present]

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

- <Tb> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<Tb>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	x	RESERVED

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

- <Ta> Is an arrangement specifier, encoded in "immh":

immh	<Ta>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	8H
001x	4S
01xx	2D
1xxx	RESERVED

- <Vb> Is the destination width specifier, encoded in "immh":

immh	<Vb>
0000	RESERVED
0001	B
001x	H
01xx	S
1xxx	RESERVED

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.

- <Va> Is the source width specifier, encoded in "immh":

immh	<Va>
0000	RESERVED
0001	H
001x	S
01xx	D
1xxx	RESERVED

- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

- <shift> For the scalar variant: is the right shift amount, in the range 1 to the destination operand width in bits, encoded in "immh:immb":

immh	<shift>
0000	RESERVED
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	RESERVED

For the vector variant: is the right shift amount, in the range 1 to the destination element width in bits, encoded in "immh:immb":

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	RESERVED

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize*2) operand = V[n];
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;
boolean sat;

for e = 0 to elements-1
    element = (Int(Elem[operand, e, 2*esize], unsigned) + round_const) >> shift;
    (Elem[result, e, esize], sat) = SatQ(element, esize, unsigned);
    if sat then FPSR.QC = '1';

Vpart[d, part] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# SQRSHRUN, SQRSHRUN2

Signed saturating Rounded Shift Right Unsigned Narrow (immediate). This instruction reads each signed integer value in the vector of the source SIMD&FP register, right shifts each value by an immediate value, saturates the result to an unsigned integer value that is half the original width, places the final result into a vector, and writes the vector to the destination SIMD&FP register. The results are rounded. For truncated results, see [SQSHRUN](#). The SQRSHRUN instruction writes the vector to the lower half of the destination register and clears the upper half, while the SQRSHRUN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register. If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set. Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	1	0	!= 0000				immb				1	0	0	0	1	1	Rn				Rd				
immh												op																			

## Scalar

```
SQRSHRUN <Vb><d>, <Va><n>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then UNDEFINED;
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = esize;
integer elements = 1;
integer part = 0;

integer shift = (2 * esize) - UInt(immh:immb);
boolean round = (op == '1');
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	0	!= 0000				immb				1	0	0	0	1	1	Rn				Rd				
immh												op																			

## Vector

```
SQRSHRUN{2} <Vd>.<Tb>, <Vn>.<Ta>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

integer shift = (2 * esize) - UInt(immh:immb);
boolean round = (op == '1');
```

## Assembler Symbols

- 2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in "Q":

Q	2
0	[absent]
1	[present]

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

- <Tb> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<Tb>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	x	RESERVED

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

- <Ta> Is an arrangement specifier, encoded in "immh":

immh	<Ta>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	8H
001x	4S
01xx	2D
1xxx	RESERVED

- <Vb> Is the destination width specifier, encoded in "immh":

immh	<Vb>
0000	RESERVED
0001	B
001x	H
01xx	S
1xxx	RESERVED

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.

- <Va> Is the source width specifier, encoded in "immh":

immh	<Va>
0000	RESERVED
0001	H
001x	S
01xx	D
1xxx	RESERVED

- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

- <shift> For the scalar variant: is the right shift amount, in the range 1 to the destination operand width in bits, encoded in "immh:immb":

immh	<shift>
0000	RESERVED
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	RESERVED

For the vector variant: is the right shift amount, in the range 1 to the destination element width in bits, encoded in "immh:immb":

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	RESERVED

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize*2) operand = V[n];
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;
boolean sat;

for e = 0 to elements-1
    element = (SInt(Elem[operand, e, 2*esize]) + round_const) >> shift;
    (Elem[result, e, esize], sat) = UnsignedSatQ(element, esize);
    if sat then FPSR.QC = '1';

Vpart[d, part] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

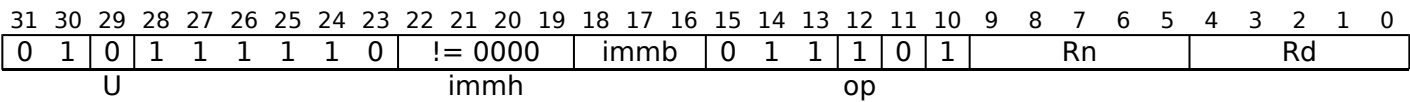
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# SQSHL (immediate)

Signed saturating Shift Left (immediate). This instruction reads each vector element in the source SIMD&FP register, shifts each result by an immediate value, places the final result in a vector, and writes the vector to the destination SIMD&FP register. The results are truncated. For rounded results, see [UQRSHL](#). If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set. Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar



## Scalar

```
SQSHL <V><d>, <V><n>, #<shift>

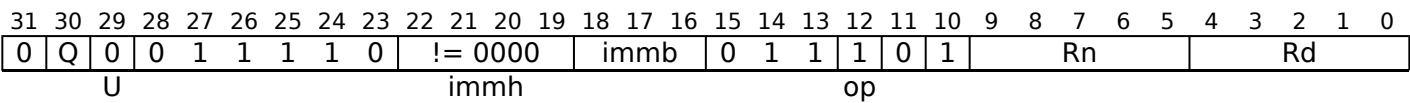
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = esize;
integer elements = 1;

integer shift = UInt(immh:immb) - esize;

boolean src_unsigned;
boolean dst_unsigned;
case op:U of
  when '00' UNDEFINED;
  when '01' src_unsigned = FALSE; dst_unsigned = TRUE;
  when '10' src_unsigned = FALSE; dst_unsigned = FALSE;
  when '11' src_unsigned = TRUE; dst_unsigned = TRUE;
```

## Vector



Vector

```
SQSHL <Vd>.<T>, <Vn>.<T>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3>:Q == '10' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer shift = UInt(immh:immb) - esize;

boolean src_unsigned;
boolean dst_unsigned;
case op:U of
  when '00' UNDEFINED;
  when '01' src_unsigned = FALSE; dst_unsigned = TRUE;
  when '10' src_unsigned = FALSE; dst_unsigned = FALSE;
  when '11' src_unsigned = TRUE; dst_unsigned = TRUE;
```

Assembler Symbols

<V> Is a width specifier, encoded in “immh”:

immh	<V>
0000	RESERVED
0001	B
001x	H
01xx	S
1xxx	D

<d> Is the number of the SIMD&FP destination register, in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in “immh:Q”:

immh	Q	<T>
0000	x	SEE Advanced SIMD modified immediate
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<shift> For the scalar variant: is the left shift amount, in the range 0 to the operand width in bits minus 1, encoded in “immh:immb”:

immh	<shift>
0000	RESERVED
0001	(UInt(immh:immb)-8)
001x	(UInt(immh:immb)-16)
01xx	(UInt(immh:immb)-32)
1xxx	(UInt(immh:immb)-64)

For the vector variant: is the left shift amount, in the range 0 to the element width in bits minus 1, encoded in “immh:immb”:



immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(UInt(immh:immb)-8)
001x	(UInt(immh:immb)-16)
01xx	(UInt(immh:immb)-32)
1xxx	(UInt(immh:immb)-64)

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
integer element;
boolean sat;

for e = 0 to elements-1
    element = Int(Elem[operand, e, esize], src_unsigned) << shift;
    (Elem[result, e, esize], sat) = SatQ(element, esize, dst_unsigned);
    if sat then FPSR.QC = '1';

V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

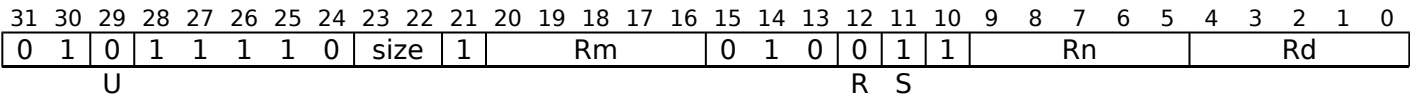
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## SQSHL (register)

Signed saturating Shift Left (register). This instruction takes each element in the vector of the first source SIMD&FP register, shifts each element by a value from the least significant byte of the corresponding element of the second source SIMD&FP register, places the results in a vector, and writes the vector to the destination SIMD&FP register. If the shift value is positive, the operation is a left shift. Otherwise, it is a right shift. The results are truncated. For rounded results, see [SQRSHL](#). If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set. Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

### Scalar

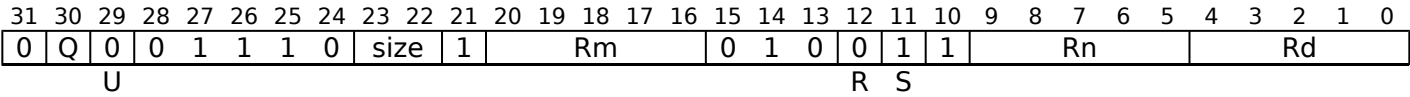


### Scalar

SQSHL [<V>](#)[<d>](#), [<V>](#)[<n>](#), [<V>](#)[<m>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
if S == '0' && size != '11' then UNDEFINED;
```

### Vector



### Vector

SQSHL [<Vd>](#)[.<T>](#), [<Vn>](#)[.<T>](#), [<Vm>](#)[.<T>](#)

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
```

### Assembler Symbols

[<V>](#) Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

integer round_const = 0;
integer shift;
integer element;
boolean sat;

for e = 0 to elements-1
    shift = SInt(Elem[operand2, e, esize]<7:0>);
    if rounding then
        round_const = 1 << (-shift - 1);    // 0 for left shift, 2^(n-1) for right shift
    element = (Int(Elem[operand1, e, esize], unsigned) + round_const) << shift;
    if saturating then
        (Elem[result, e, esize], sat) = SatQ(element, esize, unsigned);
        if sat then FPSR.QC = '1';
    else
        Elem[result, e, esize] = element<esize-1:0>;

V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

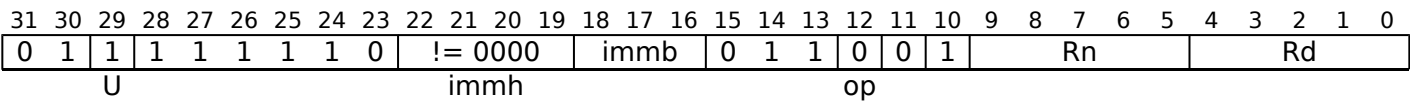
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# SQSHLU

Signed saturating Shift Left Unsigned (immediate). This instruction reads each signed integer value in the vector of the source SIMD&FP register, shifts each value by an immediate value, saturates the shifted result to an unsigned integer value, places the result in a vector, and writes the vector to the destination SIMD&FP register. The results are truncated. For rounded results, see [UQRSHL](#).  
If saturation occurs, the cumulative saturation bit *FPSR.QC* is set.  
Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar



## Scalar

```
SQSHLU <V><d>, <V><n>, #<shift>

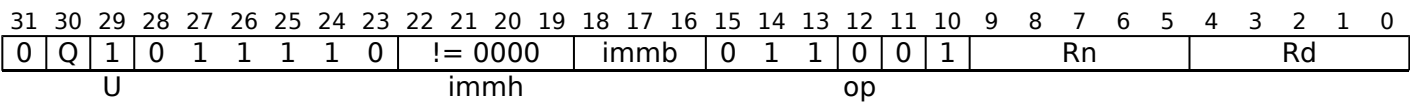
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = esize;
integer elements = 1;

integer shift = UInt(immh:immb) - esize;

boolean src_unsigned;
boolean dst_unsigned;
case op:U of
  when '00' UNDEFINED;
  when '01' src_unsigned = FALSE; dst_unsigned = TRUE;
  when '10' src_unsigned = FALSE; dst_unsigned = FALSE;
  when '11' src_unsigned = TRUE; dst_unsigned = TRUE;
```

## Vector



Vector

```
SQSHLU <Vd>.<T>, <Vn>.<T>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3>:Q == '10' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer shift = UInt(immh:immb) - esize;

boolean src_unsigned;
boolean dst_unsigned;
case op:U of
  when '00' UNDEFINED;
  when '01' src_unsigned = FALSE; dst_unsigned = TRUE;
  when '10' src_unsigned = FALSE; dst_unsigned = FALSE;
  when '11' src_unsigned = TRUE; dst_unsigned = TRUE;
```

Assembler Symbols

<V> Is a width specifier, encoded in “immh”:

immh	<V>
0000	RESERVED
0001	B
001x	H
01xx	S
1xxx	D

<d> Is the number of the SIMD&FP destination register, in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in “immh:Q”:

immh	Q	<T>
0000	x	SEE Advanced SIMD modified immediate
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<shift> For the scalar variant: is the left shift amount, in the range 0 to the operand width in bits minus 1, encoded in “immh:immb”:

immh	<shift>
0000	RESERVED
0001	(UInt(immh:immb)-8)
001x	(UInt(immh:immb)-16)
01xx	(UInt(immh:immb)-32)
1xxx	(UInt(immh:immb)-64)

For the vector variant: is the left shift amount, in the range 0 to the element width in bits minus 1, encoded in “immh:immb”:

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(UInt(immh:immb)-8)
001x	(UInt(immh:immb)-16)
01xx	(UInt(immh:immb)-32)
1xxx	(UInt(immh:immb)-64)

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
integer element;
boolean sat;

for e = 0 to elements-1
    element = Int(Elem[operand, e, esize], src_unsigned) << shift;
    (Elem[result, e, esize], sat) = SatQ(element, esize, dst_unsigned);
    if sat then FPSR.QC = '1';

V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# SQSHRN, SQSHRN2

Signed saturating Shift Right Narrow (immediate). This instruction reads each vector element in the source SIMD&FP register, right shifts and truncates each result by an immediate value, saturates each shifted result to a value that is half the original width, puts the final result into a vector, and writes the vector to the lower or upper half of the destination SIMD&FP register. All the values in this instruction are signed integer values. The destination vector elements are half as long as the source vector elements. For rounded results, see [SQRSHRN](#).

The SQSHRN instruction writes the vector to the lower half of the destination register and clears the upper half, while the SQSHRN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register.

If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	0	!= 0000				immb			1	0	0	1	0	1	Rn				Rd					
U									immh				op																		

## Scalar

```
SQSHRN <Vb><d>, <Va><n>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then UNDEFINED;
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = esize;
integer elements = 1;
integer part = 0;

integer shift = (2 * esize) - UInt(immh:immb);
boolean round = (op == '1');
boolean unsigned = (U == '1');
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	0	!= 0000				immb			1	0	0	1	0	1	Rn				Rd					
U									immh				op																		

## Vector

```
SQSHRN{2} <Vd>.<Tb>, <Vn>.<Ta>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

integer shift = (2 * esize) - UInt(immh:immb);
boolean round = (op == '1');
boolean unsigned = (U == '1');
```

## Assembler Symbols

- 2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in "Q":

Q	2
0	[absent]
1	[present]

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

- <Tb> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<Tb>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	x	RESERVED

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

- <Ta> Is an arrangement specifier, encoded in "immh":

immh	<Ta>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	8H
001x	4S
01xx	2D
1xxx	RESERVED

- <Vb> Is the destination width specifier, encoded in "immh":

immh	<Vb>
0000	RESERVED
0001	B
001x	H
01xx	S
1xxx	RESERVED

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.

- <Va> Is the source width specifier, encoded in "immh":

immh	<Va>
0000	RESERVED
0001	H
001x	S
01xx	D
1xxx	RESERVED

- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

- <shift> For the scalar variant: is the right shift amount, in the range 1 to the destination operand width in bits, encoded in "immh:immb":

immh	<shift>
0000	RESERVED
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	RESERVED

For the vector variant: is the right shift amount, in the range 1 to the destination element width in bits, encoded in "immh:immb":

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	RESERVED



## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize*2) operand = V[n];
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;
boolean sat;

for e = 0 to elements-1
    element = (Int(Elem[operand, e, 2*esize], unsigned) + round_const) >> shift;
    (Elem[result, e, esize], sat) = SatQ(element, esize, unsigned);
    if sat then FPSR.QC = '1';

Vpart[d, part] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# SQSHRUN, SQSHRUN2

Signed saturating Shift Right Unsigned Narrow (immediate). This instruction reads each signed integer value in the vector of the source SIMD&FP register, right shifts each value by an immediate value, saturates the result to an unsigned integer value that is half the original width, places the final result into a vector, and writes the vector to the destination SIMD&FP register. The results are truncated. For rounded results, see [SQRSHRUN](#).

The SQSHRUN instruction writes the vector to the lower half of the destination register and clears the upper half, while the SQSHRUN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register.

If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	1	0	!= 0000			immb			1	0	0	0	0	1	Rn				Rd						
immh												op																			

## Scalar

```
SQSHRUN <Vb><d>, <Va><n>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then UNDEFINED;
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = esize;
integer elements = 1;
integer part = 0;

integer shift = (2 * esize) - UInt(immh:immb);
boolean round = (op == '1');
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	0	!= 0000			immb			1	0	0	0	0	1	Rn				Rd						
immh												op																			

## Vector

```
SQSHRUN{2} <Vd>.<Tb>, <Vn>.<Ta>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

integer shift = (2 * esize) - UInt(immh:immb);
boolean round = (op == '1');
```

## Assembler Symbols

- 2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in "Q":

Q	2
0	[absent]
1	[present]

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

- <Tb> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<Tb>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	x	RESERVED

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

- <Ta> Is an arrangement specifier, encoded in "immh":

immh	<Ta>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	8H
001x	4S
01xx	2D
1xxx	RESERVED

- <Vb> Is the destination width specifier, encoded in "immh":

immh	<Vb>
0000	RESERVED
0001	B
001x	H
01xx	S
1xxx	RESERVED

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.

- <Va> Is the source width specifier, encoded in "immh":

immh	<Va>
0000	RESERVED
0001	H
001x	S
01xx	D
1xxx	RESERVED

- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

- <shift> For the scalar variant: is the right shift amount, in the range 1 to the destination operand width in bits, encoded in "immh:immb":

immh	<shift>
0000	RESERVED
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	RESERVED

For the vector variant: is the right shift amount, in the range 1 to the destination element width in bits, encoded in "immh:immb":

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	RESERVED

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize*2) operand = V[n];
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;
boolean sat;

for e = 0 to elements-1
    element = (SInt(Elem[operand, e, 2*esize]) + round_const) >> shift;
    (Elem[result, e, esize], sat) = UnsignedSatQ(element, esize);
    if sat then FPSR.QC = '1';

Vpart[d, part] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# SQSUB

Signed saturating Subtract. This instruction subtracts the element values of the second source SIMD&FP register from the corresponding element values of the first source SIMD&FP register, places the results into a vector, and writes the vector to the destination SIMD&FP register.

If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit `FPSR.QC` is set.

Depending on the settings in the `CPACR_EL1`, `CPTR_EL2`, and `CPTR_EL3` registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	size	1	Rm				0	0	1	0	1	1	Rn				Rd							
		U																													

## Scalar

```
SQSUB <V><d>, <V><n>, <V><m>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	size	1	Rm				0	0	1	0	1	1	Rn				Rd							
		U																													

## Vector

```
SQSUB <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
```

## Assembler Symbols

- <V>

Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D
- <d>

Is the number of the SIMD&FP destination register, in the “Rd” field.
- <n>

Is the number of the first SIMD&FP source register, encoded in the “Rn” field.
- <m>

Is the number of the second SIMD&FP source register, encoded in the “Rm” field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

### Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
integer diff;
boolean sat;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    diff = element1 - element2;
    (Elem[result, e, esize], sat) = SatQ(diff, esize, unsigned);
    if sat then FPSR.QC = '1';

V[d] = result;

```

# SQXTN, SQXTN2

Signed saturating extract Narrow. This instruction reads each vector element from the source SIMD&FP register, saturates the value to half the original width, places the result into a vector, and writes the vector to the lower or upper half of the destination SIMD&FP register. The destination vector elements are half as long as the source vector elements. All the values in this instruction are signed integer values.

If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

The SQXTN instruction writes the vector to the lower half of the destination register and clears the upper half, while the SQXTN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	size		1	0	0	0	0	1	0	1	0	0	1	0	Rn				Rd					
U																															

## Scalar

```
SQXTN <Vb><d>, <Va><n>

integer d = UInt(Rd);
integer n = UInt(Rn);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer part = 0;
integer elements = 1;

boolean unsigned = (U == '1');
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	size				1	0	0	0	0	1	0	1	0	0	1	0	Rn				Rd			
U																															

## Vector

```
SQXTN{2} <Vd>.<Tb>, <Vn>.<Ta>

integer d = UInt(Rd);
integer n = UInt(Rn);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
```

## Assembler Symbols

- 2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Tb> Is an arrangement specifier, encoded in "size:Q":

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<Ta> Is an arrangement specifier, encoded in "size":

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vb> Is the destination width specifier, encoded in "size":

size	<Vb>
00	B
01	H
10	S
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Va> Is the source width specifier, encoded in "size":

size	<Va>
00	H
01	S
10	D
11	RESERVED

<n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(2*datasize) operand = V[n];
bits(datasize) result;
bits(2*esize) element;
boolean sat;

for e = 0 to elements-1
    element = Elem[operand, e, 2*esize];
    (Elem[result, e, esize], sat) = SatQ(Int(element, unsigned), esize, unsigned);
    if sat then FPSR.QC = '1';

Vpart[d, part] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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SQXTUN, SQXTUN2

Signed saturating extract Unsigned Narrow. This instruction reads each signed integer value in the vector of the source SIMD&FP register, saturates the value to an unsigned integer value that is half the original width, places the result into a vector, and writes the vector to the lower or upper half of the destination SIMD&FP register. The destination vector elements are half as long as the source vector elements.

If saturation occurs, the cumulative saturation bit *FPSR.QC* is set.

The SQXTUN instruction writes the vector to the lower half of the destination register and clears the upper half, while the SQXTUN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	size	1	0	0	0	0	1	0	0	1	0	1	0	1	0	Rn				Rd				

Scalar

SQXTUN <Vb><d>, <Va><n>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer part = 0;
integer elements = 1;
```

Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	size	1	0	0	0	0	1	0	0	1	0	1	0	Rn				Rd						

Vector

SQXTUN{2} <Vd>.<Tb>, <Vn>.<Ta>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;
```

Assembler Symbols

- 2

Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:
- |   |           |
|---|-----------|
| Q | 2         |
| 0 | [absent]  |
| 1 | [present] |
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the “Rd” field.
- <Tb>

Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<Ta> Is an arrangement specifier, encoded in "size":

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vb> Is the destination width specifier, encoded in "size":

size	<Vb>
00	B
01	H
10	S
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Va> Is the source width specifier, encoded in "size":

size	<Va>
00	H
01	S
10	D
11	RESERVED

<n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(2*datasize) operand = V[n];
bits(datasize) result;
bits(2*esize) element;
boolean sat;

for e = 0 to elements-1
    element = Elem[operand, e, 2*esize];
    (Elem[result, e, esize], sat) = UnsignedSatQ(SInt(element), esize);
    if sat then FPSR.QC = '1';

Vpart[d, part] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

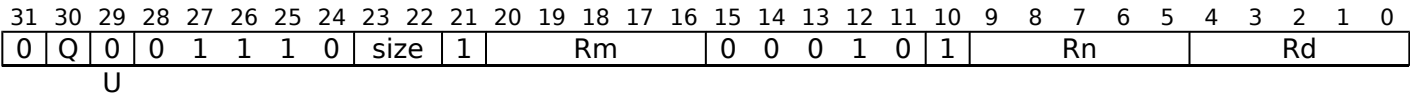
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SRHADD

Signed Rounding Halving Add. This instruction adds corresponding signed integer values from the two source SIMD&FP registers, shifts each result right one bit, places the results into a vector, and writes the vector to the destination SIMD&FP register.

The results are rounded. For truncated results, see [SHADD](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers of the same type

SRHADD <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;

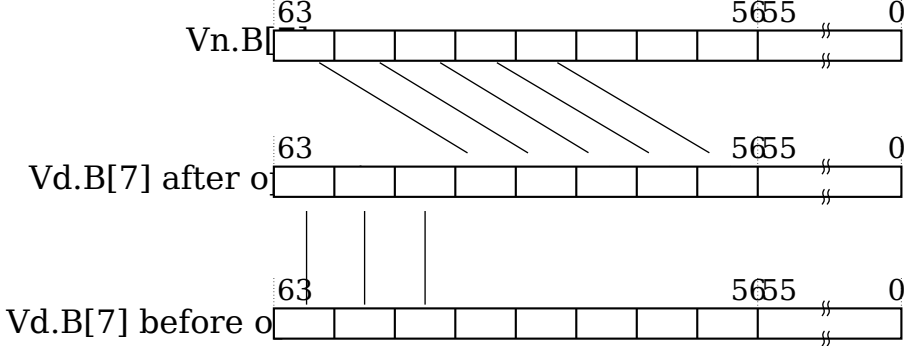
for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    Elem[result, e, esize] = (element1+element2+1)<esize:1>;

V[d] = result;
```

SRI

Shift Right and Insert (immediate). This instruction reads each vector element in the source SIMD&FP register, right shifts each vector element by an immediate value, and inserts the result into the corresponding vector element in the destination SIMD&FP register such that the new zero bits created by the shift are not inserted but retain their existing value. Bits shifted out of the right of each vector element of the source register are lost.

The following figure shows an example of the operation of shift right by 3 for an 8-bit vector element.



Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	1	0	!= 0000				immb			0	1	0	0	0	1	Rn				Rd					
immh																															

Scalar

SRI <V><d>, <V><n>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh<3> != '1' then UNDEFINED;
integer esize = 8 << 3;
integer datasize = esize;
integer elements = 1;

integer shift = (esize * 2) - UInt(immh:immb);
```

Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	0	!= 0000				immb			0	1	0	0	0	1	Rn				Rd					
immh																															

Vector

```
SRI <Vd>.<T>, <Vn>.<T>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3>:Q == '10' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer shift = (esize * 2) - UInt(immh:immb);
```

Assembler Symbols

<V> Is a width specifier, encoded in “immh”:

immh	<V>
0xxx	RESERVED
1xxx	D

<d> Is the number of the SIMD&FP destination register, in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in “immh:Q”:

immh	Q	<T>
0000	x	SEE Advanced SIMD modified immediate
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<shift> For the scalar variant: is the right shift amount, in the range 1 to 64, encoded in “immh:immb”:

immh	<shift>
0xxx	RESERVED
1xxx	(128-UInt(immh:immb))

For the vector variant: is the right shift amount, in the range 1 to the element width in bits, encoded in “immh:immb”:

immh	<shift>
0000	SEE Advanced SIMD modified immediate
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) operand2 = V[d];
bits(datasize) result;
bits(esize) mask = LSR(Ones(esize), shift);
bits(esize) shifted;

for e = 0 to elements-1
    shifted = LSR(Elem[operand, e, esize], shift);
    Elem[result, e, esize] = (Elem[operand2, e, esize] AND NOT(mask)) OR shifted;
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

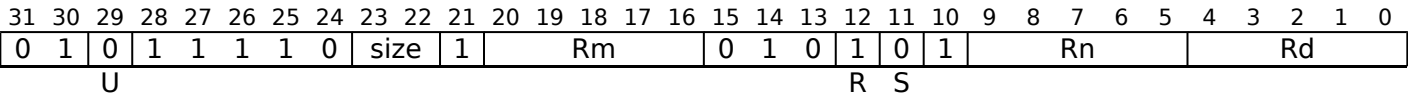
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SRSHL

Signed Rounding Shift Left (register). This instruction takes each signed integer value in the vector of the first source SIMD&FP register, shifts it by a value from the least significant byte of the corresponding element of the second source SIMD&FP register, places the results in a vector, and writes the vector to the destination SIMD&FP register. If the shift value is positive, the operation is a left shift. If the shift value is negative, it is a rounding right shift. For a truncating shift, see [SSHL](#). Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar

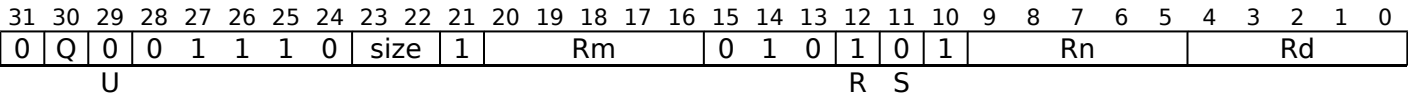


Scalar

SRSHL <V><d>, <V><n>, <V><m>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
if S == '0' && size != '11' then UNDEFINED;
```

Vector



Vector

SRSHL <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

### Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

integer round_const = 0;
integer shift;
integer element;
boolean sat;

for e = 0 to elements-1
    shift = SInt(Elem[operand2, e, esize]<7:0>);
    if rounding then
        round_const = 1 << (-shift - 1);    // 0 for left shift, 2^(n-1) for right shift
    element = (Int(Elem[operand1, e, esize], unsigned) + round_const) << shift;
    if saturating then
        (Elem[result, e, esize], sat) = SatQ(element, esize, unsigned);
        if sat then FPSR.QC = '1';
    else
        Elem[result, e, esize] = element<esize-1:0>;

V[d] = result;

```



# SRRSHR

Signed Rounding Shift Right (immediate). This instruction reads each vector element in the source SIMD&FP register, right shifts each result by an immediate value, places the final result into a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are signed integer values. The results are rounded. For truncated results, see [SSHR](#).  
Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	0	!= 0000				immb			0	0	1	0	0	1	Rn				Rd					
U									immh				o1 o0																		

## Scalar

```
SRRSHR <V><d>, <V><n>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh<3> != '1' then UNDEFINED;
integer esize = 8 << 3;
integer datasize = esize;
integer elements = 1;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	0	!= 0000				immb			0	0	1	0	0	1	Rn				Rd					
U									immh				o1 o0																		

## Vector

```
SRRSHR <Vd>.<T>, <Vn>.<T>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3>:Q == '10' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

## Assembler Symbols

<V> Is a width specifier, encoded in “immh”:

immh	<V>
0xxx	RESERVED
1xxx	D

<d> Is the number of the SIMD&FP destination register, in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<T>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<shift> For the scalar variant: is the right shift amount, in the range 1 to 64, encoded in "immh:immb":

immh	<shift>
0xxx	RESERVED
1xxx	(128-UInt(immh:immb))

For the vector variant: is the right shift amount, in the range 1 to the element width in bits, encoded in "immh:immb":

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

## Operation

```

CheckFPAdvSIMDEnabled64\(\);
bits(datasize) operand = V[n];
bits(datasize) operand2;
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;

operand2 = if accumulate then V[d] else Zeros\(\);
for e = 0 to elements-1
    element = (Int(Elem[operand, e, esize], unsigned) + round_const) >> shift;
    Elem[result, e, esize] = Elem[operand2, e, esize] + element<esize-1:0>;
V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# SRSRA

Signed Rounding Shift Right and Accumulate (immediate). This instruction reads each vector element in the source SIMD&FP register, right shifts each result by an immediate value, and accumulates the final results with the vector elements of the destination SIMD&FP register. All the values in this instruction are signed integer values. The results are rounded. For truncated results, see [SSRA](#).  
Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	0	!= 0000				immb			0	0	1	1	0	1	Rn				Rd					
U									immh				o1 o0																		

## Scalar

```
SRSRA <V><d>, <V><n>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh<3> != '1' then UNDEFINED;
integer esize = 8 << 3;
integer datasize = esize;
integer elements = 1;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	0	!= 0000				immb			0	0	1	1	0	1	Rn				Rd					
U									immh				o1 o0																		

## Vector

```
SRSRA <Vd>.<T>, <Vn>.<T>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3>:Q == '10' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

## Assembler Symbols

<V> Is a width specifier, encoded in “immh”:

immh	<V>
0xxx	RESERVED
1xxx	D

<d> Is the number of the SIMD&FP destination register, in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<T>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<shift> For the scalar variant: is the right shift amount, in the range 1 to 64, encoded in "immh:immb":

immh	<shift>
0xxx	RESERVED
1xxx	(128-UInt(immh:immb))

For the vector variant: is the right shift amount, in the range 1 to the element width in bits, encoded in "immh:immb":

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

## Operation

```

CheckFPAdvSIMDEnabled64\(\);
bits(datasize) operand = V[n];
bits(datasize) operand2;
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;

operand2 = if accumulate then V[d] else Zeros\(\);
for e = 0 to elements-1
    element = (Int(Elem[operand, e, esize], unsigned) + round_const) >> shift;
    Elem[result, e, esize] = Elem[operand2, e, esize] + element<esize-1:0>;
V[d] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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SSHL

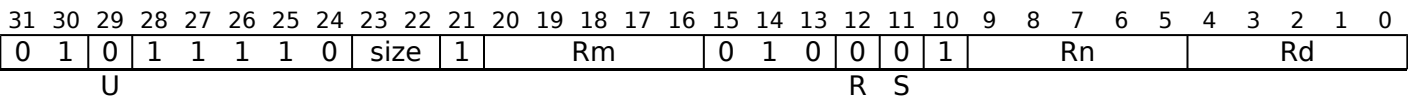
Signed Shift Left (register). This instruction takes each signed integer value in the vector of the first source SIMD&FP register, shifts each value by a value from the least significant byte of the corresponding element of the second source SIMD&FP register, places the results in a vector, and writes the vector to the destination SIMD&FP register.

If the shift value is positive, the operation is a left shift. If the shift value is negative, it is a truncating right shift. For a rounding shift, see [SRSHL](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar

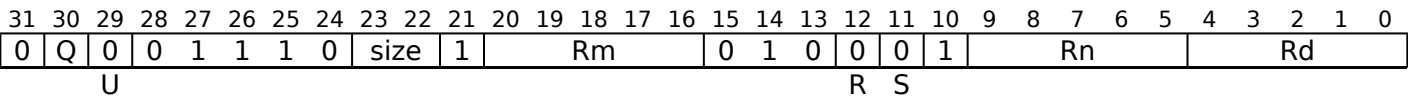


Scalar

```
SSHL <V><d>, <V><n>, <V><m>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
if S == '0' && size != '11' then UNDEFINED;
```

Vector



Vector

```
SSHL <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

integer round_const = 0;
integer shift;
integer element;
boolean sat;

for e = 0 to elements-1
    shift = SInt(Elem[operand2, e, esize]<7:0>);
    if rounding then
        round_const = 1 << (-shift - 1);    // 0 for left shift, 2^(n-1) for right shift
    element = (Int(Elem[operand1, e, esize], unsigned) + round_const) << shift;
    if saturating then
        (Elem[result, e, esize], sat) = SatQ(element, esize, unsigned);
        if sat then FPSR.QC = '1';
    else
        Elem[result, e, esize] = element<esize-1:0>;

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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SSHLL, SSHLL2

Signed Shift Left Long (immediate). This instruction reads each vector element from the source SIMD&FP register, left shifts each vector element by the specified shift amount, places the result into a vector, and writes the vector to the destination SIMD&FP register. The destination vector elements are twice as long as the source vector elements. All the values in this instruction are signed integer values.

The SSHLL instruction extracts vector elements from the lower half of the source register, while the SSHLL2 instruction extracts vector elements from the upper half of the source register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This instruction is used by the alias [SXTL](#), [SXTL2](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	0	!= 0000				immb			1	0	1	0	0	1	Rn				Rd					
U									immh																						

Vector

SSHLL{2} <Vd>.<Ta>, <Vn>.<Tb>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

integer shift = UInt(immh:immb) - esize;
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q		2
0		[absent]
1		[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the “Rd” field.

<Ta> Is an arrangement specifier, encoded in “immh”:

immh	<Ta>
0000	SEE Advanced SIMD modified immediate
0001	8H
001x	4S
01xx	2D
1xxx	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the “Rn” field.

<Tb> Is an arrangement specifier, encoded in “immh:Q”:

immh	Q	<Tb>
0000	x	SEE Advanced SIMD modified immediate
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	x	RESERVED

<shift> Is the left shift amount, in the range 0 to the source element width in bits minus 1, encoded in “immh:immb”:

immh	<shift>
0000	SEE Advanced SIMD modified immediate
0001	(UInt(immh:immb)-8)
001x	(UInt(immh:immb)-16)
01xx	(UInt(immh:immb)-32)
1xxx	RESERVED

Alias Conditions

Alias	Is preferred when
<a href="#">SXTL, SXTL2</a>	immb == '000' && <a href="#">BitCount</a> (immh) == 1

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = Vpart[n, part];
bits(datasize*2) result;
integer element;

for e = 0 to elements-1
    element = Int(Elem[operand, e, esize], unsigned) << shift;
    Elem[result, e, 2*esize] = element<2*esize-1:0>;

V[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# SSHR

Signed Shift Right (immediate). This instruction reads each vector element in the source SIMD&FP register, right shifts each result by an immediate value, places the final result into a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are signed integer values. The results are truncated. For rounded results, see [SRSHR](#).  
Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	0	!= 0000				immb			0	0	0	0	0	1	Rn				Rd					
U									immh				o1 o0																		

## Scalar

```
SSHR <V><d>, <V><n>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh<3> != '1' then UNDEFINED;
integer esize = 8 << 3;
integer datasize = esize;
integer elements = 1;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	0	!= 0000				immb			0	0	0	0	0	1	Rn				Rd					
U									immh				o1 o0																		

## Vector

```
SSHR <Vd>.<T>, <Vn>.<T>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3>:Q == '10' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

## Assembler Symbols

<V> Is a width specifier, encoded in “immh”:

immh	<V>
0xxx	RESERVED
1xxx	D

<d> Is the number of the SIMD&FP destination register, in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<T>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<shift> For the scalar variant: is the right shift amount, in the range 1 to 64, encoded in "immh:immb":

immh	<shift>
0xxx	RESERVED
1xxx	(128-UInt(immh:immb))

For the vector variant: is the right shift amount, in the range 1 to the element width in bits, encoded in "immh:immb":

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) operand2;
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;

operand2 = if accumulate then V[d] else Zeros();
for e = 0 to elements-1
    element = (Int(Elem[operand, e, esize], unsigned) + round_const) >> shift;
    Elem[result, e, esize] = Elem[operand2, e, esize] + element<esize-1:0>;

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# SSRA

Signed Shift Right and Accumulate (immediate). This instruction reads each vector element in the source SIMD&FP register, right shifts each result by an immediate value, and accumulates the final results with the vector elements of the destination SIMD&FP register. All the values in this instruction are signed integer values. The results are truncated. For rounded results, see [SRSRA](#).  
Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	1	0	!= 0000				immb			0	0	0	1	0	1	Rn				Rd					
U									immh				o1 o0																		

## Scalar

```
SSRA <V><d>, <V><n>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh<3> != '1' then UNDEFINED;
integer esize = 8 << 3;
integer datasize = esize;
integer elements = 1;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	0	!= 0000				immb			0	0	0	1	0	1	Rn				Rd					
U									immh				o1			o0															

## Vector

```
SSRA <Vd>.<T>, <Vn>.<T>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3>:Q == '10' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

## Assembler Symbols

<V> Is a width specifier, encoded in “immh”:

immh	<V>
0xxx	RESERVED
1xxx	D

<d> Is the number of the SIMD&FP destination register, in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<T>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<shift> For the scalar variant: is the right shift amount, in the range 1 to 64, encoded in "immh:immb":

immh	<shift>
0xxx	RESERVED
1xxx	(128-UInt(immh:immb))

For the vector variant: is the right shift amount, in the range 1 to the element width in bits, encoded in "immh:immb":

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) operand2;
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;

operand2 = if accumulate then V[d] else Zeros();
for e = 0 to elements-1
    element = (Int(Elem[operand, e, esize], unsigned) + round_const) >> shift;
    Elem[result, e, esize] = Elem[operand2, e, esize] + element<esize-1:0>;

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

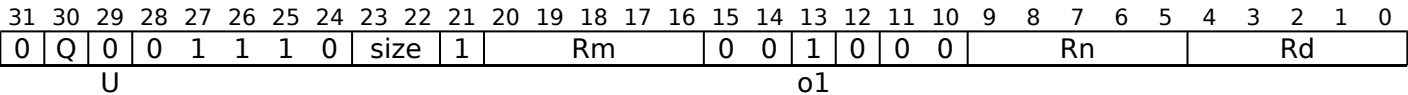
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SSUBL, SSUBL2

Signed Subtract Long. This instruction subtracts each vector element in the lower or upper half of the second source SIMD&FP register from the corresponding vector element of the first source SIMD&FP register, places the results into a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are signed integer values. The destination vector elements are twice as long as the source vector elements.

The SSUBL instruction extracts each source vector from the lower half of each source register, while the SSUBL2 instruction extracts each source vector from the upper half of each source register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers, not all the same type

```
SSUBL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(0);
integer elements = datasize DIV esize;

boolean sub_op = (o1 == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

- 2

Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Ta>

Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED
- <Vn>

Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Tb>

Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED
- <Vm>

Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
integer element1;
integer element2;
integer sum;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    if sub_op then
        sum = element1 - element2;
    else
        sum = element1 + element2;
    Elem[result, e, 2*esize] = sum<2*esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

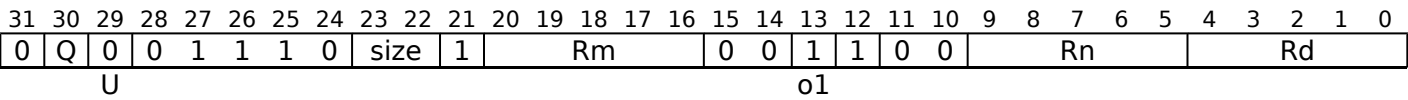
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SSUBW, SSUBW2

Signed Subtract Wide. This instruction subtracts each vector element in the lower or upper half of the second source SIMD&FP register from the corresponding vector element in the first source SIMD&FP register, places the result in a vector, and writes the vector to the SIMD&FP destination register. All the values in this instruction are signed integer values.

The SSUBW instruction extracts the second source vector from the lower half of the second source register, while the SSUBW2 instruction extracts the second source vector from the upper half of the second source register.

Depending on the settings in the CPACR EL1, CPTR EL2, and CPTR EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers, not all the same type

```
SSUBW{2} <Vd>.<Ta>, <Vn>.<Ta>, <Vm>.<Tb>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(0);
integer elements = datasize DIV esize;

boolean sub_op = (o1 == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q 2	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(2*datasize) operand1 = V[n];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
integer element1;
integer element2;
integer sum;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, 2*esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    if sub_op then
        sum = element1 - element2;
    else
        sum = element1 + element2;
    Elem[result, e, 2*esize] = sum<2*esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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ST1 (multiple structures)

Store multiple single-element structures from one, two, three, or four registers. This instruction stores elements to memory from one, two, three, or four SIMD&FP registers, without interleaving. Every element of each register is stored.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: No offset and Post-index

No offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	0	0	0	0	0	0	0	0	0	x	x	1	x	size		Rn				Rt					
L										opcode																					

One register (opcode == 0111)

ST1 { <Vt>.<T> }, [<Xn|SP>]

Two registers (opcode == 1010)

ST1 { <Vt>.<T>, <Vt2>.<T> }, [<Xn|SP>]

Three registers (opcode == 0110)

ST1 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T> }, [<Xn|SP>]

Four registers (opcode == 0010)

ST1 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T>, <Vt4>.<T> }, [<Xn|SP>]

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	0	1	0	0	Rm				x	x	1	x	size			Rn				Rt					
L										opcode																					

One register, immediate offset (Rm == 11111 && opcode == 0111)

```
ST1 { <Vt>.<T> }, [<Xn|SP>], <imm>
```

One register, register offset (Rm != 11111 && opcode == 0111)

```
ST1 { <Vt>.<T> }, [<Xn|SP>], <Xm>
```

Two registers, immediate offset (Rm == 11111 && opcode == 1010)

```
ST1 { <Vt>.<T>, <Vt2>.<T> }, [<Xn|SP>], <imm>
```

Two registers, register offset (Rm != 11111 && opcode == 1010)

```
ST1 { <Vt>.<T>, <Vt2>.<T> }, [<Xn|SP>], <Xm>
```

Three registers, immediate offset (Rm == 11111 && opcode == 0110)

```
ST1 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T> }, [<Xn|SP>], <imm>
```

Three registers, register offset (Rm != 11111 && opcode == 0110)

```
ST1 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T> }, [<Xn|SP>], <Xm>
```

Four registers, immediate offset (Rm == 11111 && opcode == 0010)

```
ST1 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T>, <Vt4>.<T> }, [<Xn|SP>], <imm>
```

Four registers, register offset (Rm != 11111 && opcode == 0010)

```
ST1 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T>, <Vt4>.<T> }, [<Xn|SP>], <Xm>
```

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

Assembler Symbols

- <Vt> Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	1D
11	1	2D

- <Vt2> Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.
- <Vt3> Is the name of the third SIMD&FP register to be transferred, encoded as "Rt" plus 2 modulo 32.
- <Vt4> Is the name of the fourth SIMD&FP register to be transferred, encoded as "Rt" plus 3 modulo 32.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> For the one register, immediate offset variant: is the post-index immediate offset, encoded in "Q":

Q	<imm>
0	#8
1	#16

For the two registers, immediate offset variant: is the post-index immediate offset, encoded in “Q”:

Q	<imm>
0	#16
1	#32

For the three registers, immediate offset variant: is the post-index immediate offset, encoded in “Q”:

Q	<imm>
0	#24
1	#48

For the four registers, immediate offset variant: is the post-index immediate offset, encoded in “Q”:

Q	<imm>
0	#32
1	#64

<Xm> Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

## Shared Decode

```
MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << UInt(size);
integer elements = datasize DIV esize;

integer rpt;    // number of iterations
integer selem;  // structure elements

case opcode of
  when '0000' rpt = 1; selem = 4;    // LD/ST4 (4 registers)
  when '0010' rpt = 4; selem = 1;    // LD/ST1 (4 registers)
  when '0100' rpt = 1; selem = 3;    // LD/ST3 (3 registers)
  when '0110' rpt = 3; selem = 1;    // LD/ST1 (3 registers)
  when '0111' rpt = 1; selem = 1;    // LD/ST1 (1 register)
  when '1000' rpt = 1; selem = 2;    // LD/ST2 (2 registers)
  when '1010' rpt = 2; selem = 1;    // LD/ST1 (2 registers)
  otherwise UNDEFINED;

// .LD format only permitted with LD1 & ST1
if size:Q == '110' && selem != 1 then UNDEFINED;
```

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(datasize) rval;
integer tt;
constant integer ebytes = esize DIV 8;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
for r = 0 to rpt-1
    for e = 0 to elements-1
        tt = (t + r) MOD 32;
        for s = 0 to selem-1
            rval = V[tt];
            if memop == MemOp_LOAD then
                Elem[rval, e, esize] = Mem[address+offs, ebytes, AccType_VEC];
                V[tt] = rval;
            else // memop == MemOp_STORE
                Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, e, esize];
                offs = offs + ebytes;
                tt = (tt + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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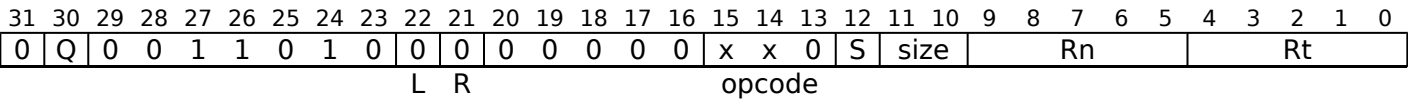
## ST1 (single structure)

Store a single-element structure from one lane of one register. This instruction stores the specified element of a SIMD&FP register to memory.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

### No offset



### 8-bit (opcode == 000)

ST1 { <Vt>.B }[<index>], [<Xn|SP>]

### 16-bit (opcode == 010 && size == x0)

ST1 { <Vt>.H }[<index>], [<Xn|SP>]

### 32-bit (opcode == 100 && size == 00)

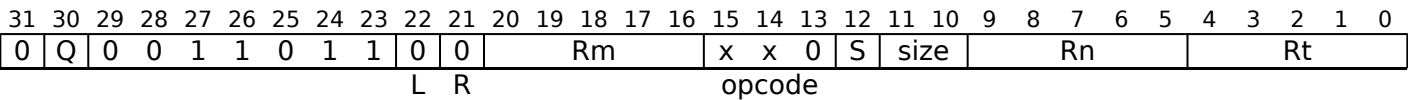
ST1 { <Vt>.S }[<index>], [<Xn|SP>]

### 64-bit (opcode == 100 && S == 0 && size == 01)

ST1 { <Vt>.D }[<index>], [<Xn|SP>]

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

### Post-index



**8-bit, immediate offset (Rm == 11111 && opcode == 000)**

```
ST1 { <Vt>.B }[<index>], [<Xn|SP>], #1
```

**8-bit, register offset (Rm != 11111 && opcode == 000)**

```
ST1 { <Vt>.B }[<index>], [<Xn|SP>], <Xm>
```

**16-bit, immediate offset (Rm == 11111 && opcode == 010 && size == x0)**

```
ST1 { <Vt>.H }[<index>], [<Xn|SP>], #2
```

**16-bit, register offset (Rm != 11111 && opcode == 010 && size == x0)**

```
ST1 { <Vt>.H }[<index>], [<Xn|SP>], <Xm>
```

**32-bit, immediate offset (Rm == 11111 && opcode == 100 && size == 00)**

```
ST1 { <Vt>.S }[<index>], [<Xn|SP>], #4
```

**32-bit, register offset (Rm != 11111 && opcode == 100 && size == 00)**

```
ST1 { <Vt>.S }[<index>], [<Xn|SP>], <Xm>
```

**64-bit, immediate offset (Rm == 11111 && opcode == 100 && S == 0 && size == 01)**

```
ST1 { <Vt>.D }[<index>], [<Xn|SP>], #8
```

**64-bit, register offset (Rm != 11111 && opcode == 100 && S == 0 && size == 01)**

```
ST1 { <Vt>.D }[<index>], [<Xn|SP>], <Xm>
```

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

**Assembler Symbols**

<Vt>	Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
<index>	For the 8-bit variant: is the element index, encoded in "Q:S:size". For the 16-bit variant: is the element index, encoded in "Q:S:size<1>". For the 32-bit variant: is the element index, encoded in "Q:S". For the 64-bit variant: is the element index, encoded in "Q".
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

## Shared Decode

```
integer scale = UInt(opcode<2:1>);
integer selem = UInt(opcode<0>:R) + 1;
boolean replicate = FALSE;
integer index;

case scale of
  when 3
    // load and replicate
    if L == '0' || S == '1' then UNDEFINED;
    scale = UInt(size);
    replicate = TRUE;
  when 0
    index = UInt(Q:S:size);    // B[0-15]
  when 1
    if size<0> == '1' then UNDEFINED;
    index = UInt(Q:S:size<1>); // H[0-7]
  when 2
    if size<1> == '1' then UNDEFINED;
    if size<0> == '0' then
      index = UInt(Q:S);    // S[0-3]
    else
      if S == '1' then UNDEFINED;
      index = UInt(Q);    // D[0-1]
      scale = 3;

MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << scale;
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(128) rval;
bits(esize) element;
constant integer ebytes = esize DIV 8;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
if replicate then
    // load and replicate to all elements
    for s = 0 to selem-1
        element = Mem[address+offs, ebytes, AccType_VEC];
        // replicate to fill 128- or 64-bit register
        V[t] = Replicate(element, datasize DIV esize);
        offs = offs + ebytes;
        t = (t + 1) MOD 32;
else
    // load/store one element per register
    for s = 0 to selem-1
        rval = V[t];
        if memop == MemOp_LOAD then
            // insert into one lane of 128-bit register
            Elem[rval, index, esize] = Mem[address+offs, ebytes, AccType_VEC];
            V[t] = rval;
        else // memop == MemOp_STORE
            // extract from one lane of 128-bit register
            Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, index, esize];
            offs = offs + ebytes;
            t = (t + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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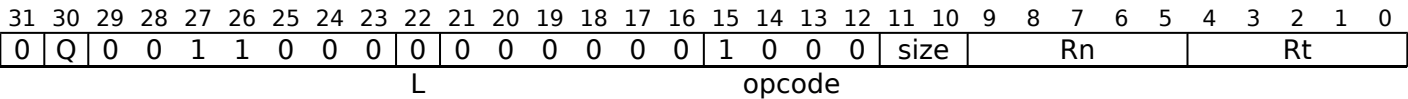
ST2 (multiple structures)

Store multiple 2-element structures from two registers. This instruction stores multiple 2-element structures from two SIMD&FP registers to memory, with interleaving. Every element of each register is stored.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

No offset

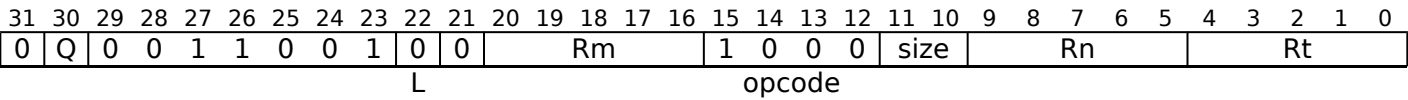


No offset

```
ST2 { <Vt>.<T>, <Vt2>.<T> }, [<Xn|SP>]

integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

Post-index



Immediate offset (Rm == 11111)

```
ST2 { <Vt>.<T>, <Vt2>.<T> }, [<Xn|SP>], <imm>
```

Register offset (Rm != 11111)

```
ST2 { <Vt>.<T>, <Vt2>.<T> }, [<Xn|SP>], <Xm>

integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

Assembler Symbols

- <Vt>

Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
- <T>

Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D
- <Vt2>

Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.

- <Xn|SP>

Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm>

Is the post-index immediate offset, encoded in "Q":

Q	<imm>
0	#16
1	#32
- <Xm>

Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

Shared Decode

```

MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << UInt(size);
integer elements = datasize DIV esize;

integer rpt;    // number of iterations
integer selem;  // structure elements

case opcode of
  when '0000' rpt = 1; selem = 4;    // LD/ST4 (4 registers)
  when '0010' rpt = 4; selem = 1;    // LD/ST1 (4 registers)
  when '0100' rpt = 1; selem = 3;    // LD/ST3 (3 registers)
  when '0110' rpt = 3; selem = 1;    // LD/ST1 (3 registers)
  when '0111' rpt = 1; selem = 1;    // LD/ST1 (1 register)
  when '1000' rpt = 1; selem = 2;    // LD/ST2 (2 registers)
  when '1010' rpt = 2; selem = 1;    // LD/ST1 (2 registers)
  otherwise UNDEFINED;

// .LD format only permitted with LD1 & ST1
if size:Q == '110' && selem != 1 then UNDEFINED;

```

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(datasize) rval;
integer tt;
constant integer ebytes = esize DIV 8;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
for r = 0 to rpt-1
    for e = 0 to elements-1
        tt = (t + r) MOD 32;
        for s = 0 to selem-1
            rval = V[tt];
            if memop == MemOp_LOAD then
                Elem[rval, e, esize] = Mem[address+offs, ebytes, AccType_VEC];
                V[tt] = rval;
            else // memop == MemOp_STORE
                Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, e, esize];
                offs = offs + ebytes;
                tt = (tt + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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## ST2 (single structure)

Store single 2-element structure from one lane of two registers. This instruction stores a 2-element structure to memory from corresponding elements of two SIMD&FP registers.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

### No offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	0	0	1	0	0	0	0	0	x	x	0	S	size	Rn				Rt						
L										R										opcode											

### 8-bit (opcode == 000)

ST2 { <Vt>.B, <Vt2>.B }[<index>], [<Xn|SP>]

### 16-bit (opcode == 010 && size == x0)

ST2 { <Vt>.H, <Vt2>.H }[<index>], [<Xn|SP>]

### 32-bit (opcode == 100 && size == 00)

ST2 { <Vt>.S, <Vt2>.S }[<index>], [<Xn|SP>]

### 64-bit (opcode == 100 && S == 0 && size == 01)

ST2 { <Vt>.D, <Vt2>.D }[<index>], [<Xn|SP>]

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

### Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	1	0	1	Rm					x	x	0	S	size	Rn				Rt						
L										R	opcode																				

**8-bit, immediate offset (Rm == 11111 && opcode == 000)**

```
ST2 { <Vt>.B, <Vt2>.B }[<index>], [<Xn|SP>], #2
```

**8-bit, register offset (Rm != 11111 && opcode == 000)**

```
ST2 { <Vt>.B, <Vt2>.B }[<index>], [<Xn|SP>], <Xm>
```

**16-bit, immediate offset (Rm == 11111 && opcode == 010 && size == x0)**

```
ST2 { <Vt>.H, <Vt2>.H }[<index>], [<Xn|SP>], #4
```

**16-bit, register offset (Rm != 11111 && opcode == 010 && size == x0)**

```
ST2 { <Vt>.H, <Vt2>.H }[<index>], [<Xn|SP>], <Xm>
```

**32-bit, immediate offset (Rm == 11111 && opcode == 100 && size == 00)**

```
ST2 { <Vt>.S, <Vt2>.S }[<index>], [<Xn|SP>], #8
```

**32-bit, register offset (Rm != 11111 && opcode == 100 && size == 00)**

```
ST2 { <Vt>.S, <Vt2>.S }[<index>], [<Xn|SP>], <Xm>
```

**64-bit, immediate offset (Rm == 11111 && opcode == 100 && S == 0 && size == 01)**

```
ST2 { <Vt>.D, <Vt2>.D }[<index>], [<Xn|SP>], #16
```

**64-bit, register offset (Rm != 11111 && opcode == 100 && S == 0 && size == 01)**

```
ST2 { <Vt>.D, <Vt2>.D }[<index>], [<Xn|SP>], <Xm>
```

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

**Assembler Symbols**

<Vt>	Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
<Vt2>	Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.
<index>	For the 8-bit variant: is the element index, encoded in "Q:S:size". For the 16-bit variant: is the element index, encoded in "Q:S:size<1>". For the 32-bit variant: is the element index, encoded in "Q:S". For the 64-bit variant: is the element index, encoded in "Q".
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

## Shared Decode

```
integer scale = UInt(opcode<2:1>);
integer selem = UInt(opcode<0>:R) + 1;
boolean replicate = FALSE;
integer index;

case scale of
  when 3
    // load and replicate
    if L == '0' || S == '1' then UNDEFINED;
    scale = UInt(size);
    replicate = TRUE;
  when 0
    index = UInt(Q:S:size);    // B[0-15]
  when 1
    if size<0> == '1' then UNDEFINED;
    index = UInt(Q:S:size<1>); // H[0-7]
  when 2
    if size<1> == '1' then UNDEFINED;
    if size<0> == '0' then
      index = UInt(Q:S);    // S[0-3]
    else
      if S == '1' then UNDEFINED;
      index = UInt(Q);    // D[0-1]
      scale = 3;

MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << scale;
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(128) rval;
bits(esize) element;
constant integer ebytes = esize DIV 8;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
if replicate then
    // load and replicate to all elements
    for s = 0 to selem-1
        element = Mem[address+offs, ebytes, AccType_VEC];
        // replicate to fill 128- or 64-bit register
        V[t] = Replicate(element, datasize DIV esize);
        offs = offs + ebytes;
        t = (t + 1) MOD 32;
else
    // load/store one element per register
    for s = 0 to selem-1
        rval = V[t];
        if memop == MemOp_LOAD then
            // insert into one lane of 128-bit register
            Elem[rval, index, esize] = Mem[address+offs, ebytes, AccType_VEC];
            V[t] = rval;
        else // memop == MemOp_STORE
            // extract from one lane of 128-bit register
            Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, index, esize];
            offs = offs + ebytes;
            t = (t + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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## ST3 (multiple structures)

Store multiple 3-element structures from three registers. This instruction stores multiple 3-element structures to memory from three SIMD&FP registers, with interleaving. Every element of each register is stored. Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

### No offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	size	Rn				Rt						
L										opcode																					

### No offset

```
ST3 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T> }, [<Xn|SP>]

integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

### Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	0	1	0	0	Rm					0	1	0	0	size		Rn					Rt				
L										opcode																					

### Immediate offset (Rm == 11111)

```
ST3 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T> }, [<Xn|SP>], <imm>
```

### Register offset (Rm != 11111)

```
ST3 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T> }, [<Xn|SP>], <Xm>

integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

## Assembler Symbols

<Vt>

Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.

<T>

Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vt2>

Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.



- <Vt3> Is the name of the third SIMD&FP register to be transferred, encoded as "Rt" plus 2 modulo 32.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the post-index immediate offset, encoded in "Q":
 

Q	<imm>
0	#24
1	#48
- <Xm> Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

Shared Decode

```

MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << UInt(size);
integer elements = datasize DIV esize;

integer rpt;    // number of iterations
integer selem;  // structure elements

case opcode of
  when '0000' rpt = 1; selem = 4;    // LD/ST4 (4 registers)
  when '0010' rpt = 4; selem = 1;    // LD/ST1 (4 registers)
  when '0100' rpt = 1; selem = 3;    // LD/ST3 (3 registers)
  when '0110' rpt = 3; selem = 1;    // LD/ST1 (3 registers)
  when '0111' rpt = 1; selem = 1;    // LD/ST1 (1 register)
  when '1000' rpt = 1; selem = 2;    // LD/ST2 (2 registers)
  when '1010' rpt = 2; selem = 1;    // LD/ST1 (2 registers)
  otherwise UNDEFINED;

// .1D format only permitted with LD1 & ST1
if size:Q == '110' && selem != 1 then UNDEFINED;

```

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(datasize) rval;
integer tt;
constant integer ebytes = esize DIV 8;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
for r = 0 to rpt-1
    for e = 0 to elements-1
        tt = (t + r) MOD 32;
        for s = 0 to selem-1
            rval = V[tt];
            if memop == MemOp_LOAD then
                Elem[rval, e, esize] = Mem[address+offs, ebytes, AccType_VEC];
                V[tt] = rval;
            else // memop == MemOp_STORE
                Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, e, esize];
                offs = offs + ebytes;
                tt = (tt + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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## ST3 (single structure)

Store single 3-element structure from one lane of three registers. This instruction stores a 3-element structure to memory from corresponding elements of three SIMD&FP registers.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

### No offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	0	0	0	0	0	0	0	0	x	x	1	S	size	Rn			Rt							
L										R										opcode											

### 8-bit (opcode == 001)

ST3 { <Vt>.B, <Vt2>.B, <Vt3>.B }[<index>], [<Xn|SP>]

### 16-bit (opcode == 011 && size == x0)

ST3 { <Vt>.H, <Vt2>.H, <Vt3>.H }[<index>], [<Xn|SP>]

### 32-bit (opcode == 101 && size == 00)

ST3 { <Vt>.S, <Vt2>.S, <Vt3>.S }[<index>], [<Xn|SP>]

### 64-bit (opcode == 101 && S == 0 && size == 01)

ST3 { <Vt>.D, <Vt2>.D, <Vt3>.D }[<index>], [<Xn|SP>]

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

### Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	1	0	0	Rm					x	x	1	S	size	Rn					Rt					
L										R	opcode																				

**8-bit, immediate offset (Rm == 11111 && opcode == 001)**

```
ST3 { <Vt>.B, <Vt2>.B, <Vt3>.B }[<index>], [<Xn|SP>], #3
```

**8-bit, register offset (Rm != 11111 && opcode == 001)**

```
ST3 { <Vt>.B, <Vt2>.B, <Vt3>.B }[<index>], [<Xn|SP>], <Xm>
```

**16-bit, immediate offset (Rm == 11111 && opcode == 011 && size == x0)**

```
ST3 { <Vt>.H, <Vt2>.H, <Vt3>.H }[<index>], [<Xn|SP>], #6
```

**16-bit, register offset (Rm != 11111 && opcode == 011 && size == x0)**

```
ST3 { <Vt>.H, <Vt2>.H, <Vt3>.H }[<index>], [<Xn|SP>], <Xm>
```

**32-bit, immediate offset (Rm == 11111 && opcode == 101 && size == 00)**

```
ST3 { <Vt>.S, <Vt2>.S, <Vt3>.S }[<index>], [<Xn|SP>], #12
```

**32-bit, register offset (Rm != 11111 && opcode == 101 && size == 00)**

```
ST3 { <Vt>.S, <Vt2>.S, <Vt3>.S }[<index>], [<Xn|SP>], <Xm>
```

**64-bit, immediate offset (Rm == 11111 && opcode == 101 && S == 0 && size == 01)**

```
ST3 { <Vt>.D, <Vt2>.D, <Vt3>.D }[<index>], [<Xn|SP>], #24
```

**64-bit, register offset (Rm != 11111 && opcode == 101 && S == 0 && size == 01)**

```
ST3 { <Vt>.D, <Vt2>.D, <Vt3>.D }[<index>], [<Xn|SP>], <Xm>
```

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

**Assembler Symbols**

<Vt>	Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
<Vt2>	Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.
<Vt3>	Is the name of the third SIMD&FP register to be transferred, encoded as "Rt" plus 2 modulo 32.
<index>	For the 8-bit variant: is the element index, encoded in "Q:S:size". For the 16-bit variant: is the element index, encoded in "Q:S:size<1>". For the 32-bit variant: is the element index, encoded in "Q:S". For the 64-bit variant: is the element index, encoded in "Q".
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

## Shared Decode

```
integer scale = UInt(opcode<2:1>);
integer selem = UInt(opcode<0>:R) + 1;
boolean replicate = FALSE;
integer index;

case scale of
  when 3
    // load and replicate
    if L == '0' || S == '1' then UNDEFINED;
    scale = UInt(size);
    replicate = TRUE;
  when 0
    index = UInt(Q:S:size);    // B[0-15]
  when 1
    if size<0> == '1' then UNDEFINED;
    index = UInt(Q:S:size<1>); // H[0-7]
  when 2
    if size<1> == '1' then UNDEFINED;
    if size<0> == '0' then
      index = UInt(Q:S);    // S[0-3]
    else
      if S == '1' then UNDEFINED;
      index = UInt(Q);    // D[0-1]
      scale = 3;

MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << scale;
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(128) rval;
bits(esize) element;
constant integer ebytes = esize DIV 8;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
if replicate then
    // load and replicate to all elements
    for s = 0 to selem-1
        element = Mem[address+offs, ebytes, AccType_VEC];
        // replicate to fill 128- or 64-bit register
        V[t] = Replicate(element, datasize DIV esize);
        offs = offs + ebytes;
        t = (t + 1) MOD 32;
else
    // load/store one element per register
    for s = 0 to selem-1
        rval = V[t];
        if memop == MemOp_LOAD then
            // insert into one lane of 128-bit register
            Elem[rval, index, esize] = Mem[address+offs, ebytes, AccType_VEC];
            V[t] = rval;
        else // memop == MemOp_STORE
            // extract from one lane of 128-bit register
            Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, index, esize];
            offs = offs + ebytes;
            t = (t + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

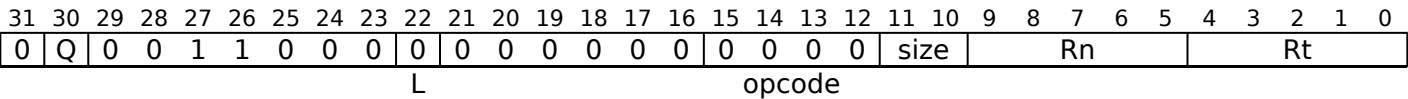
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ST4 (multiple structures)

Store multiple 4-element structures from four registers. This instruction stores multiple 4-element structures to memory from four SIMD&FP registers, with interleaving. Every element of each register is stored. Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

No offset

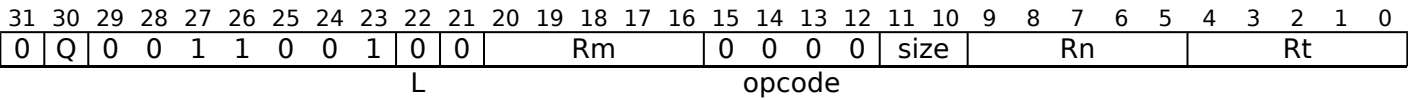


No offset

ST4 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T>, <Vt4>.<T> }, [<Xn|SP>]

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

Post-index



Immediate offset (Rm == 11111)

ST4 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T>, <Vt4>.<T> }, [<Xn|SP>], <imm>

Register offset (Rm != 11111)

ST4 { <Vt>.<T>, <Vt2>.<T>, <Vt3>.<T>, <Vt4>.<T> }, [<Xn|SP>], <Xm>

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

Assembler Symbols

- <Vt> Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vt2> Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.

- <Vt3> Is the name of the third SIMD&FP register to be transferred, encoded as "Rt" plus 2 modulo 32.
- <Vt4> Is the name of the fourth SIMD&FP register to be transferred, encoded as "Rt" plus 3 modulo 32.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the post-index immediate offset, encoded in "Q":
 

Q	<imm>
0	#32
1	#64
- <Xm> Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

### Shared Decode

```

MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << UInt(size);
integer elements = datasize DIV esize;

integer rpt;    // number of iterations
integer selem;  // structure elements

case opcode of
  when '0000' rpt = 1; selem = 4;    // LD/ST4 (4 registers)
  when '0010' rpt = 4; selem = 1;    // LD/ST1 (4 registers)
  when '0100' rpt = 1; selem = 3;    // LD/ST3 (3 registers)
  when '0110' rpt = 3; selem = 1;    // LD/ST1 (3 registers)
  when '0111' rpt = 1; selem = 1;    // LD/ST1 (1 register)
  when '1000' rpt = 1; selem = 2;    // LD/ST2 (2 registers)
  when '1010' rpt = 2; selem = 1;    // LD/ST1 (2 registers)
  otherwise UNDEFINED;

// .1D format only permitted with LD1 & ST1
if size:Q == '110' && selem != 1 then UNDEFINED;

```



## Operation

```
CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(datasize) rval;
integer tt;
constant integer ebytes = esize DIV 8;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
for r = 0 to rpt-1
    for e = 0 to elements-1
        tt = (t + r) MOD 32;
        for s = 0 to selem-1
            rval = V[tt];
            if memop == MemOp_LOAD then
                Elem[rval, e, esize] = Mem[address+offs, ebytes, AccType_VEC];
                V[tt] = rval;
            else // memop == MemOp_STORE
                Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, e, esize];
                offs = offs + ebytes;
                tt = (tt + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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## ST4 (single structure)

Store single 4-element structure from one lane of four registers. This instruction stores a 4-element structure to memory from corresponding elements of four SIMD&FP registers.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [No offset](#) and [Post-index](#)

### No offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	0	0	1	0	0	0	0	0	x	x	1	S	size	Rn				Rt						
L										R	opcode																				

### 8-bit (opcode == 001)

ST4 { <Vt>.B, <Vt2>.B, <Vt3>.B, <Vt4>.B }[<index>], [<Xn|SP>]

### 16-bit (opcode == 011 && size == x0)

ST4 { <Vt>.H, <Vt2>.H, <Vt3>.H, <Vt4>.H }[<index>], [<Xn|SP>]

### 32-bit (opcode == 101 && size == 00)

ST4 { <Vt>.S, <Vt2>.S, <Vt3>.S, <Vt4>.S }[<index>], [<Xn|SP>]

### 64-bit (opcode == 101 && S == 0 && size == 01)

ST4 { <Vt>.D, <Vt2>.D, <Vt3>.D, <Vt4>.D }[<index>], [<Xn|SP>]

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = integer UNKNOWN;
boolean wback = FALSE;
boolean tag_checked = wback || n != 31;
```

### Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	1	0	1	Rm				x	x	1	S	size	Rn				Rt							
L										R	opcode																				

### 8-bit, immediate offset (Rm == 11111 && opcode == 001)

ST4 { <Vt>.B, <Vt2>.B, <Vt3>.B, <Vt4>.B }[<index>], [<Xn|SP>], #4

### 8-bit, register offset (Rm != 11111 && opcode == 001)

ST4 { <Vt>.B, <Vt2>.B, <Vt3>.B, <Vt4>.B }[<index>], [<Xn|SP>], <Xm>

### 16-bit, immediate offset (Rm == 11111 && opcode == 011 && size == x0)

ST4 { <Vt>.H, <Vt2>.H, <Vt3>.H, <Vt4>.H }[<index>], [<Xn|SP>], #8

### 16-bit, register offset (Rm != 11111 && opcode == 011 && size == x0)

ST4 { <Vt>.H, <Vt2>.H, <Vt3>.H, <Vt4>.H }[<index>], [<Xn|SP>], <Xm>

### 32-bit, immediate offset (Rm == 11111 && opcode == 101 && size == 00)

ST4 { <Vt>.S, <Vt2>.S, <Vt3>.S, <Vt4>.S }[<index>], [<Xn|SP>], #16

### 32-bit, register offset (Rm != 11111 && opcode == 101 && size == 00)

ST4 { <Vt>.S, <Vt2>.S, <Vt3>.S, <Vt4>.S }[<index>], [<Xn|SP>], <Xm>

### 64-bit, immediate offset (Rm == 11111 && opcode == 101 && S == 0 && size == 01)

ST4 { <Vt>.D, <Vt2>.D, <Vt3>.D, <Vt4>.D }[<index>], [<Xn|SP>], #32

### 64-bit, register offset (Rm != 11111 && opcode == 101 && S == 0 && size == 01)

ST4 { <Vt>.D, <Vt2>.D, <Vt3>.D, <Vt4>.D }[<index>], [<Xn|SP>], <Xm>

```
integer t = UInt(Rt);
integer n = UInt(Rn);
integer m = UInt(Rm);
boolean wback = TRUE;
boolean tag_checked = wback || n != 31;
```

## Assembler Symbols

<Vt>	Is the name of the first or only SIMD&FP register to be transferred, encoded in the "Rt" field.
<Vt2>	Is the name of the second SIMD&FP register to be transferred, encoded as "Rt" plus 1 modulo 32.
<Vt3>	Is the name of the third SIMD&FP register to be transferred, encoded as "Rt" plus 2 modulo 32.
<Vt4>	Is the name of the fourth SIMD&FP register to be transferred, encoded as "Rt" plus 3 modulo 32.
<index>	For the 8-bit variant: is the element index, encoded in "Q:S:size". For the 16-bit variant: is the element index, encoded in "Q:S:size<1>". For the 32-bit variant: is the element index, encoded in "Q:S". For the 64-bit variant: is the element index, encoded in "Q".
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the general-purpose post-index register, excluding XZR, encoded in the "Rm" field.

## Shared Decode

```
integer scale = UInt(opcode<2:1>);
integer selem = UInt(opcode<0>:R) + 1;
boolean replicate = FALSE;
integer index;

case scale of
  when 3
    // load and replicate
    if L == '0' || S == '1' then UNDEFINED;
    scale = UInt(size);
    replicate = TRUE;
  when 0
    index = UInt(Q:S:size);    // B[0-15]
  when 1
    if size<0> == '1' then UNDEFINED;
    index = UInt(Q:S:size<1>); // H[0-7]
  when 2
    if size<1> == '1' then UNDEFINED;
    if size<0> == '0' then
      index = UInt(Q:S);    // S[0-3]
    else
      if S == '1' then UNDEFINED;
      index = UInt(Q);    // D[0-1]
      scale = 3;

MemOp memop = if L == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = if Q == '1' then 128 else 64;
integer esize = 8 << scale;
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(64) offs;
bits(128) rval;
bits(esize) element;
constant integer ebytes = esize DIV 8;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

offs = Zeros();
if replicate then
    // load and replicate to all elements
    for s = 0 to selem-1
        element = Mem[address+offs, ebytes, AccType_VEC];
        // replicate to fill 128- or 64-bit register
        V[t] = Replicate(element, datasize DIV esize);
        offs = offs + ebytes;
        t = (t + 1) MOD 32;
else
    // load/store one element per register
    for s = 0 to selem-1
        rval = V[t];
        if memop == MemOp_LOAD then
            // insert into one lane of 128-bit register
            Elem[rval, index, esize] = Mem[address+offs, ebytes, AccType_VEC];
            V[t] = rval;
        else // memop == MemOp_STORE
            // extract from one lane of 128-bit register
            Mem[address+offs, ebytes, AccType_VEC] = Elem[rval, index, esize];
            offs = offs + ebytes;
            t = (t + 1) MOD 32;

if wback then
    if m != 31 then
        offs = X[m];
    if n == 31 then
        SP[] = address + offs;
    else
        X[n] = address + offs;
```

## Operational information

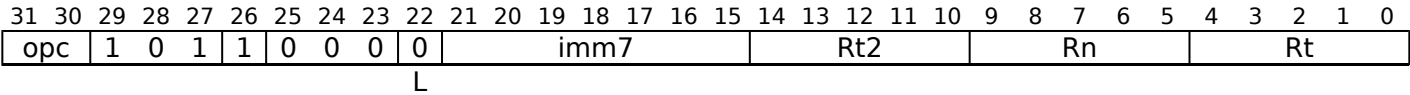
If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# STNP (SIMD&FP)

Store Pair of SIMD&FP registers, with Non-temporal hint. This instruction stores a pair of SIMD&FP registers to memory, issuing a hint to the memory system that the access is non-temporal. The address used for the store is calculated from an address from a base register value and an immediate offset. For information about non-temporal pair instructions, see *Load/Store SIMD and Floating-point Non-temporal pair*. Depending on the settings in the *CPACR EL1*, *CPTR EL2*, and *CPTR EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## 32-bit (opc == 00)

STNP <St1>, <St2>, [<Xn|SP>{, #<imm>}]

## 64-bit (opc == 01)

STNP <Dt1>, <Dt2>, [<Xn|SP>{, #<imm>}]

## 128-bit (opc == 10)

STNP <Qt1>, <Qt2>, [<Xn|SP>{, #<imm>}]

// Empty.

## Assembler Symbols

- <Dt1> Is the 64-bit name of the first SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Dt2> Is the 64-bit name of the second SIMD&FP register to be transferred, encoded in the "Rt2" field.
- <Qt1> Is the 128-bit name of the first SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Qt2> Is the 128-bit name of the second SIMD&FP register to be transferred, encoded in the "Rt2" field.
- <St1> Is the 32-bit name of the first SIMD&FP register to be transferred, encoded in the "Rt" field.
- <St2> Is the 32-bit name of the second SIMD&FP register to be transferred, encoded in the "Rt2" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> For the 32-bit variant: is the optional signed immediate byte offset, a multiple of 4 in the range -256 to 252, defaulting to 0 and encoded in the "imm7" field as <imm>/4.  
For the 64-bit variant: is the optional signed immediate byte offset, a multiple of 8 in the range -512 to 504, defaulting to 0 and encoded in the "imm7" field as <imm>/8.  
For the 128-bit variant: is the optional signed immediate byte offset, a multiple of 16 in the range -1024 to 1008, defaulting to 0 and encoded in the "imm7" field as <imm>/16.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer t2 = UInt(Rt2);
if opc == '11' then UNDEFINED;
integer scale = 2 + UInt(opc);
integer datasize = 8 << scale;
bits(64) offset = LSL(SignExtend(imm7, 64), scale);
boolean tag_checked = n != 31;
```

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(datasize) data1;
bits(datasize) data2;
constant integer dbytes = datasize DIV 8;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

data1 = V[t];
data2 = V[t2];
Mem[address, dbytes, AccType_VECSTREAM] = data1;
Mem[address+dbytes, dbytes, AccType_VECSTREAM] = data2;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

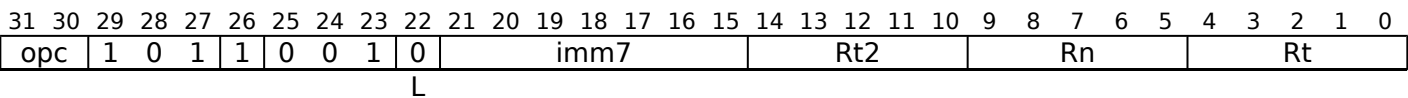
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# STP (SIMD&FP)

Store Pair of SIMD&FP registers. This instruction stores a pair of SIMD&FP registers to memory. The address used for the store is calculated from a base register value and an immediate offset.  
Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Signed offset](#)

## Post-index



### 32-bit (opc == 00)

STP <St1>, <St2>, [<Xn|SP>], #<imm>

### 64-bit (opc == 01)

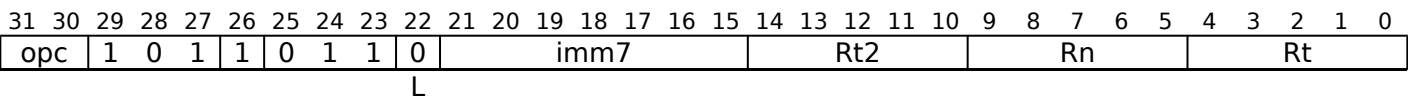
STP <Dt1>, <Dt2>, [<Xn|SP>], #<imm>

### 128-bit (opc == 10)

STP <Qt1>, <Qt2>, [<Xn|SP>], #<imm>

boolean wback = TRUE;  
boolean postindex = TRUE;

## Pre-index



### 32-bit (opc == 00)

STP <St1>, <St2>, [<Xn|SP>, #<imm>]!

### 64-bit (opc == 01)

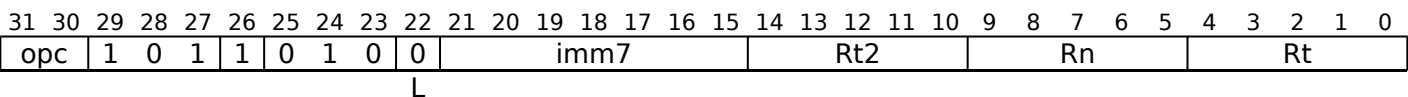
STP <Dt1>, <Dt2>, [<Xn|SP>, #<imm>]!

### 128-bit (opc == 10)

STP <Qt1>, <Qt2>, [<Xn|SP>, #<imm>]!

boolean wback = TRUE;  
boolean postindex = FALSE;

## Signed offset





### 32-bit (opc == 00)

```
STP <St1>, <St2>, [<Xn|SP>{, #<imm>}]
```

### 64-bit (opc == 01)

```
STP <Dt1>, <Dt2>, [<Xn|SP>{, #<imm>}]
```

### 128-bit (opc == 10)

```
STP <Qt1>, <Qt2>, [<Xn|SP>{, #<imm>}]
```

```
boolean wback = FALSE;  
boolean postindex = FALSE;
```

## Assembler Symbols

<Dt1>	Is the 64-bit name of the first SIMD&FP register to be transferred, encoded in the "Rt" field.
<Dt2>	Is the 64-bit name of the second SIMD&FP register to be transferred, encoded in the "Rt2" field.
<Qt1>	Is the 128-bit name of the first SIMD&FP register to be transferred, encoded in the "Rt" field.
<Qt2>	Is the 128-bit name of the second SIMD&FP register to be transferred, encoded in the "Rt2" field.
<St1>	Is the 32-bit name of the first SIMD&FP register to be transferred, encoded in the "Rt" field.
<St2>	Is the 32-bit name of the second SIMD&FP register to be transferred, encoded in the "Rt2" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<imm>	For the 32-bit post-index and 32-bit pre-index variant: is the signed immediate byte offset, a multiple of 4 in the range -256 to 252, encoded in the "imm7" field as <imm>/4.  For the 32-bit signed offset variant: is the optional signed immediate byte offset, a multiple of 4 in the range -256 to 252, defaulting to 0 and encoded in the "imm7" field as <imm>/4.  For the 64-bit post-index and 64-bit pre-index variant: is the signed immediate byte offset, a multiple of 8 in the range -512 to 504, encoded in the "imm7" field as <imm>/8.  For the 64-bit signed offset variant: is the optional signed immediate byte offset, a multiple of 8 in the range -512 to 504, defaulting to 0 and encoded in the "imm7" field as <imm>/8.  For the 128-bit post-index and 128-bit pre-index variant: is the signed immediate byte offset, a multiple of 16 in the range -1024 to 1008, encoded in the "imm7" field as <imm>/16.  For the 128-bit signed offset variant: is the optional signed immediate byte offset, a multiple of 16 in the range -1024 to 1008, defaulting to 0 and encoded in the "imm7" field as <imm>/16.

## Shared Decode

```
integer n = UInt(Rn);  
integer t = UInt(Rt);  
integer t2 = UInt(Rt2);  
if opc == '11' then UNDEFINED;  
integer scale = 2 + UInt(opc);  
integer datasize = 8 << scale;  
bits(64) offset = LSL(SignExtend(imm7, 64), scale);  
boolean tag_checked = wback || n != 31;
```

## Operation

```
CheckFPAdvSIMDEnabled64();

bits(64) address;
bits(datasize) data1;
bits(datasize) data2;
constant integer dbytes = datasize DIV 8;

if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

data1 = V[t];
data2 = V[t2];
Mem[address, dbytes, AccType_VEC] = data1;
Mem[address+dbytes, dbytes, AccType_VEC] = data2;

if wback then
    if postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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STR (immediate, SIMD&FP)

Store SIMD&FP register (immediate offset). This instruction stores a single SIMD&FP register to memory. The address that is used for the store is calculated from a base register value and an immediate offset. Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 3 classes: [Post-index](#) , [Pre-index](#) and [Unsigned offset](#)

Post-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size	1	1	1	1	0	0	x	0	0	imm9										0	1	Rn				Rt					
opc																															

8-bit (size == 00 && opc == 00)

STR <Bt>, [<Xn|SP>], #<sim>

16-bit (size == 01 && opc == 00)

STR <Ht>, [<Xn|SP>], #<sim>

32-bit (size == 10 && opc == 00)

STR <St>, [<Xn|SP>], #<sim>

64-bit (size == 11 && opc == 00)

STR <Dt>, [<Xn|SP>], #<sim>

128-bit (size == 00 && opc == 10)

STR <Qt>, [<Xn|SP>], #<sim>

```
boolean wback = TRUE;
boolean postindex = TRUE;
integer scale = UInt(opc<l>:size);
if scale > 4 then UNDEFINED;
bits(64) offset = SignExtend(imm9, 64);
```

Pre-index

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size	1	1	1	1	0	0	x	0	0	imm9										1	1	Rn				Rt					
opc																															

8-bit (size == 00 && opc == 00)

```
STR <Bt>, [<Xn|SP>, #<sim>]!
```

16-bit (size == 01 && opc == 00)

```
STR <Ht>, [<Xn|SP>, #<sim>]!
```

32-bit (size == 10 && opc == 00)

```
STR <St>, [<Xn|SP>, #<sim>]!
```

64-bit (size == 11 && opc == 00)

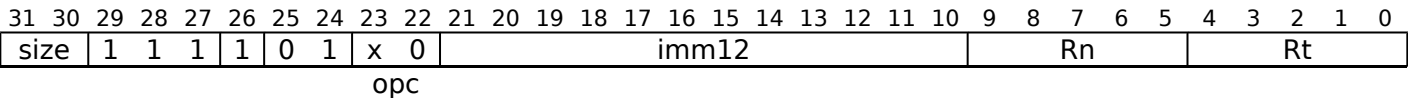
```
STR <Dt>, [<Xn|SP>, #<sim>]!
```

128-bit (size == 00 && opc == 10)

```
STR <Qt>, [<Xn|SP>, #<sim>]!
```

```
boolean wback = TRUE;
boolean postindex = FALSE;
integer scale = UInt(opc<l>:size);
if scale > 4 then UNDEFINED;
bits(64) offset = SignExtend(imm9, 64);
```

Unsigned offset



8-bit (size == 00 && opc == 00)

```
STR <Bt>, [<Xn|SP>{, #<pimm>}]
```

16-bit (size == 01 && opc == 00)

```
STR <Ht>, [<Xn|SP>{, #<pimm>}]
```

32-bit (size == 10 && opc == 00)

```
STR <St>, [<Xn|SP>{, #<pimm>}]
```

64-bit (size == 11 && opc == 00)

```
STR <Dt>, [<Xn|SP>{, #<pimm>}]
```

128-bit (size == 00 && opc == 10)

```
STR <Qt>, [<Xn|SP>{, #<pimm>}]
```

```
boolean wback = FALSE;
boolean postindex = FALSE;
integer scale = UInt(opc<l>:size);
if scale > 4 then UNDEFINED;
bits(64) offset = LSL(ZeroExtend(imm12, 64), scale);
```

## Assembler Symbols

<Bt>	Is the 8-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
<Dt>	Is the 64-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
<Ht>	Is the 16-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
<Qt>	Is the 128-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
<St>	Is the 32-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<sim>	Is the signed immediate byte offset, in the range -256 to 255, encoded in the "imm9" field.
<pimm>	For the 8-bit variant: is the optional positive immediate byte offset, in the range 0 to 4095, defaulting to 0 and encoded in the "imm12" field.  For the 16-bit variant: is the optional positive immediate byte offset, a multiple of 2 in the range 0 to 8190, defaulting to 0 and encoded in the "imm12" field as <pimm>/2.  For the 32-bit variant: is the optional positive immediate byte offset, a multiple of 4 in the range 0 to 16380, defaulting to 0 and encoded in the "imm12" field as <pimm>/4.  For the 64-bit variant: is the optional positive immediate byte offset, a multiple of 8 in the range 0 to 32760, defaulting to 0 and encoded in the "imm12" field as <pimm>/8.  For the 128-bit variant: is the optional positive immediate byte offset, a multiple of 16 in the range 0 to 65520, defaulting to 0 and encoded in the "imm12" field as <pimm>/16.

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
MemOp memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = 8 << scale;
boolean tag_checked = memop != MemOp_PREFETCH && (wback || n != 31);
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();
bits(64) address;
bits(datasize) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

if !postindex then
    address = address + offset;

case memop of
    when MemOp_STORE
        data = V[t];
        Mem[address, datasize DIV 8, AccType_VEC] = data;

    when MemOp_LOAD
        data = Mem[address, datasize DIV 8, AccType_VEC];
        V[t] = data;

if wback then
    if postindex then
        address = address + offset;
    if n == 31 then
        SP[] = address;
    else
        X[n] = address;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# STR (register, SIMD&FP)

Store SIMD&FP register (register offset). This instruction stores a single SIMD&FP register to memory. The address that is used for the store is calculated from a base register value and an offset register value. The offset can be optionally shifted and extended.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size	1	1	1	1	0	0	x	0	1	Rm					option			S	1	0	Rn					Rt					
opc																															

8-fsreg,STR-8-fsreg (size == 00 && opc == 00 && option != 011)

STR <Bt>, [<Xn|SP>, (<Wm>|<Xm>), <extend> {<amount>}]

8-fsreg,STR-8-fsreg (size == 00 && opc == 00 && option == 011)

STR <Bt>, [<Xn|SP>, <Xm>{, LSL <amount>}]

16-fsreg,STR-16-fsreg (size == 01 && opc == 00)

STR <Ht>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]

32-fsreg,STR-32-fsreg (size == 10 && opc == 00)

STR <St>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]

64-fsreg,STR-64-fsreg (size == 11 && opc == 00)

STR <Dt>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]

128-fsreg,STR-128-fsreg (size == 00 && opc == 10)

STR <Qt>, [<Xn|SP>, (<Wm>|<Xm>){, <extend> {<amount>}}]

```
integer scale = UInt(opc<1>:size);
if scale > 4 then UNDEFINED;
if option<1> == '0' then UNDEFINED;    // sub-word index
ExtendType extend_type = DecodeRegExtend(option);
integer shift = if S == '1' then scale else 0;
```

## Assembler Symbols

- <Bt> Is the 8-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Dt> Is the 64-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Ht> Is the 16-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Qt> Is the 128-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
- <St> Is the 32-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Wm> When option<0> is set to 0, is the 32-bit name of the general-purpose index register, encoded in the "Rm" field.
- <Xm> When option<0> is set to 1, is the 64-bit name of the general-purpose index register, encoded in the "Rm" field.
- <extend> For the 8-bit variant: is the index extend specifier, encoded in "option":

option	<extend>
010	UXTW
110	SXTW
111	SCTX

For the 128-bit, 16-bit, 32-bit and 64-bit variant: is the index extend/shift specifier, defaulting to LSL, and which must be omitted for the LSL option when <amount> is omitted. encoded in “option”:

option	<extend>
010	UXTW
011	LSL
110	SXTW
111	SCTX

<amount> For the 8-bit variant: is the index shift amount, it must be #0, encoded in “S” as 0 if omitted, or as 1 if present.

For the 16-bit variant: is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in “S”:

S	<amount>
0	#0
1	#1

For the 32-bit variant: is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in “S”:

S	<amount>
0	#0
1	#2

For the 64-bit variant: is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in “S”:

S	<amount>
0	#0
1	#3

For the 128-bit variant: is the index shift amount, optional only when <extend> is not LSL. Where it is permitted to be optional, it defaults to #0. It is encoded in “S”:

S	<amount>
0	#0
1	#4

## Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
integer m = UInt(Rm);
MemOp memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = 8 << scale;
boolean tag_checked = memop != MemOp_PREFETCH;
```



## Operation

```
bits(64) offset = ExtendReg(m, extend_type, shift);
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();
bits(64) address;
bits(datasize) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

case memop of
    when MemOp_STORE
        data = V[t];
        Mem[address, datasize DIV 8, AccType_VEC] = data;

    when MemOp_LOAD
        data = Mem[address, datasize DIV 8, AccType_VEC];
        V[t] = data;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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STUR (SIMD&FP)

Store SIMD&FP register (unscaled offset). This instruction stores a single SIMD&FP register to memory. The address that is used for the store is calculated from a base register value and an optional immediate offset.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size		1	1	1	1	0	0	x	0	0	imm9										0	0	Rn				Rt				
opc																															

8-bit (size == 00 && opc == 00)

STUR <Bt>, [<Xn|SP>{, #<sim>}]

16-bit (size == 01 && opc == 00)

STUR <Ht>, [<Xn|SP>{, #<sim>}]

32-bit (size == 10 && opc == 00)

STUR <St>, [<Xn|SP>{, #<sim>}]

64-bit (size == 11 && opc == 00)

STUR <Dt>, [<Xn|SP>{, #<sim>}]

128-bit (size == 00 && opc == 10)

STUR <Qt>, [<Xn|SP>{, #<sim>}]

```
integer scale = UInt(opc<1>:size);
if scale > 4 then UNDEFINED;
bits(64) offset = SignExtend(imm9, 64);
```

Assembler Symbols

- <Bt> Is the 8-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Dt> Is the 64-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Ht> Is the 16-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Qt> Is the 128-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
- <St> Is the 32-bit name of the SIMD&FP register to be transferred, encoded in the "Rt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <sim> Is the optional signed immediate byte offset, in the range -256 to 255, defaulting to 0 and encoded in the "imm9" field.

Shared Decode

```
integer n = UInt(Rn);
integer t = UInt(Rt);
MemOp memop = if opc<0> == '1' then MemOp_LOAD else MemOp_STORE;
integer datasize = 8 << scale;
boolean tag_checked = memop != MemOp_PREFETCH && (n != 31);
```

## Operation

```
if HaveMTEExt() then
    SetTagCheckedInstruction(tag_checked);

CheckFPAdvSIMDEnabled64();
bits(64) address;
bits(datasize) data;

if n == 31 then
    CheckSPAlignment();
    address = SP[];
else
    address = X[n];

address = address + offset;

case memop of
    when MemOp_STORE
        data = V[t];
        Mem[address, datasize DIV 8, AccType_VEC] = data;

    when MemOp_LOAD
        data = Mem[address, datasize DIV 8, AccType_VEC];
        V[t] = data;
```

## Operational information

If PSTATE.DIT is 1, the timing of this instruction is insensitive to the value of the data being loaded or stored.

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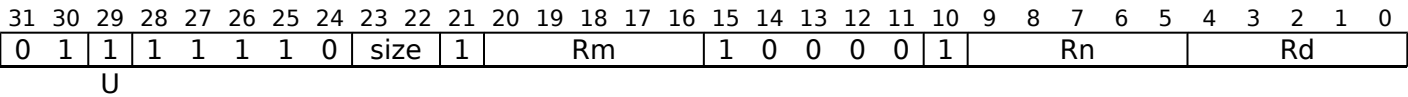
# SUB (vector)

Subtract (vector). This instruction subtracts each vector element in the second source SIMD&FP register from the corresponding vector element in the first source SIMD&FP register, places the result into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

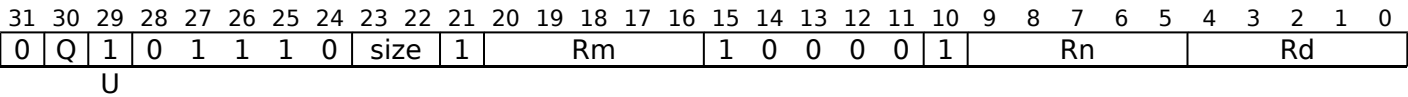


## Scalar

```
SUB <V><d>, <V><n>, <V><m>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean sub_op = (U == '1');
```

## Vector



## Vector

```
SUB <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean sub_op = (U == '1');
```

## Assembler Symbols

- <V>

Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D
- <d>

Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n>

Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m>

Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    element1 = Elem[operand1, e, esize];
    element2 = Elem[operand2, e, esize];
    if sub_op then
        Elem[result, e, esize] = element1 - element2;
    else
        Elem[result, e, esize] = element1 + element2;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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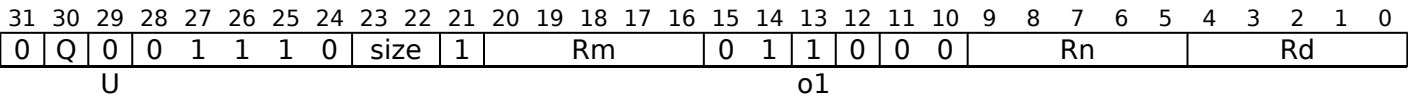
SUBHN, SUBHN2

Subtract returning High Narrow. This instruction subtracts each vector element in the second source SIMD&FP register from the corresponding vector element in the first source SIMD&FP register, places the most significant half of the result into a vector, and writes the vector to the lower or upper half of the destination SIMD&FP register. All the values in this instruction are signed integer values.

The results are truncated. For rounded results, see [RSUBHN](#).

The SUBHN instruction writes the vector to the lower half of the destination register and clears the upper half, while the SUBHN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers, not all the same type

SUBHN{2} <Vd>.<Tb>, <Vn>.<Ta>, <Vm>.<Ta>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean sub_op = (o1 == '1');
boolean round = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(2*datasize) operand1 = V[n];
bits(2*datasize) operand2 = V[m];
bits(datasize) result;
integer round_const = if round then 1 << (esize - 1) else 0;
bits(2*esize) element1;
bits(2*esize) element2;
bits(2*esize) sum;

for e = 0 to elements-1
    element1 = Elem[operand1, e, 2*esize];
    element2 = Elem[operand2, e, 2*esize];
    if sub_op then
        sum = element1 - element2;
    else
        sum = element1 + element2;
    sum = sum + round_const;
    Elem[result, e, esize] = sum<2*esize-1:esize>;

Vpart[d, part] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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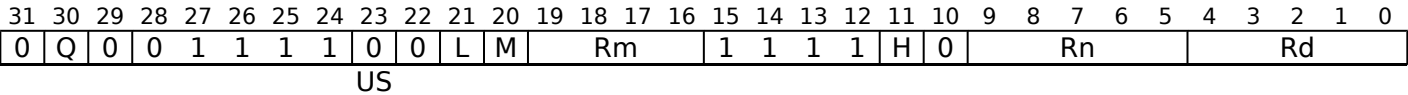
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SUDOT (by element)

Dot product index form with signed and unsigned integers. This instruction performs the dot product of the four signed 8-bit integer values in each 32-bit element of the first source register with the four unsigned 8-bit integer values in an indexed 32-bit element of the second source register, accumulating the result into the corresponding 32-bit element of the destination vector.

From Armv8.2, this is an OPTIONAL instruction. [ID\\_AA64ISAR0\\_EL1](#).I8MM indicates whether this instruction is supported.

Vector  
(Armv8.6)



Vector

```
SUDOT <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.4B[<index>]
```

```
if !HaveInt8MatMulExt() then UNDEFINED;
boolean op1_unsigned = (US == '1');
boolean op2_unsigned = (US == '0');
integer n = UInt(Rn);
integer m = UInt(M:Rm);
integer d = UInt(Rd);
integer i = UInt(H:L);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV 32;
```

Assembler Symbols

- <Vd>

Is the name of the SIMD&FP third source and destination register, encoded in the "Rd" field.
- <Ta>

Is an arrangement specifier, encoded in "Q":

Q	<Ta>
0	2S
1	4S
- <Vn>

Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Tb>

Is an arrangement specifier, encoded in "Q":

Q	<Tb>
0	8B
1	16B
- <Vm>

Is the name of the second SIMD&FP source register, encoded in the "M:Rm" fields.
- <index>

Is the immediate index of a quadruplet of four 8-bit elements in the range 0 to 3, encoded in the "H:L" fields.



## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(128) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;

for e = 0 to elements-1
    bits(32) res = Elem[operand3, e, 32];
    for b = 0 to 3
        integer element1 = Int(Elem[operand1, 4*e+b, 8], op1_unsigned);
        integer element2 = Int(Elem[operand2, 4*i+b, 8], op2_unsigned);
        res = res + element1 * element2;
    Elem[result, e, 32] = res;
V[d] = result;
```

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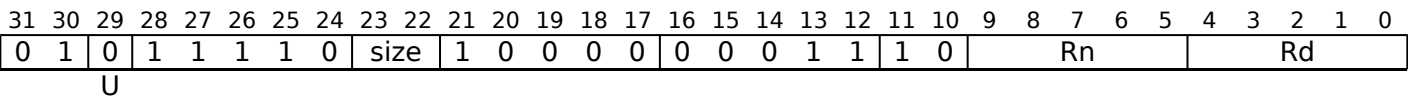
# SUQADD

Signed saturating Accumulate of Unsigned value. This instruction adds the unsigned integer values of the vector elements in the source SIMD&FP register to corresponding signed integer values of the vector elements in the destination SIMD&FP register, and writes the resulting signed integer values to the destination SIMD&FP register. If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit `FPSR.QC` is set.

Depending on the settings in the `CPACR_EL1`, `CPTR_EL2`, and `CPTR_EL3` registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar



## Scalar

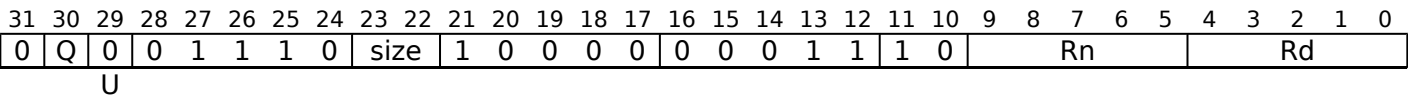
```
SUQADD <V><d>, <V><n>

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;

boolean unsigned = (U == '1');
```

## Vector



## Vector

```
SUQADD <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
```

## Assembler Symbols

- <V>

Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D
- <d>

Is the number of the SIMD&FP destination register, encoded in the “Rd” field.

- <n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

### Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;

bits(datasize) operand2 = V[d];
integer op1;
integer op2;
boolean sat;

for e = 0 to elements-1
    op1 = Int(Elem[operand, e, esize], !unsigned);
    op2 = Int(Elem[operand2, e, esize], unsigned);
    (Elem[result, e, esize], sat) = SatQ(op1 + op2, esize, unsigned);
    if sat then FPSR.QC = '1';
V[d] = result;

```

SXTL, SXTL2

Signed extend Long. This instruction duplicates each vector element in the lower or upper half of the source SIMD&FP register into a vector, and writes the vector to the destination SIMD&FP register. The destination vector elements are twice as long as the source vector elements. All the values in this instruction are signed integer values. The SXTL instruction extracts the source vector from the lower half of the source register, while the SXTL2 instruction extracts the source vector from the upper half of the source register. Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This is an alias of SSHLL, SSHLL2. This means:

- The encodings in this description are named to match the encodings of SSHLL, SSHLL2.
- The description of SSHLL, SSHLL2 gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	1	0	!= 0000				0	0	0	1	0	1	0	0	1	Rn				Rd					
U									immh				immb																		

Vector

SXTL{2} <Vd>.<Ta>, <Vn>.<Tb>

is equivalent to

SSHLL{2} <Vd>.<Ta>, <Vn>.<Tb>, #0

and is the preferred disassembly when BitCount(immh) == 1.

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “immh”:

immh	<Ta>
0000	SEE Advanced SIMD modified immediate
0001	8H
001x	4S
01xx	2D
1xxx	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “immh:Q”:

immh	Q	<Tb>
0000	x	SEE Advanced SIMD modified immediate
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	x	RESERVED

Operation

The description of SSHLL, SSHLL2 gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

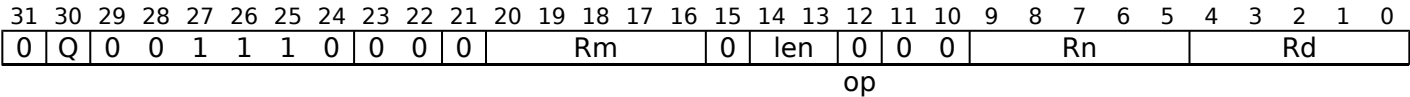
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TBL

Table vector Lookup. This instruction reads each value from the vector elements in the index source SIMD&FP register, uses each result as an index to perform a lookup in a table of bytes that is described by one to four source table SIMD&FP registers, places the lookup result in a vector, and writes the vector to the destination SIMD&FP register. If an index is out of range for the table, the result for that lookup is 0. If more than one source register is used to describe the table, the first source register describes the lowest bytes of the table.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Two register table (len == 01)

TBL <Vd>.<Ta>, { <Vn>.16B, <Vn+1>.16B }, <Vm>.<Ta>

Three register table (len == 10)

TBL <Vd>.<Ta>, { <Vn>.16B, <Vn+1>.16B, <Vn+2>.16B }, <Vm>.<Ta>

Four register table (len == 11)

TBL <Vd>.<Ta>, { <Vn>.16B, <Vn+1>.16B, <Vn+2>.16B, <Vn+3>.16B }, <Vm>.<Ta>

Single register table (len == 00)

TBL <Vd>.<Ta>, { <Vn>.16B }, <Vm>.<Ta>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV 8;
integer regs = UInt(len) + 1;
boolean is_tbl = (op == '0');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Ta> Is an arrangement specifier, encoded in "Q":

Q	<Ta>
0	8B
1	16B
- <Vn> For the four register table, three register table and two register table variant: is the name of the first SIMD&FP table register, encoded in the "Rn" field.  
For the single register table variant: is the name of the SIMD&FP table register, encoded in the "Rn" field.
- <Vn+1> Is the name of the second SIMD&FP table register, encoded as "Rn" plus 1 modulo 32.
- <Vn+2> Is the name of the third SIMD&FP table register, encoded as "Rn" plus 2 modulo 32.
- <Vn+3> Is the name of the fourth SIMD&FP table register, encoded as "Rn" plus 3 modulo 32.
- <Vm> Is the name of the SIMD&FP index register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) indices = V[m];
bits(128*regs) table = Zeros();
bits(datasize) result;
integer index;

// Create table from registers
for i = 0 to regs-1
    table<128*i+127:128*i> = V[n];
    n = (n + 1) MOD 32;

result = if is_tbl then Zeros() else V[d];
for i = 0 to elements-1
    index = UInt(Elem[indices, i, 8]);
    if index < 16 * regs then
        Elem[result, i, 8] = Elem[table, index, 8];

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

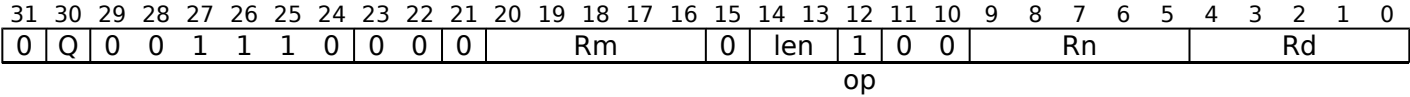
Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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TBX

Table vector lookup extension. This instruction reads each value from the vector elements in the index source SIMD&FP register, uses each result as an index to perform a lookup in a table of bytes that is described by one to four source table SIMD&FP registers, places the lookup result in a vector, and writes the vector to the destination SIMD&FP register. If an index is out of range for the table, the existing value in the vector element of the destination register is left unchanged. If more than one source register is used to describe the table, the first source register describes the lowest bytes of the table.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Two register table (len == 01)

TBX <Vd>.<Ta>, { <Vn>.16B, <Vn+1>.16B }, <Vm>.<Ta>

Three register table (len == 10)

TBX <Vd>.<Ta>, { <Vn>.16B, <Vn+1>.16B, <Vn+2>.16B }, <Vm>.<Ta>

Four register table (len == 11)

TBX <Vd>.<Ta>, { <Vn>.16B, <Vn+1>.16B, <Vn+2>.16B, <Vn+3>.16B }, <Vm>.<Ta>

Single register table (len == 00)

TBX <Vd>.<Ta>, { <Vn>.16B }, <Vm>.<Ta>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV 8;
integer regs = UInt(len) + 1;
boolean is_tbl = (op == '0');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Ta> Is an arrangement specifier, encoded in "Q":

Q	<Ta>
0	8B
1	16B
- <Vn> For the four register table, three register table and two register table variant: is the name of the first SIMD&FP table register, encoded in the "Rn" field.  
For the single register table variant: is the name of the SIMD&FP table register, encoded in the "Rn" field.
- <Vn+1> Is the name of the second SIMD&FP table register, encoded as "Rn" plus 1 modulo 32.
- <Vn+2> Is the name of the third SIMD&FP table register, encoded as "Rn" plus 2 modulo 32.
- <Vn+3> Is the name of the fourth SIMD&FP table register, encoded as "Rn" plus 3 modulo 32.
- <Vm> Is the name of the SIMD&FP index register, encoded in the "Rm" field.



## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) indices = V[m];
bits(128*regs) table = Zeros();
bits(datasize) result;
integer index;

// Create table from registers
for i = 0 to regs-1
    table<128*i+127:128*i> = V[n];
    n = (n + 1) MOD 32;

result = if is_tbl then Zeros() else V[d];
for i = 0 to elements-1
    index = UInt(Elem[indices, i, 8]);
    if index < 16 * regs then
        Elem[result, i, 8] = Elem[table, index, 8];

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

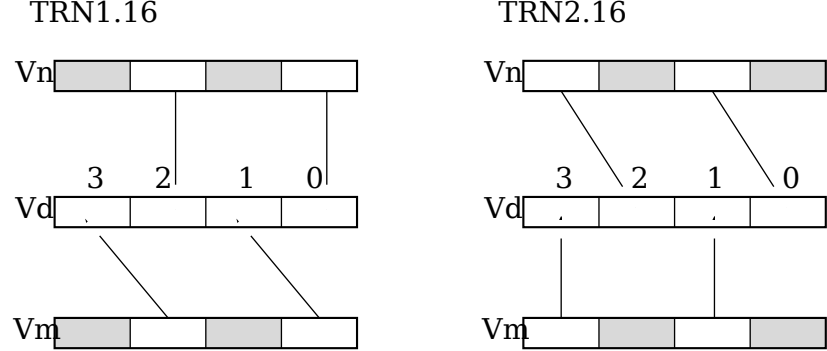
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TRN1

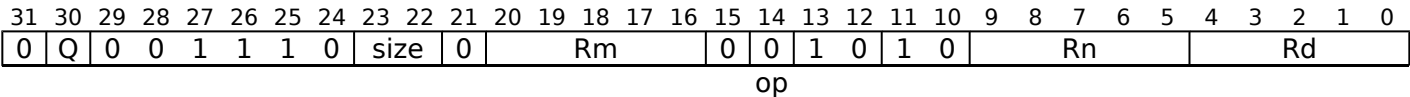
Transpose vectors (primary). This instruction reads corresponding even-numbered vector elements from the two source SIMD&FP registers, starting at zero, places each result into consecutive elements of a vector, and writes the vector to the destination SIMD&FP register. Vector elements from the first source register are placed into even-numbered elements of the destination vector, starting at zero, while vector elements from the second source register are placed into odd-numbered elements of the destination vector.

By using this instruction with TRN2, a 2 x 2 matrix can be transposed.

The following figure shows an example of the operation of TRN1 and TRN2 halfword operations where Q = 0.



Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Advanced SIMD

TRN1 <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
integer part = UInt(op);
integer pairs = elements DIV 2;
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

for p = 0 to pairs-1
    Elem[result, 2*p+0, esize] = Elem[operand1, 2*p+part, esize];
    Elem[result, 2*p+1, esize] = Elem[operand2, 2*p+part, esize];

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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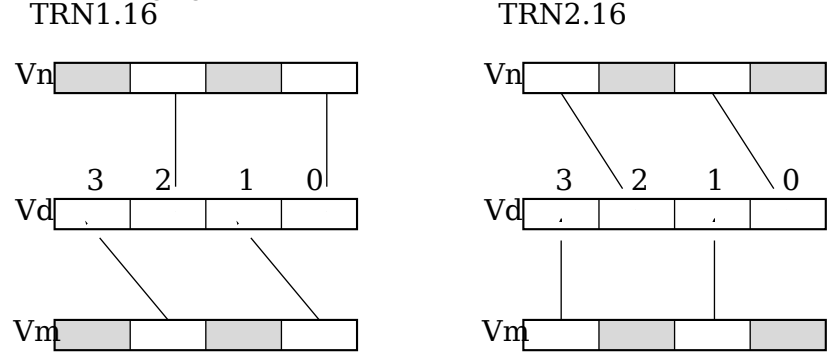
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TRN2

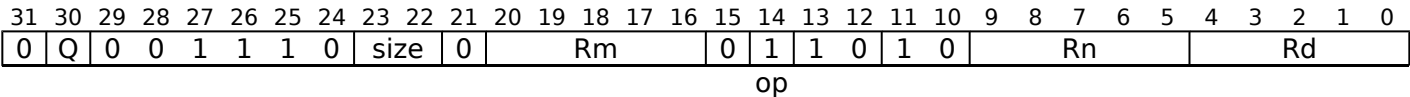
Transpose vectors (secondary). This instruction reads corresponding odd-numbered vector elements from the two source SIMD&FP registers, places each result into consecutive elements of a vector, and writes the vector to the destination SIMD&FP register. Vector elements from the first source register are placed into even-numbered elements of the destination vector, starting at zero, while vector elements from the second source register are placed into odd-numbered elements of the destination vector.

By using this instruction with TRN1, a 2 x 2 matrix can be transposed.

The following figure shows an example of the operation of TRN1 and TRN2 halfword operations where Q = 0.



Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Advanced SIMD

TRN2 <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
integer part = UInt(op);
integer pairs = elements DIV 2;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

for p = 0 to pairs-1
    Elem[result, 2*p+0, esize] = Elem[operand1, 2*p+part, esize];
    Elem[result, 2*p+1, esize] = Elem[operand2, 2*p+part, esize];

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

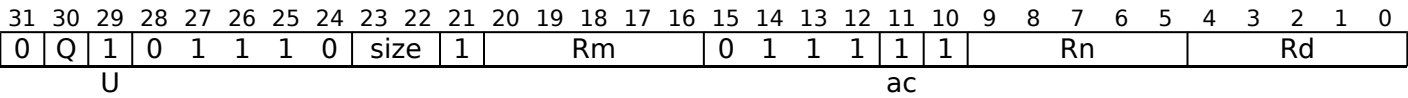
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UABA

Unsigned Absolute difference and Accumulate. This instruction subtracts the elements of the vector of the second source SIMD&FP register from the corresponding elements of the first source SIMD&FP register, and accumulates the absolute values of the results into the elements of the vector of the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers of the same type

```
UABA <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean accumulate = (ac == '1');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
bits(esize) absdiff;

result = if accumulate then V[d] else Zeros();
for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    absdiff = Abs(element1-element2)<esize-1:0>;
    Elem[result, e, esize] = Elem[result, e, esize] + absdiff;
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

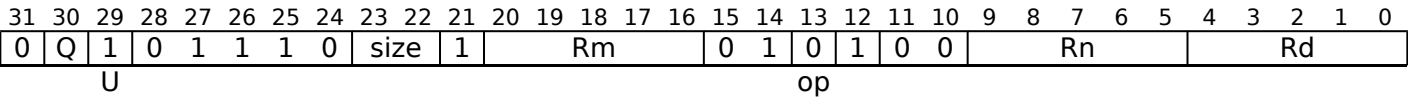
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UABAL, UABAL2

Unsigned Absolute difference and Accumulate Long. This instruction subtracts the vector elements in the lower or upper half of the second source SIMD&FP register from the corresponding vector elements of the first source SIMD&FP register, and accumulates the absolute values of the results into the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the source vector elements. All the values in this instruction are unsigned integer values.

The UABAL instruction extracts each source vector from the lower half of each source register, while the UABAL2 instruction extracts each source vector from the upper half of each source register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers, not all the same type

UABAL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean accumulate = (op == '0');
boolean unsigned = (U == '1');
```

Assembler Symbols

- 2

Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	
0	[absent]
1	[present]
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Ta>

Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED
- <Vn>

Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Tb>

Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED
- <Vm>

Is the name of the second SIMD&FP source register, encoded in the "Rm" field.



## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) absdiff;

result = if accumulate then V[d] else Zeros();
for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    absdiff = Abs(element1-element2)<2*esize-1:0>;
    Elem[result, e, 2*esize] = Elem[result, e, 2*esize] + absdiff;
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

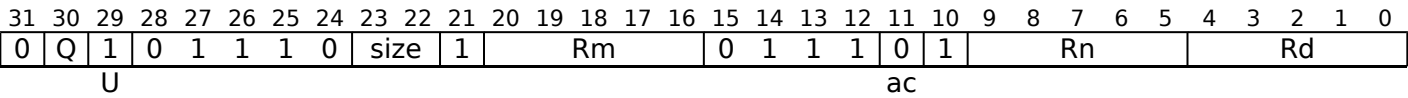
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UABD

Unsigned Absolute Difference (vector). This instruction subtracts the elements of the vector of the second source SIMD&FP register from the corresponding elements of the first source SIMD&FP register, places the the absolute values of the results into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers of the same type

```
UABD <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean accumulate = (ac == '1');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
bits(esize) absdiff;

result = if accumulate then V[d] else Zeros();
for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    absdiff = Abs(element1-element2)<esize-1:0>;
    Elem[result, e, esize] = Elem[result, e, esize] + absdiff;
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

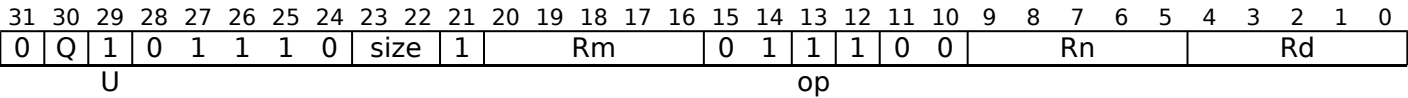
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UABDL, UABDL2

Unsigned Absolute Difference Long. This instruction subtracts the vector elements in the lower or upper half of the second source SIMD&FP register from the corresponding vector elements of the first source SIMD&FP register, places the absolute value of the result into a vector, and writes the vector to the destination SIMD&FP register. The destination vector elements are twice as long as the source vector elements. All the values in this instruction are unsigned integer values.

The UABDL instruction extracts each source vector from the lower half of each source register, while the UABDL2 instruction extracts each source vector from the upper half of each source register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers, not all the same type

UABDL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean accumulate = (op == '0');
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q 2	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) absdiff;

result = if accumulate then V[d] else Zeros();
for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    absdiff = Abs(element1-element2)<2*esize-1:0>;
    Elem[result, e, 2*esize] = Elem[result, e, 2*esize] + absdiff;
V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

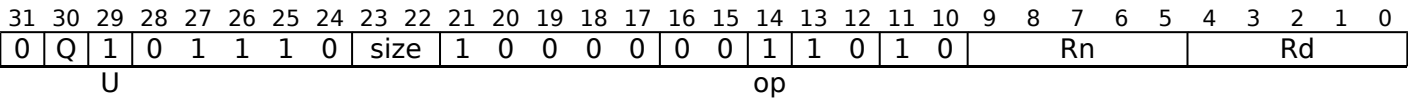
Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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UADALP

Unsigned Add and Accumulate Long Pairwise. This instruction adds pairs of adjacent unsigned integer values from the vector in the source SIMD&FP register and accumulates the results with the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the source vector elements.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Vector

UADALP <Vd>.<Ta>, <Vn>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV (2 * esize);
boolean acc = (op == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Ta> Is an arrangement specifier, encoded in "size:Q":

size	Q	<Ta>
00	0	4H
00	1	8H
01	0	2S
01	1	4S
10	0	1D
10	1	2D
11	x	RESERVED

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.
- <Tb> Is an arrangement specifier, encoded in "size:Q":

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;

bits(2*esize) sum;
integer op1;
integer op2;

if acc then result = V[d];
for e = 0 to elements-1
    op1 = Int(Elem[operand, 2*e+0, esize], unsigned);
    op2 = Int(Elem[operand, 2*e+1, esize], unsigned);
    sum = (op1+op2)<2*esize-1:0>;
    if acc then
        Elem[result, e, 2*esize] = Elem[result, e, 2*esize] + sum;
    else
        Elem[result, e, 2*esize] = sum;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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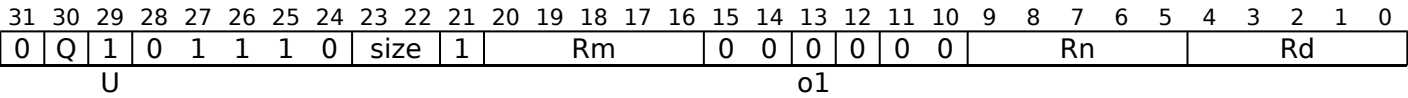
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UADDL, UADDL2

Unsigned Add Long (vector). This instruction adds each vector element in the lower or upper half of the first source SIMD&FP register to the corresponding vector element of the second source SIMD&FP register, places the result into a vector, and writes the vector to the destination SIMD&FP register. The destination vector elements are twice as long as the source vector elements. All the values in this instruction are unsigned integer values.

The UADDL instruction extracts each source vector from the lower half of each source register, while the UADDL2 instruction extracts each source vector from the upper half of each source register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers, not all the same type

```
UADDL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(0);
integer elements = datasize DIV esize;

boolean sub_op = (o1 == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

- 2

Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Ta>

Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED
- <Vn>

Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Tb>

Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED
- <Vm>

Is the name of the second SIMD&FP source register, encoded in the "Rm" field.



## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
integer element1;
integer element2;
integer sum;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    if sub_op then
        sum = element1 - element2;
    else
        sum = element1 + element2;
    Elem[result, e, 2*esize] = sum<2*esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

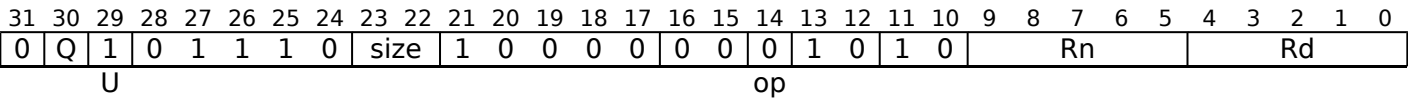
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UADDLP

Unsigned Add Long Pairwise. This instruction adds pairs of adjacent unsigned integer values from the vector in the source SIMD&FP register, places the result into a vector, and writes the vector to the destination SIMD&FP register. The destination vector elements are twice as long as the source vector elements.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Vector

UADDLP <Vd>.<Ta>, <Vn>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV (2 * esize);
boolean acc = (op == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Ta> Is an arrangement specifier, encoded in "size:Q":

size	Q	<Ta>
00	0	4H
00	1	8H
01	0	2S
01	1	4S
10	0	1D
10	1	2D
11	x	RESERVED

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.
- <Tb> Is an arrangement specifier, encoded in "size:Q":

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;

bits(2*esize) sum;
integer op1;
integer op2;

if acc then result = V[d];
for e = 0 to elements-1
    op1 = Int(Elem[operand, 2*e+0, esize], unsigned);
    op2 = Int(Elem[operand, 2*e+1, esize], unsigned);
    sum = (op1+op2)<2*esize-1:0>;
    if acc then
        Elem[result, e, 2*esize] = Elem[result, e, 2*esize] + sum;
    else
        Elem[result, e, 2*esize] = sum;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

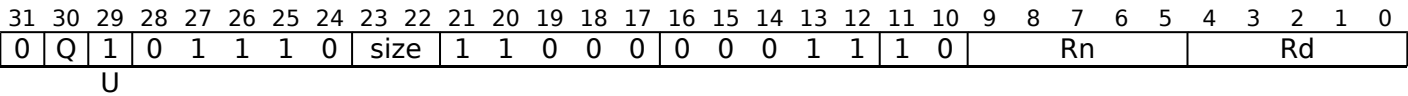
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UADDLV

Unsigned sum Long across Vector. This instruction adds every vector element in the source SIMD&FP register together, and writes the scalar result to the destination SIMD&FP register. The destination scalar is twice as long as the source vector elements. All the values in this instruction are unsigned integer values.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Advanced SIMD

UADDLV <V><d>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '100' then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
```

Assembler Symbols

- <V> Is the destination width specifier, encoded in “size”:
- | size | <V>      |
|------|----------|
| 00   | H        |
| 01   | S        |
| 10   | D        |
| 11   | RESERVED |
- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.
- <T> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	RESERVED
10	1	4S
11	x	RESERVED

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
integer sum;

sum = Int(Elem[operand, 0, esize], unsigned);
for e = 1 to elements-1
    sum = sum + Int(Elem[operand, e, esize], unsigned);

V[d] = sum<2*esize-1:0>;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

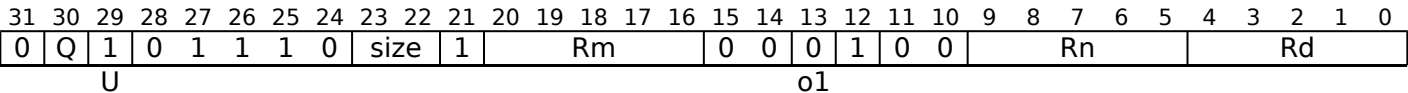
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UADDW, UADDW2

Unsigned Add Wide. This instruction adds the vector elements of the first source SIMD&FP register to the corresponding vector elements in the lower or upper half of the second source SIMD&FP register, places the result in a vector, and writes the vector to the SIMD&FP destination register. The vector elements of the destination register and the first source register are twice as long as the vector elements of the second source register. All the values in this instruction are unsigned integer values.

The UADDW instruction extracts vector elements from the lower half of the second source register, while the UADDW2 instruction extracts vector elements from the upper half of the second source register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers, not all the same type

UADDW{2} <Vd>.<Ta>, <Vn>.<Ta>, <Vm>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean sub_op = (o1 == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

- 2

Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	
0	[absent]
1	[present]
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Ta>

Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED
- <Vn>

Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm>

Is the name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Tb>

Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(2*datasize) operand1 = V[n];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
integer element1;
integer element2;
integer sum;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, 2*esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    if sub_op then
        sum = element1 - element2;
    else
        sum = element1 + element2;
    Elem[result, e, 2*esize] = sum<2*esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# UCVTF (vector, fixed-point)

Unsigned fixed-point Convert to Floating-point (vector). This instruction converts each element in a vector from fixed-point to floating-point using the rounding mode that is specified by the [FPCR](#), and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in [FPCR](#), the exception results in either a flag being set in [FPSR](#), or a synchronous exception being generated. For more information, see [Floating-point exception traps](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	1	0	!= 0000				immb			1	1	1	0	0	1	Rn				Rd					
U									immh																						

## Scalar

```
UCVTF <V><d>, <V><n>, #<fbits>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '000x' || (immh == '001x' && !HaveFP16Ext()) then UNDEFINED;
integer esize = if immh == 'lxxx' then 64 else if immh == '0lxx' then 32 else 16;
integer datasize = esize;
integer elements = 1;

integer fracbits = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
FPRounding rounding = FPRoundingMode(FPCR);
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	0	!= 0000				immb			1	1	1	0	0	1	Rn				Rd					
U									immbh																						

## Vector

```
UCVTF <Vd>.<T>, <Vn>.<T>, #<fbits>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh == '000x' || (immh == '001x' && !HaveFP16Ext()) then UNDEFINED;
if immh<3>:Q == '10' then UNDEFINED;
integer esize = if immh == 'lxxx' then 64 else if immh == '0lxx' then 32 else 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer fracbits = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
FPRounding rounding = FPRoundingMode(FPCR);
```

## Assembler Symbols

<V> Is a width specifier, encoded in “immh”:



immh	<V>
000x	RESERVED
001x	H
01xx	S
1xxx	D

<d> Is the number of the SIMD&FP destination register, in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<T>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	x	RESERVED
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<fbits> For the scalar variant: is the number of fractional bits, in the range 1 to the operand width, encoded in "immh:immb":

immh	<fbits>
000x	RESERVED
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

For the vector variant: is the number of fractional bits, in the range 1 to the element width, encoded in "immh:immb":

immh	<fbits>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	RESERVED
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FixedToFP(element, fracbits, unsigned, FPCR, rounding);
V[d] = result;

```

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# UCVTF (vector, integer)

Unsigned integer Convert to Floating-point (vector). This instruction converts each element in a vector from an unsigned integer value to a floating-point value using the rounding mode that is specified by the *FPCR*, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.

It has encodings from 4 classes: [Scalar half precision](#) , [Scalar single-precision and double-precision](#) , [Vector half precision](#) and [Vector single-precision and double-precision](#)

## Scalar half precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	0	1	1	1	1	0	0	1	1	1	0	1	1	0	Rn				Rd					
U																															

## Scalar half precision

```
UCVTF <Hd>, <Hn>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
```

## Scalar single-precision and double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	0	sz	1	0	0	0	0	1	1	1	0	1	1	0	Rn				Rd					
U																															

## Scalar single-precision and double-precision

```
UCVTF <V><d>, <V><n>

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 32 << UInt(sz);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
```

## Vector half precision (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	0	1	1	1	1	0	0	1	1	1	0	1	1	0	Rn				Rd					
U																															

Vector half precision

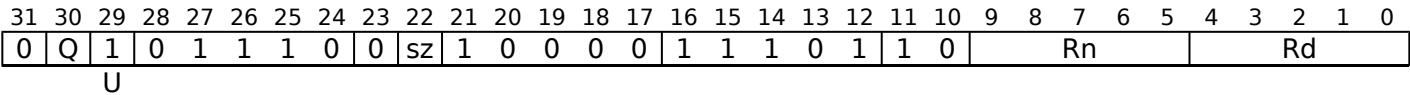
```
UCVTF <Vd>.<T>, <Vn>.<T>

if !HaveFP16Ext() then UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 16;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
```

Vector single-precision and double-precision



Vector single-precision and double-precision

```
UCVTF <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz:Q == '10' then UNDEFINED;
integer esize = 32 << UInt(sz);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
```

Assembler Symbols

- <Hd> Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Hn> Is the 16-bit name of the SIMD&FP source register, encoded in the "Rn" field.
- <V> Is a width specifier, encoded in "sz":

sz	<V>
0	S
1	D

- <d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.
- <n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> For the vector half precision variant: is an arrangement specifier, encoded in "Q":

Q	<T>
0	4H
1	8H

For the vector single-precision and double-precision variant: is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	0	RESERVED
1	1	2D

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
FPRounding rounding = FPRoundingMode(FPCR);
bits(esize) element;
for e = 0 to elements-1
    element = Elem[operand, e, esize];
    Elem[result, e, esize] = FixedToFP(element, 0, unsigned, FPCR, rounding);
V[d] = result;
```

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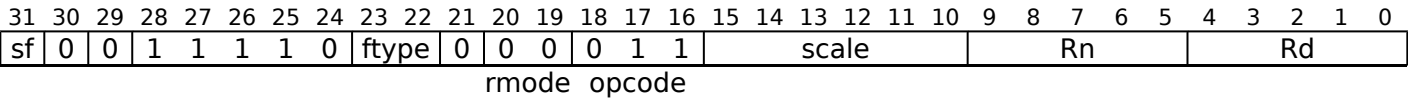
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UCVTF (scalar, fixed-point)

Unsigned fixed-point Convert to Floating-point (scalar). This instruction converts the unsigned value in the 32-bit or 64-bit general-purpose source register to a floating-point value using the rounding mode that is specified by the *FPCR*, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the Security state and Exception level in which the instruction is executed, an attempt to execute the instruction might be trapped.



**32-bit to half-precision (sf == 0 && ftype == 11)**  
(Armv8.2)

UCVTF <Hd>, <Wn>, #<fbits>

**32-bit to single-precision (sf == 0 && ftype == 00)**

UCVTF <Sd>, <Wn>, #<fbits>

**32-bit to double-precision (sf == 0 && ftype == 01)**

UCVTF <Dd>, <Wn>, #<fbits>

**64-bit to half-precision (sf == 1 && ftype == 11)**  
(Armv8.2)

UCVTF <Hd>, <Xn>, #<fbits>

**64-bit to single-precision (sf == 1 && ftype == 00)**

UCVTF <Sd>, <Xn>, #<fbits>

**64-bit to double-precision (sf == 1 && ftype == 01)**

UCVTF <Dd>, <Xn>, #<fbits>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;
FPRounding rounding;

case ftype of
  when '00' fltsize = 32;
  when '01' fltsize = 64;
  when '10' UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      fltsize = 16;
    else
      UNDEFINED;

if sf == '0' && scale<5> == '0' then UNDEFINED;
integer fracbits = 64 - UInt(scale);

rounding = FPRoundingMode(FPCR);
```

**Assembler Symbols**

<Dd>	Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Hd>	Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Sd>	Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.
<fbits>	For the 32-bit to double-precision, 32-bit to half-precision and 32-bit to single-precision variant: is the number of bits after the binary point in the fixed-point source, in the range 1 to 32, encoded as 64 minus "scale".

For the 64-bit to double-precision, 64-bit to half-precision and 64-bit to single-precision variant: is the number of bits after the binary point in the fixed-point source, in the range 1 to 64, encoded as 64 minus "scale".

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
bits(fltsize) fltval;  
bits(intsize) intval;  
  
intval = X[n];  
fltval = FixedToFP(intval, fracbits, TRUE, FPCR, rounding);  
V[d] = fltval;
```

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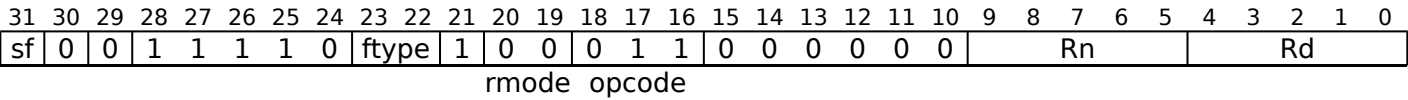
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UCVTF (scalar, integer)

Unsigned integer Convert to Floating-point (scalar). This instruction converts the unsigned integer value in the general-purpose source register to a floating-point value using the rounding mode that is specified by the *FPCR*, and writes the result to the SIMD&FP destination register.

A floating-point exception can be generated by this instruction. Depending on the settings in *FPCR*, the exception results in either a flag being set in *FPSR*, or a synchronous exception being generated. For more information, see *Floating-point exception traps*.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.





**32-bit to half-precision (sf == 0 && ftype == 11)**  
(Armv8.2)

UCVTF <Hd>, <Wn>

**32-bit to single-precision (sf == 0 && ftype == 00)**

UCVTF <Sd>, <Wn>

**32-bit to double-precision (sf == 0 && ftype == 01)**

UCVTF <Dd>, <Wn>

**64-bit to half-precision (sf == 1 && ftype == 11)**  
(Armv8.2)

UCVTF <Hd>, <Xn>

**64-bit to single-precision (sf == 1 && ftype == 00)**

UCVTF <Sd>, <Xn>

**64-bit to double-precision (sf == 1 && ftype == 01)**

UCVTF <Dd>, <Xn>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer intsize = if sf == '1' then 64 else 32;
integer fltsize;
FPRounding rounding;

case ftype of
  when '00'
    fltsize = 32;
  when '01'
    fltsize = 64;
  when '10'
    UNDEFINED;
  when '11'
    if HaveFP16Ext() then
      fltsize = 16;
    else
      UNDEFINED;

rounding = FPRoundingMode(FPCR);
```

**Assembler Symbols**

<Dd>	Is the 64-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Hd>	Is the 16-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Sd>	Is the 32-bit name of the SIMD&FP destination register, encoded in the "Rd" field.
<Xn>	Is the 64-bit name of the general-purpose source register, encoded in the "Rn" field.
<Wn>	Is the 32-bit name of the general-purpose source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();  
  
bits(fltsize) fltval;  
bits(intsize) intval;  
  
intval = X[n];  
fltval = FixedToFP(intval, 0, TRUE, FPCR, rounding);  
V[d] = fltval;
```

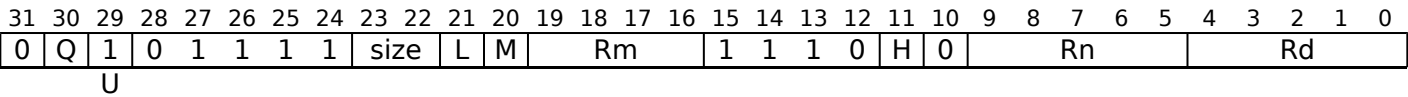
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UDOT (by element)

Dot Product unsigned arithmetic (vector, by element). This instruction performs the dot product of the four 8-bit elements in each 32-bit element of the first source register with the four 8-bit elements of an indexed 32-bit element in the second source register, accumulating the result into the corresponding 32-bit element of the destination register. Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped. In Armv8.2 and Armv8.3, this is an OPTIONAL instruction. From Armv8.4 it is mandatory for all implementations to support it. ID\_AA64ISAR0\_EL1.DP indicates whether this instruction is supported.

Vector (Armv8.2)



Vector

UDOT <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.4B[<index>]

```
if !HaveD0TPExt() then UNDEFINED;
if size != '10' then UNDEFINED;
boolean signed = (U == '0');

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(M:Rm);
integer index = UInt(H:L);

integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

- <Vd>

Is the name of the SIMD&FP third source and destination register, encoded in the "Rd" field.
- <Ta>

Is an arrangement specifier, encoded in "Q":

Q	<Ta>
0	2S
1	4S
- <Vn>

Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Tb>

Is an arrangement specifier, encoded in "Q":

Q	<Tb>
0	8B
1	16B
- <Vm>

Is the name of the second SIMD&FP source register, encoded in the "M:Rm" fields.
- <index>

Is the element index, encoded in the "H:L" fields.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(128) operand2 = V[m];
bits(datasize) result = V[d];
for e = 0 to elements-1
    integer res = 0;
    integer element1, element2;
    for i = 0 to 3
        if signed then
            element1 = SInt(Elem[operand1, 4*e+i, esize DIV 4]);
            element2 = SInt(Elem[operand2, 4*index+i, esize DIV 4]);
        else
            element1 = UInt(Elem[operand1, 4*e+i, esize DIV 4]);
            element2 = UInt(Elem[operand2, 4*index+i, esize DIV 4]);
        res = res + element1 * element2;
    Elem[result, e, esize] = Elem[result, e, esize] + res;
V[d] = result;
```

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UDOT (vector)

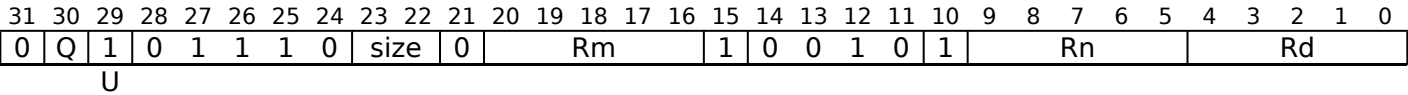
Dot Product unsigned arithmetic (vector). This instruction performs the dot product of the four unsigned 8-bit elements in each 32-bit element of the first source register with the four unsigned 8-bit elements of the corresponding 32-bit element in the second source register, accumulating the result into the corresponding 32-bit element of the destination register.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

In Armv8.2 and Armv8.3, this is an OPTIONAL instruction. From Armv8.4 it is mandatory for all implementations to support it.

*ID\_AA64ISAR0\_EL1*.DP indicates whether this instruction is supported.

Vector  
(Armv8.2)



Vector

UDOT <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
if !HaveDOTPExt() then UNDEFINED;
if size != '10' then UNDEFINED;
boolean signed = (U == '0');
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

- <Vd>

Is the name of the SIMD&FP third source and destination register, encoded in the "Rd" field.
- <Ta>

Is an arrangement specifier, encoded in "Q":

Q	<Ta>
0	2S
1	4S
- <Vn>

Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Tb>

Is an arrangement specifier, encoded in "Q":

Q	<Tb>
0	8B
1	16B
- <Vm>

Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

result = V[d];
for e = 0 to elements-1
    integer res = 0;
    integer element1, element2;
    for i = 0 to 3
        if signed then
            element1 = SInt(Elem[operand1, 4*e+i, esize DIV 4]);
            element2 = SInt(Elem[operand2, 4*e+i, esize DIV 4]);
        else
            element1 = UInt(Elem[operand1, 4*e+i, esize DIV 4]);
            element2 = UInt(Elem[operand2, 4*e+i, esize DIV 4]);
        res = res + element1 * element2;
    Elem[result, e, esize] = Elem[result, e, esize] + res;
V[d] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

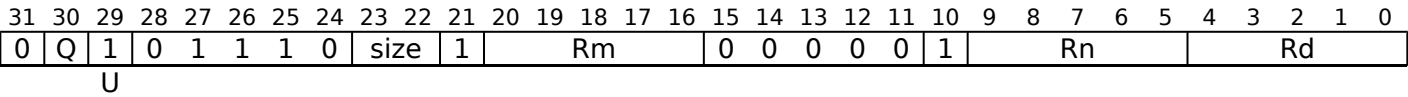
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UHADD

Unsigned Halving Add. This instruction adds corresponding unsigned integer values from the two source SIMD&FP registers, shifts each result right one bit, places the results into a vector, and writes the vector to the destination SIMD&FP register.

The results are truncated. For rounded results, see [URHADD](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers of the same type

```
UHADD <Vd>.<T>, <Vn>.<T>, <Vm>.<T>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
integer sum;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    sum = element1 + element2;
    Elem[result, e, esize] = sum<esize:1>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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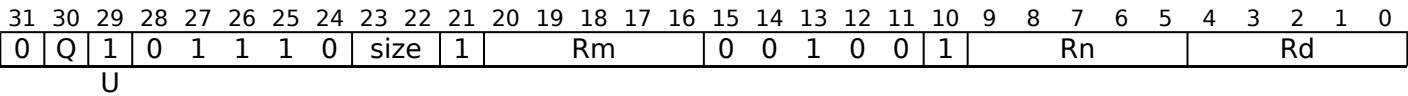
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UHSUB

Unsigned Halving Subtract. This instruction subtracts the vector elements in the second source SIMD&FP register from the corresponding vector elements in the first source SIMD&FP register, shifts each result right one bit, places each result into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers of the same type

```
UHSUB <Vd>.<T>, <Vn>.<T>, <Vm>.<T>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
integer diff;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    diff = element1 - element2;
    Elem[result, e, esize] = diff<esize:1>;

V[d] = result;
```

Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

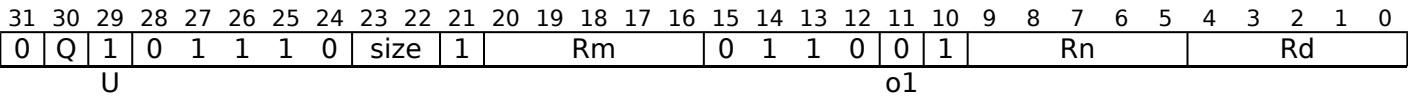
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# UMAX

Unsigned Maximum (vector). This instruction compares corresponding elements in the vectors in the two source SIMD&FP registers, places the larger of each pair of unsigned integer values into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



## Three registers of the same type

```
UMAX <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean minimum = (o1 == '1');
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
integer maxmin;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    maxmin = if minimum then Min(element1, element2) else Max(element1, element2);
    Elem[result, e, esize] = maxmin<esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

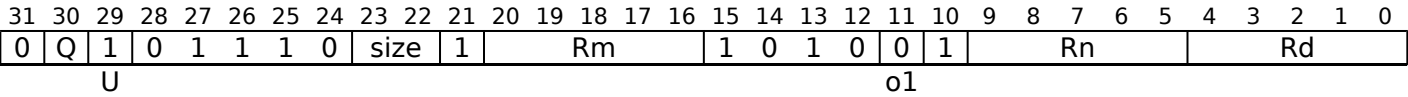
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UMAXP

Unsigned Maximum Pairwise. This instruction creates a vector by concatenating the vector elements of the first source SIMD&FP register after the vector elements of the second source SIMD&FP register, reads each pair of adjacent vector elements in the two source SIMD&FP registers, writes the largest of each pair of unsigned integer values into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers of the same type

```
UMAXP <Vd>.<T>, <Vn>.<T>, <Vm>.<T>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean minimum = (o1 == '1');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(2*datasize) concat = operand2:operand1;
integer element1;
integer element2;
integer maxmin;

for e = 0 to elements-1
    element1 = Int(Elem[concat, 2*e, esize], unsigned);
    element2 = Int(Elem[concat, (2*e)+1, esize], unsigned);
    maxmin = if minimum then Min(element1, element2) else Max(element1, element2);
    Elem[result, e, esize] = maxmin<esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

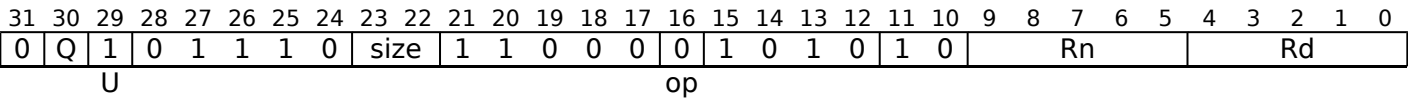
Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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UMAXV

Unsigned Maximum across Vector. This instruction compares all the vector elements in the source SIMD&FP register, and writes the largest of the values as a scalar to the destination SIMD&FP register. All the values in this instruction are unsigned integer values.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Advanced SIMD

UMAXV <V><d>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '100' then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean min = (op == '1');
```

Assembler Symbols

<V> Is the destination width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<T> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	RESERVED
10	1	4S
11	x	RESERVED

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
integer maxmin;
integer element;

maxmin = Int(Elem[operand, 0, esize], unsigned);
for e = 1 to elements-1
    element = Int(Elem[operand, e, esize], unsigned);
    maxmin = if min then Min(maxmin, element) else Max(maxmin, element);

V[d] = maxmin<esize-1:0>;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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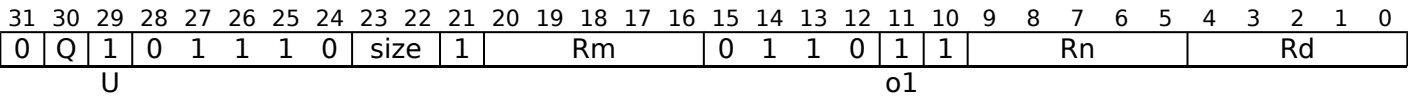
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UMIN

Unsigned Minimum (vector). This instruction compares corresponding vector elements in the two source SIMD&FP registers, places the smaller of each of the two unsigned integer values into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers of the same type

```
UMIN <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean minimum = (o1 == '1');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
integer maxmin;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    maxmin = if minimum then Min(element1, element2) else Max(element1, element2);
    Elem[result, e, esize] = maxmin<size-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

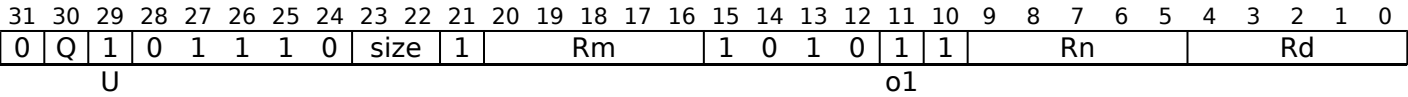
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UMINP

Unsigned Minimum Pairwise. This instruction creates a vector by concatenating the vector elements of the first source SIMD&FP register after the vector elements of the second source SIMD&FP register, reads each pair of adjacent vector elements in the two source SIMD&FP registers, writes the smallest of each pair of unsigned integer values into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers of the same type

```
UMINP <Vd>.<T>, <Vn>.<T>, <Vm>.<T>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean minimum = (o1 == '1');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
bits(2*datasize) concat = operand2:operand1;
integer element1;
integer element2;
integer maxmin;

for e = 0 to elements-1
    element1 = Int(Elem[concat, 2*e, esize], unsigned);
    element2 = Int(Elem[concat, (2*e)+1, esize], unsigned);
    maxmin = if minimum then Min(element1, element2) else Max(element1, element2);
    Elem[result, e, esize] = maxmin<esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

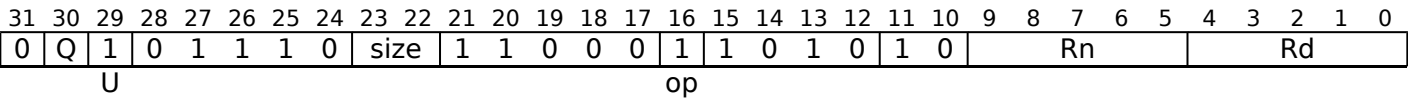
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UMINV

Unsigned Minimum across Vector. This instruction compares all the vector elements in the source SIMD&FP register, and writes the smallest of the values as a scalar to the destination SIMD&FP register. All the values in this instruction are unsigned integer values.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Advanced SIMD

```
UMINV <V><d>, <Vn>.<T>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '100' then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean min = (op == '1');
```

Assembler Symbols

<V> Is the destination width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<T> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	RESERVED
10	1	4S
11	x	RESERVED

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
integer maxmin;
integer element;

maxmin = Int(Elem[operand, 0, esize], unsigned);
for e = 1 to elements-1
    element = Int(Elem[operand, e, esize], unsigned);
    maxmin = if min then Min(maxmin, element) else Max(maxmin, element);

V[d] = maxmin<esize-1:0>;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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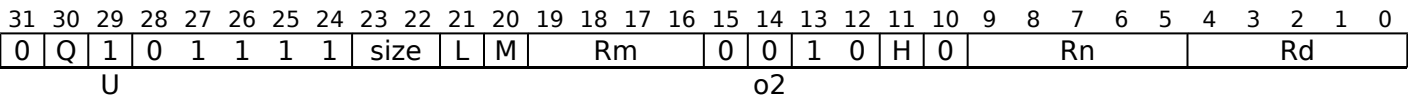
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UMLAL, UMLAL2 (by element)

Unsigned Multiply-Add Long (vector, by element). This instruction multiplies each vector element in the lower or upper half of the first source SIMD&FP register by the specified vector element of the second source SIMD&FP register and accumulates the results with the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied.

The UMLAL instruction extracts vector elements from the lower half of the first source register, while the UMLAL2 instruction extracts vector elements from the upper half of the first source register.

Depending on the settings in the CPACR EL1, CPTR EL2, and CPTR EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Vector

```
UMLAL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Ts>[<index>]

integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean sub_op = (o2 == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the “Rd” field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	RESERVED
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the “Rn” field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in “size:M:Rm”:

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

Restricted to V0-V15 when element size <Ts> is H.

<Ts> Is an element size specifier, encoded in “size”:

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in “size:L:H:M”:

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(idxsizesize) operand2 = V[m];
bits(2*datasize) operand3 = V[d];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;

element2 = Int(Elem[operand2, index, esize], unsigned);
for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    product = (element1*element2)<2*esize-1:0>;
    if sub_op then
        Elem[result, e, 2*esize] = Elem[operand3, e, 2*esize] - product;
    else
        Elem[result, e, 2*esize] = Elem[operand3, e, 2*esize] + product;

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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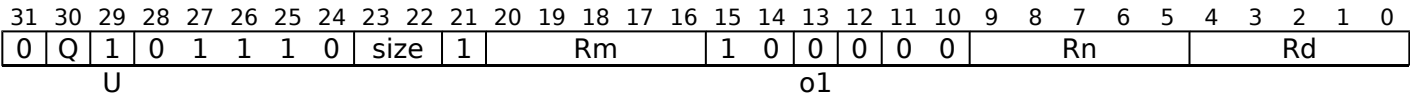


UMLAL, UMLAL2 (vector)

Unsigned Multiply-Add Long (vector). This instruction multiplies the vector elements in the lower or upper half of the first source SIMD&FP register by the corresponding vector elements of the second source SIMD&FP register, and accumulates the results with the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied.

The UMLAL instruction extracts vector elements from the lower half of the first source register, while the UMLAL2 instruction extracts vector elements from the upper half of the first source register.

Depending on the settings in the CPACR EL1, CPTR EL2, and CPTR EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers, not all the same type

```
UMLAL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(0);
integer elements = datasize DIV esize;
boolean sub_op = (o1 == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) operand3 = V[d];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;
bits(2*esize) accum;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    product = (element1*element2)<2*esize-1:0>;
    if sub_op then
        accum = Elem[operand3, e, 2*esize] - product;
    else
        accum = Elem[operand3, e, 2*esize] + product;
    Elem[result, e, 2*esize] = accum;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

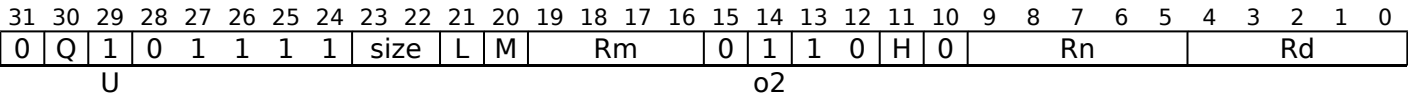
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UMLSL, UMLSL2 (by element)

Unsigned Multiply-Subtract Long (vector, by element). This instruction multiplies each vector element in the lower or upper half of the first source SIMD&FP register by the specified vector element of the second source SIMD&FP register and subtracts the results from the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied.

The UMLSL instruction extracts vector elements from the lower half of the first source register, while the UMLSL2 instruction extracts vector elements from the upper half of the first source register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Vector

```
UMLSL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Ts>[<index>]

integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
  when '01' index = UInt(H:L:M); Rmhi = '0';
  when '10' index = UInt(H:L); Rmhi = M;
  otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
boolean sub_op = (o2 == '1');
```

Assembler Symbols

- 2

Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the “Rd” field.
- <Ta>

Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	RESERVED
01	4S
10	2D
11	RESERVED
- <Vn>

Is the name of the first SIMD&FP source register, encoded in the “Rn” field.
- <Tb>

Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in “size:M:Rm”:

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

Restricted to V0-V15 when element size <Ts> is H.

<Ts> Is an element size specifier, encoded in “size”:

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in “size:L:H:M”:

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(idxsizesize) operand2 = V[m];
bits(2*datasize) operand3 = V[d];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;

element2 = Int(Elem[operand2, index, esize], unsigned);
for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    product = (element1*element2)<2*esize-1:0>;
    if sub_op then
        Elem[result, e, 2*esize] = Elem[operand3, e, 2*esize] - product;
    else
        Elem[result, e, 2*esize] = Elem[operand3, e, 2*esize] + product;
V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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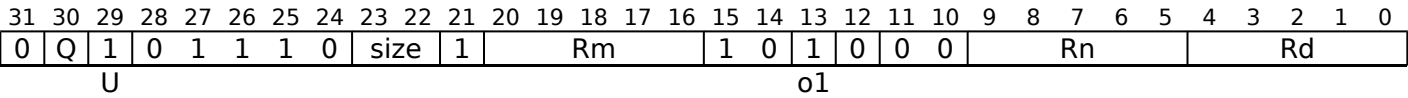
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UMLSL, UMLSL2 (vector)

Unsigned Multiply-Subtract Long (vector). This instruction multiplies corresponding vector elements in the lower or upper half of the two source SIMD&FP registers, and subtracts the results from the vector elements of the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied. All the values in this instruction are unsigned integer values.

The UMLSL instruction extracts each source vector from the lower half of each source register, while the UMLSL2 instruction extracts each source vector from the upper half of each source register.

Depending on the settings in the CPACR EL1, CPTR EL2, and CPTR EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers, not all the same type

```
UMLSL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(0);
integer elements = datasize DIV esize;
boolean sub_op = (o1 == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q 2	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) operand3 = V[d];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;
bits(2*esize) accum;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    product = (element1*element2)<2*esize-1:0>;
    if sub_op then
        accum = Elem[operand3, e, 2*esize] - product;
    else
        accum = Elem[operand3, e, 2*esize] + product;
    Elem[result, e, 2*esize] = accum;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

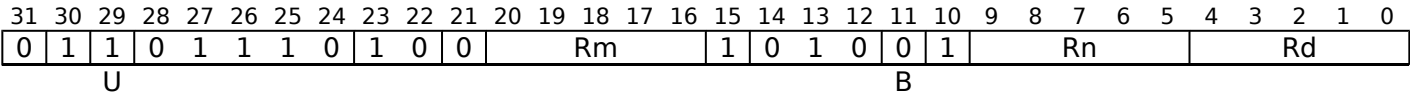
Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# UMMLA (vector)

Unsigned 8-bit integer matrix multiply-accumulate. This instruction multiplies the 2x8 matrix of unsigned 8-bit integer values in the first source vector by the 8x2 matrix of unsigned 8-bit integer values in the second source vector. The resulting 2x2 32-bit integer matrix product is destructively added to the 32-bit integer matrix accumulator in the destination vector. This is equivalent to performing an 8-way dot product per destination element. From Armv8.2, this is an OPTIONAL instruction. [ID\\_AA64ISAR0\\_EL1](#).I8MM indicates whether this instruction is supported.

## Vector (Armv8.6)



## Vector

```
UMMLA <Vd>.4S, <Vn>.16B, <Vm>.16B

if !HaveInt8MatMulExt() then UNDEFINED;
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Rd);
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP third source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(128) operand1 = V[n];
bits(128) operand2 = V[m];
bits(128) addend = V[d];

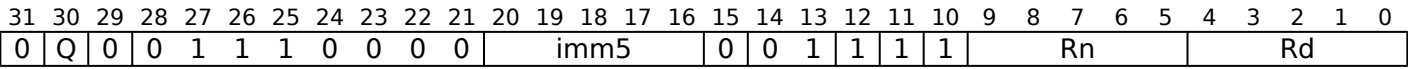
V[d] = MatMulAdd(addend, operand1, operand2, TRUE, TRUE);
```

UMOV

Unsigned Move vector element to general-purpose register. This instruction reads the unsigned integer from the source SIMD&FP register, zero-extends it to form a 32-bit or 64-bit value, and writes the result to the destination general-purpose register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This instruction is used by the alias MOV(to general).



32-bit (Q == 0)

```
UMOV <Wd>, <Vn>.<Ts>[<index>]
```

64-reg,UMOV-64-reg (Q == 1 && imm5 == x1000)

```
UMOV <Xd>, <Vn>.<Ts>[<index>]
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer size;
case Q:imm5 of
  when '0xxxx1' size = 0;    // UMOV Wd, Vn.B
  when '0xxx10' size = 1;    // UMOV Wd, Vn.H
  when '0xx100' size = 2;    // UMOV Wd, Vn.S
  when '1x1000' size = 3;    // UMOV Xd, Vn.D
  otherwise UNDEFINED;

integer idxdsize = if imm5<4> == '1' then 128 else 64;
integer index = UInt(imm5<4:size+1>);
integer esize = 8 << size;
integer datasize = if Q == '1' then 64 else 32;
```

Assembler Symbols

- <Wd> Is the 32-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Xd> Is the 64-bit name of the general-purpose destination register, encoded in the "Rd" field.
- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.
- <Ts> For the 32-bit variant: is an element size specifier, encoded in "imm5":

imm5	<Ts>
xx000	RESERVED
xxxx1	B
xxx10	H
xx100	S

For the 64-reg,UMOV-64-reg variant: is an element size specifier, encoded in "imm5":

imm5	<Ts>
x0000	RESERVED
xxxx1	RESERVED
xxx10	RESERVED
xx100	RESERVED
x1000	D

- <index> For the 32-bit variant: is the element index encoded in "imm5":



imm5	<index>
xx000	RESERVED
xxxx1	imm5<4:1>
xxx10	imm5<4:2>
xx100	imm5<4:3>

For the 64-reg,UMOV-64-reg variant: is the element index encoded in "imm5<4>".

## Alias Conditions

Alias	Is preferred when
<a href="#">MOV (to general)</a>	imm5 == 'x1000'
<a href="#">MOV (to general)</a>	imm5 == 'xx100'

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(idxsize) operand = V[n];
X[d] = ZeroExtend(Elem[operand, index, esize], datasize);

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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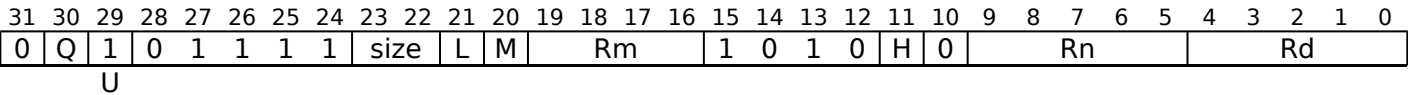
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UMULL, UMULL2 (by element)

Unsigned Multiply Long (vector, by element). This instruction multiplies each vector element in the lower or upper half of the first source SIMD&FP register by the specified vector element of the second source SIMD&FP register, places the results in a vector, and writes the vector to the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied.

The UMULL instruction extracts vector elements from the lower half of the first source register, while the UMULL2 instruction extracts vector elements from the upper half of the first source register.

Depending on the settings in the CPACR EL1, CPTR EL2, and CPTR EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Vector

```
UMULL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Ts>[<index>]
```

```
integer idxdsize = if H == '1' then 128 else 64;
integer index;
bit Rmhi;
case size of
    when '01' index = UInt(H:L:M); Rmhi = '0';
    when '10' index = UInt(H:L); Rmhi = M;
    otherwise UNDEFINED;

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rmhi:Rm);

integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	RESERVED
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	x	RESERVED
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in “size:M:Rm”:

size	<Vm>
00	RESERVED
01	0:Rm
10	M:Rm
11	RESERVED

Restricted to V0-V15 when element size <Ts> is H.

<Ts> Is an element size specifier, encoded in “size”:

size	<Ts>
00	RESERVED
01	H
10	S
11	RESERVED

<index> Is the element index, encoded in “size:L:H:M”:

size	<index>
00	RESERVED
01	H:L:M
10	H:L
11	RESERVED

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(idxdsize) operand2 = V[m];
bits(2*datasize) result;
integer element1;
integer element2;
bits(2*esize) product;

element2 = Int(Elem[operand2, index, esize], unsigned);
for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    product = (element1*element2)<2*esize-1:0>;
    Elem[result, e, 2*esize] = product;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

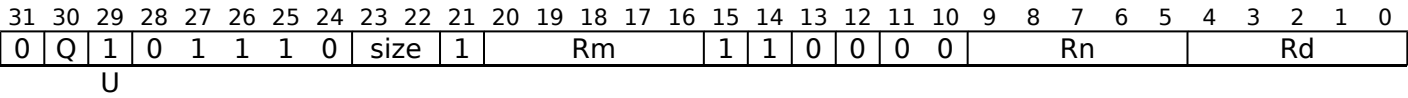
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## UMULL, UMULL2 (vector)

Unsigned Multiply long (vector). This instruction multiplies corresponding vector elements in the lower or upper half of the two source SIMD&FP registers, places the result in a vector, and writes the vector to the destination SIMD&FP register. The destination vector elements are twice as long as the elements that are multiplied. All the values in this instruction are unsigned integer values.

The UMULL instruction extracts each source vector from the lower half of each source register, while the UMULL2 instruction extracts each source vector from the upper half of each source register.

Depending on the settings in the CPACR EL1, CPTR EL2, and CPTR EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



### Three registers, not all the same type

UMULL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(0);
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
```

### Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q 2	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
integer element1;
integer element2;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    Elem[result, e, 2*esize] = (element1*element2)<2*esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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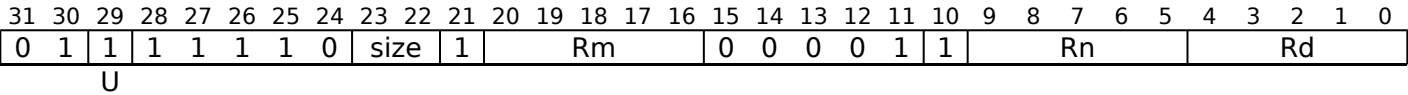
UQADD

Unsigned saturating Add. This instruction adds the values of corresponding elements of the two source SIMD&FP registers, places the results into a vector, and writes the vector to the destination SIMD&FP register. If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit *FPSR.QC* is set.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar

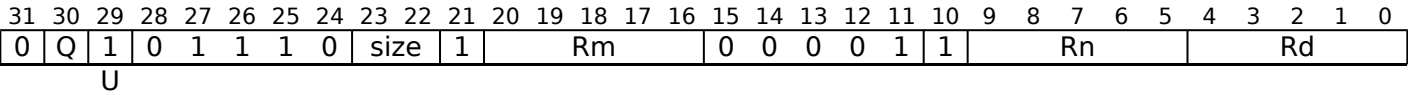


Scalar

```
UQADD <V><d>, <V><n>, <V><m>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
```

Vector



Vector

```
UQADD <Vd>.<T>, <Vn>.<T>, <Vm>.<T>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
```

Assembler Symbols

- <V>

Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D
- <d>

Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n>

Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m>

Is the number of the second SIMD&FP source register, encoded in the "Rm" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

### Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
integer sum;
boolean sat;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    sum = element1 + element2;
    (Elem[result, e, esize], sat) = SatQ(sum, esize, unsigned);
    if sat then FPSR.QC = '1';

V[d] = result;

```

# UQRSHL

Unsigned saturating Rounding Shift Left (register). This instruction takes each vector element of the first source SIMD&FP register, shifts the vector element by a value from the least significant byte of the corresponding vector element of the second source SIMD&FP register, places the results into a vector, and writes the vector to the destination SIMD&FP register.

If the shift value is positive, the operation is a left shift. Otherwise, it is a right shift. The results are rounded. For truncated results, see [UQSHL](#).

If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	size		1	Rm				0	1	0	1	1	1	Rn				Rd						
U										R										S											

## Scalar

```
UQRSHL <V><d>, <V><n>, <V><m>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
if S == '0' && size != '11' then UNDEFINED;
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
0	Q	1	0	1	1	1	0	size		1	Rm					0	1	0	1	1	1	Rn					Rd								
U										R S																									

## Vector

```
UQRSHL <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
```

## Assembler Symbols

<V> Is a width specifier, encoded in “size”:



size	<V>
00	B
01	H
10	S
11	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

integer round_const = 0;
integer shift;
integer element;
boolean sat;

for e = 0 to elements-1
    shift = SInt(Elem[operand2, e, esize]<7:0>);
    if rounding then
        round_const = 1 << (-shift - 1);    // 0 for left shift, 2^(n-1) for right shift
    element = (Int(Elem[operand1, e, esize], unsigned) + round_const) << shift;
    if saturating then
        (Elem[result, e, esize], sat) = SatQ(element, esize, unsigned);
        if sat then FPSR.QC = '1';
    else
        Elem[result, e, esize] = element<esize-1:0>;

V[d] = result;

```

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# UQRSHRN, UQRSHRN2

Unsigned saturating Rounded Shift Right Narrow (immediate). This instruction reads each vector element in the source SIMD&FP register, right shifts each result by an immediate value, puts the final result into a vector, and writes the vector to the lower or upper half of the destination SIMD&FP register. All the values in this instruction are unsigned integer values. The results are rounded. For truncated results, see [UQSHRN](#).

The UQRSHRN instruction writes the vector to the lower half of the destination register and clears the upper half, while the UQRSHRN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register.

If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	1	0	!= 0000				immb			1	0	0	1	1	1	Rn				Rd					
U									immh				op																		

## Scalar

```
UQRSHRN <Vb><d>, <Va><n>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then UNDEFINED;
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = esize;
integer elements = 1;
integer part = 0;

integer shift = (2 * esize) - UInt(immh:immb);
boolean round = (op == '1');
boolean unsigned = (U == '1');
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	0	!= 0000				immb			1	0	0	1	1	1	Rn				Rd					
U									immh				op																		

## Vector

```
UQRSHRN{2} <Vd>.<Tb>, <Vn>.<Ta>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

integer shift = (2 * esize) - UInt(immh:immb);
boolean round = (op == '1');
boolean unsigned = (U == '1');
```

## Assembler Symbols

- 2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in "Q":

Q	2
0	[absent]
1	[present]

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

- <Tb> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<Tb>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	x	RESERVED

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

- <Ta> Is an arrangement specifier, encoded in "immh":

immh	<Ta>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	8H
001x	4S
01xx	2D
1xxx	RESERVED

- <Vb> Is the destination width specifier, encoded in "immh":

immh	<Vb>
0000	RESERVED
0001	B
001x	H
01xx	S
1xxx	RESERVED

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.

- <Va> Is the source width specifier, encoded in "immh":

immh	<Va>
0000	RESERVED
0001	H
001x	S
01xx	D
1xxx	RESERVED

- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

- <shift> For the scalar variant: is the right shift amount, in the range 1 to the destination operand width in bits, encoded in "immh:immb":

immh	<shift>
0000	RESERVED
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	RESERVED

For the vector variant: is the right shift amount, in the range 1 to the destination element width in bits, encoded in "immh:immb":

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	RESERVED

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize*2) operand = V[n];
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;
boolean sat;

for e = 0 to elements-1
    element = (Int(Elem[operand, e, 2*esize], unsigned) + round_const) >> shift;
    (Elem[result, e, esize], sat) = SatQ(element, esize, unsigned);
    if sat then FPSR.QC = '1';

Vpart[d, part] = result;
```

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# UQSHL (immediate)

Unsigned saturating Shift Left (immediate). This instruction takes each vector element in the source SIMD&FP register, shifts it by an immediate value, places the results in a vector, and writes the vector to the destination SIMD&FP register. The results are truncated. For rounded results, see [UQRSHL](#). If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set. Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	1	0	!= 0000				immb			0	1	1	1	0	1	Rn				Rd					
U									immh				op																		

## Scalar

```
UQSHL <V><d>, <V><n>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = esize;
integer elements = 1;

integer shift = UInt(immh:immb) - esize;

boolean src_unsigned;
boolean dst_unsigned;
case op:U of
  when '00' UNDEFINED;
  when '01' src_unsigned = FALSE; dst_unsigned = TRUE;
  when '10' src_unsigned = FALSE; dst_unsigned = FALSE;
  when '11' src_unsigned = TRUE; dst_unsigned = TRUE;
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	0	!= 0000				immb			0	1	1	1	0	1	Rn				Rd					
U									immh				op																		

Vector

```
UQSHL <Vd>.<T>, <Vn>.<T>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3>:Q == '10' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer shift = UInt(immh:immb) - esize;

boolean src_unsigned;
boolean dst_unsigned;
case op:U of
  when '00' UNDEFINED;
  when '01' src_unsigned = FALSE; dst_unsigned = TRUE;
  when '10' src_unsigned = FALSE; dst_unsigned = FALSE;
  when '11' src_unsigned = TRUE; dst_unsigned = TRUE;
```

Assembler Symbols

<V> Is a width specifier, encoded in “immh”:

immh	<V>
0000	RESERVED
0001	B
001x	H
01xx	S
1xxx	D

<d> Is the number of the SIMD&FP destination register, in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in “immh:Q”:

immh	Q	<T>
0000	x	SEE Advanced SIMD modified immediate
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<shift> For the scalar variant: is the left shift amount, in the range 0 to the operand width in bits minus 1, encoded in “immh:immb”:

immh	<shift>
0000	RESERVED
0001	(UInt(immh:immb)-8)
001x	(UInt(immh:immb)-16)
01xx	(UInt(immh:immb)-32)
1xxx	(UInt(immh:immb)-64)

For the vector variant: is the left shift amount, in the range 0 to the element width in bits minus 1, encoded in “immh:immb”:

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(UInt(immh:immb)-8)
001x	(UInt(immh:immb)-16)
01xx	(UInt(immh:immb)-32)
1xxx	(UInt(immh:immb)-64)

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
integer element;
boolean sat;

for e = 0 to elements-1
    element = Int(Elem[operand, e, esize], src_unsigned) << shift;
    (Elem[result, e, esize], sat) = SatQ(element, esize, dst_unsigned);
    if sat then FPSR.QC = '1';

V[d] = result;

```

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# UQSHL (register)

Unsigned saturating Shift Left (register). This instruction takes each element in the vector of the first source SIMD&FP register, shifts the element by a value from the least significant byte of the corresponding element of the second source SIMD&FP register, places the results in a vector, and writes the vector to the destination SIMD&FP register.

If the shift value is positive, the operation is a left shift. Otherwise, it is a right shift. The results are truncated. For rounded results, see [UQRSHL](#).

If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	1	1	1	1	1	1	0	size	1	Rm						0	1	0	0	1	1	Rn						Rd					
U										R										S													

## Scalar

```
UQSHL <V><d>, <V><n>, <V><m>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
if S == '0' && size != '11' then UNDEFINED;
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	Q	1	0	1	1	1	0	size	1	Rm						0	1	0	0	1	1	Rn						Rd					
U										R										S													

## Vector

```
UQSHL <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
```

## Assembler Symbols

<V>            Is a width specifier, encoded in “size”:



size	<V>
00	B
01	H
10	S
11	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

integer round_const = 0;
integer shift;
integer element;
boolean sat;

for e = 0 to elements-1
    shift = SInt(Elem[operand2, e, esize]<7:0>);
    if rounding then
        round_const = 1 << (-shift - 1);    // 0 for left shift, 2^(n-1) for right shift
    element = (Int(Elem[operand1, e, esize], unsigned) + round_const) << shift;
    if saturating then
        (Elem[result, e, esize], sat) = SatQ(element, esize, unsigned);
        if sat then FPSR.QC = '1';
    else
        Elem[result, e, esize] = element<esize-1:0>;

V[d] = result;

```

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# UQSHRN, UQSHRN2

Unsigned saturating Shift Right Narrow (immediate). This instruction reads each vector element in the source SIMD&FP register, right shifts each result by an immediate value, saturates each shifted result to a value that is half the original width, puts the final result into a vector, and writes the vector to the lower or upper half of the destination SIMD&FP register. All the values in this instruction are unsigned integer values. The results are truncated. For rounded results, see [UQRSHRN](#).

The UQSHRN instruction writes the vector to the lower half of the destination register and clears the upper half, while the UQSHRN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register.

If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit [FPSR.QC](#) is set.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	1	0	!= 0000			immb			1	0	0	1	0	1	1	Rn				Rd					
U									immh						op																

## Scalar

```
UQSHRN <Vb><d>, <Va><n>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then UNDEFINED;
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = esize;
integer elements = 1;
integer part = 0;

integer shift = (2 * esize) - UInt(immh:immb);
boolean round = (op == '1');
boolean unsigned = (U == '1');
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	0	!= 0000			immb			1	0	0	1	0	1	Rn				Rd						
U									immh						op																

## Vector

UQSHRN{2} <Vd>.<Tb>, <Vn>.<Ta>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

integer shift = (2 * esize) - UInt(immh:immb);
boolean round = (op == '1');
boolean unsigned = (U == '1');
```

## Assembler Symbols

- 2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the “Rd” field.

<Tb> Is an arrangement specifier, encoded in “immh:Q”:

immh	Q	<Tb>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	x	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the “Rn” field.

<Ta> Is an arrangement specifier, encoded in “immh”:

immh	<Ta>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	8H
001x	4S
01xx	2D
1xxx	RESERVED

<Vb> Is the destination width specifier, encoded in “immh”:

immh	<Vb>
0000	RESERVED
0001	B
001x	H
01xx	S
1xxx	RESERVED

<d> Is the number of the SIMD&FP destination register, in the “Rd” field.

<Va> Is the source width specifier, encoded in “immh”:

immh	<Va>
0000	RESERVED
0001	H
001x	S
01xx	D
1xxx	RESERVED

<n> Is the number of the first SIMD&FP source register, encoded in the “Rn” field.

<shift> For the scalar variant: is the right shift amount, in the range 1 to the destination operand width in bits, encoded in “immh:immb”:

immh	<shift>
0000	RESERVED
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	RESERVED

For the vector variant: is the right shift amount, in the range 1 to the destination element width in bits, encoded in “immh:immb”:

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	RESERVED

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize*2) operand = V[n];
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;
boolean sat;

for e = 0 to elements-1
    element = (Int(Elem[operand, e, 2*esize], unsigned) + round_const) >> shift;
    (Elem[result, e, esize], sat) = SatQ(element, esize, unsigned);
    if sat then FPSR.QC = '1';

Vpart[d, part] = result;

```

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UQSUB

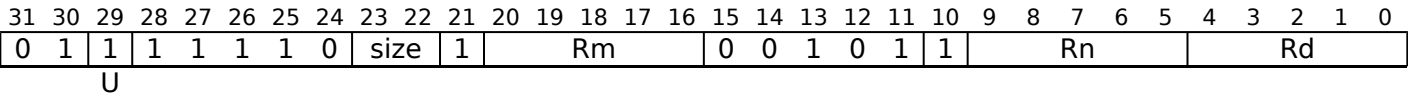
Unsigned saturating Subtract. This instruction subtracts the element values of the second source SIMD&FP register from the corresponding element values of the first source SIMD&FP register, places the results into a vector, and writes the vector to the destination SIMD&FP register.

If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit `FPSR.QC` is set.

Depending on the settings in the `CPACR_EL1`, `CPTR_EL2`, and `CPTR_EL3` registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar

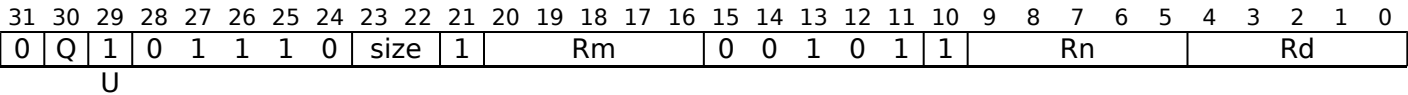


Scalar

UQSUB `<V><d>`, `<V><n>`, `<V><m>`

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
```

Vector



Vector

UQSUB `<Vd>.<T>`, `<Vn>.<T>`, `<Vm>.<T>`

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
```

Assembler Symbols

`<V>` Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D

`<d>` Is the number of the SIMD&FP destination register, in the “Rd” field.

`<n>` Is the number of the first SIMD&FP source register, encoded in the “Rn” field.

`<m>` Is the number of the second SIMD&FP source register, encoded in the “Rm” field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;
integer diff;
boolean sat;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    diff = element1 - element2;
    (Elem[result, e, esize], sat) = SatQ(diff, esize, unsigned);
    if sat then FPSR.QC = '1';

V[d] = result;
```

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# UQXTN, UQXTN2

Unsigned saturating extract Narrow. This instruction reads each vector element from the source SIMD&FP register, saturates each value to half the original width, places the result into a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are unsigned integer values.

If saturation occurs, the cumulative saturation bit *FPSR.QC* is set.

The UQXTN instruction writes the vector to the lower half of the destination register and clears the upper half, while the UQXTN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	0	size	1	0	0	0	0	1	0	1	0	0	1	0	Rn				Rd						
U																															

## Scalar

UQXTN <Vb><d>, <Va><n>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = esize;
integer part = 0;
integer elements = 1;

boolean unsigned = (U == '1');
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	size	1	0	0	0	0	1	0	1	0	0	1	0	Rn				Rd						
U																															

## Vector

UQXTN{2} <Vd>.<Tb>, <Vn>.<Ta>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
```

## Assembler Symbols

- 2
- Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Tb> Is an arrangement specifier, encoded in "size:Q":

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<Ta> Is an arrangement specifier, encoded in "size":

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

<Vb> Is the destination width specifier, encoded in "size":

size	<Vb>
00	B
01	H
10	S
11	RESERVED

<d> Is the number of the SIMD&FP destination register, encoded in the "Rd" field.

<Va> Is the source width specifier, encoded in "size":

size	<Va>
00	H
01	S
10	D
11	RESERVED

<n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(2*datasize) operand = V[n];
bits(datasize) result;
bits(2*esize) element;
boolean sat;

for e = 0 to elements-1
    element = Elem[operand, e, 2*esize];
    (Elem[result, e, esize], sat) = SatQ(Int(element, unsigned), esize, unsigned);
    if sat then FPSR.QC = '1';

Vpart[d, part] = result;

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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URECPE

Unsigned Reciprocal Estimate. This instruction reads each vector element from the source SIMD&FP register, calculates an approximate inverse for the unsigned integer value, places the result into a vector, and writes the vector to the destination SIMD&FP register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	sz	1	0	0	0	0	1	1	1	0	0	1	0	Rn				Rd					

Vector

URECPE <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if sz == '1' then UNDEFINED;
integer esize = 32;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	x	RESERVED

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(32) element;

for e = 0 to elements-1
    element = Elem[operand, e, 32];
    Elem[result, e, 32] = UnsignedRecipEstimate(element);

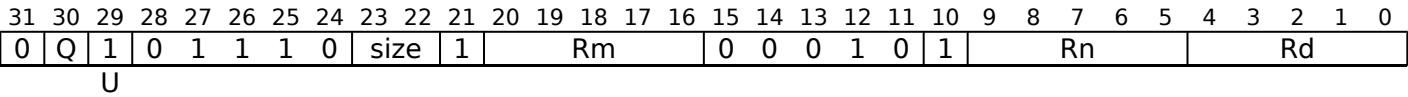
V[d] = result;
```

URHADD

Unsigned Rounding Halving Add. This instruction adds corresponding unsigned integer values from the two source SIMD&FP registers, shifts each result right one bit, places the results into a vector, and writes the vector to the destination SIMD&FP register.

The results are rounded. For truncated results, see [UHADD](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers of the same type

```
URHADD <Vd>.<T>, <Vn>.<T>, <Vm>.<T>
```

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;
integer element1;
integer element2;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    Elem[result, e, esize] = (element1+element2+1)<esize:1>;

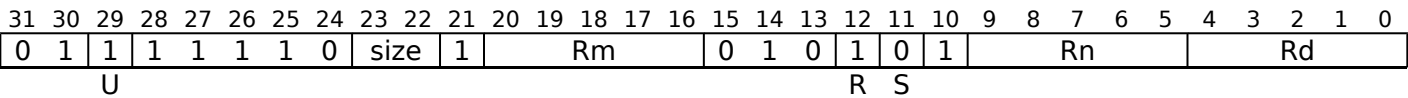
V[d] = result;
```

URSHL

Unsigned Rounding Shift Left (register). This instruction takes each element in the vector of the first source SIMD&FP register, shifts the vector element by a value from the least significant byte of the corresponding element of the second source SIMD&FP register, places the results in a vector, and writes the vector to the destination SIMD&FP register. If the shift value is positive, the operation is a left shift. If the shift value is negative, it is a rounding right shift. Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: Scalar and Vector

Scalar

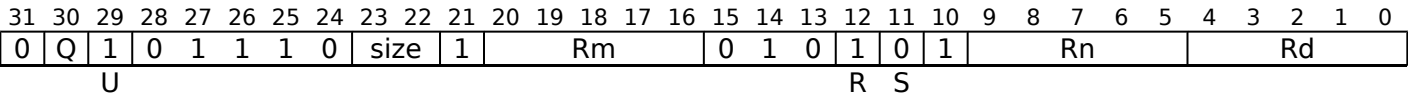


Scalar

```
URSHL <V><d>, <V><n>, <V><m>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
if S == '0' && size != '11' then UNDEFINED;
```

Vector



Vector

```
URSHL <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D

<d> Is the number of the SIMD&FP destination register, in the "Rd" field.

- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

integer round_const = 0;
integer shift;
integer element;
boolean sat;

for e = 0 to elements-1
    shift = SInt(Elem[operand2, e, esize]<7:0>);
    if rounding then
        round_const = 1 << (-shift - 1);    // 0 for left shift, 2^(n-1) for right shift
    element = (Int(Elem[operand1, e, esize], unsigned) + round_const) << shift;
    if saturating then
        (Elem[result, e, esize], sat) = SatQ(element, esize, unsigned);
        if sat then FPSR.QC = '1';
    else
        Elem[result, e, esize] = element<esize-1:0>;
V[d] = result;

```

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# URSHR

Unsigned Rounding Shift Right (immediate). This instruction reads each vector element in the source SIMD&FP register, right shifts each result by an immediate value, writes the final result to a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are unsigned integer values. The results are rounded. For truncated results, see [USHR](#). Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	1	0	!= 0000				immb		0	0	1	0	0	1	Rn				Rd						
U									immh				o1 o0																		

## Scalar

```
URSHR <V><d>, <V><n>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh<3> != '1' then UNDEFINED;
integer esize = 8 << 3;
integer datasize = esize;
integer elements = 1;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	0	!= 0000				immb		0	0	1	0	0	1	Rn				Rd						
U									immh				o1 o0																		

## Vector

```
URSHR <Vd>.<T>, <Vn>.<T>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3>:Q == '10' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

## Assembler Symbols

<V> Is a width specifier, encoded in “immh”:

immh	<V>
0xxx	RESERVED
1xxx	D

<d> Is the number of the SIMD&FP destination register, in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<T>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<shift> For the scalar variant: is the right shift amount, in the range 1 to 64, encoded in "immh:immb":

immh	<shift>
0xxx	RESERVED
1xxx	(128-UInt(immh:immb))

For the vector variant: is the right shift amount, in the range 1 to the element width in bits, encoded in "immh:immb":

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) operand2;
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;

operand2 = if accumulate then V[d] else Zeros();
for e = 0 to elements-1
    element = (Int(Elem[operand, e, esize], unsigned) + round_const) >> shift;
    Elem[result, e, esize] = Elem[operand2, e, esize] + element<esize-1:0>;
V[d] = result;

```

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# URSQRTE

Unsigned Reciprocal Square Root Estimate. This instruction reads each vector element from the source SIMD&FP register, calculates an approximate inverse square root for each value, places the result into a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are unsigned integer values.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	1	sz	1	0	0	0	0	1	1	1	0	0	1	0	Rn				Rd					

## Vector

```
URSQRTE <Vd>.<T>, <Vn>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);

if sz == '1' then UNDEFINED;
integer esize = 32;
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "sz:Q":

sz	Q	<T>
0	0	2S
0	1	4S
1	x	RESERVED

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;
bits(32) element;

for e = 0 to elements-1
    element = Elem[operand, e, 32];
    Elem[result, e, 32] = UnsignedRSqrtEstimate(element);

V[d] = result;
```

# URSRA

Unsigned Rounding Shift Right and Accumulate (immediate). This instruction reads each vector element in the source SIMD&FP register, right shifts each result by an immediate value, and accumulates the final results with the vector elements of the destination SIMD&FP register. All the values in this instruction are unsigned integer values. The results are rounded. For truncated results, see [USRA](#).  
Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	1	0	!= 0000				immb			0	0	1	1	0	1	Rn				Rd					
U									immh				o1 o0																		

## Scalar

URSRA <V><d>, <V><n>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh<3> != '1' then UNDEFINED;
integer esize = 8 << 3;
integer datasize = esize;
integer elements = 1;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	0	!= 0000				immb			0	0	1	1	0	1	Rn				Rd					
U									immh				o1 o0																		

## Vector

URSRA <Vd>.<T>, <Vn>.<T>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3>:Q == '10' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

## Assembler Symbols

<V> Is a width specifier, encoded in “immh”:



immh	<V>
0xxx	RESERVED
1xxx	D

<d> Is the number of the SIMD&FP destination register, in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<T>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<shift> For the scalar variant: is the right shift amount, in the range 1 to 64, encoded in "immh:immb":

immh	<shift>
0xxx	RESERVED
1xxx	(128-UInt(immh:immb))

For the vector variant: is the right shift amount, in the range 1 to the element width in bits, encoded in "immh:immb":

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) operand2;
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;

operand2 = if accumulate then V[d] else Zeros();
for e = 0 to elements-1
    element = (Int(Elem[operand, e, esize], unsigned) + round_const) >> shift;
    Elem[result, e, esize] = Elem[operand2, e, esize] + element<esize-1:0>;
V[d] = result;

```

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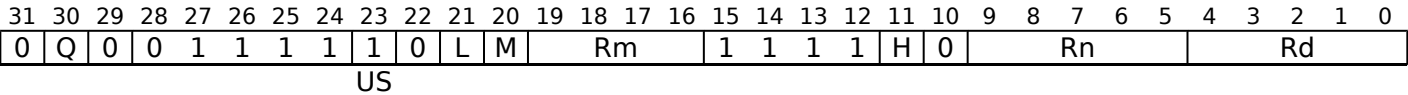
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USDOT (by element)

Dot Product index form with unsigned and signed integers. This instruction performs the dot product of the four unsigned 8-bit integer values in each 32-bit element of the first source register with the four signed 8-bit integer values in an indexed 32-bit element of the second source register, accumulating the result into the corresponding 32-bit element of the destination register.

From Armv8.2, this is an OPTIONAL instruction. *ID\_AA64ISAR0\_EL1*.I8MM indicates whether this instruction is supported.

Vector  
(Armv8.6)



Vector

```
USDOT <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.4B[<index>]
```

```
if !HaveInt8MatMulExt() then UNDEFINED;
boolean op1_unsigned = (US == '1');
boolean op2_unsigned = (US == '0');
integer n = UInt(Rn);
integer m = UInt(M:Rm);
integer d = UInt(Rd);
integer i = UInt(H:L);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV 32;
```

Assembler Symbols

- <Vd>

Is the name of the SIMD&FP third source and destination register, encoded in the "Rd" field.
- <Ta>

Is an arrangement specifier, encoded in "Q":

Q	<Ta>
0	2S
1	4S
- <Vn>

Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Tb>

Is an arrangement specifier, encoded in "Q":

Q	<Tb>
0	8B
1	16B
- <Vm>

Is the name of the second SIMD&FP source register, encoded in the "M:Rm" fields.
- <index>

Is the immediate index of a quadruplet of four 8-bit elements in the range 0 to 3, encoded in the "H:L" fields.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(128) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;

for e = 0 to elements-1
    bits(32) res = Elem[operand3, e, 32];
    for b = 0 to 3
        integer element1 = Int(Elem[operand1, 4*e+b, 8], op1_unsigned);
        integer element2 = Int(Elem[operand2, 4*i+b, 8], op2_unsigned);
        res = res + element1 * element2;
    Elem[result, e, 32] = res;
V[d] = result;
```

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# USDOT (vector)

Dot Product vector form with unsigned and signed integers. This instruction performs the dot product of the four unsigned 8-bit integer values in each 32-bit element of the first source register with the four signed 8-bit integer values in the corresponding 32-bit element of the second source register, accumulating the result into the corresponding 32-bit element of the destination register.

From Armv8.2, this is an OPTIONAL instruction. [ID\\_AA64ISAR0\\_EL1](#).I8MM indicates whether this instruction is supported.

## Vector (Armv8.6)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	1	0	0	Rm				1	0	0	1	1	1	Rn				Rd						

## Vector

```
USDOT <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

if !HaveInt8MatMulExt() then UNDEFINED;
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Rd);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV 32;
```

## Assembler Symbols

- <Vd>

Is the name of the SIMD&FP third source and destination register, encoded in the "Rd" field.
- <Ta>

Is an arrangement specifier, encoded in "Q":

Q	<Ta>
0	2S
1	4S
- <Vn>

Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Tb>

Is an arrangement specifier, encoded in "Q":

Q	<Tb>
0	8B
1	16B
- <Vm>

Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) operand3 = V[d];
bits(datasize) result;

for e = 0 to elements-1
  bits(32) res = Elem[operand3, e, 32];
  for b = 0 to 3
    integer element1 = UInt(Elem[operand1, 4*e+b, 8]);
    integer element2 = SInt(Elem[operand2, 4*e+b, 8]);
    res = res + element1 * element2;
  Elem[result, e, 32] = res;
V[d] = result;
```

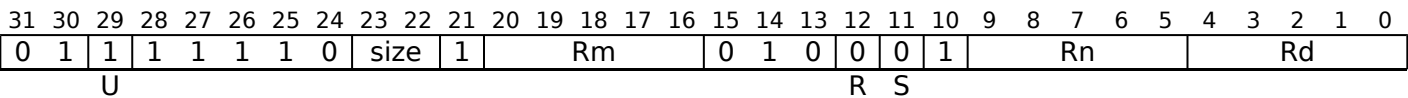


USHL

Unsigned Shift Left (register). This instruction takes each element in the vector of the first source SIMD&FP register, shifts each element by a value from the least significant byte of the corresponding element of the second source SIMD&FP register, places the results in a vector, and writes the vector to the destination SIMD&FP register. If the shift value is positive, the operation is a left shift. If the shift value is negative, it is a truncating right shift. For a rounding shift, see [URSHL](#). Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar

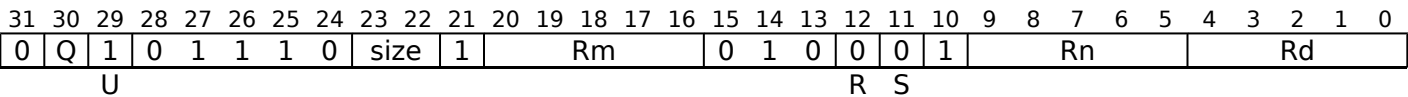


Scalar

```
USHL <V><d>, <V><n>, <V><m>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
if S == '0' && size != '11' then UNDEFINED;
```

Vector



Vector

```
USHL <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
boolean unsigned = (U == '1');
boolean rounding = (R == '1');
boolean saturating = (S == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
0x	RESERVED
10	RESERVED
11	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <m> Is the number of the second SIMD&FP source register, encoded in the "Rm" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

integer round_const = 0;
integer shift;
integer element;
boolean sat;

for e = 0 to elements-1
    shift = SInt(Elem[operand2, e, esize]<7:0>);
    if rounding then
        round_const = 1 << (-shift - 1);    // 0 for left shift, 2^(n-1) for right shift
    element = (Int(Elem[operand1, e, esize], unsigned) + round_const) << shift;
    if saturating then
        (Elem[result, e, esize], sat) = SatQ(element, esize, unsigned);
        if sat then FPSR.QC = '1';
    else
        Elem[result, e, esize] = element<esize-1:0>;

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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USHLL, USHLL2

Unsigned Shift Left Long (immediate). This instruction reads each vector element in the lower or upper half of the source SIMD&FP register, shifts the unsigned integer value left by the specified number of bits, places the result into a vector, and writes the vector to the destination SIMD&FP register. The destination vector elements are twice as long as the source vector elements.

The USHLL instruction extracts vector elements from the lower half of the source register, while the USHLL2 instruction extracts vector elements from the upper half of the source register.

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This instruction is used by the alias [UXTL](#), [UXTL2](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	0	!= 0000				immb			1	0	1	0	0	1	Rn				Rd					
U									immh																						

Vector

USHLL{2} <Vd>.<Ta>, <Vn>.<Tb>, #<shift>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3> == '1' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

integer shift = UInt(immh:immb) - esize;
boolean unsigned = (U == '1');
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q		2
0		[absent]
1		[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “immh”:

immh	<Ta>
0000	SEE Advanced SIMD modified immediate
0001	8H
001x	4S
01xx	2D
1xxx	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “immh:Q”:

immh	Q	<Tb>
0000	x	SEE Advanced SIMD modified immediate
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	x	RESERVED



<shift> Is the left shift amount, in the range 0 to the source element width in bits minus 1, encoded in “immh:immb”:

immh	<shift>
0000	SEE Advanced SIMD modified immediate
0001	(UInt(immh:immb)-8)
001x	(UInt(immh:immb)-16)
01xx	(UInt(immh:immb)-32)
1xxx	RESERVED

Alias Conditions

Alias	Is preferred when
<a href="#">UXTL, UXTL2</a>	immb == '000' && <a href="#">BitCount</a> (immh) == 1

Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand = Vpart[n, part];
bits(datasize*2) result;
integer element;

for e = 0 to elements-1
    element = Int(Elem[operand, e, esize], unsigned) << shift;
    Elem[result, e, 2*esize] = element<2*esize-1:0>;

V[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

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# USHR

Unsigned Shift Right (immediate). This instruction reads each vector element in the source SIMD&FP register, right shifts each result by an immediate value, writes the final result to a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are unsigned integer values. The results are truncated. For rounded results, see [URSHR](#).

Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

## Scalar

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	1	1	0	!= 0000				immb			0	0	0	0	0	1	Rn				Rd					
U									immh				o1 o0																		

## Scalar

```
USHR <V><d>, <V><n>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh<3> != '1' then UNDEFINED;
integer esize = 8 << 3;
integer datasize = esize;
integer elements = 1;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

## Vector

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	0	!= 0000				immb			0	0	0	0	0	1	Rn				Rd					
U									immh				o1 o0																		

## Vector

```
USHR <Vd>.<T>, <Vn>.<T>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3>:Q == '10' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

## Assembler Symbols

<V> Is a width specifier, encoded in “immh”:

immh	<V>
0xxx	RESERVED
1xxx	D

- <d> Is the number of the SIMD&FP destination register, in the "Rd" field.
- <n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<T>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.
- <shift> For the scalar variant: is the right shift amount, in the range 1 to 64, encoded in "immh:immb":

immh	<shift>
0xxx	RESERVED
1xxx	(128-UInt(immh:immb))

For the vector variant: is the right shift amount, in the range 1 to the element width in bits, encoded in "immh:immb":

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) operand2;
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;

operand2 = if accumulate then V[d] else Zeros();
for e = 0 to elements-1
    element = (Int(Elem[operand, e, esize], unsigned) + round_const) >> shift;
    Elem[result, e, esize] = Elem[operand2, e, esize] + element<esize-1:0>;

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

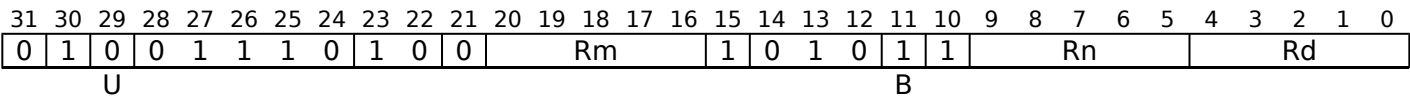
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# USMMLA (vector)

Unsigned and signed 8-bit integer matrix multiply-accumulate. This instruction multiplies the 2x8 matrix of unsigned 8-bit integer values in the first source vector by the 8x2 matrix of signed 8-bit integer values in the second source vector. The resulting 2x2 32-bit integer matrix product is destructively added to the 32-bit integer matrix accumulator in the destination vector. This is equivalent to performing an 8-way dot product per destination element. From Armv8.2, this is an OPTIONAL instruction. [ID\\_AA64ISAR0\\_EL1](#).I8MM indicates whether this instruction is supported.

## Vector (Armv8.6)



## Vector

```
USMMLA <Vd>.4S, <Vn>.16B, <Vm>.16B

if !HaveInt8MatMulExt() then UNDEFINED;
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Rd);
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP third source and destination register, encoded in the "Rd" field.
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(128) operand1 = V[n];
bits(128) operand2 = V[m];
bits(128) addend = V[d];

V[d] = MatMulAdd(addend, operand1, operand2, TRUE, FALSE);
```

USQADD

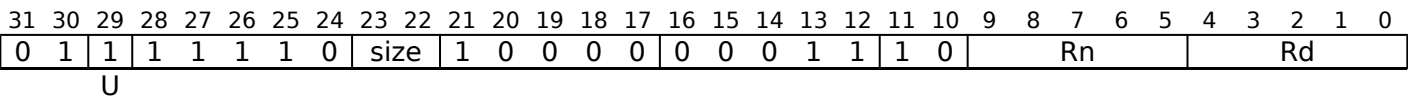
Unsigned saturating Accumulate of Signed value. This instruction adds the signed integer values of the vector elements in the source SIMD&FP register to corresponding unsigned integer values of the vector elements in the destination SIMD&FP register, and accumulates the resulting unsigned integer values with the vector elements of the destination SIMD&FP register.

If overflow occurs with any of the results, those results are saturated. If saturation occurs, the cumulative saturation bit *FPSR.QC* is set.

Depending on the settings in the *CPACR\_EL1*, *CPTR\_EL2*, and *CPTR\_EL3* registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar



Scalar

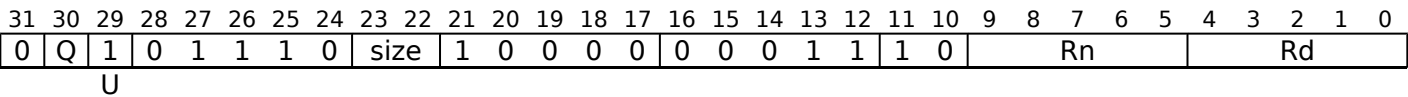
USQADD <V><d>, <V><n>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

integer esize = 8 << UInt(size);
integer datasize = esize;
integer elements = 1;

boolean unsigned = (U == '1');
```

Vector



Vector

USQADD <Vd>.<T>, <Vn>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

boolean unsigned = (U == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D

<d> Is the number of the SIMD&FP destination register, encoded in the “Rd” field.

- <n> Is the number of the SIMD&FP source register, encoded in the "Rn" field.
- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

### Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) result;

bits(datasize) operand2 = V[d];
integer op1;
integer op2;
boolean sat;

for e = 0 to elements-1
    op1 = Int(Elem[operand, e, esize], !unsigned);
    op2 = Int(Elem[operand2, e, esize], unsigned);
    (Elem[result, e, esize], sat) = SatQ(op1 + op2, esize, unsigned);
    if sat then FPSR.QC = '1';
V[d] = result;

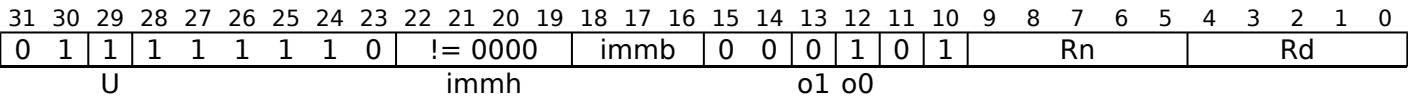
```

USRA

Unsigned Shift Right and Accumulate (immediate). This instruction reads each vector element in the source SIMD&FP register, right shifts each result by an immediate value, and accumulates the final results with the vector elements of the destination SIMD&FP register. All the values in this instruction are unsigned integer values. The results are truncated. For rounded results, see [URSRA](#).  
Depending on the settings in the [CPACR\\_EL1](#), [CPTR\\_EL2](#), and [CPTR\\_EL3](#) registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

It has encodings from 2 classes: [Scalar](#) and [Vector](#)

Scalar



Scalar

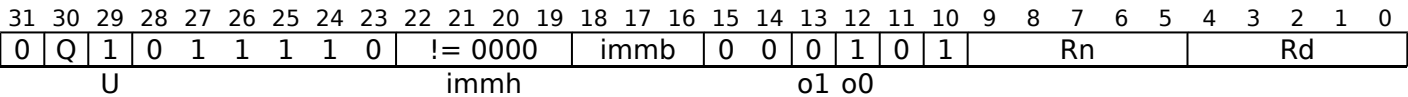
```
USRA <V><d>, <V><n>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh<3> != '1' then UNDEFINED;
integer esize = 8 << 3;
integer datasize = esize;
integer elements = 1;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

Vector



Vector

```
USRA <Vd>.<T>, <Vn>.<T>, #<shift>

integer d = UInt(Rd);
integer n = UInt(Rn);

if immh == '0000' then SEE(asimdimm);
if immh<3>:Q == '10' then UNDEFINED;
integer esize = 8 << HighestSetBit(immh);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;

integer shift = (esize * 2) - UInt(immh:immb);
boolean unsigned = (U == '1');
boolean round = (o1 == '1');
boolean accumulate = (o0 == '1');
```

Assembler Symbols

<V> Is a width specifier, encoded in “immh”:

immh	<V>
0xxx	RESERVED
1xxx	D

<d> Is the number of the SIMD&FP destination register, in the "Rd" field.

<n> Is the number of the first SIMD&FP source register, encoded in the "Rn" field.

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "immh:Q":

immh	Q	<T>
0000	x	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	0	RESERVED
1xxx	1	2D

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<shift> For the scalar variant: is the right shift amount, in the range 1 to 64, encoded in "immh:immb":

immh	<shift>
0xxx	RESERVED
1xxx	(128-UInt(immh:immb))

For the vector variant: is the right shift amount, in the range 1 to the element width in bits, encoded in "immh:immb":

immh	<shift>
0000	<a href="#">SEE Advanced SIMD modified immediate</a>
0001	(16-UInt(immh:immb))
001x	(32-UInt(immh:immb))
01xx	(64-UInt(immh:immb))
1xxx	(128-UInt(immh:immb))

## Operation

```

CheckFPAdvSIMDEnabled64();
bits(datasize) operand = V[n];
bits(datasize) operand2;
bits(datasize) result;
integer round_const = if round then (1 << (shift - 1)) else 0;
integer element;

operand2 = if accumulate then V[d] else Zeros();
for e = 0 to elements-1
    element = (Int(Elem[operand, e, esize], unsigned) + round_const) >> shift;
    Elem[result, e, esize] = Elem[operand2, e, esize] + element<esize-1:0>;

V[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

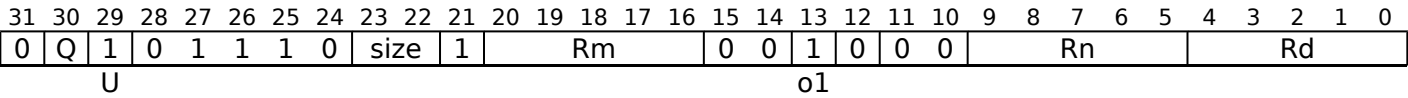
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USUBL, USUBL2

Unsigned Subtract Long. This instruction subtracts each vector element in the lower or upper half of the second source SIMD&FP register from the corresponding vector element of the first source SIMD&FP register, places the result into a vector, and writes the vector to the destination SIMD&FP register. All the values in this instruction are unsigned integer values. The destination vector elements are twice as long as the source vector elements. The USUBL instruction extracts each source vector from the lower half of each source register, while the USUBL2 instruction extracts each source vector from the upper half of each source register. Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers, not all the same type

```
USUBL{2} <Vd>.<Ta>, <Vn>.<Tb>, <Vm>.<Tb>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(0);
integer elements = datasize DIV esize;

boolean sub_op = (o1 == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

- 2

Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	
0	[absent]
1	[present]
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Ta>

Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED
- <Vn>

Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Tb>

Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED
- <Vm>

Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = Vpart[n, part];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
integer element1;
integer element2;
integer sum;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    if sub_op then
        sum = element1 - element2;
    else
        sum = element1 + element2;
    Elem[result, e, 2*esize] = sum<2*esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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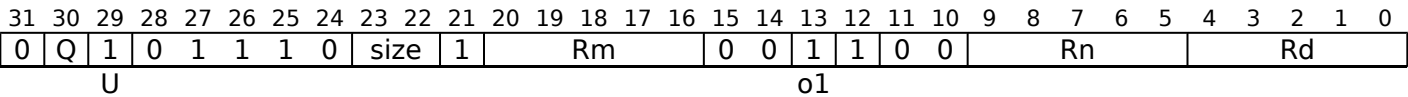
USUBW, USUBW2

Unsigned Subtract Wide. This instruction subtracts each vector element of the second source SIMD&FP register from the corresponding vector element in the lower or upper half of the first source SIMD&FP register, places the result in a vector, and writes the vector to the SIMD&FP destination register. All the values in this instruction are signed integer values.

The vector elements of the destination register and the first source register are twice as long as the vector elements of the second source register.

The USUBW instruction extracts vector elements from the lower half of the first source register, while the USUBW2 instruction extracts vector elements from the upper half of the first source register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Three registers, not all the same type

```
USUBW{2} <Vd>.<Ta>, <Vn>.<Ta>, <Vm>.<Tb>

integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;

boolean sub_op = (o1 == '1');
boolean unsigned = (U == '1');
```

Assembler Symbols

- 2

Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:
- | Q | 2         |
|---|-----------|
| 0 | [absent]  |
| 1 | [present] |
- <Vd>

Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Ta>

Is an arrangement specifier, encoded in “size”:
- | size | <Ta>     |
|------|----------|
| 00   | 8H       |
| 01   | 4S       |
| 10   | 2D       |
| 11   | RESERVED |
- <Vn>

Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm>

Is the name of the second SIMD&FP source register, encoded in the "Rm" field.
- <Tb>

Is an arrangement specifier, encoded in “size:Q”:
- | size | Q | <Tb>     |
|------|---|----------|
| 00   | 0 | 8B       |
| 00   | 1 | 16B      |
| 01   | 0 | 4H       |
| 01   | 1 | 8H       |
| 10   | 0 | 2S       |
| 10   | 1 | 4S       |
| 11   | x | RESERVED |

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(2*datasize) operand1 = V[n];
bits(datasize) operand2 = Vpart[m, part];
bits(2*datasize) result;
integer element1;
integer element2;
integer sum;

for e = 0 to elements-1
    element1 = Int(Elem[operand1, e, 2*esize], unsigned);
    element2 = Int(Elem[operand2, e, esize], unsigned);
    if sub_op then
        sum = element1 - element2;
    else
        sum = element1 + element2;
    Elem[result, e, 2*esize] = sum<2*esize-1:0>;

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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UXTL, UXTL2

Unsigned extend Long. This instruction copies each vector element from the lower or upper half of the source SIMD&FP register into a vector, and writes the vector to the destination SIMD&FP register. The destination vector elements are twice as long as the source vector elements.

The UXTL instruction extracts vector elements from the lower half of the source register, while the UXTL2 instruction extracts vector elements from the upper half of the source register.

Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

This is an alias of USHLL, USHLL2. This means:

- The encodings in this description are named to match the encodings of USHLL, USHLL2.
- The description of USHLL, USHLL2 gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	1	0	!= 0000				0	0	0	1	0	1	0	0	1	Rn				Rd					
U									immh				immb																		

Vector

UXTL{2} <Vd>.<Ta>, <Vn>.<Tb>

is equivalent to

USHLL{2} <Vd>.<Ta>, <Vn>.<Tb>, #0

and is the preferred disassembly when BitCount(immh) == 1.

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q	2
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Ta> Is an arrangement specifier, encoded in “immh”:

immh	<Ta>
0000	SEE Advanced SIMD modified immediate
0001	8H
001x	4S
01xx	2D
1xxx	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<Tb> Is an arrangement specifier, encoded in “immh:Q”:

immh	Q	<Tb>
0000	x	SEE Advanced SIMD modified immediate
0001	0	8B
0001	1	16B
001x	0	4H
001x	1	8H
01xx	0	2S
01xx	1	4S
1xxx	x	RESERVED

Operation

The description of USHLL, USHLL2 gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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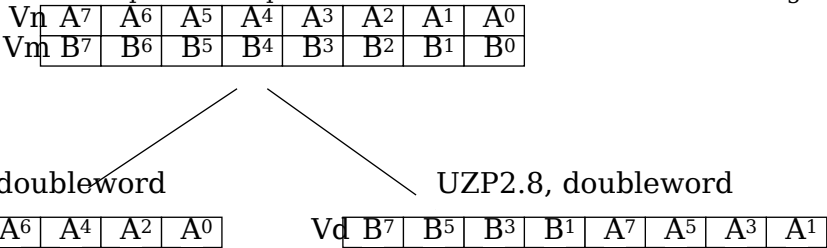
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UZP1

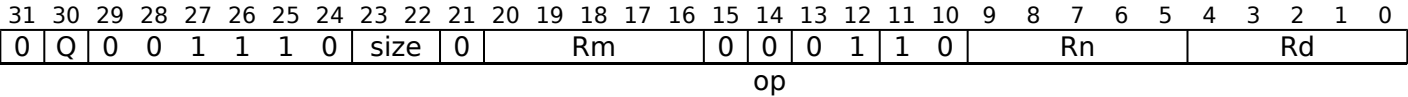
Unzip vectors (primary). This instruction reads corresponding even-numbered vector elements from the two source SIMD&FP registers, starting at zero, places the result from the first source register into consecutive elements in the lower half of a vector, and the result from the second source register into consecutive elements in the upper half of a vector, and writes the vector to the destination SIMD&FP register.

This instruction can be used with UZP2 to de-interleave two vectors.

The following figure shows an example of the operation of UZP1 and UZP2 with the arrangement specifier 8B.



Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Advanced SIMD

UZP1 <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
integer part = UInt(op);
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operandl = V[n];
bits(datasize) operandh = V[m];
bits(datasize) result;

bits(datasize*2) zipped = operandh:operandl;
for e = 0 to elements-1
    Elem[result, e, esize] = Elem[zipped, 2*e+part, esize];

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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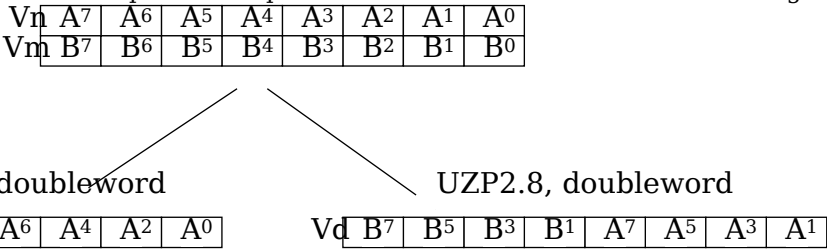


UZP2

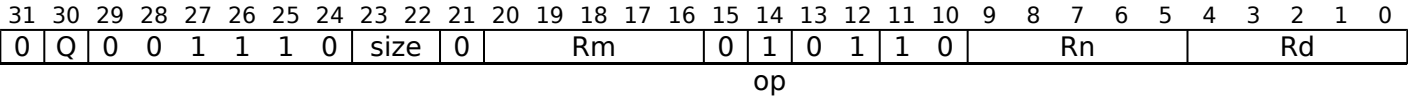
Unzip vectors (secondary). This instruction reads corresponding odd-numbered vector elements from the two source SIMD&FP registers, places the result from the first source register into consecutive elements in the lower half of a vector, and the result from the second source register into consecutive elements in the upper half of a vector, and writes the vector to the destination SIMD&FP register.

This instruction can be used with UZP1 to de-interleave two vectors.

The following figure shows an example of the operation of UZP1 and UZP2 with the arrangement specifier 8B.



Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Advanced SIMD

UZP2 <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
integer part = UInt(op);
```

Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operandl = V[n];
bits(datasize) operandh = V[m];
bits(datasize) result;

bits(datasize*2) zipped = operandh:operandl;
for e = 0 to elements-1
    Elem[result, e, esize] = Elem[zipped, 2*e+part, esize];

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# XAR

Exclusive OR and Rotate performs a bitwise exclusive OR of the 128-bit vectors in the two source SIMD&FP registers, rotates each 64-bit element of the resulting 128-bit vector right by the value specified by a 6-bit immediate value, and writes the result to the destination SIMD&FP register.

This instruction is implemented only when [ARMv8.2-SHA](#) is implemented.

## Advanced SIMD (Armv8.2)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	1	0	0	Rm			imm6						Rn			Rd								

## Advanced SIMD

XAR <Vd>.2D, <Vn>.2D, <Vm>.2D, #<imm6>

```
if !HaveSHA3Ext() then UNDEFINED;
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);
```

## Assembler Symbols

- <Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.
- <Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.
- <Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.
- <imm6> Is a rotation right, encoded in "imm6".

## Operation

```
AArch64.CheckFPAdvSIMDEnabled();

bits(128) Vm = V[m];
bits(128) Vn = V[n];
bits(128) tmp;
tmp = Vn EOR Vm;
V[d] = ROR(tmp<127:64>, UInt(imm6)):ROR(tmp<63:0>, UInt(imm6));
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

XTN, XTN2

Extract Narrow. This instruction reads each vector element from the source SIMD&FP register, narrows each value to half the original width, places the result into a vector, and writes the vector to the lower or upper half of the destination SIMD&FP register. The destination vector elements are half as long as the source vector elements. The XTN instruction writes the vector to the lower half of the destination register and clears the upper half, while the XTN2 instruction writes the vector to the upper half of the destination register without affecting the other bits of the register. Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	size		1	0	0	0	0	1	0	0	1	0	1	0	Rn				Rd					

Vector

```
XTN{2} <Vd>.<Tb>, <Vn>.<Ta>

integer d = UInt(Rd);
integer n = UInt(Rn);

if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = 64;
integer part = UInt(Q);
integer elements = datasize DIV esize;
```

Assembler Symbols

2 Is the second and upper half specifier. If present it causes the operation to be performed on the upper 64 bits of the registers holding the narrower elements, and is encoded in “Q”:

Q 2	
0	[absent]
1	[present]

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<Tb> Is an arrangement specifier, encoded in “size:Q”:

size	Q	<Tb>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	x	RESERVED

<Vn> Is the name of the SIMD&FP source register, encoded in the "Rn" field.

<Ta> Is an arrangement specifier, encoded in “size”:

size	<Ta>
00	8H
01	4S
10	2D
11	RESERVED

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(2*datasize) operand = V[n];
bits(datasize) result;
bits(2*esize) element;

for e = 0 to elements-1
    element = Elem[operand, e, 2*esize];
    Elem[result, e, esize] = element<esize-1:0>;
Vpart[d, part] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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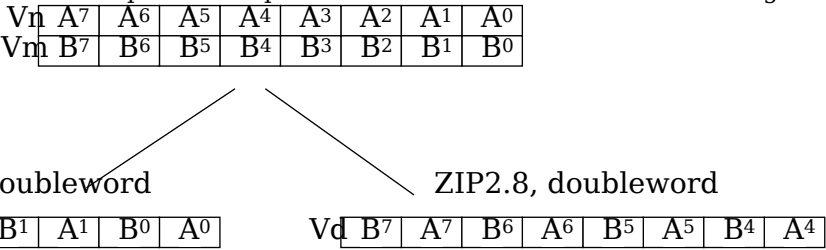
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ZIP1

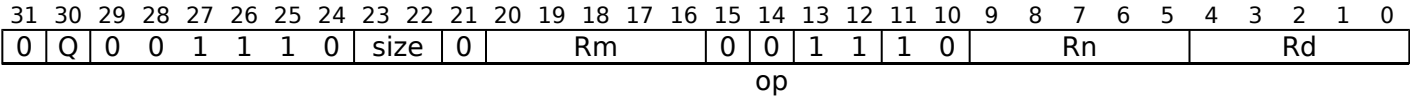
Zip vectors (primary). This instruction reads adjacent vector elements from the lower half of two source SIMD&FP registers as pairs, interleaves the pairs and places them into a vector, and writes the vector to the destination SIMD&FP register. The first pair from the first source register is placed into the two lowest vector elements, with subsequent pairs taken alternately from each source register.

This instruction can be used with ZIP2 to interleave two vectors.

The following figure shows an example of the operation of ZIP1 and ZIP2 with the arrangement specifier 8B.



Depending on the settings in the CPACR\_EL1, CPTR\_EL2, and CPTR\_EL3 registers, and the current Security state and Exception level, an attempt to execute the instruction might be trapped.



Advanced SIMD

ZIP1 <Vd>.<T>, <Vn>.<T>, <Vm>.<T>

```
integer d = UInt(Rd);
integer n = UInt(Rn);
integer m = UInt(Rm);

if size:Q == '110' then UNDEFINED;
integer esize = 8 << UInt(size);
integer datasize = if Q == '1' then 128 else 64;
integer elements = datasize DIV esize;
integer part = UInt(op);
integer pairs = elements DIV 2;
```

Assembler Symbols

<Vd> Is the name of the SIMD&FP destination register, encoded in the "Rd" field.

<T> Is an arrangement specifier, encoded in "size:Q":

size	Q	<T>
00	0	8B
00	1	16B
01	0	4H
01	1	8H
10	0	2S
10	1	4S
11	0	RESERVED
11	1	2D

<Vn> Is the name of the first SIMD&FP source register, encoded in the "Rn" field.

<Vm> Is the name of the second SIMD&FP source register, encoded in the "Rm" field.

## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

integer base = part * pairs;

for p = 0 to pairs-1
    Elem[result, 2*p+0, esize] = Elem[operand1, base+p, esize];
    Elem[result, 2*p+1, esize] = Elem[operand2, base+p, esize];

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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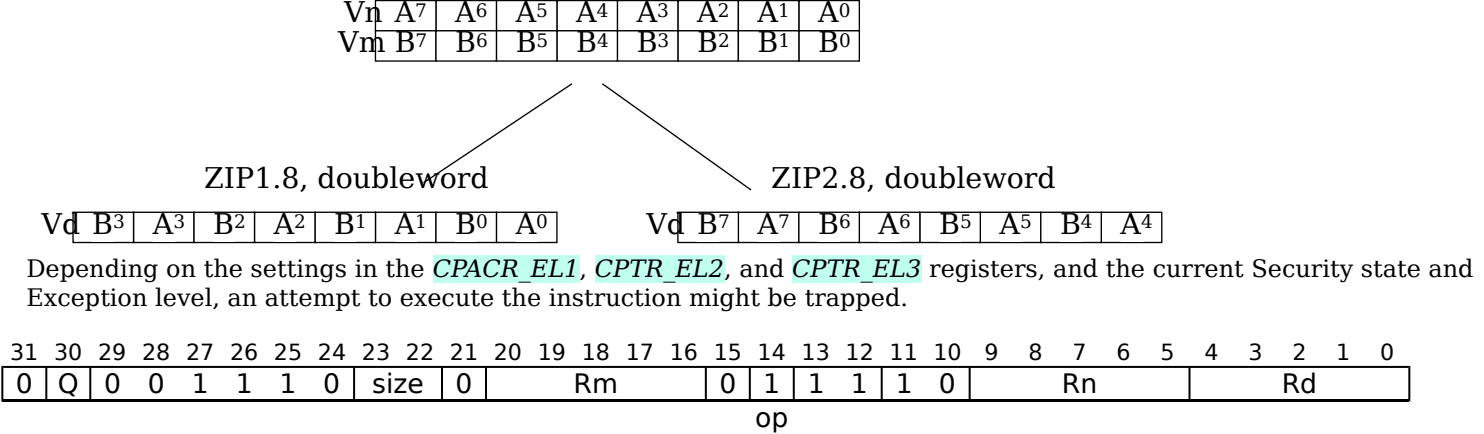
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ZIP2

Zip vectors (secondary). This instruction reads adjacent vector elements from the upper half of two source SIMD&FP registers as pairs, interleaves the pairs and places them into a vector, and writes the vector to the destination SIMD&FP register. The first pair from the first source register is placed into the two lowest vector elements, with subsequent pairs taken alternately from each source register.

This instruction can be used with ZIP1 to interleave two vectors.

The following figure shows an example of the operation of ZIP1 and ZIP2 with the arrangement specifier 8B.





## Operation

```
CheckFPAdvSIMDEnabled64();
bits(datasize) operand1 = V[n];
bits(datasize) operand2 = V[m];
bits(datasize) result;

integer base = part * pairs;

for p = 0 to pairs-1
    Elem[result, 2*p+0, esize] = Elem[operand1, base+p, esize];
    Elem[result, 2*p+1, esize] = Elem[operand2, base+p, esize];

V[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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## A64 -- SVE Instructions (alphabetic order)

[ABS](#): Absolute value (predicated).

[ADCLB](#): Add with carry long (bottom).

[ADCLT](#): Add with carry long (top).

[ADD \(immediate\)](#): Add immediate (unpredicated).

[ADD \(vectors, predicated\)](#): Add vectors (predicated).

[ADD \(vectors, unpredicated\)](#): Add vectors (unpredicated).

[ADDHNB](#): Add narrow high part (bottom).

[ADDHNT](#): Add narrow high part (top).

[ADDP](#): Add pairwise.

[ADDPL](#): Add multiple of predicate register size to scalar register.

[ADDVL](#): Add multiple of vector register size to scalar register.

[ADR](#): Compute vector address.

[AESD](#): AES single round decryption.

[AESE](#): AES single round encryption.

[AESIMC](#): AES inverse mix columns.

[AESMC](#): AES mix columns.

[AND \(immediate\)](#): Bitwise AND with immediate (unpredicated).

[AND \(vectors, predicated\)](#): Bitwise AND vectors (predicated).

[AND \(vectors, unpredicated\)](#): Bitwise AND vectors (unpredicated).

[AND, ANDS \(predicates\)](#): Bitwise AND predicates.

[ANDV](#): Bitwise AND reduction to scalar.

[ASR \(immediate, predicated\)](#): Arithmetic shift right by immediate (predicated).

[ASR \(immediate, unpredicated\)](#): Arithmetic shift right by immediate (unpredicated).

[ASR \(vectors\)](#): Arithmetic shift right by vector (predicated).

[ASR \(wide elements, predicated\)](#): Arithmetic shift right by 64-bit wide elements (predicated).

[ASR \(wide elements, unpredicated\)](#): Arithmetic shift right by 64-bit wide elements (unpredicated).

[ASRD](#): Arithmetic shift right for divide by immediate (predicated).

[ASRR](#): Reversed arithmetic shift right by vector (predicated).

[BCAX](#): Bitwise clear and exclusive OR.

[BDEP](#): Scatter lower bits into positions selected by bitmask.

[BEXT](#): Gather lower bits from positions selected by bitmask.

[BFCVT](#): Floating-point down convert to BFloat16 format (predicated).

[BFCVTNT](#): Floating-point down convert and narrow to BFloat16 (top, predicated).

[BFDOT \(indexed\)](#): BFloat16 floating-point indexed dot product.

[BFDOT \(vectors\)](#): BFloat16 floating-point dot product.

[BFMLALB \(indexed\)](#): BFloat16 floating-point multiply-add long to single-precision (bottom, indexed).

[BFMLALB \(vectors\)](#): BFloat16 floating-point multiply-add long to single-precision (bottom).

[BFMLALT \(indexed\)](#): BFloat16 floating-point multiply-add long to single-precision (top, indexed).

[BFMLALT \(vectors\)](#): BFloat16 floating-point multiply-add long to single-precision (top).

[BFMMLA](#): BFloat16 floating-point matrix multiply-accumulate.

[BGRP](#): Group bits to right or left as selected by bitmask.

[BIC \(immediate\)](#): Bitwise clear bits using immediate (unpredicated): an alias of AND (immediate).

[BIC \(vectors, predicated\)](#): Bitwise clear vectors (predicated).

[BIC \(vectors, unpredicated\)](#): Bitwise clear vectors (unpredicated).

[BIC, BICS \(predicates\)](#): Bitwise clear predicates.

[BRKA, BRKAS](#): Break after first true condition.

[BRKB, BRKBS](#): Break before first true condition.

[BRKN, BRKNS](#): Propagate break to next partition.

[BRKPA, BRKPAS](#): Break after first true condition, propagating from previous partition.

[BRKPB, BRKPBS](#): Break before first true condition, propagating from previous partition.

[BSL](#): Bitwise select.

[BSL1N](#): Bitwise select with first input inverted.

[BSL2N](#): Bitwise select with second input inverted.

[CADD](#): Complex integer add with rotate.

[CDOT \(indexed\)](#): Complex integer dot product (indexed).

[CDOT \(vectors\)](#): Complex integer dot product.

[CLASTA \(scalar\)](#): Conditionally extract element after last to general-purpose register.

[CLASTA \(SIMD&FP scalar\)](#): Conditionally extract element after last to SIMD&FP scalar register.

[CLASTA \(vectors\)](#): Conditionally extract element after last to vector register.

[CLASTB \(scalar\)](#): Conditionally extract last element to general-purpose register.

[CLASTB \(SIMD&FP scalar\)](#): Conditionally extract last element to SIMD&FP scalar register.

[CLASTB \(vectors\)](#): Conditionally extract last element to vector register.

[CLS](#): Count leading sign bits (predicated).

[CLZ](#): Count leading zero bits (predicated).

[CMLA \(indexed\)](#): Complex integer multiply-add with rotate (indexed).

[CMLA \(vectors\)](#): Complex integer multiply-add with rotate.

[CMP<cc> \(immediate\)](#): Compare vector to immediate.

[CMP<cc> \(vectors\)](#): Compare vectors.

[CMP<cc> \(wide elements\)](#): Compare vector to 64-bit wide elements.

[CMPLE \(vectors\)](#): Compare signed less than or equal to vector, setting the condition flags: an alias of CMP<cc> (vectors).

[CMPLO \(vectors\)](#): Compare unsigned lower than vector, setting the condition flags: an alias of CMP<cc> (vectors).

[CMPLS \(vectors\)](#): Compare unsigned lower or same as vector, setting the condition flags: an alias of CMP<cc> (vectors).

[CMPLT \(vectors\)](#): Compare signed less than vector, setting the condition flags: an alias of CMP<cc> (vectors).

[CNOT](#): Logically invert boolean condition in vector (predicated).

[CNT](#): Count non-zero bits (predicated).

[CNTB, CNTD, CNTH, CNTW](#): Set scalar to multiple of predicate constraint element count.

[CNTP](#): Set scalar to count of true predicate elements.

[COMPACT](#): Shuffle active elements of vector to the right and fill with zero.

[CPY \(immediate, merging\)](#): Copy signed integer immediate to vector elements (merging).

[CPY \(immediate, zeroing\)](#): Copy signed integer immediate to vector elements (zeroing).

[CPY \(scalar\)](#): Copy general-purpose register to vector elements (predicated).

[CPY \(SIMD&FP scalar\)](#): Copy SIMD&FP scalar register to vector elements (predicated).

[CTERMEQ, CTERMNE](#): Compare and terminate loop.

[DECB, DECD, DECH, DECW \(scalar\)](#): Decrement scalar by multiple of predicate constraint element count.

[DECD, DECH, DECW \(vector\)](#): Decrement vector by multiple of predicate constraint element count.

[DECP \(scalar\)](#): Decrement scalar by count of true predicate elements.

[DECP \(vector\)](#): Decrement vector by count of true predicate elements.

[DUP \(immediate\)](#): Broadcast signed immediate to vector elements (unpredicated).

[DUP \(indexed\)](#): Broadcast indexed element to vector (unpredicated).

[DUP \(scalar\)](#): Broadcast general-purpose register to vector elements (unpredicated).

[DUPM](#): Broadcast logical bitmask immediate to vector (unpredicated).

[EON](#): Bitwise exclusive OR with inverted immediate (unpredicated): an alias of EOR (immediate).

[EOR \(immediate\)](#): Bitwise exclusive OR with immediate (unpredicated).

[EOR \(vectors, predicated\)](#): Bitwise exclusive OR vectors (predicated).

[EOR \(vectors, unpredicated\)](#): Bitwise exclusive OR vectors (unpredicated).

[EOR, EORS \(predicates\)](#): Bitwise exclusive OR predicates.

[EOR3](#): Bitwise exclusive OR of three vectors.

[EORBT](#): Interleaving exclusive OR (bottom, top).

[EORTB](#): Interleaving exclusive OR (top, bottom).

[EORV](#): Bitwise exclusive OR reduction to scalar.

[EXT](#): Extract vector from pair of vectors.

[FABD](#): Floating-point absolute difference (predicated).

[FABS](#): Floating-point absolute value (predicated).

[FAC<cc>](#): Floating-point absolute compare vectors.

[FACLE](#): Floating-point absolute compare less than or equal: an alias of FAC<cc>.

[FACLT](#): Floating-point absolute compare less than: an alias of FAC<cc>.

[FADD \(immediate\)](#): Floating-point add immediate (predicated).

[FADD \(vectors, predicated\)](#): Floating-point add vector (predicated).

[FADD \(vectors, unpredicated\)](#): Floating-point add vector (unpredicated).

[FADDA](#): Floating-point add strictly-ordered reduction, accumulating in scalar.

[FADDP](#): Floating-point add pairwise.

[FADDV](#): Floating-point add recursive reduction to scalar.

[FCADD](#): Floating-point complex add with rotate (predicated).

[FCM<cc> \(vectors\)](#): Floating-point compare vectors.

[FCM<cc> \(zero\)](#): Floating-point compare vector with zero.

[FCMLA \(indexed\)](#): Floating-point complex multiply-add by indexed values with rotate.

[FCMLA \(vectors\)](#): Floating-point complex multiply-add with rotate (predicated).

[FCMLE \(vectors\)](#): Floating-point compare less than or equal to vector: an alias of FCM<cc> (vectors).

[FCMLT \(vectors\)](#): Floating-point compare less than vector: an alias of FCM<cc> (vectors).

[FCPY](#): Copy 8-bit floating-point immediate to vector elements (predicated).

[FCVT](#): Floating-point convert precision (predicated).

[FCVTLT](#): Floating-point up convert long (top, predicated).

[FCVTNT](#): Floating-point down convert and narrow (top, predicated).

[FCVTX](#): Floating-point down convert, rounding to odd (predicated).

[FCVTXNT](#): Floating-point down convert, rounding to odd (top, predicated).

[FCVTZS](#): Floating-point convert to signed integer, rounding toward zero (predicated).

[FCVTZU](#): Floating-point convert to unsigned integer, rounding toward zero (predicated).

[FDIV](#): Floating-point divide by vector (predicated).

[FDIVR](#): Floating-point reversed divide by vector (predicated).

[FDUP](#): Broadcast 8-bit floating-point immediate to vector elements (unpredicated).

[FEXPA](#): Floating-point exponential accelerator.

[FLOGB](#): Floating-point base 2 logarithm as integer.

[FMAD](#): Floating-point fused multiply-add vectors (predicated), writing multiplicand [ $Z_{dn} = Z_a + Z_{dn} * Z_m$ ].

[FMAX \(immediate\)](#): Floating-point maximum with immediate (predicated).

[FMAX \(vectors\)](#): Floating-point maximum (predicated).

[FMAXNM \(immediate\)](#): Floating-point maximum number with immediate (predicated).

[FMAXNM \(vectors\)](#): Floating-point maximum number (predicated).

[FMAXNMP](#): Floating-point maximum number pairwise.

[FMAXNMV](#): Floating-point maximum number recursive reduction to scalar.

[FMAXP](#): Floating-point maximum pairwise.

[FMAXV](#): Floating-point maximum recursive reduction to scalar.

[FMIN \(immediate\)](#): Floating-point minimum with immediate (predicated).

[FMIN \(vectors\)](#): Floating-point minimum (predicated).

[FMINNM \(immediate\)](#): Floating-point minimum number with immediate (predicated).

[FMINNM \(vectors\)](#): Floating-point minimum number (predicated).

[FMINNMP](#): Floating-point minimum number pairwise.

[FMINNMPV](#): Floating-point minimum number recursive reduction to scalar.

[FMINP](#): Floating-point minimum pairwise.

[FMINV](#): Floating-point minimum recursive reduction to scalar.

[FMLA \(indexed\)](#): Floating-point fused multiply-add by indexed elements ( $Z_{da} = Z_{da} + Z_n * Z_m[\text{indexed}]$ ).

[FMLA \(vectors\)](#): Floating-point fused multiply-add vectors (predicated), writing addend [ $Z_{da} = Z_{da} + Z_n * Z_m$ ].

[FMLALB \(indexed\)](#): Half-precision floating-point multiply-add long to single-precision (bottom, indexed).

[FMLALB \(vectors\)](#): Half-precision floating-point multiply-add long to single-precision (bottom).

[FMLALT \(indexed\)](#): Half-precision floating-point multiply-add long to single-precision (top, indexed).

[FMLALT \(vectors\)](#): Half-precision floating-point multiply-add long to single-precision (top).

[FMLS \(indexed\)](#): Floating-point fused multiply-subtract by indexed elements ( $Z_{da} = Z_{da} + -Z_n * Z_m[\text{indexed}]$ ).

[FMLS \(vectors\)](#): Floating-point fused multiply-subtract vectors (predicated), writing addend [ $Z_{da} = Z_{da} + -Z_n * Z_m$ ].

[FMLSBL \(indexed\)](#): Half-precision floating-point multiply-subtract long from single-precision (bottom, indexed).

[FMLSBL \(vectors\)](#): Half-precision floating-point multiply-subtract long from single-precision (bottom).

[FMLSBLT \(indexed\)](#): Half-precision floating-point multiply-subtract long from single-precision (top, indexed).

[FMLSBLT \(vectors\)](#): Half-precision floating-point multiply-subtract long from single-precision (top).

[FMMLA](#): Floating-point matrix multiply-accumulate.

[FMOV \(immediate, predicated\)](#): Move 8-bit floating-point immediate to vector elements (predicated): an alias of FCPY.

[FMOV \(immediate, unpredicated\)](#): Move 8-bit floating-point immediate to vector elements (unpredicated): an alias of FDUP.

[FMOV \(zero, predicated\)](#): Move floating-point +0.0 to vector elements (predicated): an alias of CPY (immediate, merging).

[FMOV \(zero, unpredicated\)](#): Move floating-point +0.0 to vector elements (unpredicated): an alias of DUP (immediate).

[FMSB](#): Floating-point fused multiply-subtract vectors (predicated), writing multiplicand [ $Z_{dn} = Z_a + -Z_{dn} * Z_m$ ].

[FMUL \(immediate\)](#): Floating-point multiply by immediate (predicated).

[FMUL \(indexed\)](#): Floating-point multiply by indexed elements.

[FMUL \(vectors, predicated\)](#): Floating-point multiply vectors (predicated).

[FMUL \(vectors, unpredicated\)](#): Floating-point multiply vectors (unpredicated).

[FMULX](#): Floating-point multiply-extended vectors (predicated).

[FNEG](#): Floating-point negate (predicated).

[FNMA](#): Floating-point negated fused multiply-add vectors (predicated), writing multiplicand [ $Z_{dn} = -Z_a + -Z_{dn} * Z_m$ ].

[FNMLA](#): Floating-point negated fused multiply-add vectors (predicated), writing addend [ $Z_{da} = -Z_{da} + -Z_n * Z_m$ ].

[FNMLS](#): Floating-point negated fused multiply-subtract vectors (predicated), writing addend [ $Z_{da} = -Z_{da} + Z_n * Z_m$ ].

[FNMSB](#): Floating-point negated fused multiply-subtract vectors (predicated), writing multiplicand [ $Z_{dn} = -Z_a + Z_{dn} * Z_m$ ].

[FRECPE](#): Floating-point reciprocal estimate (unpredicated).

[FRECPS](#): Floating-point reciprocal step (unpredicated).

[FRECPX](#): Floating-point reciprocal exponent (predicated).

[FRINT<r>](#): Floating-point round to integral value (predicated).

[FRSQRT](#): Floating-point reciprocal square root estimate (unpredicated).

[FRSQRTS](#): Floating-point reciprocal square root step (unpredicated).

[FSCALE](#): Floating-point adjust exponent by vector (predicated).

[FSQRT](#): Floating-point square root (predicated).

[FSUB \(immediate\)](#): Floating-point subtract immediate (predicated).

[FSUB \(vectors, predicated\)](#): Floating-point subtract vectors (predicated).

[FSUB \(vectors, unpredicated\)](#): Floating-point subtract vectors (unpredicated).

[FSUBR \(immediate\)](#): Floating-point reversed subtract from immediate (predicated).

[FSUBR \(vectors\)](#): Floating-point reversed subtract vectors (predicated).

[FTMAD](#): Floating-point trigonometric multiply-add coefficient.

[FTSMUL](#): Floating-point trigonometric starting value.

[FTSSEL](#): Floating-point trigonometric select coefficient.

[HISTCNT](#): Count matching elements in vector.

[HISTSEG](#): Count matching elements in vector segments.

[INCB, INCD, INCH, INCW \(scalar\)](#): Increment scalar by multiple of predicate constraint element count.

[INCD, INCH, INCW \(vector\)](#): Increment vector by multiple of predicate constraint element count.

[INCP \(scalar\)](#): Increment scalar by count of true predicate elements.

[INCP \(vector\)](#): Increment vector by count of true predicate elements.

[INDEX \(immediate, scalar\)](#): Create index starting from immediate and incremented by general-purpose register.

[INDEX \(immediates\)](#): Create index starting from and incremented by immediate.

[INDEX \(scalar, immediate\)](#): Create index starting from general-purpose register and incremented by immediate.

[INDEX \(scalars\)](#): Create index starting from and incremented by general-purpose register.

[INSR \(scalar\)](#): Insert general-purpose register in shifted vector.

[INSR \(SIMD&FP scalar\)](#): Insert SIMD&FP scalar register in shifted vector.

[LASTA \(scalar\)](#): Extract element after last to general-purpose register.

[LASTA \(SIMD&FP scalar\)](#): Extract element after last to SIMD&FP scalar register.

[LASTB \(scalar\)](#): Extract last element to general-purpose register.

[LASTB \(SIMD&FP scalar\)](#): Extract last element to SIMD&FP scalar register.

[LD1B \(scalar plus immediate\)](#): Contiguous load unsigned bytes to vector (immediate index).

[LD1B \(scalar plus scalar\)](#): Contiguous load unsigned bytes to vector (scalar index).

[LD1B \(scalar plus vector\)](#): Gather load unsigned bytes to vector (vector index).

[LD1B \(vector plus immediate\)](#): Gather load unsigned bytes to vector (immediate index).

[LD1D \(scalar plus immediate\)](#): Contiguous load doublewords to vector (immediate index).

[LD1D \(scalar plus scalar\)](#): Contiguous load doublewords to vector (scalar index).

[LD1D \(scalar plus vector\)](#): Gather load doublewords to vector (vector index).

[LD1D \(vector plus immediate\)](#): Gather load doublewords to vector (immediate index).

[LD1H \(scalar plus immediate\)](#): Contiguous load unsigned halfwords to vector (immediate index).

[LD1H \(scalar plus scalar\)](#): Contiguous load unsigned halfwords to vector (scalar index).

[LD1H \(scalar plus vector\)](#): Gather load unsigned halfwords to vector (vector index).

[LD1H \(vector plus immediate\)](#): Gather load unsigned halfwords to vector (immediate index).

[LD1RB](#): Load and broadcast unsigned byte to vector.

[LD1RD](#): Load and broadcast doubleword to vector.

[LD1RH](#): Load and broadcast unsigned halfword to vector.

[LD1ROB \(scalar plus immediate\)](#): Contiguous load and replicate thirty-two bytes (immediate index).

[LD1ROB \(scalar plus scalar\)](#): Contiguous load and replicate thirty-two bytes (scalar index).

[LD1ROD \(scalar plus immediate\)](#): Contiguous load and replicate four doublewords (immediate index).

[LD1ROD \(scalar plus scalar\)](#): Contiguous load and replicate four doublewords (scalar index).

[LD1ROH \(scalar plus immediate\)](#): Contiguous load and replicate sixteen halfwords (immediate index).

[LD1ROH \(scalar plus scalar\)](#): Contiguous load and replicate sixteen halfwords (scalar index).

[LD1ROW \(scalar plus immediate\)](#): Contiguous load and replicate eight words (immediate index).

[LD1ROW \(scalar plus scalar\)](#): Contiguous load and replicate eight words (scalar index).

[LD1ROB \(scalar plus immediate\)](#): Contiguous load and replicate sixteen bytes (immediate index).

[LD1ROB \(scalar plus scalar\)](#): Contiguous load and replicate sixteen bytes (scalar index).

[LD1ROD \(scalar plus immediate\)](#): Contiguous load and replicate two doublewords (immediate index).

[LD1ROD \(scalar plus scalar\)](#): Contiguous load and replicate two doublewords (scalar index).

[LD1ROH \(scalar plus immediate\)](#): Contiguous load and replicate eight halfwords (immediate index).

[LD1ROH \(scalar plus scalar\)](#): Contiguous load and replicate eight halfwords (scalar index).

[LD1RQW \(scalar plus immediate\)](#): Contiguous load and replicate four words (immediate index).

[LD1RQW \(scalar plus scalar\)](#): Contiguous load and replicate four words (scalar index).

[LD1RSB](#): Load and broadcast signed byte to vector.

[LD1RSH](#): Load and broadcast signed halfword to vector.

[LD1RSW](#): Load and broadcast signed word to vector.

[LD1RW](#): Load and broadcast unsigned word to vector.

[LD1SB \(scalar plus immediate\)](#): Contiguous load signed bytes to vector (immediate index).

[LD1SB \(scalar plus scalar\)](#): Contiguous load signed bytes to vector (scalar index).

[LD1SB \(scalar plus vector\)](#): Gather load signed bytes to vector (vector index).

[LD1SB \(vector plus immediate\)](#): Gather load signed bytes to vector (immediate index).



[LD1SH \(scalar plus immediate\)](#): Contiguous load signed halfwords to vector (immediate index).

[LD1SH \(scalar plus scalar\)](#): Contiguous load signed halfwords to vector (scalar index).

[LD1SH \(scalar plus vector\)](#): Gather load signed halfwords to vector (vector index).

[LD1SH \(vector plus immediate\)](#): Gather load signed halfwords to vector (immediate index).

[LD1SW \(scalar plus immediate\)](#): Contiguous load signed words to vector (immediate index).

[LD1SW \(scalar plus scalar\)](#): Contiguous load signed words to vector (scalar index).

[LD1SW \(scalar plus vector\)](#): Gather load signed words to vector (vector index).

[LD1SW \(vector plus immediate\)](#): Gather load signed words to vector (immediate index).

[LD1W \(scalar plus immediate\)](#): Contiguous load unsigned words to vector (immediate index).

[LD1W \(scalar plus scalar\)](#): Contiguous load unsigned words to vector (scalar index).

[LD1W \(scalar plus vector\)](#): Gather load unsigned words to vector (vector index).

[LD1W \(vector plus immediate\)](#): Gather load unsigned words to vector (immediate index).

[LD2B \(scalar plus immediate\)](#): Contiguous load two-byte structures to two vectors (immediate index).

[LD2B \(scalar plus scalar\)](#): Contiguous load two-byte structures to two vectors (scalar index).

[LD2D \(scalar plus immediate\)](#): Contiguous load two-doubleword structures to two vectors (immediate index).

[LD2D \(scalar plus scalar\)](#): Contiguous load two-doubleword structures to two vectors (scalar index).

[LD2H \(scalar plus immediate\)](#): Contiguous load two-halfword structures to two vectors (immediate index).

[LD2H \(scalar plus scalar\)](#): Contiguous load two-halfword structures to two vectors (scalar index).

[LD2W \(scalar plus immediate\)](#): Contiguous load two-word structures to two vectors (immediate index).

[LD2W \(scalar plus scalar\)](#): Contiguous load two-word structures to two vectors (scalar index).

[LD3B \(scalar plus immediate\)](#): Contiguous load three-byte structures to three vectors (immediate index).

[LD3B \(scalar plus scalar\)](#): Contiguous load three-byte structures to three vectors (scalar index).

[LD3D \(scalar plus immediate\)](#): Contiguous load three-doubleword structures to three vectors (immediate index).

[LD3D \(scalar plus scalar\)](#): Contiguous load three-doubleword structures to three vectors (scalar index).

[LD3H \(scalar plus immediate\)](#): Contiguous load three-halfword structures to three vectors (immediate index).

[LD3H \(scalar plus scalar\)](#): Contiguous load three-halfword structures to three vectors (scalar index).

[LD3W \(scalar plus immediate\)](#): Contiguous load three-word structures to three vectors (immediate index).

[LD3W \(scalar plus scalar\)](#): Contiguous load three-word structures to three vectors (scalar index).

[LD4B \(scalar plus immediate\)](#): Contiguous load four-byte structures to four vectors (immediate index).

[LD4B \(scalar plus scalar\)](#): Contiguous load four-byte structures to four vectors (scalar index).

[LD4D \(scalar plus immediate\)](#): Contiguous load four-doubleword structures to four vectors (immediate index).

[LD4D \(scalar plus scalar\)](#): Contiguous load four-doubleword structures to four vectors (scalar index).

[LD4H \(scalar plus immediate\)](#): Contiguous load four-halfword structures to four vectors (immediate index).

[LD4H \(scalar plus scalar\)](#): Contiguous load four-halfword structures to four vectors (scalar index).

[LD4W \(scalar plus immediate\)](#): Contiguous load four-word structures to four vectors (immediate index).

[LD4W \(scalar plus scalar\)](#): Contiguous load four-word structures to four vectors (scalar index).

[LDFF1B \(scalar plus scalar\)](#): Contiguous load first-fault unsigned bytes to vector (scalar index).

[LDFF1B \(scalar plus vector\)](#): Gather load first-fault unsigned bytes to vector (vector index).

[LDFF1B \(vector plus immediate\)](#): Gather load first-fault unsigned bytes to vector (immediate index).

[LDFF1D \(scalar plus scalar\)](#): Contiguous load first-fault doublewords to vector (scalar index).

[LDFF1D \(scalar plus vector\)](#): Gather load first-fault doublewords to vector (vector index).

[LDFF1D \(vector plus immediate\)](#): Gather load first-fault doublewords to vector (immediate index).

[LDFF1H \(scalar plus scalar\)](#): Contiguous load first-fault unsigned halfwords to vector (scalar index).

[LDFF1H \(scalar plus vector\)](#): Gather load first-fault unsigned halfwords to vector (vector index).

[LDFF1H \(vector plus immediate\)](#): Gather load first-fault unsigned halfwords to vector (immediate index).

[LDFF1SB \(scalar plus scalar\)](#): Contiguous load first-fault signed bytes to vector (scalar index).

[LDFF1SB \(scalar plus vector\)](#): Gather load first-fault signed bytes to vector (vector index).

[LDFF1SB \(vector plus immediate\)](#): Gather load first-fault signed bytes to vector (immediate index).

[LDFF1SH \(scalar plus scalar\)](#): Contiguous load first-fault signed halfwords to vector (scalar index).

[LDFF1SH \(scalar plus vector\)](#): Gather load first-fault signed halfwords to vector (vector index).

[LDFF1SH \(vector plus immediate\)](#): Gather load first-fault signed halfwords to vector (immediate index).

[LDFF1SW \(scalar plus scalar\)](#): Contiguous load first-fault signed words to vector (scalar index).

[LDFF1SW \(scalar plus vector\)](#): Gather load first-fault signed words to vector (vector index).

[LDFF1SW \(vector plus immediate\)](#): Gather load first-fault signed words to vector (immediate index).

[LDFF1W \(scalar plus scalar\)](#): Contiguous load first-fault unsigned words to vector (scalar index).

[LDFF1W \(scalar plus vector\)](#): Gather load first-fault unsigned words to vector (vector index).

[LDFF1W \(vector plus immediate\)](#): Gather load first-fault unsigned words to vector (immediate index).

[LDNF1B](#): Contiguous load non-fault unsigned bytes to vector (immediate index).

[LDNF1D](#): Contiguous load non-fault doublewords to vector (immediate index).

[LDNF1H](#): Contiguous load non-fault unsigned halfwords to vector (immediate index).

[LDNF1SB](#): Contiguous load non-fault signed bytes to vector (immediate index).

[LDNF1SH](#): Contiguous load non-fault signed halfwords to vector (immediate index).

[LDNF1SW](#): Contiguous load non-fault signed words to vector (immediate index).

[LDNF1W](#): Contiguous load non-fault unsigned words to vector (immediate index).

[LDNT1B \(scalar plus immediate\)](#): Contiguous load non-temporal bytes to vector (immediate index).

[LDNT1B \(scalar plus scalar\)](#): Contiguous load non-temporal bytes to vector (scalar index).

[LDNT1B \(vector plus scalar\)](#): Gather load non-temporal unsigned bytes.

[LDNT1D \(scalar plus immediate\)](#): Contiguous load non-temporal doublewords to vector (immediate index).

[LDNT1D \(scalar plus scalar\)](#): Contiguous load non-temporal doublewords to vector (scalar index).

[LDNT1D \(vector plus scalar\)](#): Gather load non-temporal unsigned doublewords.

[LDNT1H \(scalar plus immediate\)](#): Contiguous load non-temporal halfwords to vector (immediate index).

[LDNT1H \(scalar plus scalar\)](#): Contiguous load non-temporal halfwords to vector (scalar index).

[LDNT1H \(vector plus scalar\)](#): Gather load non-temporal unsigned halfwords.

[LDNT1SB](#): Gather load non-temporal signed bytes.

[LDNT1SH](#): Gather load non-temporal signed halfwords.

[LDNT1SW](#): Gather load non-temporal signed words.

[LDNT1W \(scalar plus immediate\)](#): Contiguous load non-temporal words to vector (immediate index).

[LDNT1W \(scalar plus scalar\)](#): Contiguous load non-temporal words to vector (scalar index).

[LDNT1W \(vector plus scalar\)](#): Gather load non-temporal unsigned words.

[LDR \(predicate\)](#): Load predicate register.

[LDR \(vector\)](#): Load vector register.

[LSL \(immediate, predicated\)](#): Logical shift left by immediate (predicated).

[LSL \(immediate, unpredicated\)](#): Logical shift left by immediate (unpredicated).

[LSL \(vectors\)](#): Logical shift left by vector (predicated).

[LSL \(wide elements, predicated\)](#): Logical shift left by 64-bit wide elements (predicated).

[LSL \(wide elements, unpredicated\)](#): Logical shift left by 64-bit wide elements (unpredicated).

[LSLR](#): Reversed logical shift left by vector (predicated).

[LSR \(immediate, predicated\)](#): Logical shift right by immediate (predicated).

[LSR \(immediate, unpredicated\)](#): Logical shift right by immediate (unpredicated).

[LSR \(vectors\)](#): Logical shift right by vector (predicated).

[LSR \(wide elements, predicated\)](#): Logical shift right by 64-bit wide elements (predicated).

[LSR \(wide elements, unpredicated\)](#): Logical shift right by 64-bit wide elements (unpredicated).

[LSRR](#): Reversed logical shift right by vector (predicated).

[MAD](#): Multiply-add vectors (predicated), writing multiplicand [ $Z_{dn} = Z_a + Z_{dn} * Z_m$ ].

[MATCH](#): Detect any matching elements, setting the condition flags.

[MLA \(indexed\)](#): Multiply-add to accumulator (indexed).

[MLA \(vectors\)](#): Multiply-add vectors (predicated), writing addend [ $Z_{da} = Z_{da} + Z_n * Z_m$ ].

[MLS \(indexed\)](#): Multiply-subtract from accumulator (indexed).

[MLS \(vectors\)](#): Multiply-subtract vectors (predicated), writing addend [ $Z_{da} = Z_{da} - Z_n * Z_m$ ].

[MOV \(bitmask immediate\)](#): Move logical bitmask immediate to vector (unpredicated): an alias of DUPM.

[MOV \(immediate, predicated, merging\)](#): Move signed integer immediate to vector elements (merging): an alias of CPY (immediate, merging).

[MOV \(immediate, predicated, zeroing\)](#): Move signed integer immediate to vector elements (zeroing): an alias of CPY (immediate, zeroing).

[MOV \(immediate, unpredicated\)](#): Move signed immediate to vector elements (unpredicated): an alias of DUP (immediate).

[MOV \(predicate, predicated, merging\)](#): Move predicates (merging): an alias of SEL (predicates).

[MOV \(predicate, predicated, zeroing\)](#): Move predicates (zeroing): an alias of AND, ANDS (predicates).

[MOV \(predicate, unpredicated\)](#): Move predicate (unpredicated): an alias of ORR, ORRS (predicates).

[MOV \(scalar, predicated\)](#): Move general-purpose register to vector elements (predicated): an alias of CPY (scalar).

[MOV \(scalar, unpredicated\)](#): Move general-purpose register to vector elements (unpredicated): an alias of DUP (scalar).

[MOV \(SIMD&FP scalar, predicated\)](#): Move SIMD&FP scalar register to vector elements (predicated): an alias of CPY (SIMD&FP scalar).

[MOV \(SIMD&FP scalar, unpredicated\)](#): Move indexed element or SIMD&FP scalar to vector (unpredicated): an alias of DUP (indexed).

[MOV \(vector, predicated\)](#): Move vector elements (predicated): an alias of SEL (vectors).

[MOV \(vector, unpredicated\)](#): Move vector register (unpredicated): an alias of ORR (vectors, unpredicated).

[MOVPREX \(predicated\)](#): Move prefix (predicated).

[MOVPREX \(unpredicated\)](#): Move prefix (unpredicated).

[MOVS \(predicated\)](#): Move predicates (zeroing), setting the condition flags: an alias of AND, ANDS (predicates).

[MOVS \(unpredicated\)](#): Move predicate (unpredicated), setting the condition flags: an alias of ORR, ORRS (predicates).

[MSB](#): Multiply-subtract vectors (predicated), writing multiplicand [ $Z_{dn} = Z_a - Z_{dn} * Z_m$ ].

[MUL \(immediate\)](#): Multiply by immediate (unpredicated).

[MUL \(indexed\)](#): Multiply (indexed).

[MUL \(vectors, predicated\)](#): Multiply vectors (predicated).

[MUL \(vectors, unpredicated\)](#): Multiply vectors (unpredicated).

[NAND, NANDS](#): Bitwise NAND predicates.

[NBSL](#): Bitwise inverted select.

[NEG](#): Negate (predicated).

[NMATCH](#): Detect no matching elements, setting the condition flags.

[NOR, NORs](#): Bitwise NOR predicates.

[NOT \(predicate\)](#): Bitwise invert predicate: an alias of EOR, EORS (predicates).

[NOT \(vector\)](#): Bitwise invert vector (predicated).

[NOTS](#): Bitwise invert predicate, setting the condition flags: an alias of EOR, EORS (predicates).

[ORN \(immediate\)](#): Bitwise inclusive OR with inverted immediate (unpredicated): an alias of ORR (immediate).

[ORN, ORNS \(predicates\)](#): Bitwise inclusive OR inverted predicate.

[ORR \(immediate\)](#): Bitwise inclusive OR with immediate (unpredicated).

[ORR \(vectors, predicated\)](#): Bitwise inclusive OR vectors (predicated).

[ORR \(vectors, unpredicated\)](#): Bitwise inclusive OR vectors (unpredicated).

[ORR, ORRS \(predicates\)](#): Bitwise inclusive OR predicate.

[ORV](#): Bitwise inclusive OR reduction to scalar.

[PFALSE](#): Set all predicate elements to false.

[PFIRST](#): Set the first active predicate element to true.

[PMUL](#): Polynomial multiply vectors (unpredicated).

[PMULLB](#): Polynomial multiply long (bottom).

[PMULLT](#): Polynomial multiply long (top).

[PNEXT](#): Find next active predicate.

[PRFB \(scalar plus immediate\)](#): Contiguous prefetch bytes (immediate index).

[PRFB \(scalar plus scalar\)](#): Contiguous prefetch bytes (scalar index).

[PRFB \(scalar plus vector\)](#): Gather prefetch bytes (scalar plus vector).

[PRFB \(vector plus immediate\)](#): Gather prefetch bytes (vector plus immediate).

[PRFD \(scalar plus immediate\)](#): Contiguous prefetch doublewords (immediate index).

[PRFD \(scalar plus scalar\)](#): Contiguous prefetch doublewords (scalar index).

[PRFD \(scalar plus vector\)](#): Gather prefetch doublewords (scalar plus vector).

[PRFD \(vector plus immediate\)](#): Gather prefetch doublewords (vector plus immediate).

[PRFH \(scalar plus immediate\)](#): Contiguous prefetch halfwords (immediate index).

[PRFH \(scalar plus scalar\)](#): Contiguous prefetch halfwords (scalar index).

[PRFH \(scalar plus vector\)](#): Gather prefetch halfwords (scalar plus vector).

[PRFH \(vector plus immediate\)](#): Gather prefetch halfwords (vector plus immediate).

[PRFW \(scalar plus immediate\)](#): Contiguous prefetch words (immediate index).

[PRFW \(scalar plus scalar\)](#): Contiguous prefetch words (scalar index).

[PRFW \(scalar plus vector\)](#): Gather prefetch words (scalar plus vector).

[PRFW \(vector plus immediate\)](#): Gather prefetch words (vector plus immediate).

[PTEST](#): Set condition flags for predicate.

[PTRUE, PTRUES](#): Initialise predicate from named constraint.

[PUNPKHL, PUNPKLO](#): Unpack and widen half of predicate.

[RADDHNB](#): Rounding add narrow high part (bottom).

[RADDHNT](#): Rounding add narrow high part (top).

[RAX1](#): Bitwise rotate left by 1 and exclusive OR.

[RBIT](#): Reverse bits (predicated).

[RDDFFR \(unpredicated\)](#): Read the first-fault register.

[RDDFFR, RDDFRS \(predicated\)](#): Return predicate of successfully loaded elements.

[RDVL](#): Read multiple of vector register size to scalar register.

[REV \(predicate\)](#): Reverse all elements in a predicate.

[REV \(vector\)](#): Reverse all elements in a vector (unpredicated).

[REVB, REVH, REVW](#): Reverse bytes / halfwords / words within elements (predicated).

[RSHRNB](#): Rounding shift right narrow by immediate (bottom).

[RSHRNT](#): Rounding shift right narrow by immediate (top).

[RSUBHNB](#): Rounding subtract narrow high part (bottom).

[RSUBHNT](#): Rounding subtract narrow high part (top).

[SABA](#): Signed absolute difference and accumulate.

[SABALB](#): Signed absolute difference and accumulate long (bottom).

[SABALT](#): Signed absolute difference and accumulate long (top).

[SABD](#): Signed absolute difference (predicated).

[SABDLB](#): Signed absolute difference long (bottom).

[SABDLT](#): Signed absolute difference long (top).

[SADALP](#): Signed add and accumulate long pairwise.

[SADDLB](#): Signed add long (bottom).

[SADDLBT](#): Signed add long (bottom + top).

[SADDLT](#): Signed add long (top).

[SADDV](#): Signed add reduction to scalar.

[SADDWB](#): Signed add wide (bottom).

[SADDWT](#): Signed add wide (top).

[SBCLB](#): Subtract with carry long (bottom).

[SBCLT](#): Subtract with carry long (top).

[SCVTF](#): Signed integer convert to floating-point (predicated).

[SDIV](#): Signed divide (predicated).

[SDIVR](#): Signed reversed divide (predicated).

[SDOT \(indexed\)](#): Signed integer indexed dot product.

[SDOT \(vectors\)](#): Signed integer dot product.

[SEL \(predicates\)](#): Conditionally select elements from two predicates.

[SEL \(vectors\)](#): Conditionally select elements from two vectors.

[SETFFR](#): Initialise the first-fault register to all true.

[SHADD](#): Signed halving addition.

[SHRNB](#): Shift right narrow by immediate (bottom).

[SHRNT](#): Shift right narrow by immediate (top).

[SHSUB](#): Signed halving subtract.

[SHSUBR](#): Signed halving subtract reversed vectors.

[SLI](#): Shift left and insert (immediate).

[SM4E](#): SM4 encryption and decryption.

[SM4EKEY](#): SM4 key updates.

[SMAX \(immediate\)](#): Signed maximum with immediate (unpredicated).

[SMAX \(vectors\)](#): Signed maximum vectors (predicated).

[SMAXP](#): Signed maximum pairwise.

[SMAXV](#): Signed maximum reduction to scalar.

[SMIN \(immediate\)](#): Signed minimum with immediate (unpredicated).

[SMIN \(vectors\)](#): Signed minimum vectors (predicated).

[SMINP](#): Signed minimum pairwise.

[SMINV](#): Signed minimum reduction to scalar.

[SMLALB \(indexed\)](#): Signed multiply-add long to accumulator (bottom, indexed).

[SMLALB \(vectors\)](#): Signed multiply-add long to accumulator (bottom).

[SMLALT \(indexed\)](#): Signed multiply-add long to accumulator (top, indexed).

[SMLALT \(vectors\)](#): Signed multiply-add long to accumulator (top).

[SMLSLB \(indexed\)](#): Signed multiply-subtract long from accumulator (bottom, indexed).

[SMLSLB \(vectors\)](#): Signed multiply-subtract long from accumulator (bottom).

[SMLSLT \(indexed\)](#): Signed multiply-subtract long from accumulator (top, indexed).

[SMLSLT \(vectors\)](#): Signed multiply-subtract long from accumulator (top).

[SMMLA](#): Signed integer matrix multiply-accumulate.

[SMULH \(predicated\)](#): Signed multiply returning high half (predicated).

[SMULH \(unpredicated\)](#): Signed multiply returning high half (unpredicated).

[SMULLB \(indexed\)](#): Signed multiply long (bottom, indexed).

[SMULLB \(vectors\)](#): Signed multiply long (bottom).

[SMULLT \(indexed\)](#): Signed multiply long (top, indexed).

[SMULLT \(vectors\)](#): Signed multiply long (top).

[SPLICE](#): Splice two vectors under predicate control.

[SQABS](#): Signed saturating absolute value.

[SQADD \(immediate\)](#): Signed saturating add immediate (unpredicated).

[SQADD \(vectors, predicated\)](#): Signed saturating addition (predicated).

[SQADD \(vectors, unpredicated\)](#): Signed saturating add vectors (unpredicated).

[SQCADD](#): Saturating complex integer add with rotate.

[SQDECB](#): Signed saturating decrement scalar by multiple of 8-bit predicate constraint element count.

[SQDECD \(scalar\)](#): Signed saturating decrement scalar by multiple of 64-bit predicate constraint element count.

[SQDECD \(vector\)](#): Signed saturating decrement vector by multiple of 64-bit predicate constraint element count.

[SQDECH \(scalar\)](#): Signed saturating decrement scalar by multiple of 16-bit predicate constraint element count.

[SQDECH \(vector\)](#): Signed saturating decrement vector by multiple of 16-bit predicate constraint element count.

[SQDECP \(scalar\)](#): Signed saturating decrement scalar by count of true predicate elements.

[SQDECP \(vector\)](#): Signed saturating decrement vector by count of true predicate elements.

[SQDECW \(scalar\)](#): Signed saturating decrement scalar by multiple of 32-bit predicate constraint element count.

[SQDECW \(vector\)](#): Signed saturating decrement vector by multiple of 32-bit predicate constraint element count.

[SQDMLALB \(indexed\)](#): Signed saturating doubling multiply-add long to accumulator (bottom, indexed).

[SQDMLALB \(vectors\)](#): Signed saturating doubling multiply-add long to accumulator (bottom).

[SQDMLALBT](#): Signed saturating doubling multiply-add long to accumulator (bottom  $\times$  top).

[SQDMLALT \(indexed\)](#): Signed saturating doubling multiply-add long to accumulator (top, indexed).

[SQDMLALT \(vectors\)](#): Signed saturating doubling multiply-add long to accumulator (top).

[SQDMLSLB \(indexed\)](#): Signed saturating doubling multiply-subtract long from accumulator (bottom, indexed).



[SQDMLSLB \(vectors\)](#): Signed saturating doubling multiply-subtract long from accumulator (bottom).

[SQDMLSLBT](#): Signed saturating doubling multiply-subtract long from accumulator (bottom × top).

[SQDMLSLT \(indexed\)](#): Signed saturating doubling multiply-subtract long from accumulator (top, indexed).

[SQDMLSLT \(vectors\)](#): Signed saturating doubling multiply-subtract long from accumulator (top).

[SQDMULH \(indexed\)](#): Signed saturating doubling multiply high (indexed).

[SQDMULH \(vectors\)](#): Signed saturating doubling multiply high (unpredicated).

[SQDMULLB \(indexed\)](#): Signed saturating doubling multiply long (bottom, indexed).

[SQDMULLB \(vectors\)](#): Signed saturating doubling multiply long (bottom).

[SQDMULLT \(indexed\)](#): Signed saturating doubling multiply long (top, indexed).

[SQDMULLT \(vectors\)](#): Signed saturating doubling multiply long (top).

[SQINCB](#): Signed saturating increment scalar by multiple of 8-bit predicate constraint element count.

[SQINCD \(scalar\)](#): Signed saturating increment scalar by multiple of 64-bit predicate constraint element count.

[SQINCD \(vector\)](#): Signed saturating increment vector by multiple of 64-bit predicate constraint element count.

[SQINCH \(scalar\)](#): Signed saturating increment scalar by multiple of 16-bit predicate constraint element count.

[SQINCH \(vector\)](#): Signed saturating increment vector by multiple of 16-bit predicate constraint element count.

[SQINCP \(scalar\)](#): Signed saturating increment scalar by count of true predicate elements.

[SQINCP \(vector\)](#): Signed saturating increment vector by count of true predicate elements.

[SQINCW \(scalar\)](#): Signed saturating increment scalar by multiple of 32-bit predicate constraint element count.

[SQINCW \(vector\)](#): Signed saturating increment vector by multiple of 32-bit predicate constraint element count.

[SQNEG](#): Signed saturating negate.

[SQRDCMLAH \(indexed\)](#): Saturating rounding doubling complex integer multiply-add high with rotate (indexed).

[SQRDCMLAH \(vectors\)](#): Saturating rounding doubling complex integer multiply-add high with rotate.

[SQRDMLAH \(indexed\)](#): Signed saturating rounding doubling multiply-add high to accumulator (indexed).

[SQRDMLAH \(vectors\)](#): Signed saturating rounding doubling multiply-add high to accumulator (unpredicated).

[SQRDMLSH \(indexed\)](#): Signed saturating rounding doubling multiply-subtract high from accumulator (indexed).

[SQRDMLSH \(vectors\)](#): Signed saturating rounding doubling multiply-subtract high from accumulator (unpredicated).

[SQRDMULH \(indexed\)](#): Signed saturating rounding doubling multiply high (indexed).

[SQRDMULH \(vectors\)](#): Signed saturating rounding doubling multiply high (unpredicated).

[SQRSHL](#): Signed saturating rounding shift left by vector (predicated).

[SQRSHLR](#): Signed saturating rounding shift left reversed vectors (predicated).

[SQRSHRNB](#): Signed saturating rounding shift right narrow by immediate (bottom).

[SQRSHRNT](#): Signed saturating rounding shift right narrow by immediate (top).

[SQRSHRUNB](#): Signed saturating rounding shift right unsigned narrow by immediate (bottom).

[SQRSHRUNT](#): Signed saturating rounding shift right unsigned narrow by immediate (top).

[SQSHL \(immediate\)](#): Signed saturating shift left by immediate.

[SQSHL \(vectors\)](#): Signed saturating shift left by vector (predicated).



[SQSHLR](#): Signed saturating shift left reversed vectors (predicated).

[SQSHLU](#): Signed saturating shift left unsigned by immediate.

[SQSHRNB](#): Signed saturating shift right narrow by immediate (bottom).

[SQSHRNT](#): Signed saturating shift right narrow by immediate (top).

[SQSHRUNB](#): Signed saturating shift right unsigned narrow by immediate (bottom).

[SQSHRUNT](#): Signed saturating shift right unsigned narrow by immediate (top).

[SQSUB \(immediate\)](#): Signed saturating subtract immediate (unpredicated).

[SQSUB \(vectors, predicated\)](#): Signed saturating subtraction (predicated).

[SQSUB \(vectors, unpredicated\)](#): Signed saturating subtract vectors (unpredicated).

[QSUBR](#): Signed saturating subtraction reversed vectors (predicated).

[SQXTNB](#): Signed saturating extract narrow (bottom).

[SQXTNT](#): Signed saturating extract narrow (top).

[SQXTUNB](#): Signed saturating unsigned extract narrow (bottom).

[SQXTUNT](#): Signed saturating unsigned extract narrow (top).

[SRHADD](#): Signed rounding halving addition.

[SRI](#): Shift right and insert (immediate).

[SRSHL](#): Signed rounding shift left by vector (predicated).

[SRSHLR](#): Signed rounding shift left reversed vectors (predicated).

[SRSHR](#): Signed rounding shift right by immediate.

[SRSRA](#): Signed rounding shift right and accumulate (immediate).

[SSHLLB](#): Signed shift left long by immediate (bottom).

[SSHLLT](#): Signed shift left long by immediate (top).

[SSRA](#): Signed shift right and accumulate (immediate).

[SSUBLB](#): Signed subtract long (bottom).

[SSUBLBT](#): Signed subtract long (bottom - top).

[SSUBLT](#): Signed subtract long (top).

[SSUBLTB](#): Signed subtract long (top - bottom).

[SSUBWB](#): Signed subtract wide (bottom).

[SSUBWT](#): Signed subtract wide (top).

[ST1B \(scalar plus immediate\)](#): Contiguous store bytes from vector (immediate index).

[ST1B \(scalar plus scalar\)](#): Contiguous store bytes from vector (scalar index).

[ST1B \(scalar plus vector\)](#): Scatter store bytes from a vector (vector index).

[ST1B \(vector plus immediate\)](#): Scatter store bytes from a vector (immediate index).

[ST1D \(scalar plus immediate\)](#): Contiguous store doublewords from vector (immediate index).

[ST1D \(scalar plus scalar\)](#): Contiguous store doublewords from vector (scalar index).

[ST1D \(scalar plus vector\)](#): Scatter store doublewords from a vector (vector index).

[ST1D \(vector plus immediate\)](#): Scatter store doublewords from a vector (immediate index).

[ST1H \(scalar plus immediate\)](#): Contiguous store halfwords from vector (immediate index).

[ST1H \(scalar plus scalar\)](#): Contiguous store halfwords from vector (scalar index).

[ST1H \(scalar plus vector\)](#): Scatter store halfwords from a vector (vector index).

[ST1H \(vector plus immediate\)](#): Scatter store halfwords from a vector (immediate index).

[ST1W \(scalar plus immediate\)](#): Contiguous store words from vector (immediate index).

[ST1W \(scalar plus scalar\)](#): Contiguous store words from vector (scalar index).

[ST1W \(scalar plus vector\)](#): Scatter store words from a vector (vector index).

[ST1W \(vector plus immediate\)](#): Scatter store words from a vector (immediate index).

[ST2B \(scalar plus immediate\)](#): Contiguous store two-byte structures from two vectors (immediate index).

[ST2B \(scalar plus scalar\)](#): Contiguous store two-byte structures from two vectors (scalar index).

[ST2D \(scalar plus immediate\)](#): Contiguous store two-doubleword structures from two vectors (immediate index).

[ST2D \(scalar plus scalar\)](#): Contiguous store two-doubleword structures from two vectors (scalar index).

[ST2H \(scalar plus immediate\)](#): Contiguous store two-halfword structures from two vectors (immediate index).

[ST2H \(scalar plus scalar\)](#): Contiguous store two-halfword structures from two vectors (scalar index).

[ST2W \(scalar plus immediate\)](#): Contiguous store two-word structures from two vectors (immediate index).

[ST2W \(scalar plus scalar\)](#): Contiguous store two-word structures from two vectors (scalar index).

[ST3B \(scalar plus immediate\)](#): Contiguous store three-byte structures from three vectors (immediate index).

[ST3B \(scalar plus scalar\)](#): Contiguous store three-byte structures from three vectors (scalar index).

[ST3D \(scalar plus immediate\)](#): Contiguous store three-doubleword structures from three vectors (immediate index).

[ST3D \(scalar plus scalar\)](#): Contiguous store three-doubleword structures from three vectors (scalar index).

[ST3H \(scalar plus immediate\)](#): Contiguous store three-halfword structures from three vectors (immediate index).

[ST3H \(scalar plus scalar\)](#): Contiguous store three-halfword structures from three vectors (scalar index).

[ST3W \(scalar plus immediate\)](#): Contiguous store three-word structures from three vectors (immediate index).

[ST3W \(scalar plus scalar\)](#): Contiguous store three-word structures from three vectors (scalar index).

[ST4B \(scalar plus immediate\)](#): Contiguous store four-byte structures from four vectors (immediate index).

[ST4B \(scalar plus scalar\)](#): Contiguous store four-byte structures from four vectors (scalar index).

[ST4D \(scalar plus immediate\)](#): Contiguous store four-doubleword structures from four vectors (immediate index).

[ST4D \(scalar plus scalar\)](#): Contiguous store four-doubleword structures from four vectors (scalar index).

[ST4H \(scalar plus immediate\)](#): Contiguous store four-halfword structures from four vectors (immediate index).

[ST4H \(scalar plus scalar\)](#): Contiguous store four-halfword structures from four vectors (scalar index).

[ST4W \(scalar plus immediate\)](#): Contiguous store four-word structures from four vectors (immediate index).

[ST4W \(scalar plus scalar\)](#): Contiguous store four-word structures from four vectors (scalar index).

[STNT1B \(scalar plus immediate\)](#): Contiguous store non-temporal bytes from vector (immediate index).

[STNT1B \(scalar plus scalar\)](#): Contiguous store non-temporal bytes from vector (scalar index).

[STNT1B \(vector plus scalar\)](#): Scatter store non-temporal bytes.

[STNT1D \(scalar plus immediate\)](#): Contiguous store non-temporal doublewords from vector (immediate index).

[STNT1D \(scalar plus scalar\)](#): Contiguous store non-temporal doublewords from vector (scalar index).

[STNT1D \(vector plus scalar\)](#): Scatter store non-temporal doublewords.

[STNT1H \(scalar plus immediate\)](#): Contiguous store non-temporal halfwords from vector (immediate index).

[STNT1H \(scalar plus scalar\)](#): Contiguous store non-temporal halfwords from vector (scalar index).

[STNT1H \(vector plus scalar\)](#): Scatter store non-temporal halfwords.

[STNT1W \(scalar plus immediate\)](#): Contiguous store non-temporal words from vector (immediate index).

[STNT1W \(scalar plus scalar\)](#): Contiguous store non-temporal words from vector (scalar index).

[STNT1W \(vector plus scalar\)](#): Scatter store non-temporal words.

[STR \(predicate\)](#): Store predicate register.

[STR \(vector\)](#): Store vector register.

[SUB \(immediate\)](#): Subtract immediate (unpredicated).

[SUB \(vectors, predicated\)](#): Subtract vectors (predicated).

[SUB \(vectors, unpredicated\)](#): Subtract vectors (unpredicated).

[SUBHNB](#): Subtract narrow high part (bottom).

[SUBHNT](#): Subtract narrow high part (top).

[SUBR \(immediate\)](#): Reversed subtract from immediate (unpredicated).

[SUBR \(vectors\)](#): Reversed subtract vectors (predicated).

[SUDOT](#): Signed by unsigned integer indexed dot product.

[SUNPKHI, SUNPKLO](#): Signed unpack and extend half of vector.

[SUQADD](#): Signed saturating addition of unsigned value.

[SXTB, SXTH, SXTW](#): Signed byte / halfword / word extend (predicated).

[TBL](#): Programmable table lookup in one or two vector table (zeroing).

[TBX](#): Programmable table lookup in single vector table (merging).

[TRN1, TRN2 \(predicates\)](#): Interleave even or odd elements from two predicates.

[TRN1, TRN2 \(vectors\)](#): Interleave even or odd elements from two vectors.

[UABA](#): Unsigned absolute difference and accumulate.

[UABALB](#): Unsigned absolute difference and accumulate long (bottom).

[UABALT](#): Unsigned absolute difference and accumulate long (top).

[UABD](#): Unsigned absolute difference (predicated).

[UABDLB](#): Unsigned absolute difference long (bottom).

[UABDLT](#): Unsigned absolute difference long (top).

[UADALP](#): Unsigned add and accumulate long pairwise.

[UADDLB](#): Unsigned add long (bottom).

[UADDLT](#): Unsigned add long (top).

[UADDV](#): Unsigned add reduction to scalar.

[UADDWB](#): Unsigned add wide (bottom).

[UADDWT](#): Unsigned add wide (top).

[UCVTF](#): Unsigned integer convert to floating-point (predicated).

[UDIV](#): Unsigned divide (predicated).

[UDIVR](#): Unsigned reversed divide (predicated).

[UDOT \(indexed\)](#): Unsigned integer indexed dot product.

[UDOT \(vectors\)](#): Unsigned integer dot product.

[UHADD](#): Unsigned halving addition.

[UHSUB](#): Unsigned halving subtract.

[UHSUBR](#): Unsigned halving subtract reversed vectors.

[UMAX \(immediate\)](#): Unsigned maximum with immediate (unpredicated).

[UMAX \(vectors\)](#): Unsigned maximum vectors (predicated).

[UMAXP](#): Unsigned maximum pairwise.

[UMAXV](#): Unsigned maximum reduction to scalar.

[UMIN \(immediate\)](#): Unsigned minimum with immediate (unpredicated).

[UMIN \(vectors\)](#): Unsigned minimum vectors (predicated).

[UMINP](#): Unsigned minimum pairwise.

[UMINV](#): Unsigned minimum reduction to scalar.

[UMLALB \(indexed\)](#): Unsigned multiply-add long to accumulator (bottom, indexed).

[UMLALB \(vectors\)](#): Unsigned multiply-add long to accumulator (bottom).

[UMLALT \(indexed\)](#): Unsigned multiply-add long to accumulator (top, indexed).

[UMLALT \(vectors\)](#): Unsigned multiply-add long to accumulator (top).

[UMLSLB \(indexed\)](#): Unsigned multiply-subtract long from accumulator (bottom, indexed).

[UMLSLB \(vectors\)](#): Unsigned multiply-subtract long from accumulator (bottom).

[UMLSLT \(indexed\)](#): Unsigned multiply-subtract long from accumulator (top, indexed).

[UMLSLT \(vectors\)](#): Unsigned multiply-subtract long from accumulator (top).

[UMMLA](#): Unsigned integer matrix multiply-accumulate.

[UMULH \(predicated\)](#): Unsigned multiply returning high half (predicated).

[UMULH \(unpredicated\)](#): Unsigned multiply returning high half (unpredicated).

[UMULLB \(indexed\)](#): Unsigned multiply long (bottom, indexed).

[UMULLB \(vectors\)](#): Unsigned multiply long (bottom).

[UMULLT \(indexed\)](#): Unsigned multiply long (top, indexed).

[UMULLT \(vectors\)](#): Unsigned multiply long (top).

[UQADD \(immediate\)](#): Unsigned saturating add immediate (unpredicated).

[UQADD \(vectors, predicated\)](#): Unsigned saturating addition (predicated).

[UQADD \(vectors, unpredicated\)](#): Unsigned saturating add vectors (unpredicated).

[UQDECB](#): Unsigned saturating decrement scalar by multiple of 8-bit predicate constraint element count.

[UQDECD \(scalar\)](#): Unsigned saturating decrement scalar by multiple of 64-bit predicate constraint element count.

[UQDECD \(vector\)](#): Unsigned saturating decrement vector by multiple of 64-bit predicate constraint element count.

[UQDECH \(scalar\)](#): Unsigned saturating decrement scalar by multiple of 16-bit predicate constraint element count.

[UQDECH \(vector\)](#): Unsigned saturating decrement vector by multiple of 16-bit predicate constraint element count.

[UQDECP \(scalar\)](#): Unsigned saturating decrement scalar by count of true predicate elements.

[UQDECP \(vector\)](#): Unsigned saturating decrement vector by count of true predicate elements.

[UQDECW \(scalar\)](#): Unsigned saturating decrement scalar by multiple of 32-bit predicate constraint element count.

[UQDECW \(vector\)](#): Unsigned saturating decrement vector by multiple of 32-bit predicate constraint element count.

[UQINCB](#): Unsigned saturating increment scalar by multiple of 8-bit predicate constraint element count.

[UQINCD \(scalar\)](#): Unsigned saturating increment scalar by multiple of 64-bit predicate constraint element count.

[UQINCD \(vector\)](#): Unsigned saturating increment vector by multiple of 64-bit predicate constraint element count.

[UQINCH \(scalar\)](#): Unsigned saturating increment scalar by multiple of 16-bit predicate constraint element count.

[UQINCH \(vector\)](#): Unsigned saturating increment vector by multiple of 16-bit predicate constraint element count.

[UQINCP \(scalar\)](#): Unsigned saturating increment scalar by count of true predicate elements.

[UQINCP \(vector\)](#): Unsigned saturating increment vector by count of true predicate elements.

[UQINCW \(scalar\)](#): Unsigned saturating increment scalar by multiple of 32-bit predicate constraint element count.

[UQINCW \(vector\)](#): Unsigned saturating increment vector by multiple of 32-bit predicate constraint element count.

[UQRSHL](#): Unsigned saturating rounding shift left by vector (predicated).

[UQRSHLR](#): Unsigned saturating rounding shift left reversed vectors (predicated).

[UQRSHRNB](#): Unsigned saturating rounding shift right narrow by immediate (bottom).

[UQRSHRNT](#): Unsigned saturating rounding shift right narrow by immediate (top).

[UQSHL \(immediate\)](#): Unsigned saturating shift left by immediate.

[UQSHL \(vectors\)](#): Unsigned saturating shift left by vector (predicated).

[UQSHLR](#): Unsigned saturating shift left reversed vectors (predicated).

[UQSHRNB](#): Unsigned saturating shift right narrow by immediate (bottom).

[UQSHRNT](#): Unsigned saturating shift right narrow by immediate (top).

[UQSUB \(immediate\)](#): Unsigned saturating subtract immediate (unpredicated).

[UQSUB \(vectors, predicated\)](#): Unsigned saturating subtraction (predicated).

[UQSUB \(vectors, unpredicated\)](#): Unsigned saturating subtract vectors (unpredicated).

[UQSUBR](#): Unsigned saturating subtraction reversed vectors (predicated).

[UQXTNB](#): Unsigned saturating extract narrow (bottom).

[UQXTNT](#): Unsigned saturating extract narrow (top).

[URECPE](#): Unsigned reciprocal estimate (predicated).

[URHADD](#): Unsigned rounding halving addition.

[URSHL](#): Unsigned rounding shift left by vector (predicated).

[URSHLR](#): Unsigned rounding shift left reversed vectors (predicated).

[URSHR](#): Unsigned rounding shift right by immediate.

[URSQRTE](#): Unsigned reciprocal square root estimate (predicated).

[URSRA](#): Unsigned rounding shift right and accumulate (immediate).

[USDOT \(indexed\)](#): Unsigned by signed integer indexed dot product.

[USDOT \(vectors\)](#): Unsigned by signed integer dot product.

[USHLLB](#): Unsigned shift left long by immediate (bottom).

[USHLLT](#): Unsigned shift left long by immediate (top).

[USMMLA](#): Unsigned by signed integer matrix multiply-accumulate.

[USQADD](#): Unsigned saturating addition of signed value.

[USRA](#): Unsigned shift right and accumulate (immediate).

[USUBLB](#): Unsigned subtract long (bottom).

[USUBLT](#): Unsigned subtract long (top).

[USUBWB](#): Unsigned subtract wide (bottom).

[USUBWT](#): Unsigned subtract wide (top).

[UUNPKHL](#), [UUNPKLO](#): Unsigned unpack and extend half of vector.

[UXTB](#), [UXTH](#), [UXTW](#): Unsigned byte / halfword / word extend (predicated).

[UZP1](#), [UZP2 \(predicates\)](#): Concatenate even or odd elements from two predicates.

[UZP1](#), [UZP2 \(vectors\)](#): Concatenate even or odd elements from two vectors.

[WHILEGE](#): While decrementing signed scalar greater than or equal to scalar.

[WHILEGT](#): While decrementing signed scalar greater than scalar.

[WHILEHI](#): While decrementing unsigned scalar higher than scalar.

[WHILEHS](#): While decrementing unsigned scalar higher or same as scalar.

[WHILELE](#): While incrementing signed scalar less than or equal to scalar.

[WHILELO](#): While incrementing unsigned scalar lower than scalar.

[WHILELS](#): While incrementing unsigned scalar lower or same as scalar.

[WHILELT](#): While incrementing signed scalar less than scalar.

[WHILERW](#): While free of read-after-write conflicts.

[WHILEWR](#): While free of write-after-read/write conflicts.

[WRFFR](#): Write the first-fault register.

[XAR](#): Bitwise exclusive OR and rotate right by immediate.

[ZIP1](#), [ZIP2 \(predicates\)](#): Interleave elements from two half predicates.

[ZIP1](#), [ZIP2 \(vectors\)](#): Interleave elements from two half vectors.

ABS

Absolute value (predicated).

Compute the absolute value of the signed integer in each active element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	0	1	1	0	0	1	0	1	Pg	Zn				Zd							

SVE

ABS <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    integer element = SInt(Elem[operand, e, esize]);
    if ElemP[mask, e, esize] == '1' then
        element = Abs(element);
        Elem[result, e, esize] = element<esize-1:0>;
Z[d] = result;
```

Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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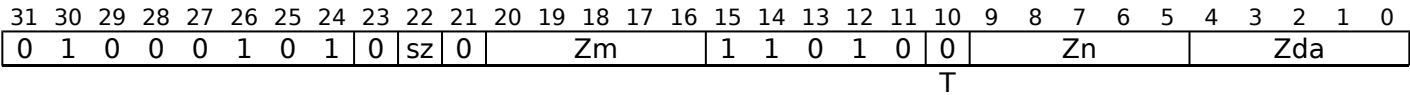
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# ADCLB

Add with carry long (bottom).

Add the even-numbered elements of the first source vector and the 1-bit carry from the least-significant bit of the odd-numbered elements of the second source vector to the even-numbered elements of the destination and accumulator vector. The 1-bit carry output is placed in the corresponding odd-numbered element of the destination vector.



## SVE2

ADCLB <Zda>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32 << UInt(sz);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <T> Is the size specifier, encoded in "sz":

sz	<T>
0	S
1	D

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer pairs = VL DIV (esize * 2);
bits(VL) operand = Z[n];
bits(VL) carries = Z[m];
bits(VL) result = Z[da];

for p = 0 to pairs-1
    bits(esize) element1 = Elem[result, 2*p + 0, esize];
    bits(esize) element2 = Elem[operand, 2*p + 0, esize];
    bit carry_in = Elem[carries, 2*p + 1, esize]<0>;

    (res, nzcvc) = AddWithCarry(element1, element2, carry_in);
    carry_out = nzcvc<1>;

    Elem[result, 2*p + 0, esize] = res;
    Elem[result, 2*p + 1, esize] = ZeroExtend(carry_out);

Z[da] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.

- The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

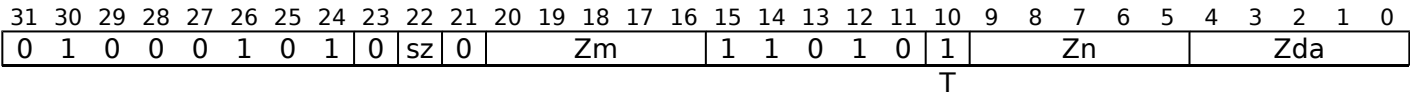
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# ADCLT

Add with carry long (top).

Add the odd-numbered elements of the first source vector and the 1-bit carry from the least-significant bit of the odd-numbered elements of the second source vector to the even-numbered elements of the destination and accumulator vector. The 1-bit carry output is placed in the corresponding odd-numbered element of the destination vector.



## SVE2

ADCLT <Zda>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32 << UInt(sz);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

<Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.

<T> Is the size specifier, encoded in "sz":

sz	<T>
0	S
1	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer pairs = VL DIV (esize * 2);
bits(VL) operand = Z[n];
bits(VL) carries = Z[m];
bits(VL) result = Z[da];

for p = 0 to pairs-1
    bits(esize) element1 = Elem[result, 2*p + 0, esize];
    bits(esize) element2 = Elem[operand, 2*p + 1, esize];
    bit carry_in = Elem[carries, 2*p + 1, esize]<0>;

    (res, nzcvc) = AddWithCarry(element1, element2, carry_in);
    carry_out = nzcvc<1>;

    Elem[result, 2*p + 0, esize] = res;
    Elem[result, 2*p + 1, esize] = ZeroExtend(carry_out);

Z[da] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.

- The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# ADD (vectors, predicated)

Add vectors (predicated).

Add active elements of the second source vector to corresponding elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	0	0	0	0	0	0	0	0	0	Pg	Zm				Zdn							

## SVE

ADD <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = element1 + element2;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:

- The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
- The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# ADD (immediate)

Add immediate (unpredicated).

Add an unsigned immediate to each element of the source vector, and destructively place the results in the corresponding elements of the source vector. This instruction is unpredicated.

The immediate is an unsigned value in the range 0 to 255, and for element widths of 16 bits or higher it may also be a positive multiple of 256 in the range 256 to 65280.

The immediate is encoded in 8 bits with an optional left shift by 8. The preferred disassembly when the shift option is specified is "#<uimm8>, LSL #8". However an assembler and disassembler may also allow use of the shifted 16-bit value unless the immediate is 0 and the shift amount is 8, which must be unambiguously described as "#0, LSL #8".

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size		1	0	0	0	0	0	1	1	sh	imm8								Zdn				

## SVE

ADD <Zdn>.<T>, <Zdn>.<T>, #<imm>{, <shift>}

```
if !HaveSVE() then UNDEFINED;
if size:sh == '001' then UNDEFINED;
integer esize = 8 << UInt(size);
integer dn = UInt(Zdn);
integer imm = UInt(imm8);
if sh == '1' then imm = imm << 8;
```

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<imm> Is an unsigned immediate in the range 0 to 255, encoded in the "imm8" field.

<shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #8

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    Elem[result, e, esize] = element1 + imm;

Z[dn] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a **MOVPRFX** instruction. The **MOVPRFX** instruction must conform to all of the following requirements, otherwise the behavior of the **MOVPRFX** and this instruction is UNPREDICTABLE:

- The **MOVPRFX** instruction must be unpredicated.
- The **MOVPRFX** instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# ADD (vectors, unpredicated)

Add vectors (unpredicated).

Add all elements of the second source vector to corresponding elements of the first source vector and place the results in the corresponding elements of the destination vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	0	0	0	0	1	0	0	size	1	Zm						0	0	0	0	0	0	Zn						Zd					

## SVE

ADD <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = element1 + element2;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

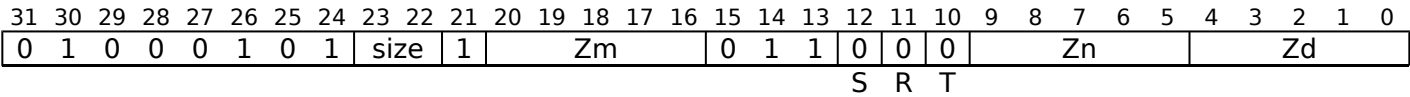
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ADDHNB

Add narrow high part (bottom).

Add each vector element of the first source vector to the corresponding vector element of the second source vector, and place the most significant half of the result in the even-numbered half-width destination elements, while setting the odd-numbered elements to zero. This instruction is unpredicated.



SVE2

```
ADDHNB <Zd>.<T>, <Zn>.<Tb>, <Zm>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	B
10	H
11	S

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	H
10	S
11	D

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;
integer halfesize = esize DIV 2;

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, e, esize]);
    integer res = (element1 + element2) >> halfesize;
    Elem[result, 2*e + 0, halfesize] = res<halfesize-1:0>;
    Elem[result, 2*e + 1, halfesize] = Zeros();

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

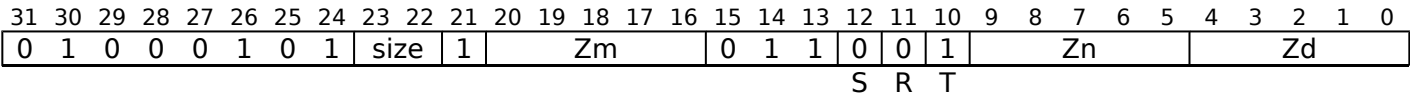
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ADDHNT

Add narrow high part (top).

Add each vector element of the first source vector to the corresponding vector element of the second source vector, and place the most significant half of the result in the odd-numbered half-width destination elements, leaving the even-numbered elements unchanged. This instruction is unpredicated.



SVE2

```
ADDHNT <Zd>.<T>, <Zn>.<Tb>, <Zm>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	B
10	H
11	S

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	H
10	S
11	D

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[d];
integer halfesize = esize DIV 2;

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, e, esize]);
    integer res = (element1 + element2) >> halfesize;
    Elem[result, 2*e + 1, halfesize] = res<halfesize-1:0>;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

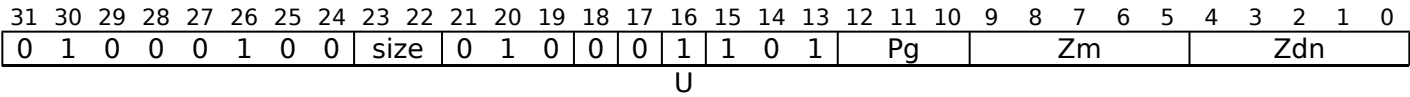
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ADDP

Add pairwise.

Add pairs of adjacent elements within each source vector, and interleave the results from corresponding lanes. The interleaved result values are destructively placed in the first source vector.



SVE2

ADDP <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer m = UInt(Zm);
integer dn = UInt(Zdn);
```

Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;
integer element1;
integer element2;

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '0' then
    Elem[result, e, esize] = Elem[operand1, e, esize];
  else
    if IsEven(e) then
      element1 = UInt(Elem[operand1, e + 0, esize]);
      element2 = UInt(Elem[operand1, e + 1, esize]);
    else
      element1 = UInt(Elem[operand2, e - 1, esize]);
      element2 = UInt(Elem[operand2, e + 0, esize]);
    integer res = element1 + element2;
    Elem[result, e, esize] = res<esize-1:0>;

Z[dn] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# ADDPL

Add multiple of predicate register size to scalar register.

Add the current predicate register size in bytes multiplied by an immediate in the range -32 to 31 to the 64-bit source general-purpose register or current stack pointer and place the result in the 64-bit destination general-purpose register or current stack pointer.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	1	1	Rn				0	1	0	1	0	imm6						Rd					

## SVE

ADDPL <Xd|SP>, <Xn|SP>, #<imm>

```
if !HaveSVE() then UNDEFINED;
integer n = UInt(Rn);
integer d = UInt(Rd);
integer imm = SInt(imm6);
```

## Assembler Symbols

- <Xd|SP> Is the 64-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Xn|SP> Is the 64-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.
- <imm> Is the signed immediate operand, in the range -32 to 31, encoded in the "imm6" field.

## Operation

```
CheckSVEEnabled();
bits(64) operand1 = if n == 31 then SP[] else X[n];
bits(64) result = operand1 + (imm * (PL DIV 8));

if d == 31 then
    SP[] = result;
else
    X[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.



## ADDVL

Add multiple of vector register size to scalar register.

Add the current vector register size in bytes multiplied by an immediate in the range -32 to 31 to the 64-bit source general-purpose register or current stack pointer, and place the result in the 64-bit destination general-purpose register or current stack pointer.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	1	Rn				0	1	0	1	0	imm6						Rd					

## SVE

ADDVL <Xd|SP>, <Xn|SP>, #<imm>

```
if !HaveSVE() then UNDEFINED;
integer n = UInt(Rn);
integer d = UInt(Rd);
integer imm = SInt(imm6);
```

## Assembler Symbols

- <Xd|SP> Is the 64-bit name of the destination general-purpose register or stack pointer, encoded in the "Rd" field.
- <Xn|SP> Is the 64-bit name of the source general-purpose register or stack pointer, encoded in the "Rn" field.
- <imm> Is the signed immediate operand, in the range -32 to 31, encoded in the "imm6" field.

## Operation

```
CheckSVEEnabled();
bits(64) operand1 = if n == 31 then SP[] else X[n];
bits(64) result = operand1 + (imm * (VL DIV 8));

if d == 31 then
    SP[] = result;
else
    X[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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## ADR

Compute vector address.

Optionally sign or zero-extend the least significant 32-bits of each element from a vector of offsets or indices in the second source vector, scale each index by 2, 4 or 8, add to a vector of base addresses from the first source vector, and place the resulting addresses in the destination vector. This instruction is unpredicated.

It has encodings from 3 classes: [Packed offsets](#) , [Unpacked 32-bit signed offsets](#) and [Unpacked 32-bit unsigned offsets](#)

### Packed offsets

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	sz	1			Zm			1	0	1	0	msz				Zn					Zd		

### Packed offsets

ADR <Zd>.<T>, [<Zn>.<T>, <Zm>.<T>{, <mod> <amount>}]

```
if !HaveSVE() then UNDEFINED;
integer esize = 32 << UInt(sz);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer osize = esize;
boolean unsigned = TRUE;
integer mbytes = 1 << UInt(msz);
```

### Unpacked 32-bit signed offsets

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	1			Zm			1	0	1	0	msz				Zn					Zd		

### Unpacked 32-bit signed offsets

ADR <Zd>.D, [<Zn>.D, <Zm>.D, SXTW{ <amount>}]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer osize = 32;
boolean unsigned = FALSE;
integer mbytes = 1 << UInt(msz);
```

### Unpacked 32-bit unsigned offsets

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	1	1			Zm			1	0	1	0	msz				Zn					Zd		

Unpacked 32-bit unsigned offsets

```
ADR <Zd>.D, [<Zn>.D, <Zm>.D, UXTW{ <amount>}]
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer osize = 32;
boolean unsigned = TRUE;
integer mbytes = 1 << UInt(msz);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "sz":

sz	<T>
0	S
1	D

<Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.

<mod> Is the index extend and shift specifier, encoded in "msz":

msz	<mod>
00	[absent]
x1	LSL
10	LSL

<amount> Is the index shift amount, encoded in "msz":

msz	<amount>
00	[absent]
01	#1
10	#2
11	#3

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) base = Z[n];
bits(VL) offs = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) addr = Elem[base, e, esize];
    integer offset = Int(Elem[offs, e, esize]<osize-1:0>, unsigned);
    Elem[result, e, esize] = addr + (offset * mbytes);

Z[d] = result;
```

Operational information

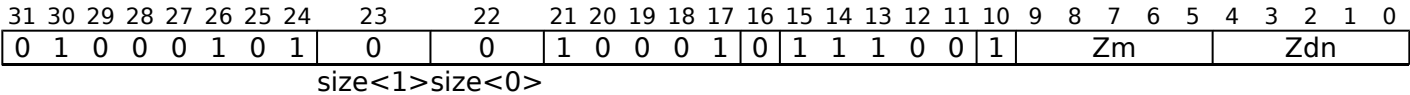
- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# AESD

AES single round decryption.

The AESD instruction reads a 16-byte state array from each 128-bit segment of the first source vector, together with a round key from the corresponding 128-bit segment of the second source vector. Each state array undergoes a single round of the ADDROUNDKEY(), INVSUBBYTES() and INVSHIFROWS() transformations in accordance with the AES standard. Each updated state array is destructively placed in the corresponding segment of the first source vector. This instruction is unpredicated.

ID\_AA64ZFR0\_EL1.AES indicates whether this instruction is implemented.



## SVE2

AESD <Zdn>.B, <Zdn>.B, <Zm>.B

```
if !HaveSVE2AES() then UNDEFINED;
integer m = UInt(Zm);
integer dn = UInt(Zdn);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer segments = VL DIV 128;
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

result = operand1 EOR operand2;
for s = 0 to segments-1
    Elem[result, s, 128] = AESInvSubBytes(AESInvShiftRows(Elem[result, s, 128]));
Z[dn] = result;
```

## Operational information

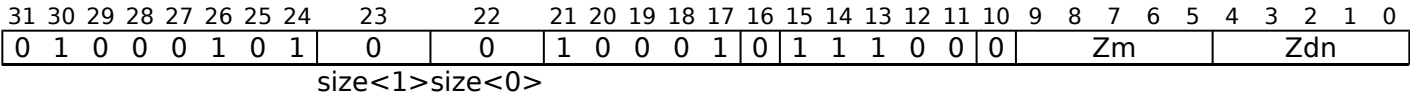
- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# AESE

AES single round encryption.

The AESE instruction reads a 16-byte state array from each 128-bit segment of the first source vector together with a round key from the corresponding 128-bit segment of the second source vector. Each state array undergoes a single round of the ADDROUNDKEY(), SUBBYTES() and SHIFTRROWS() transformations in accordance with the AES standard. Each updated state array is destructively placed in the corresponding segment of the first source vector. This instruction is unpredicated.

ID\_AA64ZFR0\_EL1.AES indicates whether this instruction is implemented.



## SVE2

AESE <Zdn>.B, <Zdn>.B, <Zm>.B

```

if !HaveSVE2AES() then UNDEFINED;
integer m = UInt(Zm);
integer dn = UInt(Zdn);
  
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```

CheckSVEEnabled();
integer segments = VL DIV 128;
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

result = operand1 EOR operand2;
for s = 0 to segments-1
    Elem[result, s, 128] = AESSubBytes(AESShiftRows(Elem[result, s, 128]));
Z[dn] = result;
  
```

## Operational information

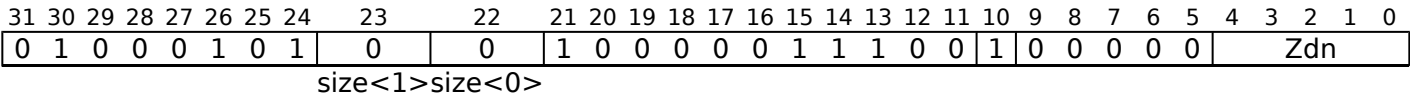
- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# AESIMC

AES inverse mix columns.

The AESIMC instruction reads a 16-byte state array from each 128-bit segment of the source register, and performs a single round of the INVMIXCOLUMNS() transformation on each state array in accordance with the AES standard. Each updated state array is destructively placed in the corresponding segment of the first source vector. This instruction is unpredicated.

ID\_AA64ZFR0\_EL1.AES indicates whether this instruction is implemented.



## SVE2

AESIMC <Zdn>.B, <Zdn>.B

```
if !HaveSVE2AES() then UNDEFINED;
integer dn = UInt(Zdn);
```

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

## Operation

```
CheckSVEEnabled();
integer segments = VL DIV 128;
bits(VL) operand = Z[dn];
bits(VL) result;

for s = 0 to segments-1
    Elem[result, s, 128] = AESInvMixColumns(Elem[operand, s, 128]);

Z[dn] = result;
```

## Operational information

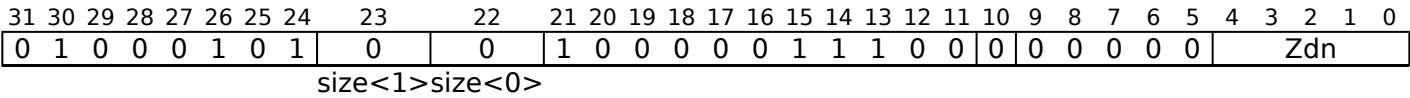
- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# AESMC

AES mix columns.

The AESMC instruction reads a 16-byte state array from each 128-bit segment of the source register, and performs a single round of the MIXCOLUMNS() transformation on each state array in accordance with the AES standard. Each updated state array is destructively placed in the corresponding segment of the first source vector. This instruction is unpredicated.

ID\_AA64ZFR0\_EL1.AES indicates whether this instruction is implemented.



## SVE2

AESMC <Zdn>.B, <Zdn>.B

```
if !HaveSVE2AES() then UNDEFINED;
integer dn = UInt(Zdn);
```

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

## Operation

```
CheckSVEEnabled();
integer segments = VL DIV 128;
bits(VL) operand = Z[dn];
bits(VL) result;

for s = 0 to segments-1
    Elem[result, s, 128] = AESMixColumns(Elem[operand, s, 128]);

Z[dn] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

## AND, ANDS (predicates)

Bitwise AND predicates.

Bitwise AND active elements of the second source predicate with corresponding elements of the first source predicate and place the results in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Optionally sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

This instruction is used by the aliases [MOVS \(predicated\)](#), and [MOV \(predicate, predicated, zeroing\)](#).

It has encodings from 2 classes: [Not setting the condition flags](#) and [Setting the condition flags](#)

### Not setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	0	0	0	Pm				0	1	Pg				0	Pn				0	Pd			
S																															

### Not setting the condition flags

AND <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = FALSE;
```

### Setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	1	0	0	Pm				0	1	Pg				0	Pn				0	Pd			
S																															

### Setting the condition flags

ANDS <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = TRUE;
```

### Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.
- <Pm> Is the name of the second source scalable predicate register, encoded in the "Pm" field.

### Alias Conditions

Alias	Is preferred when
<a href="#">MOVS (predicated)</a>	S == '1' && Pn == Pm



Alias	Is preferred when
<a href="#">MOV (predicate, predicated, zeroing)</a>	<code>S == '0' &amp;&amp; Pn == Pm</code>

## Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(PL) operand1 = P[n];
bits(PL) operand2 = P[m];
bits(PL) result;

for e = 0 to elements-1
    bit element1 = ElemP[operand1, e, esize];
    bit element2 = ElemP[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        ElemP[result, e, esize] = element1 AND element2;
    else
        ElemP[result, e, esize] = '0';

if setflags then
    PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

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## AND (vectors, predicated)

Bitwise AND vectors (predicated).

Bitwise AND active elements of the second source vector with corresponding elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	0	1	0	0	0	0		Pg												

### SVE

AND <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

### Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = element1 AND element2;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

### Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:

- The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
- The values of the NZCV flags.

This instruction might be immediately preceded in program order by a **MOVPRFX** instruction. The **MOVPRFX** instruction must conform to all of the following requirements, otherwise the behavior of the **MOVPRFX** and this instruction is UNPREDICTABLE:

- The **MOVPRFX** instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The **MOVPRFX** instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# AND (immediate)

Bitwise AND with immediate (unpredicated).

Bitwise AND an immediate with each 64-bit element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate is a 64-bit value consisting of a single run of ones or zeros repeating every 2, 4, 8, 16, 32 or 64 bits. This instruction is unpredicated.

This instruction is used by the pseudo-instruction [BIC \(immediate\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	1	0	0	0	0	0	imm13														Zdn			

## SVE

AND <Zdn>.<T>, <Zdn>.<T>, #<const>

```
if !HaveSVE() then UNDEFINED;
integer dn = UInt(Zdn);
bits(64) imm;
(imm, -) = DecodeBitMasks(imm13<12>, imm13<5:0>, imm13<11:6>, TRUE);
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "imm13<12>:imm13<5:0>":

imm13<12>	imm13<5:0>	<T>
0	0xxxxx	S
0	10xxxx	H
0	110xxx	B
0	1110xx	B
0	11110x	B
0	111110	RESERVED
0	111111	RESERVED
1	xxxxxx	D

- <const> Is a 64, 32, 16 or 8-bit bitmask consisting of replicated 2, 4, 8, 16, 32 or 64 bit fields, each field containing a rotated run of non-zero bits, encoded in the "imm13" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV 64;
bits(VL) operand = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    bits(64) element1 = Elem[operand, e, 64];
    Elem[result, e, 64] = element1 AND imm;

Z[dn] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# AND (vectors, unpredicated)

Bitwise AND vectors (unpredicated).

Bitwise AND all elements of the second source vector with corresponding elements of the first source vector and place the results in the corresponding elements of the destination vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	1					Zm		0	0	1	1	0	0							Zd		

## SVE

AND <Zd>.D, <Zn>.D, <Zm>.D

```
if !HaveSVE() then UNDEFINED;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];

Z[d] = operand1 AND operand2;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

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ANDV

Bitwise AND reduction to scalar.

Bitwise AND horizontally across all lanes of a vector, and place the result in the SIMD&FP scalar destination register. Inactive elements in the source vector are treated as all ones.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	0	1	0	0	0	1	Pg				Zn				Vd					

SVE

```
ANDV <V><d>, <Pg>, <Zn>.<T>

if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);
```

Assembler Symbols

- <V>

Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D
- <d>

Is the number [0-31] of the destination SIMD&FP register, encoded in the "Vd" field.
- <Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn>

Is the name of the source scalable vector register, encoded in the "Zn" field.
- <T>

Is the size specifier, encoded in “size”:

size	<T>
00	B
01	H
10	S
11	D

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(esize) result = Ones(esize);

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        result = result AND Elem[operand, e, esize];

V[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:

- The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
- The values of the NZCV flags.

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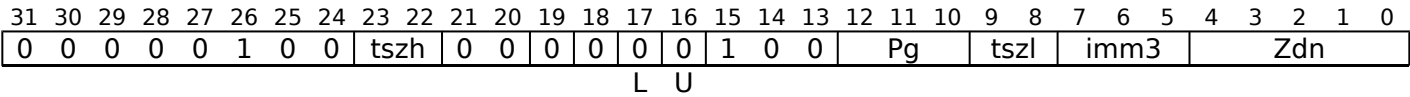
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## ASR (immediate, predicated)

Arithmetic shift right by immediate (predicated).

Shift right by immediate, preserving the sign bit, each active element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate shift amount is an unsigned value in the range 1 to number of bits per element. Inactive elements in the destination vector register remain unmodified.



### SVE

ASR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, #<const>

```
if !HaveSVE() then UNDEFINED;
bits(4) tsize = tszh:tszl;
case tsize of
  when '0000' UNDEFINED;
  when '0001' esize = 8;
  when '001x' esize = 16;
  when '01xx' esize = 32;
  when '1xxx' esize = 64;
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer shift = (2 * esize) - UInt(tsize:imm3);
```

### Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
00	00	RESERVED
00	01	B
00	1x	H
01	xx	S
1x	xx	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <const> Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(PL) mask = P[g];
bits(VL) result;

for e = 0 to elements-1
  bits(esize) element1 = Elem[operand1, e, esize];
  if ElemP[mask, e, esize] == '1' then
    Elem[result, e, esize] = ASR(element1, shift);
  else
    Elem[result, e, esize] = Elem[operand1, e, esize];
Z[dn] = result;
```

### Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

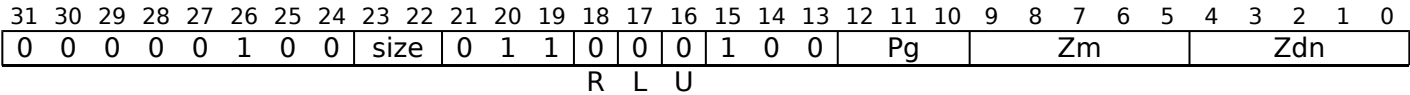
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ASR (wide elements, predicated)

Arithmetic shift right by 64-bit wide elements (predicated).

Shift right, preserving the sign bit, active elements of the first source vector by corresponding overlapping 64-bit elements of the second source vector and destructively place the results in the corresponding elements of the first source vector. The shift amount is a vector of unsigned 64-bit doubleword elements in which all bits are significant, and not used modulo the destination element size. Inactive elements in the destination vector register remain unmodified.



SVE

ASR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.D

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	RESERVED

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(64) element2 = Elem[operand2, (e * esize) DIV 64, 64];
    integer shift = Min(UInt(element2), esize);
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = ASR(element1, shift);
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];
Z[dn] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:

- The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and destination element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

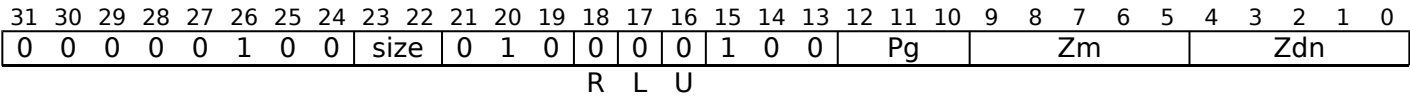
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# ASR (vectors)

Arithmetic shift right by vector (predicated).

Shift right, preserving the sign bit, active elements of the first source vector by corresponding elements of the second source vector and destructively place the results in the corresponding elements of the first source vector. The shift amount operand is a vector of unsigned elements in which all bits are significant, and not used modulo the element size. Inactive elements in the destination vector register remain unmodified.



## SVE

ASR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    integer shift = Min(UInt(element2), esize);
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = ASR(element1, shift);
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];
Z[dn] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.

- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

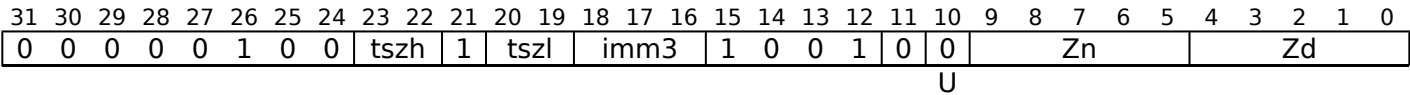
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ASR (immediate, unpredicated)

Arithmetic shift right by immediate (unpredicated).

Shift right by immediate, preserving the sign bit, each element of the source vector, and place the results in the corresponding elements of the destination vector. The immediate shift amount is an unsigned value in the range 1 to number of bits per element. This instruction is unpredicated.



SVE

ASR <Zd>.<T>, <Zn>.<T>, #<const>

```
if !HaveSVE() then UNDEFINED;
bits(4) tsize = tszh:tszl;
case tsize of
  when '0000' UNDEFINED;
  when '0001' esize = 8;
  when '001x' esize = 16;
  when '01xx' esize = 32;
  when '1xxx' esize = 64;
integer n = UInt(Zn);
integer d = UInt(Zd);
integer shift = (2 * esize) - UInt(tsize:imm3);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
00	00	RESERVED
00	01	B
00	1x	H
01	xx	S
1x	xx	D

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<const> Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) result;

for e = 0 to elements-1
  bits(esize) element1 = Elem[operand1, e, esize];
  Elem[result, e, esize] = ASR(element1, shift);

Z[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:

- The values of the data supplied in any of its registers.
- The values of the NZCV flags.

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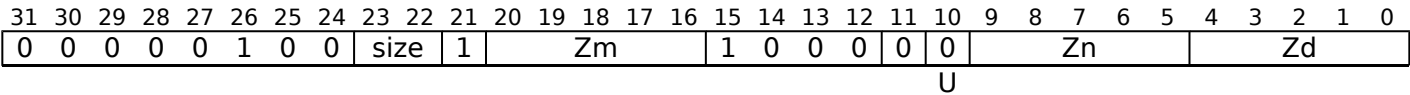
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ASR (wide elements, unpredicated)

Arithmetic shift right by 64-bit wide elements (unpredicated).

Shift right, preserving the sign bit, all elements of the first source vector by corresponding overlapping 64-bit elements of the second source vector and place the first in the corresponding elements of the destination vector. The shift amount is a vector of unsigned 64-bit doubleword elements in which all bits are significant, and not used modulo the destination element size. This instruction is unpredicated.



SVE

ASR <Zd>.<T>, <Zn>.<T>, <Zm>.D

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	RESERVED

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(64) element2 = Elem[operand2, (e * esize) DIV 64, 64];
    integer shift = Min(UInt(element2), esize);
    Elem[result, e, esize] = ASR(element1, shift);

Z[d] = result;
```

Operational information

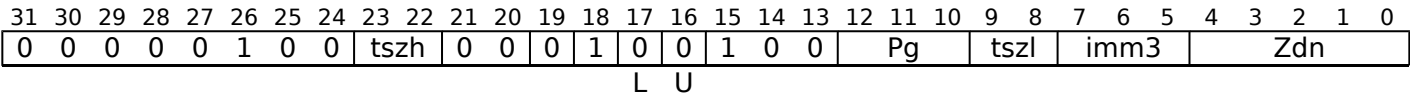
- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.



ASRD

Arithmetic shift right for divide by immediate (predicated).

Shift right by immediate, preserving the sign bit, each active element of the source vector, and destructively place the results in the corresponding elements of the source vector. The result rounds toward zero as in a signed division. The immediate shift amount is an unsigned value in the range 1 to number of bits per element. Inactive elements in the destination vector register remain unmodified.



SVE

ASRD <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, #<const>

```
if !HaveSVE() then UNDEFINED;
bits(4) tsize = tszh:tszl;
case tsize of
  when '0000' UNDEFINED;
  when '0001' esize = 8;
  when '001x' esize = 16;
  when '01xx' esize = 32;
  when '1xxx' esize = 64;
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer shift = (2 * esize) - UInt(tsize:imm3);
```

Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
00	00	RESERVED
00	01	B
00	1x	H
01	xx	S
1x	xx	D
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <const> Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
  integer element1 = SInt(Elem[operand1, e, esize]);
  if ElemP[mask, e, esize] == '1' then
    if element1 < 0 then
      element1 = element1 + ((1 << shift) - 1);
    Elem[result, e, esize] = (element1 >> shift)<esize-1:0>;
  else
    Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

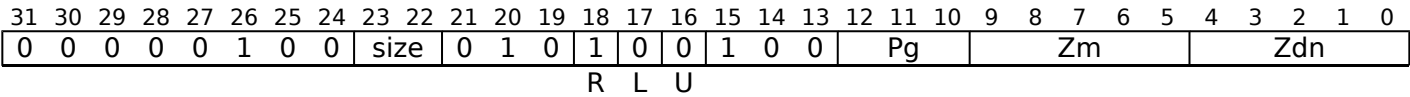
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ASRR

Reversed arithmetic shift right by vector (predicated).

Reversed shift right, preserving the sign bit, active elements of the second source vector by corresponding elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. The shift amount operand is a vector of unsigned elements in which all bits are significant, and not used modulo the element size. Inactive elements in the destination vector register remain unmodified.



SVE

ASRR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    integer shift = Min(UInt(element1), esize);
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = ASR(element2, shift);
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.

- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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BCAX

Bitwise clear and exclusive OR.

Bitwise AND elements of the second source vector with the corresponding inverted elements of the third source vector, then exclusive OR the results with corresponding elements of the first source vector. The final results are destructively placed in the corresponding elements of the destination and first source vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	1	1	Zm				0	0	1	1	1	0	Zk				Zdn						

SVE2

BCAX <Zdn>.D, <Zdn>.D, <Zm>.D, <Zk>.D

```
if !HaveSVE2() then UNDEFINED;
integer m = UInt(Zm);
integer k = UInt(Zk);
integer dn = UInt(Zdn);
```

Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <Zk> Is the name of the third source scalable vector register, encoded in the "Zk" field.

Operation

```
CheckSVEEnabled();
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[k];

Z[dn] = operand1 EOR (operand2 AND NOT(operand3));
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

BDEP

Scatter lower bits into positions selected by bitmask.

This instruction scatters the lowest-numbered contiguous bits within each element of the first source vector to the bit positions indicated by non-zero bits in the corresponding mask element of the second source vector, preserving their order, and set the bits corresponding to a zero mask bit to zero. This instruction is unpredicated.  
ID\_AA64ZFR0\_EL1.BitPerm indicates whether this instruction is implemented.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	size		0	Zm				1	0	1	1	0	1	Zn				Zd						

SVE2

BDEP <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE2BitPerm() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) data = Z[n];
bits(VL) mask = Z[m];
bits(VL) result;

for e = 0 to elements - 1
    Elem[result, e, esize] = BitDeposit(Elem[data, e, esize], Elem[mask, e, esize]);

Z[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.



BEXT

Gather lower bits from positions selected by bitmask.

This instruction gathers bits in each element of the first source vector from the bit positions indicated by non-zero bits in the corresponding mask element of the second source vector to the lowest-numbered contiguous bits of the corresponding destination element, preserving their order, and sets the remaining higher-numbered bits to zero. This instruction is unpredicated.

ID\_AA64ZFR0\_EL1.BitPerm indicates whether this instruction is implemented.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	size	0	Zm						1	0	1	1	0	0	Zn						Zd			

SVE2

BEXT <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE2BitPerm() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) data = Z[n];
bits(VL) mask = Z[m];
bits(VL) result;

for e = 0 to elements - 1
    Elem[result, e, esize] = BitExtract(Elem[data, e, esize], Elem[mask, e, esize]);

Z[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# BFCVT

Floating-point down convert to BFloat16 format (predicated).

Convert to BFloat16 from single-precision in each active floating-point element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

Since the result type is smaller than the input type, the results are zero-extended to fill each destination element.

Unlike the BFloat16 matrix multiplication and dot product instructions, this instruction honors all of the FPCR bits that apply to single-precision arithmetic. It can also generate a floating-point exception that causes cumulative exception bits in the FPSR to be set, or a synchronous exception to be taken, depending on the enable bits in the FPCR.

ID\_AA64ZFR0\_EL1.BF16 indicates whether this instruction is implemented.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	1	0	0	0	1	0	1	0	1	0	1	Pg			Zn			Zd						

## SVE

BFCVT <Zd>.H, <Pg>/M, <Zn>.S

```
if !HaveSVE() || !HaveBF16Ext() then UNDEFINED;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV 32;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    bits(32) element = Elem[operand, e, 32];
    if ElemP[mask, e, 32] == '1' then
        Elem[result, 2*e, 16] = FPConvertBF(element, FPCR<31:0>);
        Elem[result, 2*e+1, 16] = Zeros();

Z[d] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

BFCVTNT

Floating-point down convert and narrow to BFloat16 (top, predicated).

Convert active 32-bit single-precision elements from the source vector to BFloat16 format, and place the results in the odd-numbered 16-bit elements of the destination vector, leaving the even-numbered elements unchanged. Inactive elements in the destination vector register remain unmodified.

Unlike the BFloat16 matrix multiplication and dot product instructions, this instruction honors all of the FPCR bits that apply to single-precision arithmetic. It can also generate a floating-point exception that causes cumulative exception bits in the FPSR to be set, or a synchronous exception to be taken, depending on the enable bits in the FPCR.

ID\_AA64ZFR0\_EL1.BF16 indicates whether this instruction is implemented.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	1	0	0	0	1	0	1	0	1	0	1	Pg			Zn			Zd						

SVE

BFCVTNT <Zd>.H, <Pg>/M, <Zn>.S

```
if !HaveSVE() || !HaveBF16Ext() then UNDEFINED;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV 32;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    bits(32) element = Elem[operand, e, 32];
    if ElemP[mask, e, 32] == '1' then
        Elem[result, 2*e+1, 16] = FPConvertBF(element, FPCR<31:0>);
Z[d] = result;
```

# BFDOT (vectors)

BFloat16 floating-point dot product.

The BFloat16 floating-point (BF16) dot product instruction computes the dot product of a pair of BF16 values held in each 32-bit element of the first source vector multiplied by a pair of BF16 values in the corresponding 32-bit element of the second source vector, and then destructively adds the single-precision dot product to the corresponding single-precision element of the destination vector.

This instruction is unpredicated.

All floating-point calculations performed by this instruction are performed with the following behaviors, irrespective of the value in FPCR:

\* Uses the non-IEEE 754 Round-to-Odd mode, which forces bit 0 of an inexact result to 1, and rounds an overflow to an appropriately signed Infinity.

\* The cumulative FPSR exception bits (IDC, IXC, UFC, OFC, DZC and IOC) are not modified.

\* Trapped floating-point exceptions are disabled, as if the FPCR trap enable bits (IDE, IXE, UFE, OFE, DZE and IOE) are all zero.

\* Denormalized inputs and results are flushed to zero, as if FPCR.FZ == 1.

\* Only the Default NaN is generated, as if FPCR.DN == 1.

ID\_AA64ZFR0\_EL1.BF16 indicates whether this instruction is implemented.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	0	1	1	Zm				1	0	0	0	0	0	Zn				Zda						

## SVE

BFDOT <Zda>.S, <Zn>.H, <Zm>.H

```
if !HaveSVE() || !HaveBF16Ext() then UNDEFINED;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

- <Zda>
- Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn>
- Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm>
- Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV 32;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    bits(16) elt1_a = Elem[operand1, 2 * e + 0, 16];
    bits(16) elt1_b = Elem[operand1, 2 * e + 1, 16];
    bits(16) elt2_a = Elem[operand2, 2 * e + 0, 16];
    bits(16) elt2_b = Elem[operand2, 2 * e + 1, 16];

    bits(32) sum = BFAdd(BFMul(elt1_a, elt2_a), BFMul(elt1_b, elt2_b));
    Elem[result, e, 32] = BFAdd(Elem[operand3, e, 32], sum);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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BFDOT (indexed)

BFloat16 floating-point indexed dot product.

The BFloat16 floating-point (BF16) indexed dot product instruction computes the dot product of a pair of BF16 values held in each 32-bit element of the first source vector multiplied by a pair of BF16 values in an indexed 32-bit element of the second source vector, and then destructively adds the single-precision dot product to the corresponding single-precision element of the destination vector.

The BF16 pairs within the second source vector are specified using an immediate index which selects the same BF16 pair position within each 128-bit vector segment. The index range is from 0 to 3. This instruction is unpredicated.

All floating-point calculations performed by this instruction are performed with the following behaviors, irrespective of the value in FPCR:

- \* Uses the non-IEEE 754 Round-to-Odd mode, which forces bit 0 of an inexact result to 1, and rounds an overflow to an appropriately signed Infinity.
- \* The cumulative FPSR exception bits (IDC, IXC, UFC, OFC, DZC and IOC) are not modified.
- \* Trapped floating-point exceptions are disabled, as if the FPCR trap enable bits (IDE, IXE, UFE, OFE, DZE and IOE) are all zero.
- \* Denormalized inputs and results are flushed to zero, as if FPCR.FZ == 1.
- \* Only the Default NaN is generated, as if FPCR.DN == 1.

ID\_AA64ZFR0\_EL1.BF16 indicates whether this instruction is implemented.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	1	1	0	0	1	0	0	0	1	1	i2		Zm			0	1	0	0	0	0		Zn					Zda				

SVE

BFDOT <Zda>.S, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE() || !HaveBF16Ext() then UNDEFINED;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer index = UInt(i2);
```

Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.
- <imm> Is the immediate index, in the range 0 to 3, encoded in the "i2" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV 32;
integer eltspersegment = 128 DIV 32;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    integer segmentbase = e - (e MOD eltspersegment);
    integer s = segmentbase + index;
    bits(16) elt1_a = Elem[operand1, 2 * e + 0, 16];
    bits(16) elt1_b = Elem[operand1, 2 * e + 1, 16];
    bits(16) elt2_a = Elem[operand2, 2 * s + 0, 16];
    bits(16) elt2_b = Elem[operand2, 2 * s + 1, 16];

    bits(32) sum = BFAdd(BFMul(elt1_a, elt2_a), BFMul(elt1_b, elt2_b));
    Elem[result, e, 32] = BFAdd(Elem[operand3, e, 32], sum);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# BFMLALB (vectors)

BFloat16 floating-point multiply-add long to single-precision (bottom).

This BFloat16 floating-point multiply-add long instruction widens the even-numbered 16-bit BFloat16 elements in the first source vector and the corresponding elements in the second source vector to single-precision format and then destructively multiplies and adds these values without intermediate rounding to the overlapping 32-bit single-precision elements of the addend and destination vector. This instruction is unpredicated.

Unlike the BFloat16 matrix multiplication and dot product instructions, this instruction performs a fused multiply-add that honors all of the FPCR bits that apply to single-precision arithmetic. It can also generate a floating-point exception that causes cumulative exception bits in the FPSR to be set, or a synchronous exception to be taken, depending on the enable bits in the FPCR.

ID\_AA64ZFR0\_EL1.BF16 indicates whether this instruction is implemented.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	1	1	1	Zm					1	0	0	0	0	0	Zn					Zda				
o2										op										T											

## SVE

BFMLALB <Zda>.S, <Zn>.H, <Zm>.H

```
if !HaveSVE() || !HaveBF16Ext() then UNDEFINED;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV 32;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    bits(32) element1 = Elem[operand1, 2 * e + 0, 16] : Zeros(16);
    bits(32) element2 = Elem[operand2, 2 * e + 0, 16] : Zeros(16);
    bits(32) element3 = Elem[operand3, e, 32];
    Elem[result, e, 32] = FPMulAdd(element3, element1, element2, FPCR<31:0>);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

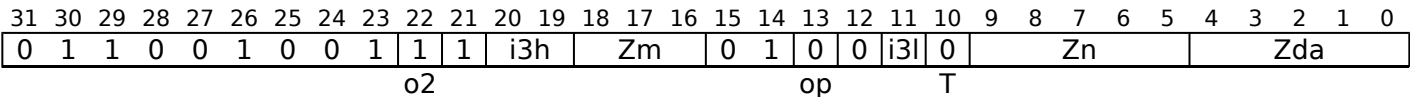


# BFMLALB (indexed)

BFloat16 floating-point multiply-add long to single-precision (bottom, indexed).

This BFloat16 floating-point multiply-add long instruction widens the even-numbered 16-bit BFloat16 elements in the first source vector and the indexed element from the corresponding 128-bit segment in the second source vector to single-precision format and then destructively multiplies and adds these values without intermediate rounding to the overlapping 32-bit single-precision elements of the addend and destination vector. This instruction is unpredicated. Unlike the BFloat16 matrix multiplication and dot product instructions, this instruction performs a fused multiply-add that honors all of the FPCR bits that apply to single-precision arithmetic. It can also generate a floating-point exception that causes cumulative exception bits in the FPSR to be set, or a synchronous exception to be taken, depending on the enable bits in the FPCR.

ID\_AA64ZFR0\_EL1.BF16 indicates whether this instruction is implemented.



## SVE

BFMLALB <Zda>.S, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE() || !HaveBF16Ext() then UNDEFINED;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer index = UInt(i3h:i3l);
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.
- <imm> Is the immediate index, in the range 0 to 7, encoded in the "i3h:i3l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV 32;
integer eltsegment = 128 DIV 32;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    integer segmentbase = e - (e MOD eltsegment);
    integer s = 2 * segmentbase + index;
    bits(32) element1 = Elem[operand1, 2 * e + 0, 16] : Zeros(16);
    bits(32) element2 = Elem[operand2, s, 16] : Zeros(16);
    bits(32) element3 = Elem[operand3, e, 32];
    Elem[result, e, 32] = FPMulAdd(element3, element1, element2, FPCR<31:0>);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.

- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# BFMLALT (vectors)

BFloat16 floating-point multiply-add long to single-precision (top).

This BFloat16 floating-point multiply-add long instruction widens the odd-numbered 16-bit BFloat16 elements in the first source vector and the corresponding elements in the second source vector to single-precision format and then destructively multiplies and adds these values without intermediate rounding to the overlapping 32-bit single-precision elements of the addend and destination vector. This instruction is unpredicated.

Unlike the BFloat16 matrix multiplication and dot product instructions, this instruction performs a fused multiply-add that honors all of the FPCR bits that apply to single-precision arithmetic. It can also generate a floating-point exception that causes cumulative exception bits in the FPSR to be set, or a synchronous exception to be taken, depending on the enable bits in the FPCR.

ID\_AA64ZFR0\_EL1.BF16 indicates whether this instruction is implemented.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	1	1	1	Zm					1	0	0	0	0	1	Zn					Zda				
o2										op										T											

## SVE

BFMLALT <Zda>.S, <Zn>.H, <Zm>.H

```
if !HaveSVE() || !HaveBF16Ext() then UNDEFINED;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV 32;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    bits(32) element1 = Elem[operand1, 2 * e + 1, 16] : Zeros(16);
    bits(32) element2 = Elem[operand2, 2 * e + 1, 16] : Zeros(16);
    bits(32) element3 = Elem[operand3, e, 32];
    Elem[result, e, 32] = FPMulAdd(element3, element1, element2, FPCR<31:0>);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

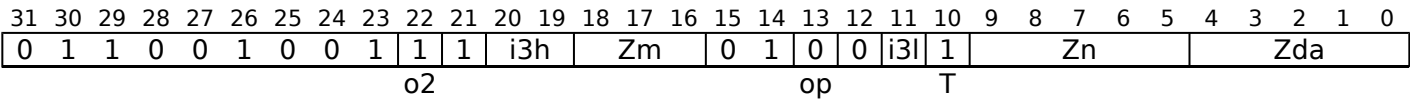
- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

# BFMLALT (indexed)

BFloat16 floating-point multiply-add long to single-precision (top, indexed).

This BFloat16 floating-point multiply-add long instruction widens the odd-numbered 16-bit BFloat16 elements in the first source vector and the indexed element from the corresponding 128-bit segment in the second source vector to single-precision format and then destructively multiplies and adds these values without intermediate rounding to the overlapping 32-bit single-precision elements of the addend and destination vector. This instruction is unpredicated. Unlike the BFloat16 matrix multiplication and dot product instructions, this instruction performs a fused multiply-add that honors all of the FPCR bits that apply to single-precision arithmetic. It can also generate a floating-point exception that causes cumulative exception bits in the FPSR to be set, or a synchronous exception to be taken, depending on the enable bits in the FPCR.

ID\_AA64ZFR0\_EL1.BF16 indicates whether this instruction is implemented.



## SVE

BFMLALT <Zda>.S, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE() || !HaveBF16Ext() then UNDEFINED;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer index = UInt(i3h:i3l);
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.
- <imm> Is the immediate index, in the range 0 to 7, encoded in the "i3h:i3l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV 32;
integer eltsegment = 128 DIV 32;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    integer segmentbase = e - (e MOD eltsegment);
    integer s = 2 * segmentbase + index;
    bits(32) element1 = Elem[operand1, 2 * e + 1, 16] : Zeros(16);
    bits(32) element2 = Elem[operand2, s, 16] : Zeros(16);
    bits(32) element3 = Elem[operand3, e, 32];
    Elem[result, e, 32] = FPMulAdd(element3, element1, element2, FPCR<31:0>);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.

- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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BFMMLA

BFloat16 floating-point matrix multiply-accumulate.

This BFloat16 floating-point (BF16) matrix multiply-accumulate instruction multiplies the 2×4 matrix of BF16 values held in each 128-bit segment of the first source vector by the 4×2 BF16 matrix in the corresponding segment of the second source vector. The resulting 2×2 single-precision (FP32) matrix product is then destructively added to the FP32 matrix accumulator held in the corresponding segment of the addend and destination vector. This is equivalent to performing a 4-way dot product per destination element.

This instruction is unpredicated and vector length agnostic.

All floating-point calculations performed by this instruction are performed with the following behaviors, irrespective of the value in FPCR:

- \* Uses the non-IEEE 754 Round-to-Odd mode, which forces bit 0 of an inexact result to 1, and rounds an overflow to an appropriately signed Infinity.
- \* The cumulative FPSR exception bits (IDC, IXC, UFC, OFC, DZC and IOC) are not modified.
- \* Trapped floating-point exceptions are disabled, as if the FPCR trap enable bits (IDE, IXE, UFE, OFE, DZE and IOE) are all zero.
- \* Denormalized inputs and results are flushed to zero, as if FPCR.FZ == 1.
- \* Only the Default NaN is generated, as if FPCR.DN == 1.

ID\_AA64ZFR0\_EL1.BF16 indicates whether this instruction is implemented.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	0	1	1	Zm				1	1	1	0	0	1	Zn				Zda						

SVE

BFMMLA <Zda>.S, <Zn>.H, <Zm>.H

```
if !HaveSVE() || !HaveBF16Ext() then UNDEFINED;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer segments = VL DIV 128;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;
bits(128) op1, op2;
bits(128) res, addend;

for s = 0 to segments-1
    op1 = Elem[operand1, s, 128];
    op2 = Elem[operand2, s, 128];
    addend = Elem[operand3, s, 128];
    res = BFMatMulAdd(addend, op1, op2);
    Elem[result, s, 128] = res;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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BGRP

Group bits to right or left as selected by bitmask.

This instruction separates bits in each element of the first source vector by gathering from the bit positions indicated by non-zero bits in the corresponding mask element of the second source vector to the lowest-numbered contiguous bits of the corresponding destination element, and from positions indicated by zero bits to the highest-numbered bits of the destination element, preserving the bit order within each group. This instruction is unpredicated.

ID\_AA64ZFR0\_EL1.BitPerm indicates whether this instruction is implemented.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	size			0	Zm				1	0	1	1	1	0	Zn				Zd					

SVE2

BGRP <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE2BitPerm() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) data = Z[n];
bits(VL) mask = Z[m];
bits(VL) result;

for e = 0 to elements - 1
    Elem[result, e, esize] = BitGroup(Elem[data, e, esize], Elem[mask, e, esize]);
Z[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.



# BIC (immediate)

Bitwise clear bits using immediate (unpredicated).

Bitwise clear bits using immediate with each 64-bit element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate is a 64-bit value consisting of a single run of ones or zeros repeating every 2, 4, 8, 16, 32 or 64 bits. This instruction is unpredicated.

This is a pseudo-instruction of [AND \(immediate\)](#). This means:

- The encodings in this description are named to match the encodings of [AND \(immediate\)](#).
- The assembler syntax is used only for assembly, and is not used on disassembly.
- The description of [AND \(immediate\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	1	0	0	0	0	0	imm13														Zdn			

## SVE

BIC <Zdn>.<T>, <Zdn>.<T>, #<const>

is equivalent to

AND <Zdn>.<T>, <Zdn>.<T>, #(-<const> - 1)

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "imm13<12>:imm13<5:0>":

imm13<12>	imm13<5:0>	<T>
0	0xxxxx	S
0	10xxxx	H
0	110xxx	B
0	1110xx	B
0	11110x	B
0	111110	RESERVED
0	111111	RESERVED
1	xxxxxx	D

<const> Is a 64, 32, 16 or 8-bit bitmask consisting of replicated 2, 4, 8, 16, 32 or 64 bit fields, each field containing a rotated run of non-zero bits, encoded in the "imm13" field.

## Operation

The description of [AND \(immediate\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



# BIC, BICS (predicates)

Bitwise clear predicates.

Bitwise AND inverted active elements of the second source predicate with corresponding elements of the first source predicate and place the results in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Optionally sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

It has encodings from 2 classes: [Not setting the condition flags](#) and [Setting the condition flags](#)

## Not setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	0	0	0	Pm			0	1	Pg			0	Pn			1	Pd						
S																															

## Not setting the condition flags

BIC <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = FALSE;
```

## Setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	1	0	0	Pm			0	1	Pg			0	Pn			1	Pd						
S																															

## Setting the condition flags

BICS <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = TRUE;
```

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.
- <Pm> Is the name of the second source scalable predicate register, encoded in the "Pm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(PL) operand1 = P[n];
bits(PL) operand2 = P[m];
bits(PL) result;

for e = 0 to elements-1
    bit element1 = ElemP[operand1, e, esize];
    bit element2 = ElemP[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        ElemP[result, e, esize] = element1 AND (NOT element2);
    else
        ElemP[result, e, esize] = '0';

if setflags then
    PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

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# BIC (vectors, predicated)

Bitwise clear vectors (predicated).

Bitwise AND inverted active elements of the second source vector with corresponding elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	0	1	1	0	0	0		Pg												

## SVE

BIC <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = element1 AND (NOT element2);
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:

- The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
- The values of the NZCV flags.

This instruction might be immediately preceded in program order by a **MOVPRFX** instruction. The **MOVPRFX** instruction must conform to all of the following requirements, otherwise the behavior of the **MOVPRFX** and this instruction is UNPREDICTABLE:

- The **MOVPRFX** instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The **MOVPRFX** instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# BIC (vectors, unpredicated)

Bitwise clear vectors (unpredicated).

Bitwise AND inverted all elements of the second source vector with corresponding elements of the first source vector and place the results in the corresponding elements of the destination vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	1	1	Zm					0	0	1	1	0	0	Zn					Zd				

## SVE

BIC <Zd>.D, <Zn>.D, <Zm>.D

```
if !HaveSVE() then UNDEFINED;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];

Z[d] = operand1 AND (NOT operand2);
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# BRKA, BRKAS

Break after first true condition.

Sets destination predicate elements up to and including the first active and true source element to true, then sets subsequent elements to false. Inactive elements in the destination predicate register remain unmodified or are set to zero, depending on whether merging or zeroing predication is selected. Optionally sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

It has encodings from 2 classes: [Not setting the condition flags](#) and [Setting the condition flags](#)

## Not setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	0	0	1	0	0	0	0	0	1	Pg			0	Pn			M	Pd					
								B		S																					

## Not setting the condition flags

BRKA <Pd>.B, <Pg>/<ZM>, <Pn>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer d = UInt(Pd);
boolean merging = (M == '1');
boolean setflags = FALSE;
```

## Setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	1	0	1	0	0	0	0	0	1	Pg			0	Pn			0	Pd					
B S																		M													

## Setting the condition flags

BRKAS <Pd>.B, <Pg>/Z, <Pn>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer d = UInt(Pd);
boolean merging = FALSE;
boolean setflags = TRUE;
```

## Assembler Symbols

- <Pd>Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg>Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <ZM>Is the predication qualifier, encoded in "M":

M		<ZM>	
0		Z	
1		M	
- <Pn>Is the name of the source scalable predicate register, encoded in the "Pn" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(PL) operand = P[n];
bits(PL) operand2 = P[d];
boolean break = FALSE;
bits(PL) result;

for e = 0 to elements-1
    boolean element = ElemP[operand, e, esize] == '1';
    if ElemP[mask, e, esize] == '1' then
        ElemP[result, e, esize] = if !break then '1' else '0';
        break = break || element;
    elsif merging then
        ElemP[result, e, esize] = ElemP[operand2, e, esize];
    else
        ElemP[result, e, esize] = '0';

if setflags then
    PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

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BRKB, BRKBS

Break before first true condition.

Sets destination predicate elements up to but not including the first active and true source element to true, then sets subsequent elements to false. Inactive elements in the destination predicate register remain unmodified or are set to zero, depending on whether merging or zeroing predication is selected. Optionally sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

It has encodings from 2 classes: [Not setting the condition flags](#) and [Setting the condition flags](#)

Not setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	1	0	0	1	0	0	0	0	0	1	Pg			0	Pn			M	Pd					
								B		S																					

Not setting the condition flags

BRKB <Pd>.B, <Pg>/<ZM>, <Pn>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer d = UInt(Pd);
boolean merging = (M == '1');
boolean setflags = FALSE;
```

Setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	1	1	0	1	0	0	0	0	0	1	Pg			0		Pn			0		Pd			
B										S										M											

Setting the condition flags

BRKBS <Pd>.B, <Pg>/Z, <Pn>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer d = UInt(Pd);
boolean merging = FALSE;
boolean setflags = TRUE;
```

Assembler Symbols

- <Pd>

Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg>

Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <ZM>

Is the predication qualifier, encoded in "M":

M		<ZM>
0		Z
1		M
- <Pn>

Is the name of the source scalable predicate register, encoded in the "Pn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(PL) operand = P[n];
bits(PL) operand2 = P[d];
boolean break = FALSE;
bits(PL) result;

for e = 0 to elements-1
    boolean element = ElemP[operand, e, esize] == '1';
    if ElemP[mask, e, esize] == '1' then
        break = break || element;
        ElemP[result, e, esize] = if !break then '1' else '0';
    elseif merging then
        ElemP[result, e, esize] = ElemP[operand2, e, esize];
    else
        ElemP[result, e, esize] = '0';

if setflags then
    PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

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# BRKN, BRKNS

Propagate break to next partition.

If the last active element of the first source predicate is false then set the destination predicate to all-false. Otherwise leaves the destination and second source predicate unchanged. Inactive elements in the destination predicate register are set to zero. Optionally sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

It has encodings from 2 classes: [Not setting the condition flags](#) and [Setting the condition flags](#)

## Not setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0						
0	0	1	0	0	1	0	1	0	0	0	1	1	0	0	0	0	1	Pg			0	Pn			0	Pdm											
S																																					

## Not setting the condition flags

BRKN <Pdm>.B, <Pg>/Z, <Pn>.B, <Pdm>.B

```
if !HaveSVE() then UNDEFINED;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer dm = UInt(Pdm);
boolean setflags = FALSE;
```

## Setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	1	0	1	1	0	0	0	0	1	Pg			0	Pn			0	Pdm					
S																															

## Setting the condition flags

BRKNS <Pdm>.B, <Pg>/Z, <Pn>.B, <Pdm>.B

```
if !HaveSVE() then UNDEFINED;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer dm = UInt(Pdm);
boolean setflags = TRUE;
```

## Assembler Symbols

- <Pdm> Is the name of the second source and destination scalable predicate register, encoded in the "Pdm" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.

## Operation

```
CheckSVEEnabled();
bits(PL) mask = P[g];
bits(PL) operand1 = P[n];
bits(PL) operand2 = P[dm];
bits(PL) result;

if LastActive(mask, operand1, 8) == '1' then
    result = operand2;
else
    result = Zeros();

if setflags then
    PSTATE.<N,Z,C,V> = PredTest(Ones(PL), result, 8);
P[dm] = result;
```

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# BRKPA, BRKPAS

Break after first true condition, propagating from previous partition.

If the last active element of the first source predicate is false then set the destination predicate to all-false. Otherwise sets destination predicate elements up to and including the first active and true source element to true, then sets subsequent elements to false. Inactive elements in the destination predicate register are set to zero. Optionally sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

It has encodings from 2 classes: [Not setting the condition flags](#) and [Setting the condition flags](#)

## Not setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	0	0	0	Pm			1	1	Pg			0	Pn			0	Pd						
S												B																			

## Not setting the condition flags

BRKPA <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = FALSE;
```

## Setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	1	0	0	Pm			1	1	Pg			0	Pn			0	Pd						
S												B																			

## Setting the condition flags

BRKPAS <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = TRUE;
```

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.
- <Pm> Is the name of the second source scalable predicate register, encoded in the "Pm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(PL) operand1 = P[n];
bits(PL) operand2 = P[m];
bits(PL) result;
boolean last = (LastActive(mask, operand1, 8) == '1');

for e = 0 to elements-1
    if ElemP[mask, e, 8] == '1' then
        ElemP[result, e, 8] = if last then '1' else '0';
        last = last && (ElemP[operand2, e, 8] == '0');
    else
        ElemP[result, e, 8] = '0';

if setflags then
    PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

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# BRKPB, BRKPBS

Break before first true condition, propagating from previous partition.

If the last active element of the first source predicate is false then set the destination predicate to all-false. Otherwise sets destination predicate elements up to but not including the first active and true source element to true, then sets subsequent elements to false. Inactive elements in the destination predicate register are set to zero. Optionally sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

It has encodings from 2 classes: [Not setting the condition flags](#) and [Setting the condition flags](#)

## Not setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	0	0	0	Pm				1	1	Pg				0	Pn				1	Pd			
S																B															

## Not setting the condition flags

BRKPB <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = FALSE;
```

## Setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	1	0	0	Pm				1	1	Pg				0	Pn				1	Pd			
S																B															

## Setting the condition flags

BRKPBS <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = TRUE;
```

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.
- <Pm> Is the name of the second source scalable predicate register, encoded in the "Pm" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(PL) operand1 = P[n];
bits(PL) operand2 = P[m];
bits(PL) result;
boolean last = (LastActive(mask, operand1, 8) == '1');

for e = 0 to elements-1
    if ElemP[mask, e, 8] == '1' then
        last = last && (ElemP[operand2, e, 8] == '0');
        ElemP[result, e, 8] = if last then '1' else '0';
    else
        ElemP[result, e, 8] = '0';

if setflags then
    PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

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BSL1N

Bitwise select with first input inverted.

Selects bits from the inverted first source vector where the corresponding bit in the third source vector is '1', and from the second source vector where the corresponding bit in the third source vector is '0'. The result is placed destructively in the destination and first source vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	1	1	Zm					0	0	1	1	1	1	Zk					Zdn				

SVE2

BSL1N <Zdn>.D, <Zdn>.D, <Zm>.D, <Zk>.D

```
if !HaveSVE2() then UNDEFINED;
integer m = UInt(Zm);
integer k = UInt(Zk);
integer dn = UInt(Zdn);
```

Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <Zk> Is the name of the third source scalable vector register, encoded in the "Zk" field.

Operation

```
CheckSVEEnabled();
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[k];

Z[dn] = (NOT(operand1) AND operand3) OR (operand2 AND NOT(operand3));
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

# BSL2N

Bitwise select with second input inverted.

Selects bits from the first source vector where the corresponding bit in the third source vector is '1', and from the inverted second source vector where the corresponding bit in the third source vector is '0'. The result is placed destructively in the destination and first source vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	0	1	Zm					0	0	1	1	1	1	Zk					Zdn				

## SVE2

BSL2N <Zdn>.D, <Zdn>.D, <Zm>.D, <Zk>.D

```
if !HaveSVE2() then UNDEFINED;
integer m = UInt(Zm);
integer k = UInt(Zk);
integer dn = UInt(Zdn);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <Zk> Is the name of the third source scalable vector register, encoded in the "Zk" field.

## Operation

```
CheckSVEEnabled();
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[k];

Z[dn] = (operand1 AND operand3) OR (NOT(operand2) AND NOT(operand3));
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

BSL

Bitwise select.

Selects bits from the first source vector where the corresponding bit in the third source vector is '1', and from the second source vector where the corresponding bit in the third source vector is '0'. The result is placed destructively in the destination and first source vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	1	Zm					0	0	1	1	1	1	Zk					Zdn				

SVE2

BSL <Zdn>.D, <Zdn>.D, <Zm>.D, <Zk>.D

```
if !HaveSVE2() then UNDEFINED;
integer m = UInt(Zm);
integer k = UInt(Zk);
integer dn = UInt(Zdn);
```

Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <Zk> Is the name of the third source scalable vector register, encoded in the "Zk" field.

Operation

```
CheckSVEEnabled();
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[k];

Z[dn] = (operand1 AND operand3) OR (operand2 AND NOT(operand3));
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

CADD

Complex integer add with rotate.

Add the real and imaginary components of the integral complex numbers from the first source vector to the complex numbers from the second source vector which have first been rotated by 90 or 270 degrees in the direction from the positive real axis towards the positive imaginary axis, when considered in polar representation, equivalent to multiplying the complex numbers in the second source vector by  $\pm j$  beforehand. Destructively place the results in the corresponding elements of the first source vector. This instruction is unpredicated.

Each complex number is represented in a vector register as an even/odd pair of elements with the real part in the even-numbered element and the imaginary part in the odd-numbered element.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	size			0	0	0	0	0	0	1	1	0	1	1	rot		Zm				Zdn			

SVE2

CADD <Zdn>.<T>, <Zdn>.<T>, <Zm>.<T>, <const>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Zm);
integer dn = UInt(Zdn);
boolean sub_i = (rot == '0');
boolean sub_r = (rot == '1');
```

Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <const> Is the const specifier, encoded in "rot":

rot	<const>
0	#90
1	#270

## Operation

```
CheckSVEEnabled();
integer pairs = VL DIV (2 * esize);
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for p = 0 to pairs-1
    integer acc_r = SInt(Elem[operand1, 2 * p + 0, esize]);
    integer acc_i = SInt(Elem[operand1, 2 * p + 1, esize]);
    integer elt2_r = SInt(Elem[operand2, 2 * p + 0, esize]);
    integer elt2_i = SInt(Elem[operand2, 2 * p + 1, esize]);
    if sub_i then
        acc_r = acc_r - elt2_i;
        acc_i = acc_i + elt2_r;
    if sub_r then
        acc_r = acc_r + elt2_i;
        acc_i = acc_i - elt2_r;

    Elem[result, 2 * p + 0, esize] = acc_r<esize-1:0>;
    Elem[result, 2 * p + 1, esize] = acc_i<esize-1:0>;

Z[dn] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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CDOT (vectors)

Complex integer dot product.

The complex integer dot product instructions delimit the source vectors into pairs of 8-bit or 16-bit signed integer complex numbers. Within each pair, the complex numbers in the first source vector are multiplied by the corresponding complex numbers in the second source vector and the resulting wide real or wide imaginary part of the product is accumulated into a 32-bit or 64-bit destination vector element which overlaps all four of the elements that comprise a pair of complex number values in the first source vector.

As a result each instruction implicitly deinterleaves the real and imaginary components of their complex number inputs, so that the destination vector accumulates 4×wide real sums or 4×wide imaginary sums.

The complex numbers in the second source vector are rotated by 0, 90, 180 or 270 degrees in the direction from the positive real axis towards the positive imaginary axis, when considered in polar representation, by performing the following transformations prior to the dot product operations:

- \* If the rotation is #0, the imaginary parts of the complex numbers in the second source vector are negated. The destination vector therefore accumulates the real parts of a complex dot product.
- \* If the rotation is #90, the real and imaginary parts of the complex numbers the second source vector are swapped. The destination vector therefore accumulates the imaginary parts of a complex dot product.
- \* If the rotation is #180, there is no transformation. The destination vector therefore accumulates the real parts of a complex conjugate dot product.
- \* If the rotation is #270, the real parts of the complex numbers in the second source vector are negated and then swapped with the imaginary parts. The destination vector therefore accumulates the imaginary parts of a complex conjugate dot product.

Each complex number is represented in a vector register as an even/odd pair of elements with the real part in the even-numbered element and the imaginary part in the odd-numbered element.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	1	0	0	0	1	0	0	size	0	Zm						0	0	0	1	rot	Zn						Zda					

SVE2

CDOT <Zda>.<T>, <Zn>.<Tb>, <Zm>.<Tb>, <const>

```
if !HaveSVE2() then UNDEFINED;
if size == '0x' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel_a = UInt(rot<0>);
integer sel_b = UInt(NOT(rot<0>));
boolean sub_i = (rot<0> == rot<1>);
```

Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <T> Is the size specifier, encoded in "size<0>":

size<0>	<T>
0	S
1	D
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "size<0>":

size<0>	<Tb>
0	B
1	H
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <const> Is the const specifier, encoded in "rot":

rot	<const>
00	#0
01	#90
10	#180
11	#270

## Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) res = Elem[operand3, e, esize];
    for i = 0 to 1
        integer elt1_r = SInt(Elem[operand1, 4 * e + 2 * i + 0, esize DIV 4]);
        integer elt1_i = SInt(Elem[operand1, 4 * e + 2 * i + 1, esize DIV 4]);
        integer elt2_a = SInt(Elem[operand2, 4 * e + 2 * i + sel_a, esize DIV 4]);
        integer elt2_b = SInt(Elem[operand2, 4 * e + 2 * i + sel_b, esize DIV 4]);
        if sub_i then
            res = res + (elt1_r * elt2_a) - (elt1_i * elt2_b);
        else
            res = res + (elt1_r * elt2_a) + (elt1_i * elt2_b);
        Elem[result, e, esize] = res;
Z[da] = result;

```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# CDOT (indexed)

Complex integer dot product (indexed).

The complex integer dot product instructions delimit the source vectors into pairs of 8-bit or 16-bit signed integer complex numbers. Within each pair, the complex numbers in the first source vector are multiplied by the corresponding complex numbers in the second source vector and the resulting wide real or wide imaginary part of the product is accumulated into a 32-bit or 64-bit destination vector element which overlaps all four of the elements that comprise a pair of complex number values in the first source vector.

As a result each instruction implicitly deinterleaves the real and imaginary components of their complex number inputs, so that the destination vector accumulates 4×wide real sums or 4×wide imaginary sums.

The complex numbers in the second source vector are rotated by 0, 90, 180 or 270 degrees in the direction from the positive real axis towards the positive imaginary axis, when considered in polar representation, by performing the following transformations prior to the dot product operations:

- \* If the rotation is #0, the imaginary parts of the complex numbers in the second source vector are negated. The destination vector therefore accumulates the real parts of a complex dot product.
- \* If the rotation is #90, the real and imaginary parts of the complex numbers the second source vector are swapped. The destination vector therefore accumulates the imaginary parts of a complex dot product.
- \* If the rotation is #180, there is no transformation. The destination vector therefore accumulates the real parts of a complex conjugate dot product.
- \* If the rotation is #270, the real parts of the complex numbers in the second source vector are negated and then swapped with the imaginary parts. The destination vector therefore accumulates the imaginary parts of a complex conjugate dot product.

The indexed form of these instructions select a single pair of complex numbers within each 128-bit segment of the second source vector as the multiplier for all pairs of complex numbers within the corresponding 128-bit segment of the first source vector. The complex number pairs within the second source vector are specified using an immediate index which selects the same complex number pair position within each 128-bit vector segment. The index range is from 0 to one less than the number of complex number pairs per 128-bit segment, encoded in 1 or 2 bits depending on the size of the complex number pair.

Each complex number is represented in a vector register as an even/odd pair of elements with the real part in the even-numbered element and the imaginary part in the odd-numbered element.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	1	0	1	i2	Zm	0	1	0	0	rot	Zn					Zda								
size<1>size<0>																															

## 32-bit

CDOT <Zda>.S, <Zn>.B, <Zm>.B[<imm>], <const>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel_a = UInt(rot<0>);
integer sel_b = UInt(NOT(rot<0>));
boolean sub_i = (rot<0> == rot<1>);
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	1	1	i1	Zm	0	1	0	0	rot	Zn	Zda													
size<1>size<0>																															

64-bit

```
CDOT <Zda>.D, <Zn>.H, <Zm>.H[<imm>], <const>
```

```
if !HaveSVE2() then UNDEFINED;
integer esize = 64;
integer index = UInt(i1);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel_a = UInt(rot<0>);
integer sel_b = UInt(NOT(rot<0>));
boolean sub_i = (rot<0> == rot<1>);
```

Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> For the 32-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  
For the 64-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
- <imm> For the 32-bit variant: is the immediate index of a quadruplet of four 8-bit elements within each 128-bit vector segment, in the range 0 to 3, encoded in the "i2" field.  
For the 64-bit variant: is the immediate index of a quadruplet of four 16-bit elements within each 128-bit vector segment, in the range 0 to 1, encoded in the "i1" field.
- <const> Is the const specifier, encoded in "rot":

rot	<const>
00	#0
01	#90
10	#180
11	#270

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer eltsegment = 128 DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
  integer segmentbase = e - (e MOD eltsegment);
  integer s = segmentbase + index;
  bits(esize) res = Elem[operand3, e, esize];
  for i = 0 to 1
    integer elt1_r = SInt(Elem[operand1, 4 * e + 2 * i + 0, esize DIV 4]);
    integer elt1_i = SInt(Elem[operand1, 4 * e + 2 * i + 1, esize DIV 4]);
    integer elt2_a = SInt(Elem[operand2, 4 * s + 2 * i + sel_a, esize DIV 4]);
    integer elt2_b = SInt(Elem[operand2, 4 * s + 2 * i + sel_b, esize DIV 4]);
    if sub_i then
      res = res + (elt1_r * elt2_a) - (elt1_i * elt2_b);
    else
      res = res + (elt1_r * elt2_a) + (elt1_i * elt2_b);
  Elem[result, e, esize] = res;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

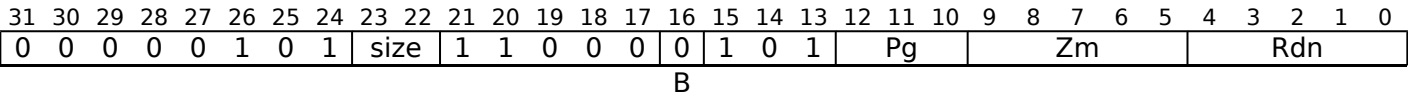
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CLASTA (scalar)

Conditionally extract element after last to general-purpose register.

From the source vector register extract the element after the last active element, or if the last active element is the final element extract element zero, and then zero-extend that element to destructively place in the destination and first source general-purpose register. If there are no active elements then destructively zero-extend the least significant element-size bits of the destination and first source general-purpose register.



SVE

CLASTA <R><dn>, <Pg>, <R><dn>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Rdn);
integer m = UInt(Zm);
integer csize = if esize < 64 then 32 else 64;
boolean isBefore = FALSE;
```

Assembler Symbols

- <R>

Is a width specifier, encoded in "size":

size	<R>
01	W
x0	W
11	X
- <dn>

Is the number [0-30] of the source and destination general-purpose register or the name ZR (31), encoded in the "Rdn" field.
- <Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm>

Is the name of the source scalable vector register, encoded in the "Zm" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(esize) operand1 = X[dn];
bits(VL) operand2 = Z[m];
bits(csize) result;
integer last = LastActiveElement(mask, esize);

if last < 0 then
    result = ZeroExtend(operand1);
else
    if !isBefore then
        last = last + 1;
        if last >= elements then last = 0;
    result = ZeroExtend(Elem[operand2, last, esize]);

X[dn] = result;
```

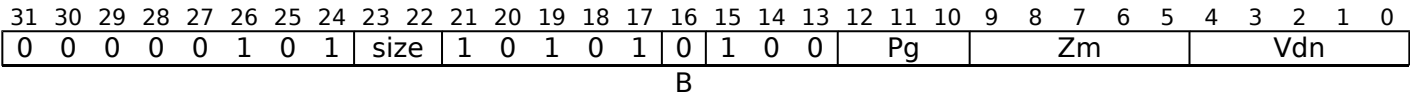
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# CLASTA (SIMD&FP scalar)

Conditionally extract element after last to SIMD&FP scalar register.

From the source vector register extract the element after the last active element, or if the last active element is the final element extract element zero, and then zero-extend that element to destructively place in the destination and first source SIMD & floating-point scalar register. If there are no active elements then destructively zero-extend the least significant element-size bits of the destination and first source SIMD & floating-point scalar register.



## SVE

CLASTA <V><dn>, <Pg>, <V><dn>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Vdn);
integer m = UInt(Zm);
boolean isBefore = FALSE;
```

## Assembler Symbols

<V>	Is a width specifier, encoded in "size":										
<table><tr><th>size</th><th>&lt;V&gt;</th></tr><tr><td>00</td><td>B</td></tr><tr><td>01</td><td>H</td></tr><tr><td>10</td><td>S</td></tr><tr><td>11</td><td>D</td></tr></table>	size	<V>	00	B	01	H	10	S	11	D	
size	<V>										
00	B										
01	H										
10	S										
11	D										
<dn>	Is the number [0-31] of the source and destination SIMD&FP register, encoded in the "Vdn" field.										
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.										
<Zm>	Is the name of the source scalable vector register, encoded in the "Zm" field.										
<T>	Is the size specifier, encoded in "size":										
<table><tr><th>size</th><th>&lt;T&gt;</th></tr><tr><td>00</td><td>B</td></tr><tr><td>01</td><td>H</td></tr><tr><td>10</td><td>S</td></tr><tr><td>11</td><td>D</td></tr></table>	size	<T>	00	B	01	H	10	S	11	D	
size	<T>										
00	B										
01	H										
10	S										
11	D										

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(esize) operand1 = V[dn];
bits(VL) operand2 = Z[m];
bits(esize) result;
integer last = LastActiveElement(mask, esize);

if last < 0 then
    result = ZeroExtend(operand1);
else
    if !isBefore then
        last = last + 1;
        if last >= elements then last = 0;
    result = Elem[operand2, last, esize];

V[dn] = result;
```

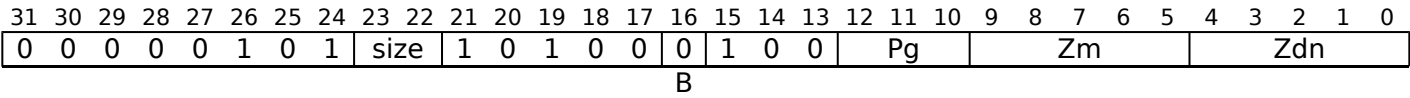


CLASTA (vectors)

Conditionally extract element after last to vector register.

From the second source vector register extract the element after the last active element, or if the last active element is the final element extract element zero, and then replicate that element to destructively fill the destination and first source vector.

If there are no active elements then leave the destination and source vector unmodified.



SVE

CLASTA <Zdn>.<T>, <Pg>, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean isBefore = FALSE;
```

Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;
integer last = LastActiveElement(mask, esize);

if last < 0 then
    result = operand1;
else
    if !isBefore then
        last = last + 1;
        if last >= elements then last = 0;
    for e = 0 to elements-1
        Elem[result, e, esize] = Elem[operand2, last, esize];
Z[dn] = result;
```



## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

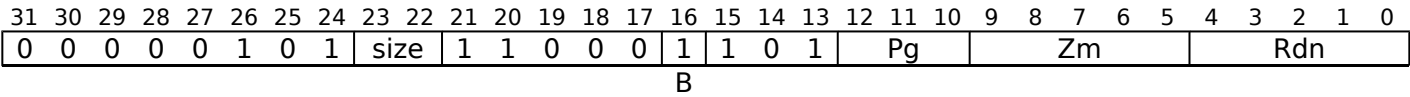
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# CLASTB (scalar)

Conditionally extract last element to general-purpose register.

From the source vector register extract the last active element, and then zero-extend that element to destructively place in the destination and first source general-purpose register. If there are no active elements then destructively zero-extend the least significant element-size bits of the destination and first source general-purpose register.



## SVE

CLASTB <R><dn>, <Pg>, <R><dn>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Rdn);
integer m = UInt(Zm);
integer csize = if esize < 64 then 32 else 64;
boolean isBefore = TRUE;
```

## Assembler Symbols

- <R>

Is a width specifier, encoded in "size":

size	<R>
01	W
x0	W
11	X
- <dn>

Is the number [0-30] of the source and destination general-purpose register or the name ZR (31), encoded in the "Rdn" field.
- <Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm>

Is the name of the source scalable vector register, encoded in the "Zm" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(esize) operand1 = X[dn];
bits(VL) operand2 = Z[m];
bits(csize) result;
integer last = LastActiveElement(mask, esize);

if last < 0 then
    result = ZeroExtend(operand1);
else
    if !isBefore then
        last = last + 1;
        if last >= elements then last = 0;
    result = ZeroExtend(Elem[operand2, last, esize]);

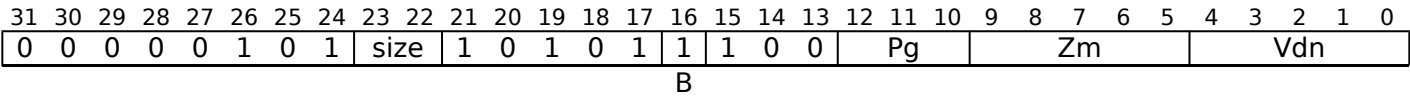
X[dn] = result;
```



# CLASTB (SIMD&FP scalar)

Conditionally extract last element to SIMD&FP scalar register.

From the source vector register extract the last active element, and then zero-extend that element to destructively place in the destination and first source SIMD & floating-point scalar register. If there are no active elements then destructively zero-extend the least significant element-size bits of the destination and first source SIMD & floating-point scalar register.



## SVE

CLASTB <V><dn>, <Pg>, <V><dn>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Vdn);
integer m = UInt(Zm);
boolean isBefore = TRUE;
```

## Assembler Symbols

- <V> Is a width specifier, encoded in "size":

size	<V>
00	B
01	H
10	S
11	D
- <dn> Is the number [0-31] of the source and destination SIMD&FP register, encoded in the "Vdn" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the source scalable vector register, encoded in the "Zm" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(esize) operand1 = V[dn];
bits(VL) operand2 = Z[m];
bits(esize) result;
integer last = LastActiveElement(mask, esize);

if last < 0 then
    result = ZeroExtend(operand1);
else
    if !isBefore then
        last = last + 1;
        if last >= elements then last = 0;
    result = Elem[operand2, last, esize];

V[dn] = result;
```

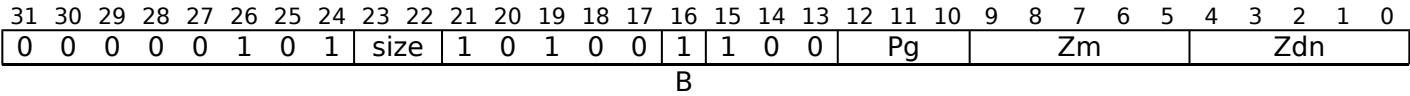


# CLASTB (vectors)

Conditionally extract last element to vector register.

From the second source vector register extract the last active element, and then replicate that element to destructively fill the destination and first source vector.

If there are no active elements then leave the destination and source vector unmodified.



## SVE

CLASTB <Zdn>.<T>, <Pg>, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean isBefore = TRUE;
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;
integer last = LastActiveElement(mask, esize);

if last < 0 then
    result = operand1;
else
    if !isBefore then
        last = last + 1;
        if last >= elements then last = 0;
    for e = 0 to elements-1
        Elem[result, e, esize] = Elem[operand2, last, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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CLS

Count leading sign bits (predicated).

Count leading sign bits in each active element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	0	0	0	1	0	1	Pg				Zn				Zd					

SVE

CLS <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    bits(esize) element = Elem[operand, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = CountLeadingSignBits(element)<esize-1:0>;

Z[d] = result;
```

Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:



- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# CLZ

Count leading zero bits (predicated).

Count leading zero bits in each active element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	0	0	1	1	0	1	Pg													

## SVE

CLZ <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    bits(esize) element = Elem[operand, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = CountLeadingZeroBits(element)<esize-1:0>;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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CMLA (vectors)

Complex integer multiply-add with rotate.

Multiply the duplicated real components for rotations 0 and 180, or imaginary components for rotations 90 and 270, of the integral numbers in the first source vector by the corresponding complex number in the second source vector rotated by 0, 90, 180 or 270 degrees in the direction from the positive real axis towards the positive imaginary axis, when considered in polar representation.

Then add the products to the corresponding components of the complex numbers in the addend vector. Destructively place the results in the corresponding elements of the addend vector. This instruction is unpredicated.

These transformations permit the creation of a variety of multiply-add and multiply-subtract operations on complex numbers by combining two of these instructions with the same vector operands but with rotations that are 90 degrees apart.

Each complex number is represented in a vector register as an even/odd pair of elements with the real part in the even-numbered element and the imaginary part in the odd-numbered element.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size	0				Zm			0	0	1	0	rot				Zn					Zda		

SVE2

CMLA <Zda>.<T>, <Zn>.<T>, <Zm>.<T>, <const>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel_a = UInt(rot<0>);
integer sel_b = UInt(NOT(rot<0>));
boolean sub_r = (rot<0> != rot<1>);
boolean sub_i = (rot<1> == '1');
```

Assembler Symbols

<Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

<const> Is the const specifier, encoded in "rot":

rot	<const>
00	#0
01	#90
10	#180
11	#270

## Operation

```
CheckSVEEnabled();
integer pairs = VL DIV (2 * esize);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for p = 0 to pairs-1
    integer elt1_a = SInt(Elem[operand1, 2 * p + sel_a, esize]);
    integer elt2_a = SInt(Elem[operand2, 2 * p + sel_a, esize]);
    integer elt2_b = SInt(Elem[operand2, 2 * p + sel_b, esize]);
    bits(esize) elt3_r = Elem[operand3, 2 * p + 0, esize];
    bits(esize) elt3_i = Elem[operand3, 2 * p + 1, esize];
    integer product_r = elt1_a * elt2_a;
    integer product_i = elt1_a * elt2_b;
    if sub_r then
        Elem[result, 2 * p + 0, esize] = elt3_r - product_r;
    else
        Elem[result, 2 * p + 0, esize] = elt3_r + product_r;
    if sub_i then
        Elem[result, 2 * p + 1, esize] = elt3_i - product_i;
    else
        Elem[result, 2 * p + 1, esize] = elt3_i + product_i;

Z[da] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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## CMLA (indexed)

Complex integer multiply-add with rotate (indexed).

Multiply the duplicated real components for rotations 0 and 180, or imaginary components for rotations 90 and 270, of the integral numbers in each 128-bit segment of the first source vector by the specified complex number in the corresponding the second source vector segment rotated by 0, 90, 180 or 270 degrees in the direction from the positive real axis towards the positive imaginary axis, when considered in polar representation.

Then add the products to the corresponding components of the complex numbers in the addend vector. Destructively place the results in the corresponding elements of the addend vector. This instruction is unpredicated.

These transformations permit the creation of a variety of multiply-add and multiply-subtract operations on complex numbers by combining two of these instructions with the same vector operands but with rotations that are 90 degrees apart.

Each complex number is represented in a vector register as an even/odd pair of elements with the real part in the even-numbered element and the imaginary part in the odd-numbered element.

It has encodings from 2 classes: [16-bit](#) and [32-bit](#)

### 16-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	1	0	0	0	1	0	0	1	0	1	i2	Zm	0	1	1	0	rot	Zn	Zda														
size<1>size<0>																																	

### 16-bit

CMLA <Zda>.H, <Zn>.H, <Zm>.H[<imm>], <const>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 16;
integer index = UInt(i2);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel_a = UInt(rot<0>);
integer sel_b = UInt(NOT(rot<0>));
boolean sub_r = (rot<0> != rot<1>);
boolean sub_i = (rot<1> == '1');
```

### 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	1	1	i1	Zm	0	1	1	0	rot	Zn	Zda													
size<1>size<0>																															

### 32-bit

CMLA <Zda>.S, <Zn>.S, <Zm>.S[<imm>], <const>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer index = UInt(i1);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel_a = UInt(rot<0>);
integer sel_b = UInt(NOT(rot<0>));
boolean sub_r = (rot<0> != rot<1>);
boolean sub_i = (rot<1> == '1');
```

Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> For the 16-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  
For the 32-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
- <imm> For the 16-bit variant: is the element index, in the range 0 to 3, encoded in the "i2" field.  
For the 32-bit variant: is the element index, in the range 0 to 1, encoded in the "i1" field.
- <const> Is the const specifier, encoded in "rot":

rot	<const>
00	#0
01	#90
10	#180
11	#270

Operation

```
CheckSVEEnabled();
integer pairs = VL DIV (2 * esize);
integer pairspersegment = 128 DIV (2 * esize);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for p = 0 to pairs-1
    integer segmentbase = p - (p MOD pairspersegment);
    integer s = segmentbase + index;
    integer elt1_a = SInt(Elem[operand1, 2 * p + sel_a, esize]);
    integer elt2_a = SInt(Elem[operand2, 2 * s + sel_a, esize]);
    integer elt2_b = SInt(Elem[operand2, 2 * s + sel_b, esize]);
    bits(esize) elt3_r = Elem[operand3, 2 * p + 0, esize];
    bits(esize) elt3_i = Elem[operand3, 2 * p + 1, esize];
    integer product_r = elt1_a * elt2_a;
    integer product_i = elt1_a * elt2_b;
    if sub_r then
        Elem[result, 2 * p + 0, esize] = elt3_r - product_r;
    else
        Elem[result, 2 * p + 0, esize] = elt3_r + product_r;
    if sub_i then
        Elem[result, 2 * p + 1, esize] = elt3_i - product_i;
    else
        Elem[result, 2 * p + 1, esize] = elt3_i + product_i;

Z[da] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# CMP<cc> (immediate)

Compare vector to immediate.

Compare active integer elements in the source vector with an immediate, and place the boolean results of the specified comparison in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

The <cc> symbol specifies one of the standard ARM condition codes: EQ, GE, GT, HI, HS, LE, LO, LS, LT or NE.

It has encodings from 10 classes: [Equal](#) , [Greater than](#) , [Greater than or equal](#) , [Higher](#) , [Higher or same](#) , [Less than](#) , [Less than or equal](#) , [Lower](#) , [Lower or same](#) and [Not equal](#)

## Equal

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	0	1	0	0	1	0	1	size	0	imm5					1	0	0	Pg				Zn				0	Pd						
																														ne			

## Equal

CMPEQ <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #<imm>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Cmp_EQ;
integer imm = SInt(imm5);
boolean unsigned = FALSE;
```

## Greater than

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	0	imm5					0	0	0	Pg				Zn				1	Pd				
																lt				ne											

## Greater than

CMPGT <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #<imm>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Cmp_GT;
integer imm = SInt(imm5);
boolean unsigned = FALSE;
```

## Greater than or equal

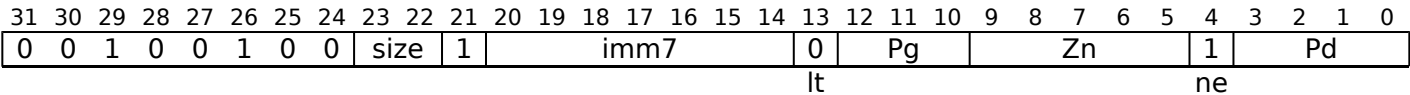
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	0	imm5					0	0	0	Pg				Zn				0	Pd				
																lt				ne											

Greater than or equal

CMPGE <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #<imm>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Cmp_GE;
integer imm = SInt(imm5);
boolean unsigned = FALSE;
```

Higher

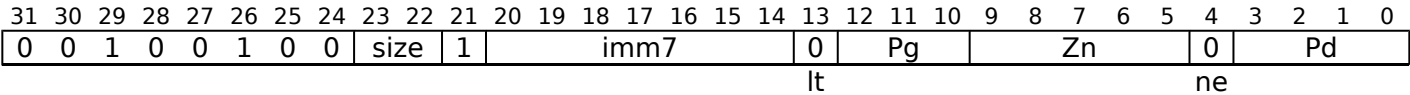


Higher

CMPHI <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #<imm>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Cmp_GT;
integer imm = UInt(imm7);
boolean unsigned = TRUE;
```

Higher or same

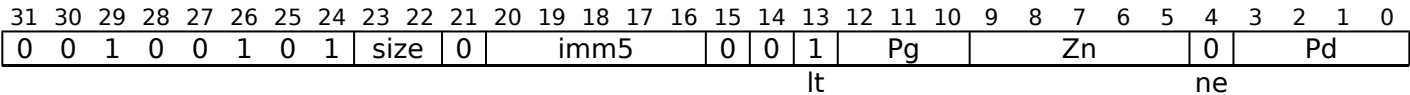


Higher or same

CMPHS <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #<imm>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Cmp_GE;
integer imm = UInt(imm7);
boolean unsigned = TRUE;
```

Less than

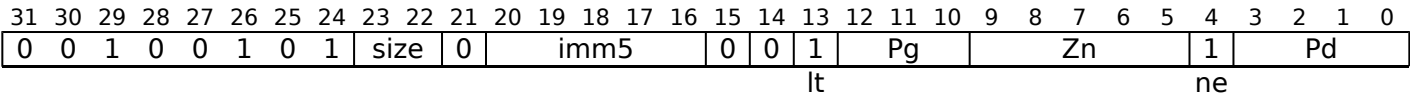


Less than

```
CMPLT <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #<imm>
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Cmp_LT;
integer imm = SInt(imm5);
boolean unsigned = FALSE;
```

Less than or equal

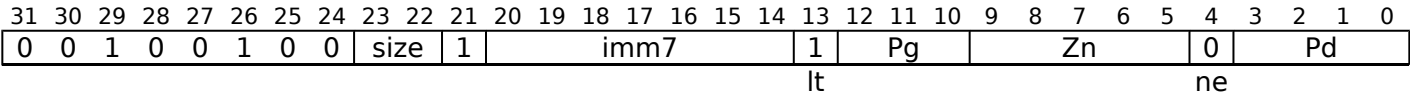


Less than or equal

```
CMPLE <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #<imm>
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Cmp_LE;
integer imm = SInt(imm5);
boolean unsigned = FALSE;
```

Lower

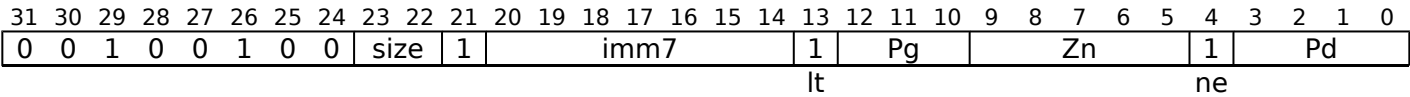


Lower

```
CMPL0 <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #<imm>
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Cmp_LT;
integer imm = UInt(imm7);
boolean unsigned = TRUE;
```

Lower or same

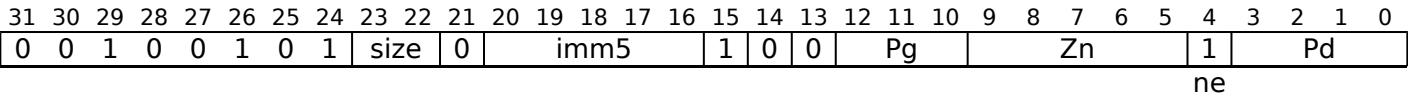


Lower or same

```
CMPLS <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #<imm>
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Cmp_LE;
integer imm = UInt(imm7);
boolean unsigned = TRUE;
```

Not equal



Not equal

```
CMPNE <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #<imm>
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Cmp_NE;
integer imm = SInt(imm5);
boolean unsigned = FALSE;
```

Assembler Symbols

- <Pd>

Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn>

Is the name of the source scalable vector register, encoded in the "Zn" field.
- <imm>

For the equal, greater than, greater than or equal, less than, less than or equal and not equal variant: is the signed immediate operand, in the range -16 to 15, encoded in the "imm5" field.

For the higher, higher or same, lower and lower or same variant: is the unsigned immediate operand, in the range 0 to 127, encoded in the "imm7" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[n];
bits(PL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    if ElemP[mask, e, esize] == '1' then
        boolean cond;
        case op of
            when Cmp_EQ cond = element1 == imm;
            when Cmp_NE cond = element1 != imm;
            when Cmp_GE cond = element1 >= imm;
            when Cmp_LT cond = element1 < imm;
            when Cmp_GT cond = element1 > imm;
            when Cmp_LE cond = element1 <= imm;
        ElemP[result, e, esize] = if cond then '1' else '0';
    else
        ElemP[result, e, esize] = '0';

PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

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# CMP<cc> (wide elements)

Compare vector to 64-bit wide elements.

Compare active integer elements in the first source vector with overlapping 64-bit doubleword elements in the second source vector, and place the boolean results of the specified comparison in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

The <cc> symbol specifies one of the standard ARM condition codes: EQ, GE, GT, HI, HS, LE, LO, LS, LT or NE.

It has encodings from 10 classes: [Equal](#) , [Greater than](#) , [Greater than or equal](#) , [Higher](#) , [Higher or same](#) , [Less than](#) , [Less than or equal](#) , [Lower](#) , [Lower or same](#) and [Not equal](#)

## Equal

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
0	0	1	0	0	1	0	0	size		0	Zm				0	0	1	Pg				Zn				0	Pd								
																															ne				

## Equal

CMPEQ <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<D>

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_EQ;
boolean unsigned = FALSE;
```

## Greater than

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size		0	Zm				0	1	0	Pg				Zn				1	Pd				
																U		lt										ne			

## Greater than

CMPGT <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<D>

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_GT;
boolean unsigned = FALSE;
```

## Greater than or equal

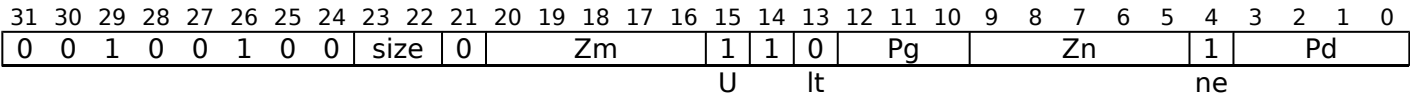
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size		0	Zm				0	1	0	Pg				Zn				0	Pd				
																U		lt										ne			

Greater than or equal

```
CMPGE <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<D>
```

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_GE;
boolean unsigned = FALSE;
```

Higher

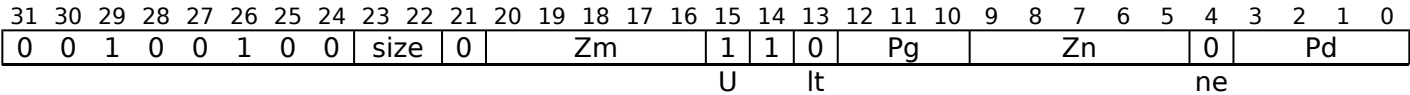


Higher

```
CMPHI <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<D>
```

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_GT;
boolean unsigned = TRUE;
```

Higher or same

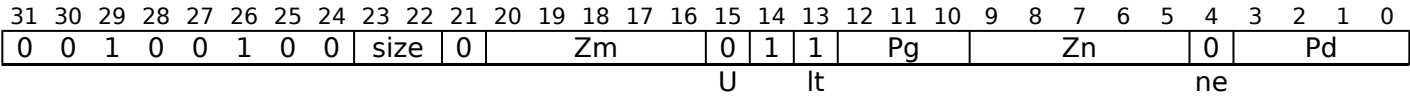


Higher or same

```
CMPHS <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<D>
```

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_GE;
boolean unsigned = TRUE;
```

Less than

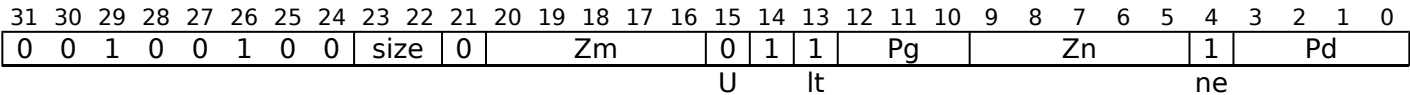


Less than

```
CMPLT <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.D
```

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_LT;
boolean unsigned = FALSE;
```

Less than or equal

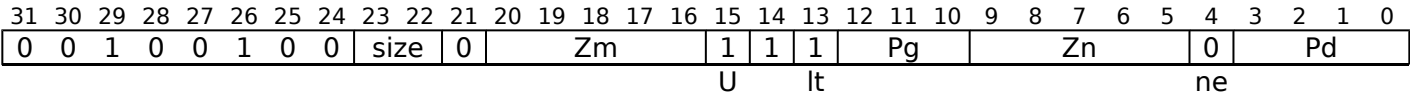


Less than or equal

```
CMPLT <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.D
```

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_LE;
boolean unsigned = FALSE;
```

Lower

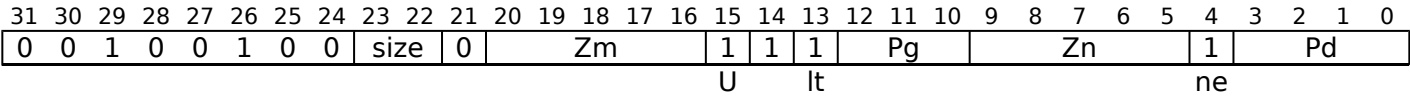


Lower

```
CMPL0 <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.D
```

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_LT;
boolean unsigned = TRUE;
```

Lower or same



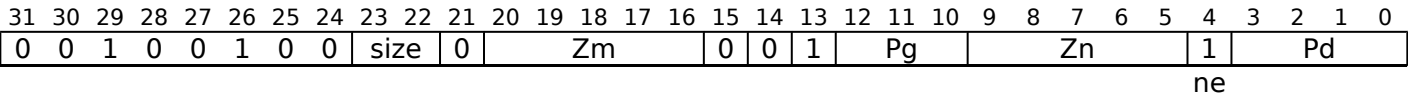


Lower or same

```
CMPLS <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<D>
```

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_LE;
boolean unsigned = TRUE;
```

Not equal



Not equal

```
CMPNE <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<D>
```

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_NE;
boolean unsigned = FALSE;
```

Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	RESERVED

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(PL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, (e * esize) DIV 64, 64], unsigned);
    if ElemP[mask, e, esize] == '1' then
        boolean cond;
        case op of
            when Cmp_EQ cond = element1 == element2;
            when Cmp_NE cond = element1 != element2;
            when Cmp_GE cond = element1 >= element2;
            when Cmp_LT cond = element1 < element2;
            when Cmp_GT cond = element1 > element2;
            when Cmp_LE cond = element1 <= element2;
        ElemP[result, e, esize] = if cond then '1' else '0';
    else
        ElemP[result, e, esize] = '0';

PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

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# CMP<cc> (vectors)

Compare vectors.

Compare active integer elements in the first source vector with corresponding elements in the second source vector, and place the boolean results of the specified comparison in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

The <cc> symbol specifies one of the standard ARM condition codes: EQ, GE, GT, HI, HS or NE.

This instruction is used by the pseudo-instructions [CMPLE \(vectors\)](#), [CMPLO \(vectors\)](#), [CMPLS \(vectors\)](#), and [CMPLT \(vectors\)](#).

It has encodings from 6 classes: [Equal](#) , [Greater than](#) , [Greater than or equal](#) , [Higher](#) , [Higher or same](#) and [Not equal](#)

## Equal

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size	0	Zm				1	0	1	Pg				Zn				0	Pd				ne	

## Equal

CMPEQ <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_EQ;
boolean unsigned = FALSE;
```

## Greater than

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size	0	Zm				1	0	0	Pg				Zn				1	Pd				ne	

## Greater than

CMPGT <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_GT;
boolean unsigned = FALSE;
```

## Greater than or equal

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size	0	Zm				1	0	0	Pg				Zn				0	Pd				ne	

Greater than or equal

CMPGE <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_GE;
boolean unsigned = FALSE;
```

Higher

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size	0	Zm			0	0	0	Pg			Zn			1	Pd								
																												ne			

Higher

CMPHI <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_GT;
boolean unsigned = TRUE;
```

Higher or same

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size	0	Zm			0	0	0	Pg			Zn			0	Pd								
																															ne

Higher or same

CMPHS <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_GE;
boolean unsigned = TRUE;
```

Not equal

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size	0	Zm			1	0	1	Pg			Zn			1	Pd								
																												ne			

Not equal

```
CMPNE <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_NE;
boolean unsigned = FALSE;
```

Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <T> Is the size specifier, encoded in "size":
- | size | <T> |
|------|-----|
| 00   | B   |
| 01   | H   |
| 10   | S   |
| 11   | D   |
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(PL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    if ElemP[mask, e, esize] == '1' then
        boolean cond;
        case op of
            when Cmp_EQ cond = element1 == element2;
            when Cmp_NE cond = element1 != element2;
            when Cmp_GE cond = element1 >= element2;
            when Cmp_LT cond = element1 < element2;
            when Cmp_GT cond = element1 > element2;
            when Cmp_LE cond = element1 <= element2;
        ElemP[result, e, esize] = if cond then '1' else '0';
    else
        ElemP[result, e, esize] = '0';

PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.

- The values of the NZCV flags.

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# CMPLE (vectors)

Compare signed less than or equal to vector, setting the condition flags.

Compare active signed integer elements in the first source vector being less than or equal to corresponding signed elements in the second source vector, and place the boolean results of the comparison in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

This is a pseudo-instruction of [CMP<cc> \(vectors\)](#). This means:

- The encodings in this description are named to match the encodings of [CMP<cc> \(vectors\)](#).
- The assembler syntax is used only for assembly, and is not used on disassembly.
- The description of [CMP<cc> \(vectors\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size	0			Zm		1	0	0		Pg						Zn		0					
																															ne

## Greater than or equal

CMPLE <Pd>.<T>, <Pg>/Z, <Zm>.<T>, <Zn>.<T>

is equivalent to

CMPGE <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

## Assembler Symbols

- <Pd>

Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Zm>

Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <Zn>

Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

## Operation

The description of [CMP<cc> \(vectors\)](#) gives the operational pseudocode for this instruction.

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.

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CMPLO (vectors)

Compare unsigned lower than vector, setting the condition flags.

Compare active unsigned integer elements in the first source vector being lower than corresponding unsigned elements in the second source vector, and place the boolean results of the comparison in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

This is a pseudo-instruction of [CMP<cc> \(vectors\)](#). This means:

- The encodings in this description are named to match the encodings of [CMP<cc> \(vectors\)](#).
- The assembler syntax is used only for assembly, and is not used on disassembly.
- The description of [CMP<cc> \(vectors\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size	0	Zm			0	0	0	Pg			Zn			1	Pd								
																												ne			

Higher

CMPLO <Pd>.<T>, <Pg>/Z, <Zm>.<T>, <Zn>.<T>

is equivalent to

CMPHI <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

Assembler Symbols

- <Pd>

Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Zm>

Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <Zn>

Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

Operation

The description of [CMP<cc> \(vectors\)](#) gives the operational pseudocode for this instruction.

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.



# CMPLS (vectors)

Compare unsigned lower or same as vector, setting the condition flags.

Compare active unsigned integer elements in the first source vector being lower than or same as corresponding unsigned elements in the second source vector, and place the boolean results of the comparison in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

This is a pseudo-instruction of [CMP<cc> \(vectors\)](#). This means:

- The encodings in this description are named to match the encodings of [CMP<cc> \(vectors\)](#).
- The assembler syntax is used only for assembly, and is not used on disassembly.
- The description of [CMP<cc> \(vectors\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size	0	Zm			0	0	0	Pg			Zn			0	Pd								
ne																															

## Higher or same

CMPLS <Pd>.<T>, <Pg>/Z, <Zm>.<T>, <Zn>.<T>

is equivalent to

CMPHS <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

## Assembler Symbols

<Pd>	Is the name of the destination scalable predicate register, encoded in the "Pd" field.										
<Zm>	Is the name of the second source scalable vector register, encoded in the "Zm" field.										
<Zn>	Is the name of the first source scalable vector register, encoded in the "Zn" field.										
<T>	Is the size specifier, encoded in "size":										
<table><tr><th>size</th><th>&lt;T&gt;</th></tr><tr><td>00</td><td>B</td></tr><tr><td>01</td><td>H</td></tr><tr><td>10</td><td>S</td></tr><tr><td>11</td><td>D</td></tr></table>		size	<T>	00	B	01	H	10	S	11	D
size	<T>										
00	B										
01	H										
10	S										
11	D										
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.										

## Operation

The description of [CMP<cc> \(vectors\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

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# CMPLT (vectors)

Compare signed less than vector, setting the condition flags.

Compare active signed integer elements in the first source vector being less than corresponding signed elements in the second source vector, and place the boolean results of the comparison in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

This is a pseudo-instruction of [CMP<cc> \(vectors\)](#). This means:

- The encodings in this description are named to match the encodings of [CMP<cc> \(vectors\)](#).
- The assembler syntax is used only for assembly, and is not used on disassembly.
- The description of [CMP<cc> \(vectors\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size	0	Zm			1	0	0	Pg			Zn			1	Pd								
																												ne			

## Greater than

CMPLT <Pd>.<T>, <Pg>/Z, <Zm>.<T>, <Zn>.<T>

is equivalent to

CMPGT <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

## Assembler Symbols

- <Pd>

Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Zm>

Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <Zn>

Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

## Operation

The description of [CMP<cc> \(vectors\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

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# CNOT

Logically invert boolean condition in vector (predicated).

Logically invert the boolean value in each active element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

Boolean TRUE is any non-zero value in a source, and one in a result element. Boolean FALSE is always zero.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	0	1	1	1	0	1	Pg			Zn			Zd							

## SVE

CNOT <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

### Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    bits(esize) element = Elem[operand, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = ZeroExtend(IsZeroBit(element), esize);

Z[d] = result;
```

### Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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CNT

Count non-zero bits (predicated).

Count non-zero bits in each active element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	0	1	0	1	0	1	Pg	Zn			Zd									

SVE

CNT <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    bits(esize) element = Elem[operand, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = BitCount(element)<esize-1:0>;

Z[d] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

# CNTB, CNTD, CNTH, CNTW

Set scalar to multiple of predicate constraint element count.

Determines the number of active elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then places the result in the scalar destination.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 4 classes: [Byte](#) , [Doubleword](#) , [Halfword](#) and [Word](#)

## Byte

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	1	0	imm4				1	1	1	0	0	0	pattern					Rd				
size<1>size<0>																															

## Byte

CNTB <Xd>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer d = UInt(Rd);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

## Doubleword

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	1	0	imm4				1	1	1	0	0	0	pattern					Rd					
size<1>size<0>																															

## Doubleword

CNTD <Xd>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer d = UInt(Rd);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

## Halfword

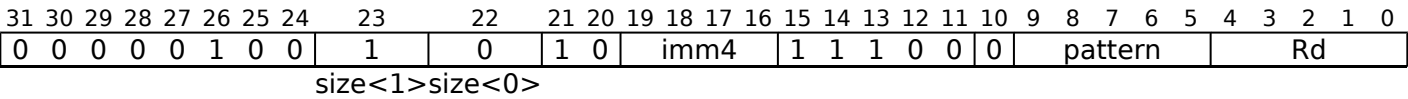
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	1	1	0	imm4				1	1	1	0	0	0	pattern					Rd				
size<1>size<0>																															

Halfword

```
CNTH <Xd>{, <pattern>{, MUL #<imm>}}
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer d = UInt(Rd);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

Word



Word

```
CNTW <Xd>{, <pattern>{, MUL #<imm>}}
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer d = UInt(Rd);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

Assembler Symbols

- <Xd> Is the 64-bit name of the destination general-purpose register, encoded in the "Rd" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

Operation

```
CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
X[d] = (count * imm)<63:0>;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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CNTP

Set scalar to count of true predicate elements.

Counts the number of active and true elements in the source predicate and places the scalar result in the destination general-purpose register. Inactive predicate elements are not counted.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size		1	0	0	0	0	0	1	0	Pg			0	Pn			Rd						

SVE

CNTP <Xd>, <Pg>, <Pn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Pn);
integer d = UInt(Rd);
```

Assembler Symbols

- <Xd> Is the 64-bit name of the destination general-purpose register, encoded in the "Rd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the source scalable predicate register, encoded in the "Pn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(PL) operand = P[n];
bits(64) sum = Zeros();

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' && ElemP[operand, e, esize] == '1' then
        sum = sum + 1;
X[d] = sum;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.

COMPACT

Shuffle active elements of vector to the right and fill with zero.

Read the active elements from the source vector and pack them into the lowest-numbered elements of the destination vector. Then set any remaining elements of the destination vector to zero.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	0	0	0	1	1	0	0	Pg													

SVE

COMPACT <Zd>.<T>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '0x' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "size<0>":

size<0>	<T>
0	S
1	D
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[n];
bits(VL) result;
integer x = 0;

for e = 0 to elements-1
    Elem[result, e, esize] = Zeros();
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element = Elem[operand1, e, esize];
        Elem[result, x, esize] = element;
        x = x + 1;

Z[d] = result;
```

CPY (immediate, zeroing)

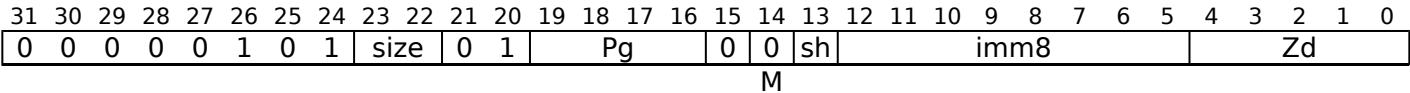
Copy signed integer immediate to vector elements (zeroing).

Copy a signed integer immediate to each active element in the destination vector. Inactive elements in the destination vector register are set to zero.

The immediate operand is a signed value in the range -128 to +127, and for element widths of 16 bits or higher it may also be a signed multiple of 256 in the range -32768 to +32512 (excluding 0).

The immediate is encoded in 8 bits with an optional left shift by 8. The preferred disassembly when the shift option is specified is "#<imm8>, LSL #8". However an assembler and disassembler may also allow use of the shifted 16-bit value unless the immediate is 0 and the shift amount is 8, which must be unambiguously described as "#0, LSL #8".

This instruction is used by the alias [MOV \(immediate, predicated, zeroing\)](#).



SVE

CPY <Zd>.<T>, <Pg>/Z, #<imm>{, <shift>}

```
if !HaveSVE() then UNDEFINED;
if size:sh == '001' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer d = UInt(Zd);
boolean merging = FALSE;
integer imm = SInt(imm8);
if sh == '1' then imm = imm << 8;
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.

<imm> Is a signed immediate in the range -128 to 127, encoded in the "imm8" field.

<shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #8

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) dest = Z[d];
bits(VL) result;

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = imm<esize-1:0>;
    elsif merging then
        Elem[result, e, esize] = Elem[dest, e, esize];
    else
        Elem[result, e, esize] = Zeros();

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

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# CPY (immediate, merging)

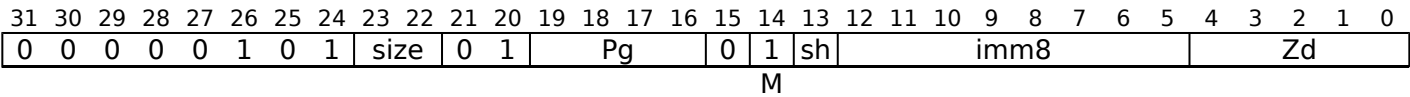
Copy signed integer immediate to vector elements (merging).

Copy a signed integer immediate to each active element in the destination vector. Inactive elements in the destination vector register remain unmodified.

The immediate operand is a signed value in the range -128 to +127, and for element widths of 16 bits or higher it may also be a signed multiple of 256 in the range -32768 to +32512 (excluding 0).

The immediate is encoded in 8 bits with an optional left shift by 8. The preferred disassembly when the shift option is specified is "#<imm8>, LSL #8". However an assembler and disassembler may also allow use of the shifted 16-bit value unless the immediate is 0 and the shift amount is 8, which must be unambiguously described as "#0, LSL #8".

This instruction is used by the aliases [FMOV \(zero, predicated\)](#), and [MOV \(immediate, predicated, merging\)](#).



## SVE

CPY <Zd>.<T>, <Pg>/M, #<imm>{, <shift>}

```
if !HaveSVE() then UNDEFINED;
if size:sh == '001' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer d = UInt(Zd);
boolean merging = TRUE;
integer imm = SInt(imm8);
if sh == '1' then imm = imm << 8;
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.

<imm> Is a signed immediate in the range -128 to 127, encoded in the "imm8" field.

<shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #8

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) dest = Z[d];
bits(VL) result;

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = imm<esize-1:0>;
    elsif merging then
        Elem[result, e, esize] = Elem[dest, e, esize];
    else
        Elem[result, e, esize] = Zeros();

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# CPY (scalar)

Copy general-purpose register to vector elements (predicated).

Copy the general-purpose scalar source register to each active element in the destination vector. Inactive elements in the destination vector register remain unmodified.

This instruction is used by the alias [MOV \(scalar, predicated\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	1	0	0	0	1	0	1	Pg	Rn			Zd									

## SVE

CPY <Zd>.<T>, <Pg>/M, <R><n|SP>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Rn);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<R> Is a width specifier, encoded in "size":

size	<R>
01	W
x0	W
11	X

<n|SP> Is the number [0-30] of the general-purpose source register or the name SP (31), encoded in the "Rn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) operand1;
if n == 31 then
    operand1 = SP[];
else
    operand1 = X[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = operand1<esize-1:0>;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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## CPY (SIMD&FP scalar)

Copy SIMD&FP scalar register to vector elements (predicated).

Copy the SIMD & floating-point scalar source register to each active element in the destination vector. Inactive elements in the destination vector register remain unmodified.

This instruction is used by the alias [MOV \(SIMD&FP scalar, predicated\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	0	0	0	0	1	0	0	Pg													Zd

### SVE

CPY <Zd>.<T>, <Pg>/M, <V><n>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Vn);
integer d = UInt(Zd);
```

### Assembler Symbols

- <Zd>

Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <V>

Is a width specifier, encoded in "size":

size	<V>
00	B
01	H
10	S
11	D
- <n>

Is the number [0-31] of the source SIMD&FP register, encoded in the "Vn" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(esize) operand1 = V[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = operand1;

Z[d] = result;
```

### Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.

- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# CTERMEQ, CTERMNE

Compare and terminate loop.

Detect termination conditions in serialized vector loops. Tests whether the comparison between the scalar source operands holds true and if not tests the state of the !LAST condition flag (C) which indicates whether the previous flag-setting predicate instruction selected the last element of the vector partition.

The Z and C condition flags are preserved by this instruction. The N and V condition flags are set as a pair to generate one of the following conditions for a subsequent conditional instruction:

- \* GE (N=0 & V=0): continue loop (compare failed and last element not selected);
- \* LT (N=0 & V=1): terminate loop (last element selected);
- \* LT (N=1 & V=0): terminate loop (compare succeeded);

The scalar source operands are 32-bit or 64-bit general-purpose registers of the same size.

It has encodings from 2 classes: [Equal](#) and [Not equal](#)

## Equal

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	1	sz	1	Rm					0	0	1	0	0	0	Rn					0	0	0	0	0
ne																															

## Equal

CTERMEQ <R><n>, <R><m>

```
if !HaveSVE() then UNDEFINED;
integer esize = 32 << UInt(sz);
integer n = UInt(Rn);
integer m = UInt(Rm);
SVEComp op = Cmp_EQ;
```

## Not equal

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	1	sz	1	Rm					0	0	1	0	0	0	Rn					1	0	0	0	0
ne																															

## Not equal

CTERMNE <R><n>, <R><m>

```
if !HaveSVE() then UNDEFINED;
integer esize = 32 << UInt(sz);
integer n = UInt(Rn);
integer m = UInt(Rm);
SVEComp op = Cmp_NE;
```

## Assembler Symbols

- <R>

Is a width specifier, encoded in “sz”:

sz	<R>
0	W
1	X
- <n>

Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the “Rn” field.
- <m>

Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the “Rm” field.

## Operation

```
CheckSVEEnabled();
bits(esize) operand1 = X[n];
bits(esize) operand2 = X[m];
integer element1 = UInt(operand1);
integer element2 = UInt(operand2);
boolean term;

case op of
  when Cmp_EQ term = element1 == element2;
  when Cmp_NE term = element1 != element2;
if term then
  PSTATE.N = '1';
  PSTATE.V = '0';
else
  PSTATE.N = '0';
  PSTATE.V = (NOT PSTATE.C);
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# DECB, DECD, DECH, DECW (scalar)

Decrement scalar by multiple of predicate constraint element count.

Determines the number of active elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement the scalar destination.

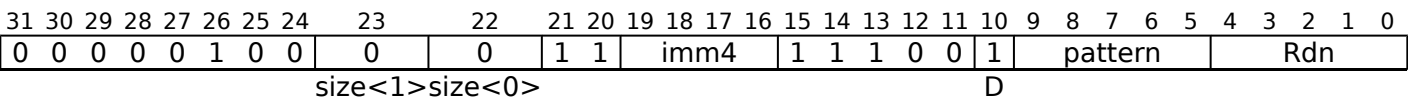
The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 4 classes: [Byte](#) , [Doubleword](#) , [Halfword](#) and [Word](#)

## Byte

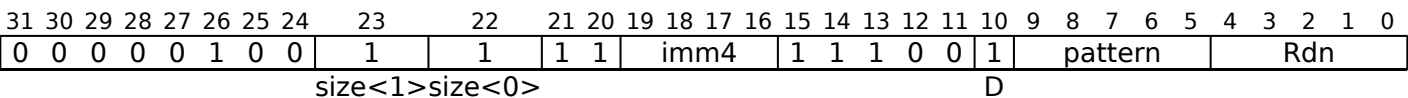


## Byte

DECB <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

## Doubleword

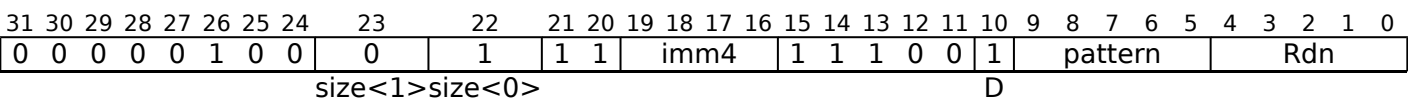


## Doubleword

DECD <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

## Halfword

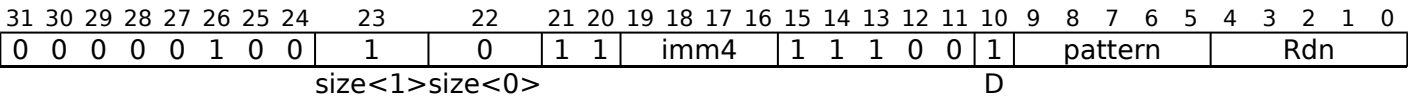


Halfword

```
DECH <Xdn>{, <pattern>{, MUL #<imm>}}
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

Word



Word

```
DECW <Xdn>{, <pattern>{, MUL #<imm>}}
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

Assembler Symbols

- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

Operation

```
CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(64) operand1 = X[dn];

X[dn] = operand1 - (count * imm);
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# DECD, DECH, DECW (vector)

Decrement vector by multiple of predicate constraint element count.

Determines the number of active elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement all destination vector elements.

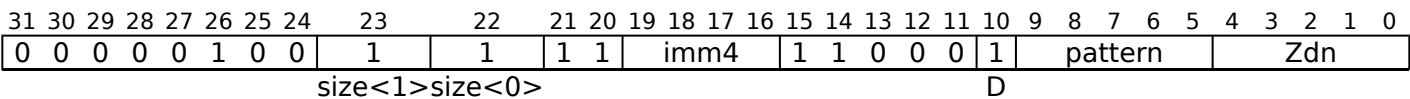
The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 3 classes: [Doubleword](#) , [Halfword](#) and [Word](#)

## Doubleword

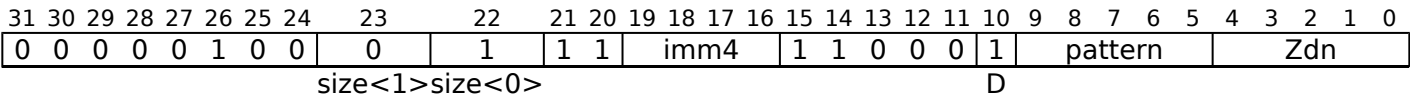


## Doubleword

DECD <Zdn>.D{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

## Halfword

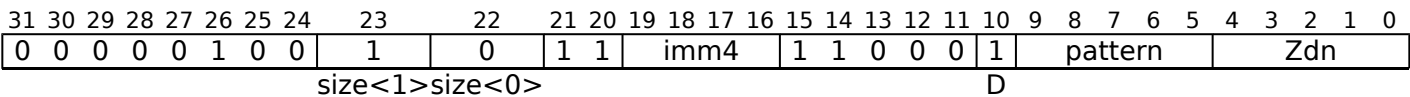


## Halfword

DECH <Zdn>.H{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

## Word





Word

```
DECW <Zdn>.S{, <pattern>{, MUL #<imm>}}
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer count = DecodePredCount(pat, esize);
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    Elem[result, e, esize] = Elem[operand1, e, esize] - (count * imm);

Z[dn] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

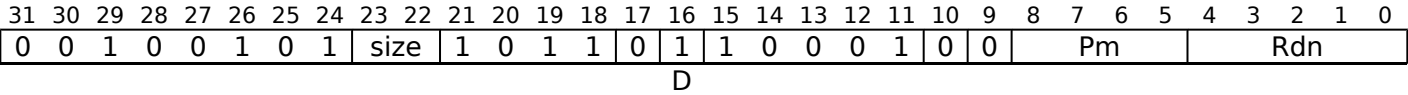
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# DECP (scalar)

Decrement scalar by count of true predicate elements.

Counts the number of true elements in the source predicate and then uses the result to decrement the scalar destination.



## SVE

DECP <Xdn>, <Pm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Rdn);
```

## Assembler Symbols

- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Pm> Is the name of the source scalable predicate register, encoded in the "Pm" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) operand1 = X[dn];
bits(PL) operand2 = P[m];
integer count = 0;

for e = 0 to elements-1
    if ElemP[operand2, e, esize] == '1' then
        count = count + 1;

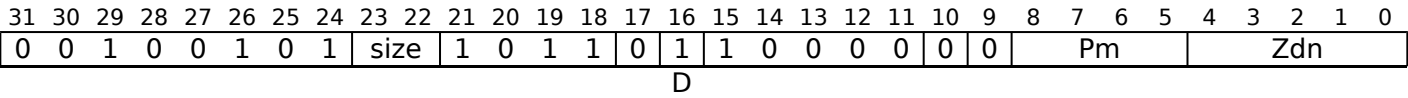
X[dn] = operand1 - count;
```

# DECP (vector)

Decrement vector by count of true predicate elements.

Counts the number of true elements in the source predicate and then uses the result to decrement all destination vector elements.

The predicate size specifier may be omitted in assembler source code, but this is deprecated and will be prohibited in a future release of the architecture.



## SVE

DECP <Zdn>.<T>, <Pm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Zdn);
```

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pm> Is the name of the source scalable predicate register, encoded in the "Pm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(PL) operand2 = P[m];
bits(VL) result;
integer count = 0;

for e = 0 to elements-1
    if ElemP[operand2, e, esize] == '1' then
        count = count + 1;

for e = 0 to elements-1
    Elem[result, e, esize] = Elem[operand1, e, esize] - count;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



DUP (immediate)

Broadcast signed immediate to vector elements (unpredicated).

Unconditionally broadcast the signed integer immediate into each element of the destination vector. This instruction is unpredicated.

The immediate operand is a signed value in the range -128 to +127, and for element widths of 16 bits or higher it may also be a signed multiple of 256 in the range -32768 to +32512 (excluding 0).

The immediate is encoded in 8 bits with an optional left shift by 8. The preferred disassembly when the shift option is specified is "#<imm8>, LSL #8". However an assembler and disassembler may also allow use of the shifted 16-bit value unless the immediate is 0 and the shift amount is 8, which must be unambiguously described as "#0, LSL #8".

This instruction is used by the aliases [FMOV \(zero, unpredicated\)](#), and [MOV \(immediate, unpredicated\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size		1	1	1	0	0	0	1	1	sh	imm8								Zd				

SVE

```
DUP <Zd>.<T>, #<imm>{, <shift>}
```

```
if !HaveSVE() then UNDEFINED;
if size:sh == '001' then UNDEFINED;
integer esize = 8 << UInt(size);
integer d = UInt(Zd);
integer imm = SInt(imm8);
if sh == '1' then imm = imm << 8;
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<imm> Is a signed immediate in the range -128 to 127, encoded in the "imm8" field.

<shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #8

Operation

```
CheckSVEEnabled();
bits(VL) result = Replicate(imm<esize-1:0>);
Z[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.



# DUP (scalar)

Broadcast general-purpose register to vector elements (unpredicated).

Unconditionally broadcast the general-purpose scalar source register into each element of the destination vector. This instruction is unpredicated.

This instruction is used by the alias [MOV \(scalar, unpredicated\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	0	0	0	0	0	0	1	1	1	0	Rn				Zd						

## SVE

DUP <Zd>.<T>, <R><n|SP>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Rn);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<R> Is a width specifier, encoded in "size":

size	<R>
01	W
x0	W
11	X

<n|SP> Is the number [0-30] of the general-purpose source register or the name SP (31), encoded in the "Rn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) operand;
if n == 31 then
    operand = SP[];
else
    operand = X[n];
bits(VL) result;

for e = 0 to elements-1
    Elem[result, e, esize] = operand<esize-1:0>;

Z[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.



- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# DUP (indexed)

Broadcast indexed element to vector (unpredicated).

Unconditionally broadcast the indexed source vector element into each element of the destination vector. This instruction is unpredicated.  
The immediate element index is in the range of 0 to 63 (bytes), 31 (halfwords), 15 (words), 7 (doublewords) or 3 (quadwords). Selecting an element beyond the accessible vector length causes the destination vector to be set to zero.

This instruction is used by the alias [MOV \(SIMD&FP scalar, unpredicated\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	0	0	0	0	1	0	1	imm2	1	tsz						0	0	1	0	0	0	Zn						Zd					

## SVE

DUP <Zd>.<T>, <Zn>.<T>[<imm>]

```
if !HaveSVE() then UNDEFINED;
bits(7) imm = imm2:tsz;
case tsz of
  when '00000' UNDEFINED;
  when '10000' esize = 128; index = UInt(imm<6:5>);
  when 'x1000' esize = 64;  index = UInt(imm<6:4>);
  when 'xx100' esize = 32;  index = UInt(imm<6:3>);
  when 'xxx10' esize = 16;  index = UInt(imm<6:2>);
  when 'xxxx1' esize = 8;   index = UInt(imm<6:1>);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "tsz":

tsz	<T>
00000	RESERVED
xxxx1	B
xx100	H
xx100	S
x1000	D
10000	Q

- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.
- <imm> Is the immediate index, in the range 0 to one less than the number of elements in 512 bits, encoded in "imm2:tsz".

## Alias Conditions

Alias	Is preferred when
<a href="#">MOV (SIMD&amp;FP scalar, unpredicated)</a>	<code>BitCount(imm2:tsz) == 1</code>
<a href="#">MOV (SIMD&amp;FP scalar, unpredicated)</a>	<code>BitCount(imm2:tsz) &gt; 1</code>

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) result;
bits(esize) element;

if index >= elements then
    element = Zeros();
else
    element = Elem[operand1, index, esize];
result = Replicate(element);

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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DUPM

Broadcast logical bitmask immediate to vector (unpredicated).

Unconditionally broadcast the logical bitmask immediate into each element of the destination vector. This instruction is unpredicated. The immediate is a 64-bit value consisting of a single run of ones or zeros repeating every 2, 4, 8, 16, 32 or 64 bits.

This instruction is used by the alias [MOV \(bitmask immediate\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	1	1	0	0	0	0	imm13														Zd			

SVE

DUPM <Zd>.<T>, #<const>

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer d = UInt(Zd);
bits(esize) imm;
(imm, -) = DecodeBitMasks(imm13<12>, imm13<5:0>, imm13<11:6>, TRUE);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "imm13<12>:imm13<5:0>":

imm13<12>	imm13<5:0>	<T>
0	0xxxxx	S
0	10xxxx	H
0	110xxx	B
0	1110xx	B
0	11110x	B
0	111110	RESERVED
0	111111	RESERVED
1	xxxxxx	D

<const> Is a 64, 32, 16 or 8-bit bitmask consisting of replicated 2, 4, 8, 16, 32 or 64 bit fields, each field containing a rotated run of non-zero bits, encoded in the "imm13" field.

Alias Conditions

Alias	Is preferred when
<a href="#">MOV (bitmask immediate)</a>	<a href="#">SVEMoveMaskPreferred</a> (imm13)

Operation

```
CheckSVEEnabled();
bits(VL) result = Replicate(imm);
Z[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.



EON

Bitwise exclusive OR with inverted immediate (unpredicated).

Bitwise exclusive OR an inverted immediate with each 64-bit element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate is a 64-bit value consisting of a single run of ones or zeros repeating every 2, 4, 8, 16, 32 or 64 bits. This instruction is unpredicated.

This is a pseudo-instruction of [EOR \(immediate\)](#). This means:

- The encodings in this description are named to match the encodings of [EOR \(immediate\)](#).
- The assembler syntax is used only for assembly, and is not used on disassembly.
- The description of [EOR \(immediate\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	0	1	0	0	0	0	imm13													Zdn				

SVE

EON <Zdn>.<T>, <Zdn>.<T>, #<const>

is equivalent to

EOR <Zdn>.<T>, <Zdn>.<T>, #(-<const> - 1)

Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "imm13<12>:imm13<5:0>":

imm13<12>	imm13<5:0>	<T>
0	0xxxxx	S
0	10xxxx	H
0	110xxx	B
0	1110xx	B
0	11110x	B
0	111110	RESERVED
0	111111	RESERVED
1	xxxxxx	D

<const> Is a 64, 32, 16 or 8-bit bitmask consisting of replicated 2, 4, 8, 16, 32 or 64 bit fields, each field containing a rotated run of non-zero bits, encoded in the "imm13" field.

Operation

The description of [EOR \(immediate\)](#) gives the operational pseudocode for this instruction.

Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



# EOR3

Bitwise exclusive OR of three vectors.

Bitwise exclusive OR the corresponding elements of all three source vectors, and destructively place the results in the corresponding elements of the destination and first source vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	1	Zm					0	0	1	1	1	0	Zk					Zdn				

## SVE2

EOR3 <Zdn>.D, <Zdn>.D, <Zm>.D, <Zk>.D

```
if !HaveSVE2() then UNDEFINED;
integer m = UInt(Zm);
integer k = UInt(Zk);
integer dn = UInt(Zdn);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <Zk> Is the name of the third source scalable vector register, encoded in the "Zk" field.

## Operation

```
CheckSVEEnabled();
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[k];

Z[dn] = operand1 EOR operand2 EOR operand3;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



# EOR, EORS (predicates)

Bitwise exclusive OR predicates.

Bitwise exclusive OR active elements of the second source predicate with corresponding elements of the first source predicate and place the results in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Optionally sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

This instruction is used by the aliases [NOTS](#), and [NOT \(predicate\)](#).

It has encodings from 2 classes: [Not setting the condition flags](#) and [Setting the condition flags](#)

## Not setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	0	0	0	Pm				0	1	Pg				1	Pn				0	Pd			
S																															

## Not setting the condition flags

EOR <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = FALSE;
```

## Setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	1	0	0	Pm				0	1	Pg				1	Pn				0	Pd			
S																															

## Setting the condition flags

EORS <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = TRUE;
```

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.
- <Pm> Is the name of the second source scalable predicate register, encoded in the "Pm" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">NOTS</a>	Pm == Pg

Alias	Is preferred when
<a href="#">NOT (predicate)</a>	$P_m == P_g$

## Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(PL) operand1 = P[n];
bits(PL) operand2 = P[m];
bits(PL) result;

for e = 0 to elements-1
    bit element1 = ElemP[operand1, e, esize];
    bit element2 = ElemP[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        ElemP[result, e, esize] = element1 EOR element2;
    else
        ElemP[result, e, esize] = '0';

if setflags then
    PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

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## EOR (vectors, predicated)

Bitwise exclusive OR vectors (predicated).

Bitwise exclusive OR active elements of the second source vector with corresponding elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	0	0	1	0	0	0		Pg						Zm					Zdn	

### SVE

EOR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

### Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = element1 EOR element2;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

### Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:

- The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
- The values of the NZCV flags.

This instruction might be immediately preceded in program order by a **MOVPRFX** instruction. The **MOVPRFX** instruction must conform to all of the following requirements, otherwise the behavior of the **MOVPRFX** and this instruction is UNPREDICTABLE:

- The **MOVPRFX** instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The **MOVPRFX** instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# EOR (immediate)

Bitwise exclusive OR with immediate (unpredicated).

Bitwise exclusive OR an immediate with each 64-bit element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate is a 64-bit value consisting of a single run of ones or zeros repeating every 2, 4, 8, 16, 32 or 64 bits. This instruction is unpredicated.

This instruction is used by the pseudo-instruction [EON](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	0	1	0	0	0	0	imm13														Zdn			

## SVE

EOR <Zdn>.<T>, <Zdn>.<T>, #<const>

```
if !HaveSVE() then UNDEFINED;
integer dn = UInt(Zdn);
bits(64) imm;
(imm, -) = DecodeBitMasks(imm13<12>, imm13<5:0>, imm13<11:6>, TRUE);
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "imm13<12>:imm13<5:0>":

imm13<12>	imm13<5:0>	<T>
0	0xxxxx	S
0	10xxxx	H
0	110xxx	B
0	1110xx	B
0	11110x	B
0	111110	RESERVED
0	111111	RESERVED
1	xxxxxx	D

- <const> Is a 64, 32, 16 or 8-bit bitmask consisting of replicated 2, 4, 8, 16, 32 or 64 bit fields, each field containing a rotated run of non-zero bits, encoded in the "imm13" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV 64;
bits(VL) operand = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    bits(64) element1 = Elem[operand, e, 64];
    Elem[result, e, 64] = element1 EOR imm;

Z[dn] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# EOR (vectors, unpredicated)

Bitwise exclusive OR vectors (unpredicated).

Bitwise exclusive OR all elements of the second source vector with corresponding elements of the first source vector and place the results in the corresponding elements of the destination vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	0	1	Zm					0	0	1	1	0	0	Zn					Zd				

## SVE

EOR <Zd>.D, <Zn>.D, <Zm>.D

```
if !HaveSVE() then UNDEFINED;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];

Z[d] = operand1 EOR operand2;
```

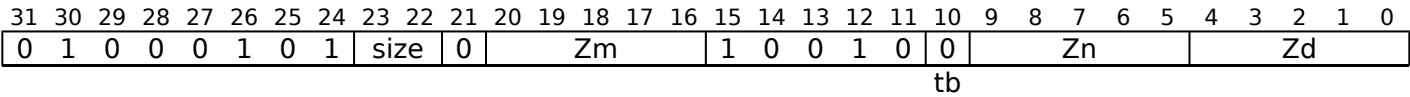
## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

EORBT

Interleaving exclusive OR (bottom, top).

Interleaving exclusive OR between the even-numbered elements of the first source vector register and the odd-numbered elements of the second source vector register, placing the result in the even-numbered elements of the destination vector, leaving the odd-numbered elements unchanged. This instruction is unpredicated.



SVE2

```
EORBT <Zd>.<T>, <Zn>.<T>, <Zm>.<T>
```

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer sel1 = 0;
integer sel2 = 1;
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[d];

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, 2*e + sel1, esize];
    bits(esize) element2 = Elem[operand2, 2*e + sel2, esize];
    Elem[result, 2*e + sel1, esize] = element1 EOR element2;

Z[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.



This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

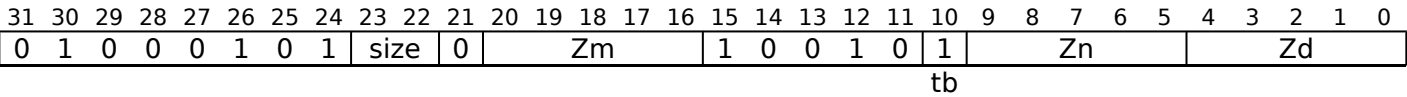
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EORTB

Interleaving exclusive OR (top, bottom).

Interleaving exclusive OR between the odd-numbered elements of the first source vector register and the even-numbered elements of the second source vector register, placing the result in the odd-numbered elements of the destination vector, leaving the even-numbered elements unchanged. This instruction is unpredicated.



SVE2

```
EORTB <Zd>.<T>, <Zn>.<T>, <Zm>.<T>
```

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer sel1 = 1;
integer sel2 = 0;
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[d];

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, 2*e + sel1, esize];
    bits(esize) element2 = Elem[operand2, 2*e + sel2, esize];
    Elem[result, 2*e + sel1, esize] = element1 EOR element2;

Z[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# EORV

Bitwise exclusive OR reduction to scalar.

Bitwise exclusive OR horizontally across all lanes of a vector, and place the result in the SIMD&FP scalar destination register. Inactive elements in the source vector are treated as zero.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	0	0	1	0	0	1	Pg													

## SVE

EORV <V><d>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);
```

## Assembler Symbols

<V> Is a width specifier, encoded in "size":

size	<V>
00	B
01	H
10	S
11	D

<d> Is the number [0-31] of the destination SIMD&FP register, encoded in the "Vd" field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(esize) result = Zeros(esize);

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        result = result EOR Elem[operand, e, esize];

V[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:

- The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
- The values of the NZCV flags.

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# EXT

Extract vector from pair of vectors.

Copy the indexed byte up to the last byte of the first source vector to the bottom of the result vector, then fill the remainder of the result starting from the first byte of the second source vector. The result is placed destructively in the destination and first source vector, or constructively in the destination vector. This instruction is unpredicated. An index that is greater than or equal to the vector length in bytes is treated as zero, resulting in the first source vector being copied to the result unchanged.

It has encodings from 2 classes: [Constructive](#) and [Destructive](#)

## Constructive

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	0	1	1	imm8h				0	0	0	imm8l				Zn				Zd					

## Constructive

EXT [<Zd>](#).B, { [<Zn1>](#).B, [<Zn2>](#).B }, #[<imm>](#)

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8;
integer dst = UInt(Zd);
integer s1 = UInt(Zn);
integer s2 = (s1 + 1) MOD 32;
integer position = UInt(imm8h:imm8l);
```

## Destructive

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	0	0	1	imm8h				0	0	0	imm8l				Zm				Zdn					

## Destructive

EXT [<Zdn>](#).B, [<Zdn>](#).B, [<Zm>](#).B, #[<imm>](#)

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer dst = UInt(Zdn);
integer s1 = dst;
integer s2 = UInt(Zm);
integer position = UInt(imm8h:imm8l);
```

## Assembler Symbols

- [<Zd>](#) Is the name of the destination scalable vector register, encoded in the "Zd" field.
- [<Zn1>](#) Is the name of the first scalable vector register of a multi-vector sequence, encoded in the "Zn" field.
- [<Zn2>](#) Is the name of the second scalable vector register of a multi-vector sequence, encoded in the "Zn" field.
- [<Zdn>](#) Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- [<Zm>](#) Is the name of the second source scalable vector register, encoded in the "Zm" field.
- [<imm>](#) Is the unsigned immediate operand, in the range 0 to 255, encoded in the "imm8h:imm8l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[s1];
bits(VL) operand2 = Z[s2];
bits(VL) result;

if position >= elements then
    position = 0;

position = position << 3;
bits(VL*2) concat = operand2 : operand1;
result = concat<position+VL-1:position>;

Z[dst] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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FABD

Floating-point absolute difference (predicated).

Compute the absolute difference of active floating-point elements of the second source vector and corresponding floating-point elements of the first source vector and destructively place the result in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	1	0	0	0	1	0	0	Pg	Zm				Zdn								

SVE

FABD <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPAbs(FPSub(element1, element2, FPCR<31:0>));
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.



- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# FABS

Floating-point absolute value (predicated).

Take the absolute value of each active floating-point element of the source vector, and place the results in the corresponding elements of the destination vector. This clears the sign bit and cannot signal a floating-point exception. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	1	0	0	1	0	1	Pg				Zn				Zd					

## SVE

FABS <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    bits(esize) element = Elem[operand, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPAbs(element);

Z[d] = result;
```

## Operational information

- This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:
- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
  - The MOVPRFX instruction must specify the same destination register as this instruction.
  - The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



FAC<cc>

Floating-point absolute compare vectors.

Compare active absolute values of floating-point elements in the first source vector with corresponding absolute values of elements in the second source vector, and place the boolean results of the specified comparison in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Does not set the condition flags.

The <cc> symbol specifies one of the standard ARM condition codes: GE, GT, LE, or LT.

This instruction is used by the pseudo-instructions [FACLE](#), and [FACLT](#).

It has encodings from 2 classes: [Greater than](#) and [Greater than or equal](#)

Greater than

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size		0	Zm				1	1	1	Pg			Zn				1	Pd					

Greater than

FACGT <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_GT;
```

Greater than or equal

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size			0	Zm				1	1	0	Pg			Zn				1	Pd				

Greater than or equal

FACGE <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_GE;
```

Assembler Symbols

- <Pd>

Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D
- <Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(PL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        case op of
            when Cmp_GE res = FPCompareGE(FPAbs(element1), FPAbs(element2), FPCR<31:0>);
            when Cmp_GT res = FPCompareGT(FPAbs(element1), FPAbs(element2), FPCR<31:0>);
            ElemP[result, e, esize] = if res then '1' else '0';
    else
        ElemP[result, e, esize] = '0';
P[d] = result;

```

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FACLE

Floating-point absolute compare less than or equal.

Compare active absolute values of floating-point elements in the first source vector being less than or equal to corresponding absolute values of elements in the second source vector, and place the boolean results of the comparison in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Does not set the condition flags.

This is a pseudo-instruction of [FAC<cc>](#). This means:

- The encodings in this description are named to match the encodings of [FAC<cc>](#).
- The assembler syntax is used only for assembly, and is not used on disassembly.
- The description of [FAC<cc>](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	Zm			1	1	0	Pg			Zn			1	Pd								

Greater than or equal

FACLE <Pd>.<T>, <Pg>/Z, <Zm>.<T>, <Zn>.<T>

is equivalent to

FACGE <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

Assembler Symbols

- <Pd>

Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Zm>

Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <Zn>

Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D
- <Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

Operation

The description of [FAC<cc>](#) gives the operational pseudocode for this instruction.

FACLT

Floating-point absolute compare less than.

Compare active absolute values of floating-point elements in the first source vector being less than corresponding absolute values of elements in the second source vector, and place the boolean results of the comparison in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Does not set the condition flags.

This is a pseudo-instruction of [FAC<cc>](#). This means:

- The encodings in this description are named to match the encodings of [FAC<cc>](#).
- The assembler syntax is used only for assembly, and is not used on disassembly.
- The description of [FAC<cc>](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	Zm			1	1	1	Pg			Zn			1	Pd								

Greater than

FACLT <Pd>.<T>, <Pg>/Z, <Zm>.<T>, <Zn>.<T>

is equivalent to

FACGT <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

Assembler Symbols

- <Pd>

Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Zm>

Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <Zn>

Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D
- <Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

Operation

The description of [FAC<cc>](#) gives the operational pseudocode for this instruction.

# FADD (immediate)

Floating-point add immediate (predicated).

Add an immediate to each active floating-point element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate may take the value +0.5 or +1.0 only. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	1	1	0	0	0	1	0	0	Pg	0	0	0	0	i1								Zdn

## SVE

FADD <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <const>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
bits(esize) imm = if i1 == '0' then FPPointFive('0') else FPOne('0');
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <const> Is the floating-point immediate value, encoded in "i1":

i1	<const>
0	#0.5
1	#1.0

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPAAdd(element1, imm, FPCR<31:0>);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:



- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# FADD (vectors, predicated)

Floating-point add vector (predicated).

Add active floating-point elements of the second source vector to corresponding floating-point elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	0	0	0	0	1	0	0	Pg	Zm				Zdn							

## SVE

FADD <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FAdd(element1, element2, FPCR<31:0>);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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FADD (vectors, unpredicated)

Floating-point add vector (unpredicated).

Add all floating-point elements of the second source vector to corresponding elements of the first source vector and place the results in the corresponding elements of the destination vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size			0	Zm				0	0	0	0	0	0	Zn				Zd					

SVE

```
FADD <Zd>.<T>, <Zn>.<T>, <Zm>.<T>
```

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = FPAdd(element1, element2, FPCR<31:0>);

Z[d] = result;
```

FADDA

Floating-point add strictly-ordered reduction, accumulating in scalar.

Floating-point add a SIMD&FP scalar source and all active lanes of the vector source and place the result destructively in the SIMD&FP scalar source register. Vector elements are processed strictly in order from low to high, with the scalar source providing the initial value. Inactive elements in the source vector are ignored.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	1	1	0	0	0	0	0	1	Pg	Zm				Vdn								

SVE

FADDA <V><dn>, <Pg>, <V><dn>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Vdn);
integer m = UInt(Zm);
```

Assembler Symbols

<V> Is a width specifier, encoded in "size":

size	<V>
00	RESERVED
01	H
10	S
11	D

<dn> Is the number [0-31] of the source and destination SIMD&FP register, encoded in the "Vdn" field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the source scalable vector register, encoded in the "Zm" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(esize) operand1 = V[dn];
bits(VL) operand2 = Z[m];
bits(esize) result = operand1;

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    bits(esize) element = Elem[operand2, e, esize];
    result = FAdd(result, element, FPCR<31:0>);

V[dn] = result;
```

# FADDP

Floating-point add pairwise.

Add pairs of adjacent floating-point elements within each source vector, and interleave the results from corresponding lanes. The interleaved result values are destructively placed in the first source vector.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	size	0	1	0	0	0	0	1	0	0	Pg	Zm				Zdn								

## SVE2

FADDP <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer m = UInt(Zm);
integer dn = UInt(Zdn);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[dn];
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        if IsEven(e) then
            element1 = Elem[operand1, e + 0, esize];
            element2 = Elem[operand1, e + 1, esize];
        else
            element1 = Elem[operand2, e - 1, esize];
            element2 = Elem[operand2, e + 0, esize];
        Elem[result, e, esize] = FPAAdd(element1, element2, FPCR<31:0>);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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FADDV

Floating-point add recursive reduction to scalar.

Floating-point add horizontally over all lanes of a vector using a recursive pairwise reduction, and place the result in the SIMD&FP scalar destination register. Inactive elements in the source vector are treated as +0.0.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size		0	0	0	0	0	0	0	1	Pg			Zn			Vd							

SVE

FADDV <V><d>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	RESERVED
01	H
10	S
11	D

<d> Is the number [0-31] of the destination SIMD&FP register, encoded in the "Vd" field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<T> Is the size specifier, encoded in “size”:

size	<T>
00	RESERVED
01	H
10	S
11	D

Operation

```
CheckSVEEnabled();
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(esize) identity = FPZero('0');
V[d] = ReducePredicated(ReduceOp_FADD, operand, mask, identity);
```



FCADD

Floating-point complex add with rotate (predicated).

Add the real and imaginary components of the active floating-point complex numbers from the first source vector to the complex numbers from the second source vector which have first been rotated by 90 or 270 degrees in the direction from the positive real axis towards the positive imaginary axis, when considered in polar representation, equivalent to multiplying the complex numbers in the second source vector by  $\pm j$  beforehand. Destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

Each complex number is represented in a vector register as an even/odd pair of elements with the real part in the even-numbered element and the imaginary part in the odd-numbered element.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	size	0	0	0	0	0	0	rot	1	0	0	Pg	Zm			Zdn								

SVE

FCADD <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>, <const>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean sub_i = (rot == '0');
boolean sub_r = (rot == '1');
```

Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <const> Is the const specifier, encoded in "rot":

rot	<const>
0	#90
1	#270

## Operation

```
CheckSVEEnabled();
integer pairs = VL DIV (2 * esize);
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for p = 0 to pairs-1
    acc_r = Elem[operand1, 2 * p + 0, esize];
    acc_i = Elem[operand1, 2 * p + 1, esize];
    elt2_r = Elem[operand2, 2 * p + 0, esize];
    elt2_i = Elem[operand2, 2 * p + 1, esize];
    if ElemP[mask, 2 * p + 0, esize] == '1' then
        if sub_i then elt2_i = FPNeg(elt2_i);
        acc_r = FPAAdd(acc_r, elt2_i, FPCR<31:0>);
    if ElemP[mask, 2 * p + 1, esize] == '1' then
        if sub_r then elt2_r = FPNeg(elt2_r);
        acc_i = FPAAdd(acc_i, elt2_r, FPCR<31:0>);
    Elem[result, 2 * p + 0, esize] = acc_r;
    Elem[result, 2 * p + 1, esize] = acc_i;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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FCM<cc> (zero)

Floating-point compare vector with zero.

Compare active floating-point elements in the source vector with zero, and place the boolean results of the specified comparison in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Does not set the condition flags.  
The <cc> symbol specifies one of the standard ARM condition codes: EQ, GE, GT, LE, LT, or NE.

It has encodings from 6 classes: [Equal](#) , [Greater than](#) , [Greater than or equal](#) , [Less than](#) , [Less than or equal](#) and [Not equal](#)

Equal

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0										
0	1	1	0	0	1	0	1	size	0	1	0	0	1	0	0	0	1	Pg				Zn				0	Pd														
eq														lt														ne													

Equal

FCMEQ <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #0.0

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Cmp_EQ;
```

Greater than

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0						
0	1	1	0	0	1	0	1	size	0	1	0	0	0	0	0	0	1	Pg				Zn				1	Pd										
eq														lt														ne									

Greater than

FCMGT <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #0.0

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Cmp_GT;
```

Greater than or equal

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0										
0	1	1	0	0	1	0	1	size	0	1	0	0	0	0	0	0	1	Pg				Zn				0	Pd														
eq														lt														ne													

Greater than or equal

FCMGE <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #0.0

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Cmp_GE;
```

Less than

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	1	0	0	0	0	1	0	0	1	Pg								0			Pd	
eq lt																ne															

Less than

FCMLT <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #0.0

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Cmp_LT;
```

Less than or equal

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	1	0	0	0	0	1	0	0	1	Pg			Zn			1			Pd			
eq lt																ne															

Less than or equal

FCMLE <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #0.0

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Cmp_LE;
```

Not equal

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	1	0	0	1	1	0	0	1	Pg	Zn				0	Pd							
eq lt																ne															

Not equal

```
FCMNE <Pd>.<T>, <Pg>/Z, <Zn>.<T>, #0.0
```

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Pd);
SVEComp op = Cmp_NE;
```

Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(PL) result;

for e = 0 to elements-1
    bits(esize) element = Elem[operand, e, esize];
    if ElemP[mask, e, esize] == '1' then
        case op of
            when Cmp_EQ res = FPCmpareEQ(element, 0<esize-1:0>, FPCR<31:0>);
            when Cmp_GE res = FPCmpareGE(element, 0<esize-1:0>, FPCR<31:0>);
            when Cmp_GT res = FPCmpareGT(element, 0<esize-1:0>, FPCR<31:0>);
            when Cmp_NE res = FPCmpareNE(element, 0<esize-1:0>, FPCR<31:0>);
            when Cmp_LT res = FPCmpareGT(0<esize-1:0>, element, FPCR<31:0>);
            when Cmp_LE res = FPCmpareGE(0<esize-1:0>, element, FPCR<31:0>);
        ElemP[result, e, esize] = if res then '1' else '0';
    else
        ElemP[result, e, esize] = '0';

P[d] = result;
```

## FCM<cc> (vectors)

Floating-point compare vectors.

Compare active floating-point elements in the first source vector with corresponding elements in the second source vector, and place the boolean results of the specified comparison in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Does not set the condition flags. The <cc> symbol specifies one of the standard ARM condition codes: EQ, GE, GT, or NE, with the addition of UO for an unordered comparison.

This instruction is used by the pseudo-instructions [FCMLE \(vectors\)](#), and [FCMLT \(vectors\)](#).

It has encodings from 5 classes: [Equal](#) , [Greater than](#) , [Greater than or equal](#) , [Not equal](#) and [Unordered](#)

### Equal

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	Zm						0	1	1	Pg			Zn				0	Pd				
cmph																		cmpl													

### Equal

FCMEQ <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_EQ;
```

### Greater than

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	Zm						0	1	0	Pg			Zn				1	Pd				
cmph																		cmpl													

### Greater than

FCMGT <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_GT;
```

### Greater than or equal

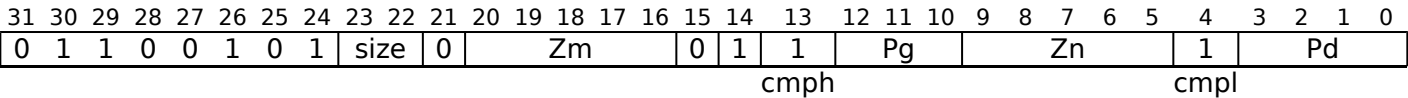
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	Zm						0	1	0	Pg			Zn				0	Pd				
cmph																		cmpl													

Greater than or equal

```
FCMGE <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>
```

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_GE;
```

Not equal

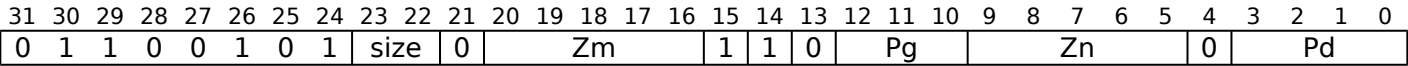


Not equal

```
FCMNE <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>
```

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_NE;
```

Unordered



Unordered

```
FCMUO <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>
```

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Pd);
SVEComp op = Cmp_UN;
```

Assembler Symbols

- <Pd>

Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D
- <Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn>

Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(PL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        case op of
            when Cmp_EQ res = FPCCompareEQ(element1, element2, FPCR<31:0>);
            when Cmp_GE res = FPCCompareGE(element1, element2, FPCR<31:0>);
            when Cmp_GT res = FPCCompareGT(element1, element2, FPCR<31:0>);
            when Cmp_UN res = FPCCompareUN(element1, element2, FPCR<31:0>);
            when Cmp_NE res = FPCCompareNE(element1, element2, FPCR<31:0>);
            when Cmp_LT res = FPCCompareGT(element2, element1, FPCR<31:0>);
            when Cmp_LE res = FPCCompareGE(element2, element1, FPCR<31:0>);
        ElemP[result, e, esize] = if res then '1' else '0';
    else
        ElemP[result, e, esize] = '0';
P[d] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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FCMLA (vectors)

Floating-point complex multiply-add with rotate (predicated).

Multiply the duplicated real components for rotations 0 and 180, or imaginary components for rotations 90 and 270, of the floating-point complex numbers in the first source vector by the corresponding complex number in the second source vector rotated by 0, 90, 180 or 270 degrees in the direction from the positive real axis towards the positive imaginary axis, when considered in polar representation. Then destructively add the products to the corresponding components of the complex numbers in the addend and destination vector, without intermediate rounding. These transformations permit the creation of a variety of multiply-add and multiply-subtract operations on complex numbers by combining two of these instructions with the same vector operands but with rotations that are 90 degrees apart. Each complex number is represented in a vector register as an even/odd pair of elements with the real part in the even-numbered element and the imaginary part in the odd-numbered element. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	size	0			Zm	0	rot		Pg			Zn									Zda			

SVE

FCMLA <Zda>.<T>, <Pg>/M, <Zn>.<T>, <Zm>.<T>, <const>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel_a = UInt(rot<0>);
integer sel_b = UInt(NOT(rot<0>));
boolean neg_i = (rot<1> == '1');
boolean neg_r = (rot<0> != rot<1>);
```

Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <const> Is the const specifier, encoded in "rot":

rot	<const>
00	#0
01	#90
10	#180
11	#270

## Operation

```
CheckSVEEnabled();
integer pairs = VL DIV (2 * esize);
bits(PL) mask = P[g];
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for p = 0 to pairs-1
    addend_r = Elem[operand3, 2 * p + 0, esize];
    addend_i = Elem[operand3, 2 * p + 1, esize];
    elt1_a = Elem[operand1, 2 * p + sel_a, esize];
    elt2_a = Elem[operand2, 2 * p + sel_a, esize];
    elt2_b = Elem[operand2, 2 * p + sel_b, esize];
    if ElemP[mask, 2 * p + 0, esize] == '1' then
        if neg_r then elt2_a = FPNeg(elt2_a);
        addend_r = FPMulAdd(addend_r, elt1_a, elt2_a, FPCR<31:0>);
    if ElemP[mask, 2 * p + 1, esize] == '1' then
        if neg_i then elt2_b = FPNeg(elt2_b);
        addend_i = FPMulAdd(addend_i, elt1_a, elt2_b, FPCR<31:0>);
    Elem[result, 2 * p + 0, esize] = addend_r;
    Elem[result, 2 * p + 1, esize] = addend_i;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# FCMLA (indexed)

Floating-point complex multiply-add by indexed values with rotate.

Multiply the duplicated real components for rotations 0 and 180, or imaginary components for rotations 90 and 270, of the floating-point complex numbers in each 128-bit segment of the first source vector by the specified complex number in the corresponding the second source vector segment rotated by 0, 90, 180 or 270 degrees in the direction from the positive real axis towards the positive imaginary axis, when considered in polar representation.

Then destructively add the products to the corresponding components of the complex numbers in the addend and destination vector, without intermediate rounding.

These transformations permit the creation of a variety of multiply-add and multiply-subtract operations on complex numbers by combining two of these instructions with the same vector operands but with rotations that are 90 degrees apart.

Each complex number is represented in a vector register as an even/odd pair of elements with the real part in the even-numbered element and the imaginary part in the odd-numbered element.

The complex numbers within the second source vector are specified using an immediate index which selects the same complex number position within each 128-bit vector segment. The index range is from 0 to one less than the number of complex numbers per 128-bit segment, encoded in 1 to 2 bits depending on the size of the complex number. This instruction is unpredicated.

It has encodings from 2 classes: [Half-precision](#) and [Single-precision](#)

## Half-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	1	0	1	i2	Zm	0	0	0	1	rot	Zn					Zda								
size<1>size<0>																															

## Half-precision

FCMLA <Zda>.H, <Zn>.H, <Zm>.H[<imm>], <const>

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer index = UInt(i2);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel_a = UInt(rot<0>);
integer sel_b = UInt(NOT(rot<0>));
boolean neg_i = (rot<1> == '1');
boolean neg_r = (rot<0> != rot<1>);
```

## Single-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	1	1	i1	Zm		0		0	0	1	rot		Zn			Zda								
size<1>size<0>																															

## Single-precision

FCMLA <Zda>.S, <Zn>.S, <Zm>.S[<imm>], <const>

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer index = UInt(i1);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel_a = UInt(rot<0>);
integer sel_b = UInt(NOT(rot<0>));
boolean neg_i = (rot<1> == '1');
boolean neg_r = (rot<0> != rot<1>);
```

Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> For the half-precision variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  
For the single-precision variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
- <imm> For the half-precision variant: is the index of a Real and Imaginary pair, in the range 0 to 3, encoded in the "i2" field.  
For the single-precision variant: is the index of a Real and Imaginary pair, in the range 0 to 1, encoded in the "i1" field.
- <const> Is the const specifier, encoded in "rot":

rot	<const>
00	#0
01	#90
10	#180
11	#270

Operation

```
CheckSVEEnabled();
integer pairs = VL DIV (2 * esize);
integer pairspersegment = 128 DIV (2 * esize);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for p = 0 to pairs-1
    segmentbase = p - (p MOD pairspersegment);
    s = segmentbase + index;
    addend_r = Elem[operand3, 2 * p + 0, esize];
    addend_i = Elem[operand3, 2 * p + 1, esize];
    elt1_a = Elem[operand1, 2 * p + sel_a, esize];
    elt2_a = Elem[operand2, 2 * s + sel_a, esize];
    elt2_b = Elem[operand2, 2 * s + sel_b, esize];
    if neg_r then elt2_a = FPNeg(elt2_a);
    if neg_i then elt2_b = FPNeg(elt2_b);
    addend_r = FPMulAdd(addend_r, elt1_a, elt2_a, FPCR<31:0>);
    addend_i = FPMulAdd(addend_i, elt1_a, elt2_b, FPCR<31:0>);
    Elem[result, 2 * p + 0, esize] = addend_r;
    Elem[result, 2 * p + 1, esize] = addend_i;

Z[da] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

# FCMLE (vectors)

Floating-point compare less than or equal to vector.

Compare active floating-point elements in the first source vector being less than or equal to corresponding elements in the second source vector, and place the boolean results of the comparison in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Does not set the condition flags.

This is a pseudo-instruction of [FCM<cc> \(vectors\)](#). This means:

- The encodings in this description are named to match the encodings of [FCM<cc> \(vectors\)](#).
- The assembler syntax is used only for assembly, and is not used on disassembly.
- The description of [FCM<cc> \(vectors\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	Zm				0	1	0	Pg			Zn				0	Pd						
																cmph				cmpl											

## Greater than or equal

FCMLE <Pd>.<T>, <Pg>/Z, <Zm>.<T>, <Zn>.<T>

is equivalent to

FCMGE <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

## Assembler Symbols

<Pd>	Is the name of the destination scalable predicate register, encoded in the "Pd" field.										
<Zm>	Is the name of the second source scalable vector register, encoded in the "Zm" field.										
<Zn>	Is the name of the first source scalable vector register, encoded in the "Zn" field.										
<T>	Is the size specifier, encoded in "size": <table><tr><th>size</th><th>&lt;T&gt;</th></tr><tr><td>00</td><td>RESERVED</td></tr><tr><td>01</td><td>H</td></tr><tr><td>10</td><td>S</td></tr><tr><td>11</td><td>D</td></tr></table>	size	<T>	00	RESERVED	01	H	10	S	11	D
size	<T>										
00	RESERVED										
01	H										
10	S										
11	D										
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.										

## Operation

The description of [FCM<cc> \(vectors\)](#) gives the operational pseudocode for this instruction.

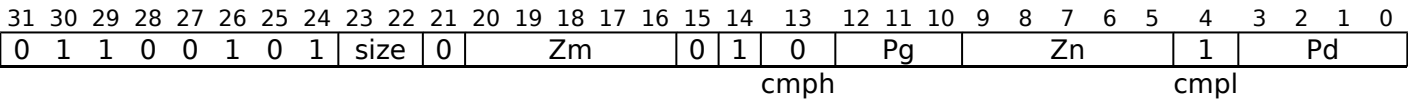
FCMLT (vectors)

Floating-point compare less than vector.

Compare active floating-point elements in the first source vector being less than corresponding elements in the second source vector, and place the boolean results of the comparison in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Does not set the condition flags.

This is a pseudo-instruction of [FCM<cc> \(vectors\)](#). This means:

- The encodings in this description are named to match the encodings of [FCM<cc> \(vectors\)](#).
- The assembler syntax is used only for assembly, and is not used on disassembly.
- The description of [FCM<cc> \(vectors\)](#) gives the operational pseudocode for this instruction.



Greater than

FCMLT <Pd>.<T>, <Pg>/Z, <Zm>.<T>, <Zn>.<T>

is equivalent to

FCMGT <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

Assembler Symbols

- <Pd>

Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Zm>

Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <Zn>

Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D
- <Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

Operation

The description of [FCM<cc> \(vectors\)](#) gives the operational pseudocode for this instruction.

FCPY

Copy 8-bit floating-point immediate to vector elements (predicated).

Copy a floating-point immediate into each active element in the destination vector. Inactive elements in the destination vector register remain unmodified.

This instruction is used by the alias [FMOV \(immediate, predicated\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size		0	1	Pg			1	1	0	imm8								Zd					

SVE

FCPY <Zd>.<T>, <Pg>/M, #<const>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer d = UInt(Zd);
bits(esize) imm = VFPEExpandImm(imm8);
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <const> Is a floating-point immediate value expressable as  $\pm n \div 16 \times 2^r$ , where n and r are integers such that  $16 \leq n \leq 31$  and  $-3 \leq r \leq 4$ , i.e. a normalized binary floating-point encoding with 1 sign bit, 3-bit exponent, and 4-bit fractional part, encoded in the "imm8" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) result = Z[d];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = imm;

Z[d] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.





# FCVT

Floating-point convert precision (predicated).

Convert the size and precision of each active floating-point element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

Since the input and result types have a different size the smaller type is held unpacked in the least significant bits of elements of the larger size. When the input is the smaller type the upper bits of each source element are ignored. When the result is the smaller type the results are zero-extended to fill each destination element.

It has encodings from 6 classes: [Half-precision to single-precision](#) , [Half-precision to double-precision](#) , [Single-precision to half-precision](#) , [Single-precision to double-precision](#) , [Double-precision to half-precision](#) and [Double-precision to single-precision](#)

## Half-precision to single-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	1	0	0	0	1	0	0	1	1	0	1	Pg			Zn			Zd						

## Half-precision to single-precision

FCVT <Zd>.S, <Pg>/M, <Zn>.H

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 16;
integer d_esize = 32;
```

## Half-precision to double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	1	1	0	0	1	0	0	1	1	0	1	Pg			Zn			Zd						

## Half-precision to double-precision

FCVT <Zd>.D, <Pg>/M, <Zn>.H

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 16;
integer d_esize = 64;
```

## Single-precision to half-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	1	0	0	0	1	0	0	0	1	0	1	Pg			Zn			Zd						

Single-precision to half-precision

```
FCVT <Zd>.H, <Pg>/M, <Zn>.S

if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 32;
integer d_esize = 16;
```

Single-precision to double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	1	1	0	0	1	0	1	1	1	0	1	Pg			Zn			Zd						

Single-precision to double-precision

```
FCVT <Zd>.D, <Pg>/M, <Zn>.S

if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 32;
integer d_esize = 64;
```

Double-precision to half-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	1	1	0	0	1	0	0	0	1	0	1	Pg			Zn			Zd						

Double-precision to half-precision

```
FCVT <Zd>.H, <Pg>/M, <Zn>.D

if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 64;
integer d_esize = 16;
```

Double-precision to single-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	1	1	0	0	1	0	1	0	1	0	1	Pg			Zn			Zd						

Double-precision to single-precision

```
FCVT <Zd>.S, <Pg>/M, <Zn>.D

if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 64;
integer d_esize = 32;
```

## Assembler Symbols

<Zd>	Is the name of the destination scalable vector register, encoded in the "Zd" field.
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
<Zn>	Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    bits(esize) element = Elem[operand, e, esize];
    if ElemP[mask, e, esize] == '1' then
        bits(d_esize) res = FPConvertSVE(element<s_esize-1:0>, FPCR<31:0>);
        Elem[result, e, esize] = ZeroExtend(res);

Z[d] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# FCVTLT

Floating-point up convert long (top, predicated).

Convert odd-numbered floating-point elements from the source vector to the next higher precision, and place the results in the active overlapping double-width elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

It has encodings from 2 classes: [Half-precision to single-precision](#) and [Single-precision to double-precision](#)

## Half-precision to single-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	1	0	0	0	1	0	0	1	1	0	1	Pg			Zn			Zd						

## Half-precision to single-precision

FCVTLT <Zd>.S, <Pg>/M, <Zn>.H

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

## Single-precision to double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	1	1	0	0	1	0	1	1	1	0	1	Pg			Zn			Zd						

## Single-precision to double-precision

FCVTLT <Zd>.D, <Pg>/M, <Zn>.S

```
if !HaveSVE2() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize DIV 2) element = Elem[operand, 2*e + 1, esize DIV 2];
        Elem[result, e, esize] = FPConvertSVE(element, FPCR<31:0>);

Z[d] = result;
```



# FCVTNT

Floating-point down convert and narrow (top, predicated).

Convert active floating-point elements from the source vector to the next lower precision, and place the results in the odd-numbered half-width elements of the destination vector, leaving the even-numbered elements unchanged. Inactive elements in the destination vector register remain unmodified.

It has encodings from 2 classes: [Single-precision to half-precision](#) and [Double-precision to single-precision](#)

## Single-precision to half-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	1	0	0	0	1	0	0	0	1	0	1	Pg			Zn			Zd						

## Single-precision to half-precision

FCVTNT <Zd>.H, <Pg>/M, <Zn>.S

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

## Double-precision to single-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	1	1	0	0	1	0	1	0	1	0	1	Pg			Zn			Zd						

## Double-precision to single-precision

FCVTNT <Zd>.S, <Pg>/M, <Zn>.D

```
if !HaveSVE2() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element = Elem[operand, e, esize];
        Elem[result, 2*e + 1, esize DIV 2] = FPConvertSVE(element, FPCR<31:0>);

Z[d] = result;
```



# FCVTX

Floating-point down convert, rounding to odd (predicated).

Convert active double-precision floating-point elements from the source vector to single-precision, rounding to Odd, and place the results in the even-numbered 32-bit elements of the destination vector, while setting the odd-numbered elements to zero. Inactive elements in the destination vector register remain unmodified.

Rounding to Odd (aka Von Neumann rounding) permits a two-step conversion from double-precision to half-precision without incurring intermediate rounding errors.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	0	0	0	0	1	0	1	0	1	0	1	Pg			Zn			Zd						

## Double-precision to single-precision

FCVTX <Zd>.S, <Pg>/M, <Zn>.D

```
if !HaveSVE2() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 64;
integer d_esize = 32;
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    bits(esize) element = Elem[operand, e, esize];
    if ElemP[mask, e, esize] == '1' then
        bits(d_esize) res = FPCConvertSVE(element<s_esize-1:0>, FPCR<31:0>, FPRounding_ODD);
        Elem[result, e, esize] = ZeroExtend(res);

Z[d] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# FCVTXNT

Floating-point down convert, rounding to odd (top, predicated).

Convert active double-precision floating-point elements from the source vector to single-precision, rounding to Odd, and place the results in the odd-numbered 32-bit elements of the destination vector, leaving the even-numbered elements unchanged. Inactive elements in the destination vector register remain unmodified.  
Rounding to Odd (aka Von Neumann rounding) permits a two-step conversion from double-precision to half-precision without incurring intermediate rounding errors.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	0	0	0	1	0	1	0	1	0	1		Pg												

## Double-precision to single-precision

FCVTXNT <Zd>.S, <Pg>/M, <Zn>.D

```
if !HaveSVE2() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    bits(esize) element = Elem[operand, e, esize];
    Elem[result, 2*e + 1, esize DIV 2] = FPConvertSVE(element, FPCR<31:0>, FPRounding_ODD);
Z[d] = result;
```

# FCVTZS

Floating-point convert to signed integer, rounding toward zero (predicated).

Convert to the signed integer nearer to zero from each active floating-point element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

If the input and result types have a different size the smaller type is held unpacked in the least significant bits of elements of the larger size. When the input is the smaller type the upper bits of each source element are ignored. When the result is the smaller type the results are sign-extended to fill each destination element.

It has encodings from 7 classes: [Half-precision to 16-bit](#) , [Half-precision to 32-bit](#) , [Half-precision to 64-bit](#) , [Single-precision to 32-bit](#) , [Single-precision to 64-bit](#) , [Double-precision to 32-bit](#) and [Double-precision to 64-bit](#)

## Half-precision to 16-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	0	1	0	1	1	0	1	0	1	0	1	Pg			Zn				Zd					
int U																															

## Half-precision to 16-bit

FCVTZS <Zd>.H, <Pg>/M, <Zn>.H

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 16;
integer d_esize = 16;
boolean unsigned = FALSE;
FPRounding rounding = FPRounding_ZERO;
```

## Half-precision to 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	0	1	0	1	1	1	0	0	1	0	1	Pg			Zn				Zd					
int_U																															

## Half-precision to 32-bit

FCVTZS <Zd>.S, <Pg>/M, <Zn>.H

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 16;
integer d_esize = 32;
boolean unsigned = FALSE;
FPRounding rounding = FPRounding_ZERO;
```

## Half-precision to 64-bit

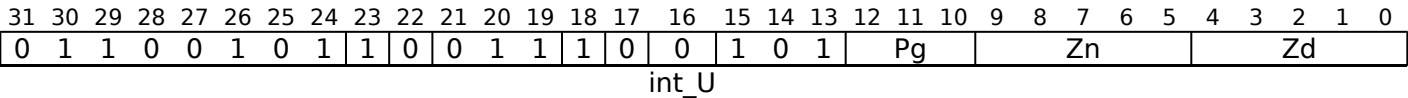
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	0	1	0	1	1	1	1	0	1	0	1	Pg			Zn				Zd					
int U																															

Half-precision to 64-bit

```
FCVTZS <Zd>.D, <Pg>/M, <Zn>.H

if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 16;
integer d_esize = 64;
boolean unsigned = FALSE;
FPRounding rounding = FPRounding_ZERO;
```

Single-precision to 32-bit

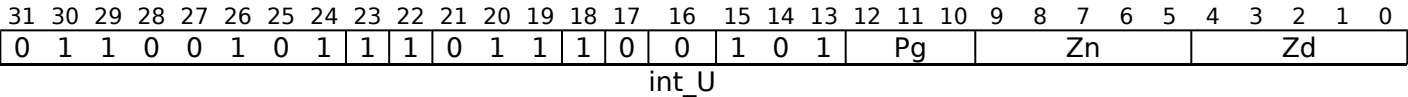


Single-precision to 32-bit

```
FCVTZS <Zd>.S, <Pg>/M, <Zn>.S

if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 32;
integer d_esize = 32;
boolean unsigned = FALSE;
FPRounding rounding = FPRounding_ZERO;
```

Single-precision to 64-bit

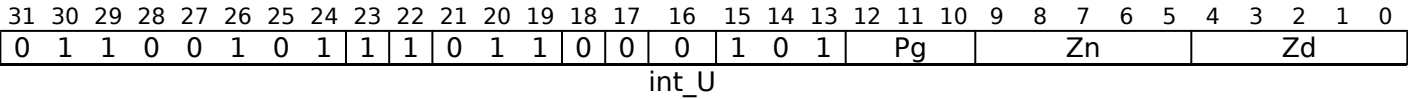


Single-precision to 64-bit

```
FCVTZS <Zd>.D, <Pg>/M, <Zn>.S

if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 32;
integer d_esize = 64;
boolean unsigned = FALSE;
FPRounding rounding = FPRounding_ZERO;
```

Double-precision to 32-bit

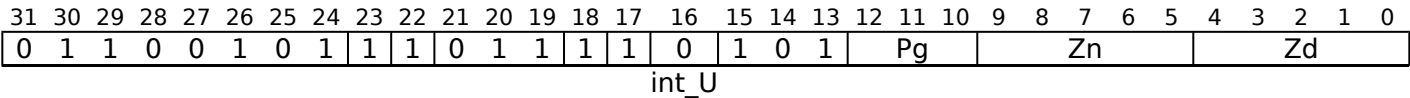


Double-precision to 32-bit

```
FCVTZS <Zd>.S, <Pg>/M, <Zn>.D

if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 64;
integer d_esize = 32;
boolean unsigned = FALSE;
FPRounding rounding = FPRounding_ZERO;
```

Double-precision to 64-bit



Double-precision to 64-bit

```
FCVTZS <Zd>.D, <Pg>/M, <Zn>.D

if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 64;
integer d_esize = 64;
boolean unsigned = FALSE;
FPRounding rounding = FPRounding_ZERO;
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    bits(esize) element = Elem[operand, e, esize];
    if ElemP[mask, e, esize] == '1' then
        bits(d_esize) res = FPToFixed(element<s_esize-1:0>, 0, unsigned, FPCR<31:0>, rounding);
        Elem[result, e, esize] = Extend(res, unsigned);

Z[d] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# FCVTZU

Floating-point convert to unsigned integer, rounding toward zero (predicated).

Convert to the unsigned integer nearer to zero from each active floating-point element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

If the input and result types have a different size the smaller type is held unpacked in the least significant bits of elements of the larger size. When the input is the smaller type the upper bits of each source element are ignored. When the result is the smaller type the results are zero-extended to fill each destination element.

It has encodings from 7 classes: [Half-precision to 16-bit](#) , [Half-precision to 32-bit](#) , [Half-precision to 64-bit](#) , [Single-precision to 32-bit](#) , [Single-precision to 64-bit](#) , [Double-precision to 32-bit](#) and [Double-precision to 64-bit](#)

## Half-precision to 16-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	0	1	0	1	1	0	1	1	1	0	1	Pg			Zn			Zd						
int_U																															

## Half-precision to 16-bit

FCVTZU <Zd>.H, <Pg>/M, <Zn>.H

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 16;
integer d_esize = 16;
boolean unsigned = TRUE;
FPRounding rounding = FPRounding_ZERO;
```

## Half-precision to 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	0	1	0	1	1	1	0	1	1	0	1	Pg			Zn			Zd						
int_U																															

## Half-precision to 32-bit

FCVTZU <Zd>.S, <Pg>/M, <Zn>.H

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 16;
integer d_esize = 32;
boolean unsigned = TRUE;
FPRounding rounding = FPRounding_ZERO;
```

## Half-precision to 64-bit

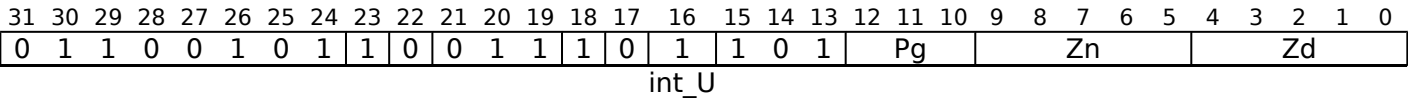
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	0	1	0	1	1	1	1	1	1	0	1	Pg			Zn			Zd						
int_U																															

Half-precision to 64-bit

```
FCVTZU <Zd>.D, <Pg>/M, <Zn>.H
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 16;
integer d_esize = 64;
boolean unsigned = TRUE;
FPRounding rounding = FPRounding_ZERO;
```

Single-precision to 32-bit

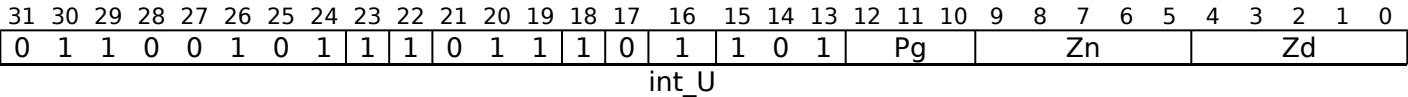


Single-precision to 32-bit

```
FCVTZU <Zd>.S, <Pg>/M, <Zn>.S
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 32;
integer d_esize = 32;
boolean unsigned = TRUE;
FPRounding rounding = FPRounding_ZERO;
```

Single-precision to 64-bit

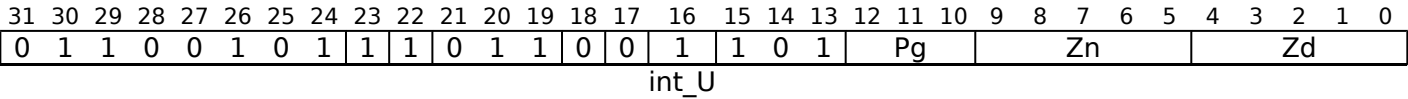


Single-precision to 64-bit

```
FCVTZU <Zd>.D, <Pg>/M, <Zn>.S
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 32;
integer d_esize = 64;
boolean unsigned = TRUE;
FPRounding rounding = FPRounding_ZERO;
```

Double-precision to 32-bit

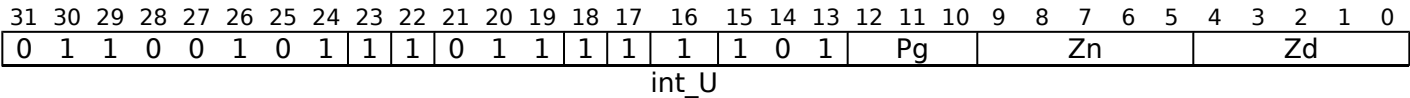


Double-precision to 32-bit

```
FCVTZU <Zd>.S, <Pg>/M, <Zn>.D

if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 64;
integer d_esize = 32;
boolean unsigned = TRUE;
FPRounding rounding = FPRounding_ZERO;
```

Double-precision to 64-bit



Double-precision to 64-bit

```
FCVTZU <Zd>.D, <Pg>/M, <Zn>.D

if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 64;
integer d_esize = 64;
boolean unsigned = TRUE;
FPRounding rounding = FPRounding_ZERO;
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    bits(esize) element = Elem[operand, e, esize];
    if ElemP[mask, e, esize] == '1' then
        bits(d_esize) res = FPToFixed(element<s_esize-1:0>, 0, unsigned, FPCR<31:0>, rounding);
        Elem[result, e, esize] = Extend(res, unsigned);

Z[d] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.



- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# FDIV

Floating-point divide by vector (predicated).

Divide active floating-point elements of the first source vector by corresponding floating-point elements of the second source vector and destructively place the quotient in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	1	1	0	1	1	0	0	Pg	Zm				Zdn								

## SVE

FDIV <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPDIV(element1, element2, FPCR<31:0>);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# FDIVR

Floating-point reversed divide by vector (predicated).

Reversed divide active floating-point elements of the second source vector by corresponding floating-point elements of the first source vector and destructively place the quotient in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	1	1	0	0	1	0	0	Pg				Zm				Zdn					

## SVE

FDIVR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPDiv(element2, element1, FPCR<31:0>);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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FDUP

Broadcast 8-bit floating-point immediate to vector elements (unpredicated).

Unconditionally broadcast the floating-point immediate into each element of the destination vector. This instruction is unpredicated.

This instruction is used by the alias [FMOV \(immediate, unpredicated\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size		1	1	1	0	0	1	1	1	0	imm8								Zd				

SVE

FDUP <Zd>.<T>, #<const>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer d = UInt(Zd);
bits(esize) imm = VFPEExpandImm(imm8);
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D
- <const> Is a floating-point immediate value expressable as  $\pm n \div 16 \times 2^r$ , where n and r are integers such that  $16 \leq n \leq 31$  and  $-3 \leq r \leq 4$ , i.e. a normalized binary floating-point encoding with 1 sign bit, 3-bit exponent, and 4-bit fractional part, encoded in the "imm8" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) result;

for e = 0 to elements-1
    Elem[result, e, esize] = imm;

Z[d] = result;
```

FEXPA

Floating-point exponential accelerator.

The FEXPA instruction accelerates the polynomial series calculation of the EXP(x) function.

The double-precision variant copies the low 52 bits of an entry from a hard-wired table of 64-bit coefficients, indexed by the low 6 bits of each element of the source vector, and prepends to that the next 11 bits of the source element (src<16:6>), setting the sign bit to zero.

The single-precision variant copies the low 23 bits of an entry from hard-wired table of 32-bit coefficients, indexed by the low 6 bits of each element of the source vector, and prepends to that the next 8 bits of the source element (src<13:6>), setting the sign bit to zero.

The half-precision variant copies the low 10 bits of an entry from hard-wired table of 16-bit coefficients, indexed by the low 5 bits of each element of the source vector, and prepends to that the next 5 bits of the source element (src<9:5>), setting the sign bit to zero.

A coefficient table entry with index m holds the floating-point value  $2^{(m/64)}$ , or for the half-precision variant  $2^{(m/32)}$ .

This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	1	0	0	0	0	0	0	1	0	1	1	1	0	Zn				Zd					

SVE

FEXPA <Zd>.<T>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand = Z[n];
bits(VL) result;

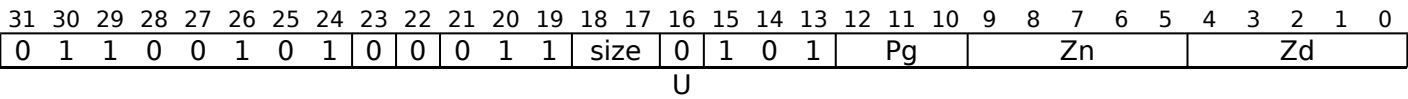
for e = 0 to elements-1
    bits(esize) element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPEXP(element);

Z[d] = result;
```

FLOGB

Floating-point base 2 logarithm as integer.

This instruction returns the signed integer base 2 logarithm of each floating-point input element |x| after normalization.  
This is the unbiased exponent of x used in the representation of the floating-point value, such that, for positive x,  $x = \text{significand} \times 2^{\text{exponent}}$ .  
The integer results are placed in elements of the destination vector which have the same width (ESIZE) as the floating-point input elements:  
\* If x is normal, the result is the base 2 logarithm of x.  
\* If x is subnormal, the result corresponds to the normalized representation.  
\* If x is infinite, the result is  $2^{(\text{esize}-1)}-1$ .  
\* If x is  $\pm 0.0$  or NaN, the result is  $-2^{(\text{esize}-1)}$ .  
Inactive elements in the destination vector register remain unmodified.



SVE2

FLOGB <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    bits(esize) element = Elem[operand, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPLogB(element, FPCR<31:0>);

Z[d] = result;
```



## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

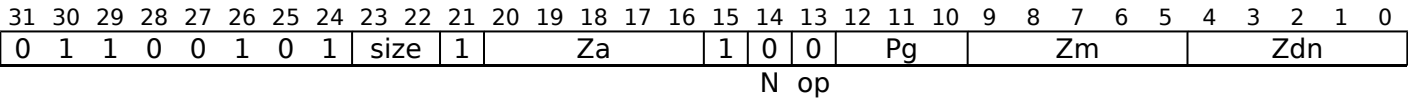
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FMAD

Floating-point fused multiply-add vectors (predicated), writing multiplicand [ $Z_{dn} = Z_a + Z_{dn} * Z_m$ ].

Multiply the corresponding active floating-point elements of the first and second source vectors and add to elements of the third (addend) vector without intermediate rounding. Destructively place the results in the destination and first source (multiplicand) vector. Inactive elements in the destination vector register remain unmodified.



SVE

FMAD <Zdn>.<T>, <Pg>/M, <Zm>.<T>, <Za>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
integer a = UInt(Za);
boolean op1_neg = FALSE;
boolean op3_neg = FALSE;
```

Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <Za> Is the name of the third source scalable vector register, encoded in the "Za" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[a];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    bits(esize) element3 = Elem[operand3, e, esize];

    if ElemP[mask, e, esize] == '1' then
        if op1_neg then element1 = FPNeg(element1);
        if op3_neg then element3 = FPNeg(element3);
        Elem[result, e, esize] = FPMu1Add(element3, element1, element2, FPCR<31:0>);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# FMAX (immediate)

Floating-point maximum with immediate (predicated).

Determine the maximum of an immediate and each active floating-point element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate may take the value +0.0 or +1.0 only. If the element value is NaN then the result is NaN. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	1	1	1	1	0	1	0	0	Pg	0	0	0	0	i1	Zdn							

## SVE

FMAX <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <const>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
bits(esize) imm = if i1 == '0' then Zeros() else FPOne('0');
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <const> Is the floating-point immediate value, encoded in "i1":

i1	<const>
0	#0.0
1	#1.0

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPMMax(element1, imm, FPCR<31:0>);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# FMAX (vectors)

Floating-point maximum (predicated).

Determine the maximum of active floating-point elements of the second source vector and corresponding floating-point elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. If either element value is NaN then the result is NaN. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	1	1	0	1	0	0	Pg				Zm				Zdn					

## SVE

FMAX <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```

if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);

```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPMAX(element1, element2, FPCR<31:0>);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;

```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.

- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# FMAXNM (immediate)

Floating-point maximum number with immediate (predicated).

Determine the maximum number value of an immediate and each active floating-point element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate may take the value +0.0 or +1.0 only. If the element value is NaN then the result is the immediate. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	1	1	1	0	0	0	1	0	0	Pg	0	0	0	0	i1							Zdn

## SVE

FMAXNM <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <const>

```

if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
bits(esize) imm = if i1 == '0' then Zeros() else FPOne('0');

```

## Assembler Symbols

<Zdn>	Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.										
<T>	Is the size specifier, encoded in "size": <table> <tr> <th>size</th><th>&lt;T&gt;</th></tr> <tr> <td>00</td><td>RESERVED</td></tr> <tr> <td>01</td><td>H</td></tr> <tr> <td>10</td><td>S</td></tr> <tr> <td>11</td><td>D</td></tr> </table>	size	<T>	00	RESERVED	01	H	10	S	11	D
size	<T>										
00	RESERVED										
01	H										
10	S										
11	D										
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.										
<const>	Is the floating-point immediate value, encoded in "i1": <table> <tr> <th>i1</th><th>&lt;const&gt;</th></tr> <tr> <td>0</td><td>#0.0</td></tr> <tr> <td>1</td><td>#1.0</td></tr> </table>	i1	<const>	0	#0.0	1	#1.0				
i1	<const>										
0	#0.0										
1	#1.0										

## Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPMaXNum(element1, imm, FPCR<31:0>);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;

```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:



- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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FMAXNM (vectors)

Floating-point maximum number (predicated).

Determine the maximum number value of active floating-point elements of the second source vector and corresponding floating-point elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. If one element value is NaN then the result is the numeric value. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	1	0	0	0	1	0	0	Pg	Zm				Zdn							

SVE

FMAXNM <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPMaXNum(element1, element2, FPCR<31:0>);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.

- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# FMAXNMP

Floating-point maximum number pairwise.

Compute the maximum value of each pair of adjacent floating-point elements within each source vector, and interleave the results from corresponding lanes. The interleaved result values are destructively placed in the first source vector. NaNs are handled according to the IEEE 754-2008 standard. If one vector element is numeric and the other is a quiet NaN, the result is the numerical value.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	size	0	1	0	1	0	0	0	1	0	0	Pg	Zm				Zdn							

## SVE2

FMAXNMP <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer m = UInt(Zm);
integer dn = UInt(Zdn);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[dn];
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    if IsEven(e) then
      element1 = Elem[operand1, e + 0, esize];
      element2 = Elem[operand1, e + 1, esize];
    else
      element1 = Elem[operand2, e - 1, esize];
      element2 = Elem[operand2, e + 0, esize];
    Elem[result, e, esize] = FPMaXNum(element1, element2, FPCR<31:0>);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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FMAXNMV

Floating-point maximum number recursive reduction to scalar.

Floating-point maximum number horizontally over all lanes of a vector using a recursive pairwise reduction, and place the result in the SIMD&FP scalar destination register. Inactive elements in the source vector are treated as the default NaN.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	1	0	0	0	0	1	Pg	Zn				Vd								

SVE

FMAXNMV <V><d>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);
```

Assembler Symbols

<V> Is a width specifier, encoded in "size":

size	<V>
00	RESERVED
01	H
10	S
11	D

<d> Is the number [0-31] of the destination SIMD&FP register, encoded in the "Vd" field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

Operation

```
CheckSVEEnabled();
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(esize) identity = FPDefaultNaN();

V[d] = ReducePredicated(ReduceOp_FMAXNUM, operand, mask, identity);
```

FMAXP

Floating-point maximum pairwise.

Compute the maximum value of each pair of adjacent floating-point elements within each source vector, and interleave the results from corresponding lanes. The interleaved result values are destructively placed in the first source vector.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	size		0	1	0	1	1	0	1	0	0	Pg		Zm				Zdn						

SVE2

FMAXP <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer m = UInt(Zm);
integer dn = UInt(Zdn);
```

Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[dn];
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    if IsEven(e) then
      element1 = Elem[operand1, e + 0, esize];
      element2 = Elem[operand1, e + 1, esize];
    else
      element1 = Elem[operand2, e - 1, esize];
      element2 = Elem[operand2, e + 0, esize];
    Elem[result, e, esize] = FPMMax(element1, element2, FPCR<31:0>);

Z[dn] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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FMAXV

Floating-point maximum recursive reduction to scalar.

Floating-point maximum horizontally over all lanes of a vector using a recursive pairwise reduction, and place the result in the SIMD&FP scalar destination register. Inactive elements in the source vector are treated as -Infinity.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size			0	0	0	1	1	0	0	0	1	Pg			Zn			Vd					

SVE

FMAXV <V><d>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	RESERVED
01	H
10	S
11	D

<d> Is the number [0-31] of the destination SIMD&FP register, encoded in the "Vd" field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<T> Is the size specifier, encoded in “size”:

size	<T>
00	RESERVED
01	H
10	S
11	D

Operation

```
CheckSVEEnabled();
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(esize) identity = FPInfinity('1');
V[d] = ReducePredicated(ReduceOp_FMAX, operand, mask, identity);
```

# FMIN (immediate)

Floating-point minimum with immediate (predicated).

Determine the minimum of an immediate and each active floating-point element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate may take the value +0.0 or +1.0 only. If the element value is NaN then the result is NaN. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	1	1	1	1	1	1	0	0	Pg	0	0	0	0	i1								Zdn

## SVE

FMIN <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <const>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
bits(esize) imm = if i1 == '0' then Zeros() else FPOne('0');
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <const> Is the floating-point immediate value, encoded in "i1":

i1	<const>
0	#0.0
1	#1.0

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPMIn(element1, imm, FPCR<31:0>);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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## FMIN (vectors)

Floating-point minimum (predicated).

Determine the minimum of active floating-point elements of the second source vector and corresponding floating-point elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. If either element value is NaN then the result is NaN. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	1	1	1	1	0	0	Pg				Zm				Zdn					

### SVE

FMIN <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

### Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPMIn(element1, element2, FPCR<31:0>);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

### Operational information

- This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:
- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.

- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# FMINNM (immediate)

Floating-point minimum number with immediate (predicated).

Determine the minimum number value of an immediate and each active floating-point element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate may take the value +0.0 or +1.0 only. If the element value is NaN then the result is the immediate. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	1	1	1	0	1	1	0	0	Pg	0	0	0	0	i1								Zdn

## SVE

FMINNM <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <const>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
bits(esize) imm = if i1 == '0' then Zeros() else FPOne('0');
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <const> Is the floating-point immediate value, encoded in "i1":

i1	<const>
0	#0.0
1	#1.0

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPMinNum(element1, imm, FPCR<31:0>);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# FMINNM (vectors)

Floating-point minimum number (predicated).

Determine the minimum number value of active floating-point elements of the second source vector and corresponding floating-point elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. If one element value is NaN then the result is the numeric value. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	1	0	1	1	0	0	Pg													

## SVE

FMINNM <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPMinNum(element1, element2, FPCR<31:0>);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

- This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:
- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.



- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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FMINNMP

Floating-point minimum number pairwise.

Compute the minimum value of each pair of adjacent floating-point elements within each source vector, and interleave the results from corresponding lanes. The interleaved result values are destructively placed in the first source vector. NaNs are handled according to the IEEE 754-2008 standard. If one vector element is numeric and the other is a quiet NaN, the result is the numerical value.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	size	0	1	0	1	0	1	1	0	0		Pg												

SVE2

FMINNMP <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer m = UInt(Zm);
integer dn = UInt(Zdn);
```

Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[dn];
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    if IsEven(e) then
      element1 = Elem[operand1, e + 0, esize];
      element2 = Elem[operand1, e + 1, esize];
    else
      element1 = Elem[operand2, e - 1, esize];
      element2 = Elem[operand2, e + 0, esize];
    Elem[result, e, esize] = FPMinNum(element1, element2, FPCR<31:0>);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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FMINNMV

Floating-point minimum number recursive reduction to scalar.

Floating-point minimum number horizontally over all lanes of a vector using a recursive pairwise reduction, and place the result in the SIMD&FP scalar destination register. Inactive elements in the source vector are treated as the default NaN.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size		0	0	0	1	0	1	0	0	1	Pg			Zn			Vd						

SVE

FMINNMV <V><d>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);
```

Assembler Symbols

<V> Is a width specifier, encoded in "size":

size	<V>
00	RESERVED
01	H
10	S
11	D

<d> Is the number [0-31] of the destination SIMD&FP register, encoded in the "Vd" field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

Operation

```
CheckSVEEnabled();
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(esize) identity = FPDefaultNaN();

V[d] = ReducePredicated(ReduceOp_FMINNUM, operand, mask, identity);
```

# FMINP

Floating-point minimum pairwise.

Compute the minimum value of each pair of adjacent floating-point elements within each source vector, and interleave the results from corresponding lanes. The interleaved result values are destructively placed in the first source vector.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	size	0	1	0	1	1	1	1	0	0	Pg	Zm				Zdn								

## SVE2

FMINP <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer m = UInt(Zm);
integer dn = UInt(Zdn);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[dn];
bits(esize) element1;
bits(esize) element2;

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    if IsEven(e) then
      element1 = Elem[operand1, e + 0, esize];
      element2 = Elem[operand1, e + 1, esize];
    else
      element1 = Elem[operand2, e - 1, esize];
      element2 = Elem[operand2, e + 0, esize];
    Elem[result, e, esize] = FPMIn(element1, element2, FPCR<31:0>);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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FMINV

Floating-point minimum recursive reduction to scalar.

Floating-point minimum horizontally over all lanes of a vector using a recursive pairwise reduction, and place the result in the SIMD&FP scalar destination register. Inactive elements in the source vector are treated as +Infinity.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size		0	0	0	1	1	1	0	0	1	Pg			Zn			Vd						

SVE

FMINV <V><d>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	RESERVED
01	H
10	S
11	D

<d> Is the number [0-31] of the destination SIMD&FP register, encoded in the "Vd" field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<T> Is the size specifier, encoded in “size”:

size	<T>
00	RESERVED
01	H
10	S
11	D

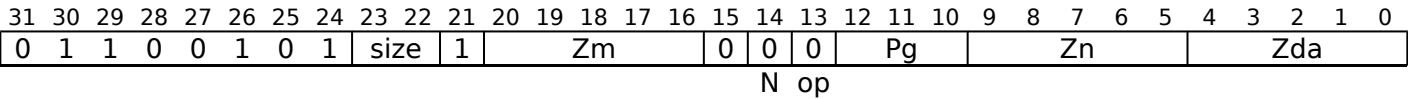
Operation

```
CheckSVEEnabled();
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(esize) identity = FPInfinity('0');
V[d] = ReducePredicated(ReduceOp_FMIN, operand, mask, identity);
```

FMLA (vectors)

Floating-point fused multiply-add vectors (predicated), writing addend [Zda = Zda + Zn \* Zm].

Multiply the corresponding active floating-point elements of the first and second source vectors and add to elements of the third source (addend) vector without intermediate rounding. Destructively place the results in the destination and third source (addend) vector. Inactive elements in the destination vector register remain unmodified.



SVE

FMLA <Zda>.<T>, <Pg>/M, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean op1_neg = FALSE;
boolean op3_neg = FALSE;
```

Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    bits(esize) element3 = Elem[operand3, e, esize];

    if ElemP[mask, e, esize] == '1' then
        if op1_neg then element1 = FPNeg(element1);
        if op3_neg then element3 = FPNeg(element3);
        Elem[result, e, esize] = FPMu1Add(element3, element1, element2, FPCR<31:0>);
    else
        Elem[result, e, esize] = element3;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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## FMLA (indexed)

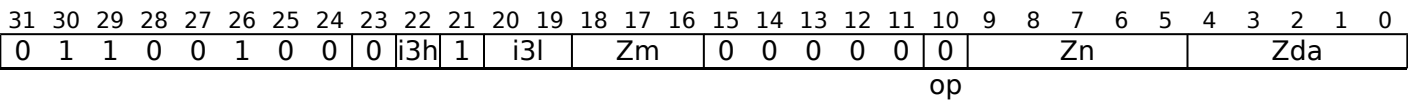
Floating-point fused multiply-add by indexed elements ( $Zda = Zda + Z_n * Z_m[\text{indexed}]$ ).

Multiply all floating-point elements within each 128-bit segment of the first source vector by the specified element in the corresponding second source vector segment. The products are then destructively added without intermediate rounding to the corresponding elements of the addend and destination vector.

The elements within the second source vector are specified using an immediate index which selects the same element position within each 128-bit vector segment. The index range is from 0 to one less than the number of elements per 128-bit segment, encoded in 1 to 3 bits depending on the size of the element. This instruction is unpredicated.

It has encodings from 3 classes: [Half-precision](#) , [Single-precision](#) and [Double-precision](#)

### Half-precision

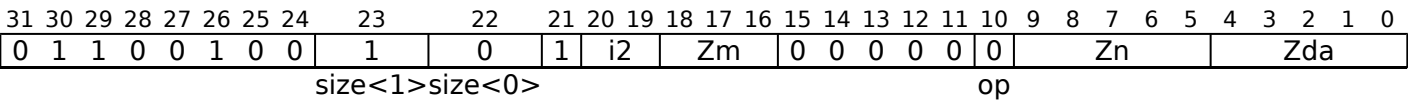


### Half-precision

FMLA <Zda>.H, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer index = UInt(i3h:i3l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean op1_neg = FALSE;
boolean op3_neg = FALSE;
```

### Single-precision

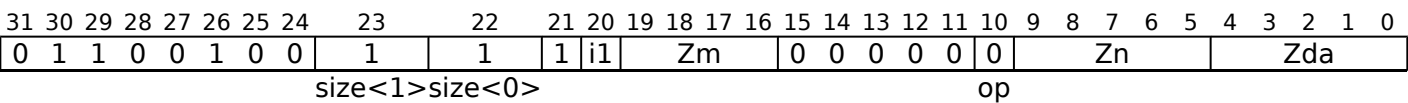


### Single-precision

FMLA <Zda>.S, <Zn>.S, <Zm>.S[<imm>]

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean op1_neg = FALSE;
boolean op3_neg = FALSE;
```

### Double-precision



## Double-precision

FMLA <Zda>.D, <Zn>.D, <Zm>.D[<imm>]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer index = UInt(i1);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean op1_neg = FALSE;
boolean op3_neg = FALSE;
```

## Assembler Symbols

<Zda>	Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
<Zn>	Is the name of the first source scalable vector register, encoded in the "Zn" field.
<Zm>	For the half-precision and single-precision variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  For the double-precision variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
<imm>	For the half-precision variant: is the immediate index, in the range 0 to 7, encoded in the "i3h:i3l" fields. For the single-precision variant: is the immediate index, in the range 0 to 3, encoded in the "i2" field. For the double-precision variant: is the immediate index, in the range 0 to 1, encoded in the "i1" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer eltsegment = 128 DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer segmentbase = e - (e MOD eltsegment);
    integer s = segmentbase + index;
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, s, esize];
    bits(esize) element3 = Elem[result, e, esize];
    if op1_neg then element1 = FPNeg(element1);
    if op3_neg then element3 = FPNeg(element3);
    Elem[result, e, esize] = FPMulAdd(element3, element1, element2, FPCR<31:0>);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

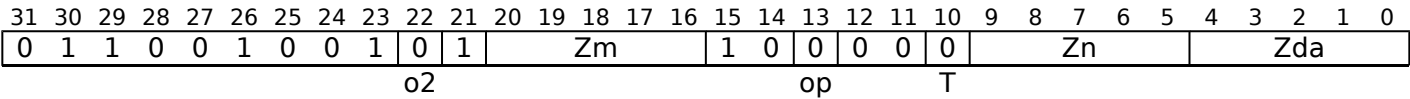
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# FMLALB (vectors)

Half-precision floating-point multiply-add long to single-precision (bottom).

This half-precision floating-point multiply-add long instruction widens the even-numbered 16-bit half-precision elements in the first source vector and the corresponding elements in the second source vector to single-precision format and then destructively multiplies and adds these values without intermediate rounding to the overlapping 32-bit single-precision elements of the addend and destination vector. This instruction is unpredicated.



## SVE2

FMLALB <Zda>.S, <Zn>.H, <Zm>.H

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean op1_neg = FALSE;
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    bits(esize DIV 2) element1 = Elem[operand1, 2 * e + 0, esize DIV 2];
    bits(esize DIV 2) element2 = Elem[operand2, 2 * e + 0, esize DIV 2];
    bits(esize) element3 = Elem[operand3, e, esize];
    if op1_neg then element1 = FPNeg(element1);
    Elem[result, e, esize] = FPMulAddH(element3, element1, element2, FPCR<31:0>);

Z[da] = result;
```

## Operational information

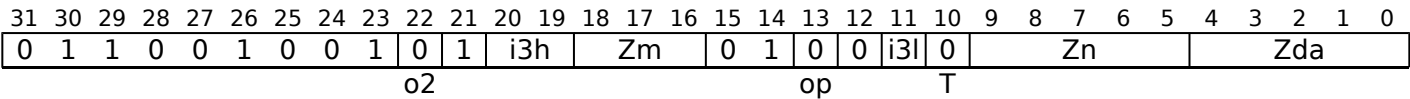
This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

# FMLALB (indexed)

Half-precision floating-point multiply-add long to single-precision (bottom, indexed).

This half-precision floating-point multiply-add long instruction widens the even-numbered 16-bit half-precision elements in the first source vector and the indexed element from the corresponding 128-bit segment in the second source vector to single-precision format and then destructively multiplies and adds these values without intermediate rounding to the overlapping 32-bit single-precision elements of the addend and destination vector. This instruction is unpredicated.



## Single-precision

FMLALB <Zda>.S, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer index = UInt(i3h:i3l);
boolean op1_neg = FALSE;
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.
- <imm> Is the immediate index, in the range 0 to 7, encoded in the "i3h:i3l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer eltspersegment = 128 DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    integer segmentbase = e - (e MOD eltspersegment);
    integer s = 2 * segmentbase + index;
    bits(esize DIV 2) element1 = Elem[operand1, 2 * e + 0, esize DIV 2];
    bits(esize DIV 2) element2 = Elem[operand2, s, esize DIV 2];
    bits(esize) element3 = Elem[operand3, e, esize];
    if op1_neg then element1 = FPNeg(element1);
    Elem[result, e, esize] = FPMulAddH(element3, element1, element2, FPCR<31:0>);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

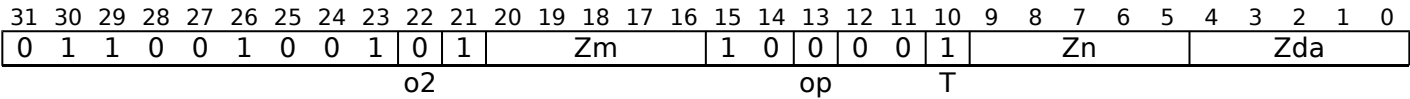
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# FMLALT (vectors)

Half-precision floating-point multiply-add long to single-precision (top).

This half-precision floating-point multiply-add long instruction widens the odd-numbered 16-bit half-precision elements in the first source vector and the corresponding elements in the second source vector to single-precision format and then destructively multiplies and adds these values without intermediate rounding to the overlapping 32-bit single-precision elements of the addend and destination vector. This instruction is unpredicated.



## SVE2

FMLALT <Zda>.S, <Zn>.H, <Zm>.H

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean op1_neg = FALSE;
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    bits(esize DIV 2) element1 = Elem[operand1, 2 * e + 1, esize DIV 2];
    bits(esize DIV 2) element2 = Elem[operand2, 2 * e + 1, esize DIV 2];
    bits(esize) element3 = Elem[operand3, e, esize];
    if op1_neg then element1 = FPNeg(element1);
    Elem[result, e, esize] = FPMulAddH(element3, element1, element2, FPCR<31:0>);

Z[da] = result;
```

## Operational information

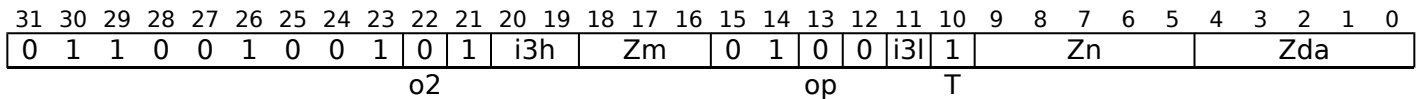
This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

## FMLALT (indexed)

Half-precision floating-point multiply-add long to single-precision (top, indexed).

This half-precision floating-point multiply-add long instruction widens the odd-numbered 16-bit half-precision elements in the first source vector and the indexed element from the corresponding 128-bit segment in the second source vector to single-precision format and then destructively multiplies and adds these values without intermediate rounding to the overlapping 32-bit single-precision elements of the addend and destination vector. This instruction is unpredicated.



### Single-precision

FMLALT <Zda>.S, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer index = UInt(i3h:i3l);
boolean op1_neg = FALSE;
```

### Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.
- <imm> Is the immediate index, in the range 0 to 7, encoded in the "i3h:i3l" fields.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer eltsegment = 128 DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    integer segmentbase = e - (e MOD eltsegment);
    integer s = 2 * segmentbase + index;
    bits(esize DIV 2) element1 = Elem[operand1, 2 * e + 1, esize DIV 2];
    bits(esize DIV 2) element2 = Elem[operand2, s, esize DIV 2];
    bits(esize) element3 = Elem[operand3, e, esize];
    if op1_neg then element1 = FPNeg(element1);
    Elem[result, e, esize] = FPMulAddH(element3, element1, element2, FPCR<31:0>);

Z[da] = result;
```

### Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

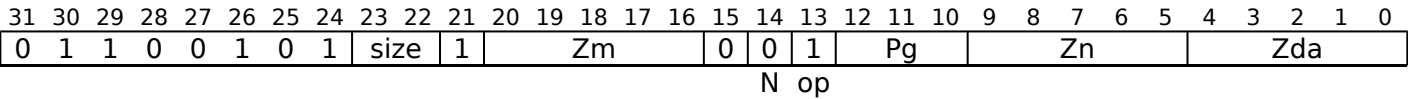




FMLS (vectors)

Floating-point fused multiply-subtract vectors (predicated), writing addend [Zda = Zda + -Zn \* Zm].

Multiply the corresponding active floating-point elements of the first and second source vectors and subtract from elements of the third source (addend) vector without intermediate rounding. Destructively place the results in the destination and third source (addend) vector. Inactive elements in the destination vector register remain unmodified.



SVE

FMLS <Zda>.<T>, <Pg>/M, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean op1_neg = TRUE;
boolean op3_neg = FALSE;
```

Assembler Symbols

<Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    bits(esize) element3 = Elem[operand3, e, esize];

    if ElemP[mask, e, esize] == '1' then
        if op1_neg then element1 = FPNeg(element1);
        if op3_neg then element3 = FPNeg(element3);
        Elem[result, e, esize] = FPMu1Add(element3, element1, element2, FPCR<31:0>);
    else
        Elem[result, e, esize] = element3;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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## FMLS (indexed)

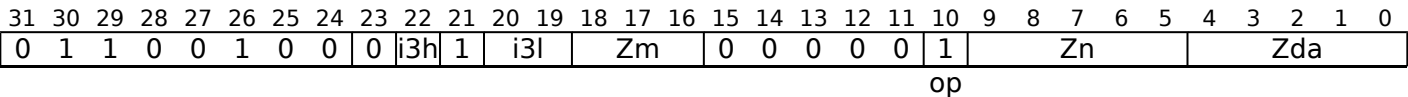
Floating-point fused multiply-subtract by indexed elements ( $Zda = Zda + -Zn * Zm[indexed]$ ).

Multiply all floating-point elements within each 128-bit segment of the first source vector by the specified element in the corresponding second source vector segment. The products are then destructively subtracted without intermediate rounding from the corresponding elements of the addend and destination vector.

The elements within the second source vector are specified using an immediate index which selects the same element position within each 128-bit vector segment. The index range is from 0 to one less than the number of elements per 128-bit segment, encoded in 1 to 3 bits depending on the size of the element. This instruction is unpredicated.

It has encodings from 3 classes: [Half-precision](#) , [Single-precision](#) and [Double-precision](#)

### Half-precision

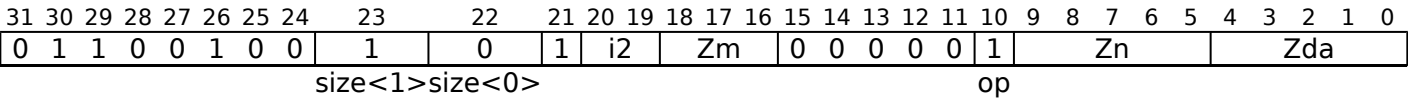


### Half-precision

FMLS <Zda>.H, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer index = UInt(i3h:i3l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean op1_neg = TRUE;
boolean op3_neg = FALSE;
```

### Single-precision

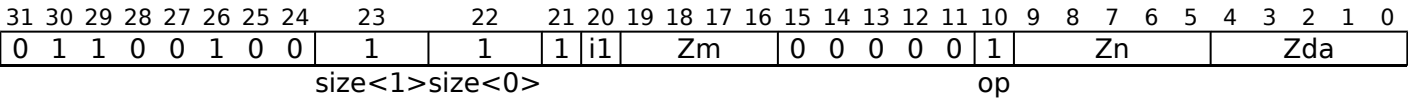


### Single-precision

FMLS <Zda>.S, <Zn>.S, <Zm>.S[<imm>]

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean op1_neg = TRUE;
boolean op3_neg = FALSE;
```

### Double-precision



## Double-precision

FMLS <Zda>.D, <Zn>.D, <Zm>.D[<imm>]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer index = UInt(i1);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean op1_neg = TRUE;
boolean op3_neg = FALSE;
```

## Assembler Symbols

<Zda>	Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
<Zn>	Is the name of the first source scalable vector register, encoded in the "Zn" field.
<Zm>	For the half-precision and single-precision variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  For the double-precision variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
<imm>	For the half-precision variant: is the immediate index, in the range 0 to 7, encoded in the "i3h:i3l" fields. For the single-precision variant: is the immediate index, in the range 0 to 3, encoded in the "i2" field. For the double-precision variant: is the immediate index, in the range 0 to 1, encoded in the "i1" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer eltsegment = 128 DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer segmentbase = e - (e MOD eltsegment);
    integer s = segmentbase + index;
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, s, esize];
    bits(esize) element3 = Elem[result, e, esize];
    if op1_neg then element1 = FPNeg(element1);
    if op3_neg then element3 = FPNeg(element3);
    Elem[result, e, esize] = FPMulAdd(element3, element1, element2, FPCR<31:0>);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

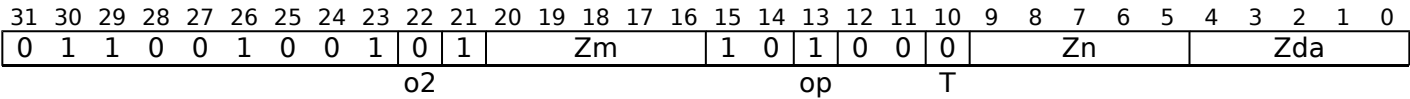
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# FMLSLB (vectors)

Half-precision floating-point multiply-subtract long from single-precision (bottom).

This half-precision floating-point multiply-subtract long instruction widens the even-numbered 16-bit half-precision elements in the first source vector and the corresponding elements in the second source vector to single-precision format and then destructively multiplies and subtracts these values without intermediate rounding from the overlapping 32-bit single-precision elements of the addend and destination vector. This instruction is unpredicated.



## SVE2

FMLSLB <Zda>.S, <Zn>.H, <Zm>.H

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean op1_neg = TRUE;
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    bits(esize DIV 2) element1 = Elem[operand1, 2 * e + 0, esize DIV 2];
    bits(esize DIV 2) element2 = Elem[operand2, 2 * e + 0, esize DIV 2];
    bits(esize) element3 = Elem[operand3, e, esize];
    if op1_neg then element1 = FPNeg(element1);
    Elem[result, e, esize] = FPMulAddH(element3, element1, element2, FPCR<31:0>);

Z[da] = result;
```

## Operational information

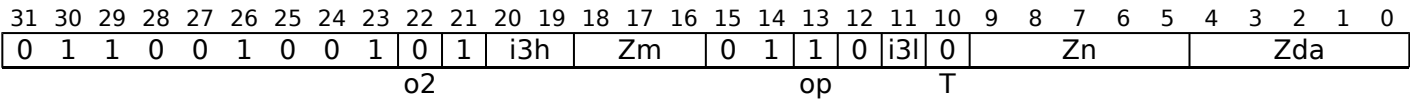
This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

# FMLSLB (indexed)

Half-precision floating-point multiply-subtract long from single-precision (bottom, indexed).

This half-precision floating-point multiply-subtract long instruction widens the even-numbered 16-bit half-precision elements in the first source vector and the indexed element from the corresponding 128-bit segment in the second source vector to single-precision format and then destructively multiplies and subtracts these values without intermediate rounding from the overlapping 32-bit single-precision elements of the addend and destination vector. This instruction is unpredicated.



## Single-precision

FMLSLB <Zda>.S, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer index = UInt(i3h:i3l);
boolean opl_neg = TRUE;
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.
- <imm> Is the immediate index, in the range 0 to 7, encoded in the "i3h:i3l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer eltspersegment = 128 DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    integer segmentbase = e - (e MOD eltspersegment);
    integer s = 2 * segmentbase + index;
    bits(esize DIV 2) element1 = Elem[operand1, 2 * e + 0, esize DIV 2];
    bits(esize DIV 2) element2 = Elem[operand2, s, esize DIV 2];
    bits(esize) element3 = Elem[operand3, e, esize];
    if opl_neg then element1 = FPNeg(element1);
    Elem[result, e, esize] = FPMulAddH(element3, element1, element2, FPCR<31:0>);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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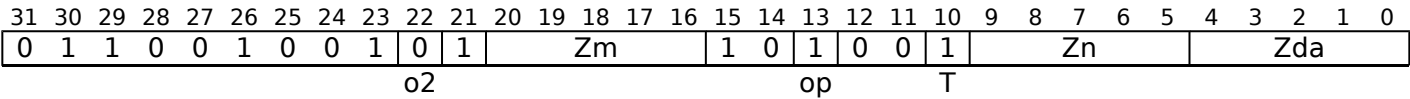
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# FMLSLT (vectors)

Half-precision floating-point multiply-subtract long from single-precision (top).

This half-precision floating-point multiply-subtract long instruction widens the odd-numbered 16-bit half-precision elements in the first source vector and the corresponding elements in the second source vector to single-precision format and then destructively multiplies and subtracts these values without intermediate rounding from the overlapping 32-bit single-precision elements of the addend and destination vector. This instruction is unpredicated.



## SVE2

FMLSLT <Zda>.S, <Zn>.H, <Zm>.H

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean op1_neg = TRUE;
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    bits(esize DIV 2) element1 = Elem[operand1, 2 * e + 1, esize DIV 2];
    bits(esize DIV 2) element2 = Elem[operand2, 2 * e + 1, esize DIV 2];
    bits(esize) element3 = Elem[operand3, e, esize];
    if op1_neg then element1 = FPNeg(element1);
    Elem[result, e, esize] = FPMulAddH(element3, element1, element2, FPCR<31:0>);

Z[da] = result;
```

## Operational information

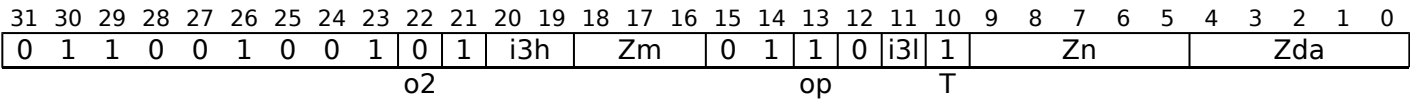
This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

# FMLSLT (indexed)

Half-precision floating-point multiply-subtract long from single-precision (top, indexed).

This half-precision floating-point multiply-subtract long instruction widens the odd-numbered 16-bit half-precision elements in the first source vector and the indexed element from the corresponding 128-bit segment in the second source vector to single-precision format and then destructively multiplies and subtracts these values without intermediate rounding from the overlapping 32-bit single-precision elements of the addend and destination vector. This instruction is unpredicated.



## Single-precision

FMLSLT <Zda>.S, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer index = UInt(i3h:i3l);
boolean opl_neg = TRUE;
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.
- <imm> Is the immediate index, in the range 0 to 7, encoded in the "i3h:i3l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer eltspersegment = 128 DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    integer segmentbase = e - (e MOD eltspersegment);
    integer s = 2 * segmentbase + index;
    bits(esize DIV 2) element1 = Elem[operand1, 2 * e + 1, esize DIV 2];
    bits(esize DIV 2) element2 = Elem[operand2, s, esize DIV 2];
    bits(esize) element3 = Elem[operand3, e, esize];
    if opl_neg then element1 = FPNeg(element1);
    Elem[result, e, esize] = FPMulAddH(element3, element1, element2, FPCR<31:0>);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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FMMLA

Floating-point matrix multiply-accumulate.

The floating-point matrix multiply-accumulate instruction supports single-precision and double-precision data types in a 2×2 matrix contained in segments of 128 or 256 bits, respectively. It multiplies the 2×2 matrix in each segment of the first source vector by the 2×2 matrix in the corresponding segment of the second source vector. The resulting 2×2 matrix product is then destructively added to the matrix accumulator held in the corresponding segment of the addend and destination vector. This is equivalent to performing a 2-way dot product per destination element. This instruction is unpredicated. The single-precision variant is vector length agnostic. The double-precision variant requires that the current vector length is at least 256 bits, and if the current vector length is not an integer multiple of 256 bits then the trailing bits are set to zero.

ID\_AA64ZFR0\_EL1.F32MM indicates whether the single-precision variant is implemented.

ID\_AA64ZFR0\_EL1.F64MM indicates whether the double-precision variant is implemented.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

32-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	1	0	1	Zm				1	1	1	0	0	1	Zn				Zda						

32-bit element

FMMLA <Zda>.S, <Zn>.S, <Zm>.S

```
if !HaveSVEFP32MatMulExt() then UNDEFINED;
integer esize = 32;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

64-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	1	1	1	Zm				1	1	1	0	0	1	Zn				Zda						

64-bit element

FMMLA <Zda>.D, <Zn>.D, <Zm>.D

```
if !HaveSVEFP64MatMulExt() then UNDEFINED;
integer esize = 64;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
if VL < esize * 4 then UNDEFINED;
integer segments = VL DIV (4 * esize);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result = Zeros();
bits(4*esize) op1, op2;
bits(4*esize) res, addend;

for s = 0 to segments-1
    op1    = Elem[operand1, s, 4*esize];
    op2    = Elem[operand2, s, 4*esize];
    addend = Elem[operand3, s, 4*esize];
    res    = FPMatMulAdd(addend, op1, op2, esize, FPCR<31:0>);
    Elem[result, s, 4*esize] = res;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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FMOV (zero, predicated)

Move floating-point +0.0 to vector elements (predicated).

Move floating-point constant +0.0 to to each active element in the destination vector. Inactive elements in the destination vector register remain unmodified.

This is a pseudo-instruction of [CPY \(immediate, merging\)](#). This means:

- The encodings in this description are named to match the encodings of [CPY \(immediate, merging\)](#).
- The assembler syntax is used only for assembly, and is not used on disassembly.
- The description of [CPY \(immediate, merging\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size		0	1	Pg			0	1	0	0	0	0	0	0	0	0	0	Zd					
M sh																imm8															

SVE

FMOV <Zd>.<T>, <Pg>/M, #0.0

is equivalent to

[CPY](#) <Zd>.<T>, <Pg>/M, #0

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.

Operation

The description of [CPY \(immediate, merging\)](#) gives the operational pseudocode for this instruction.

Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



## FMOV (zero, unpredicated)

Move floating-point +0.0 to vector elements (unpredicated).

Unconditionally broadcast the floating-point constant +0.0 into each element of the destination vector. This instruction is unpredicated.

This is a pseudo-instruction of [DUP \(immediate\)](#). This means:

- The encodings in this description are named to match the encodings of [DUP \(immediate\)](#).
- The assembler syntax is used only for assembly, and is not used on disassembly.
- The description of [DUP \(immediate\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0					Zd
sh																imm8															

### SVE

FMOV <Zd>.<T>, #0.0

is equivalent to

[DUP](#) <Zd>.<T>, #0

### Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

### Operation

The description of [DUP \(immediate\)](#) gives the operational pseudocode for this instruction.

### Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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FMOV (immediate, predicated)

Move 8-bit floating-point immediate to vector elements (predicated).

Move a floating-point immediate into each active element in the destination vector. Inactive elements in the destination vector register remain unmodified.

This is an alias of FCPY. This means:

- The encodings in this description are named to match the encodings of FCPY.
- The description of FCPY gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size		0	1	Pg			1	1	0	imm8						Zd							

SVE

FMOV <Zd>.<T>, <Pg>/M, #<const>

is equivalent to

FCPY <Zd>.<T>, <Pg>/M, #<const>

and is always the preferred disassembly.

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.

<const> Is a floating-point immediate value expressable as  $\pm n \div 16 \times 2^r$ , where n and r are integers such that  $16 \leq n \leq 31$  and  $-3 \leq r \leq 4$ , i.e. a normalized binary floating-point encoding with 1 sign bit, 3-bit exponent, and 4-bit fractional part, encoded in the "imm8" field.

Operation

The description of FCPY gives the operational pseudocode for this instruction.

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# FMOV (immediate, unpredicated)

Move 8-bit floating-point immediate to vector elements (unpredicated).

Unconditionally broadcast the floating-point immediate into each element of the destination vector. This instruction is unpredicated.

This is an alias of [FDUP](#). This means:

- The encodings in this description are named to match the encodings of [FDUP](#).
- The description of [FDUP](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size		1	1	1	0	0	1	1	1	0	imm8								Zd				

## SVE

FMOV <Zd>.<T>, #<const>

is equivalent to

[FDUP](#) <Zd>.<T>, #<const>

and is always the preferred disassembly.

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<const> Is a floating-point immediate value expressable as  $\pm n \div 16 \times 2^r$ , where n and r are integers such that  $16 \leq n \leq 31$  and  $-3 \leq r \leq 4$ , i.e. a normalized binary floating-point encoding with 1 sign bit, 3-bit exponent, and 4-bit fractional part, encoded in the "imm8" field.

## Operation

The description of [FDUP](#) gives the operational pseudocode for this instruction.

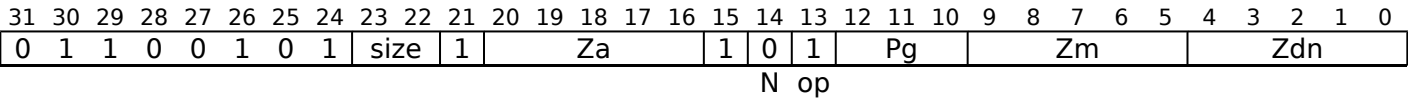
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FMSB

Floating-point fused multiply-subtract vectors (predicated), writing multiplicand [Zdn = Za + -Zdn \* Zm].

Multiply the corresponding active floating-point elements of the first and second source vectors and subtract from elements of the third (addend) vector without intermediate rounding. Destructively place the results in the destination and first source (multiplicand) vector. Inactive elements in the destination vector register remain unmodified.



SVE

FMSB <Zdn>.<T>, <Pg>/M, <Zm>.<T>, <Za>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
integer a = UInt(Za);
boolean op1_neg = TRUE;
boolean op3_neg = FALSE;
```

Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <Za> Is the name of the third source scalable vector register, encoded in the "Za" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[a];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    bits(esize) element3 = Elem[operand3, e, esize];

    if ElemP[mask, e, esize] == '1' then
        if op1_neg then element1 = FPNeg(element1);
        if op3_neg then element3 = FPNeg(element3);
        Elem[result, e, esize] = FPMu1Add(element3, element1, element2, FPCR<31:0>);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# FMUL (immediate)

Floating-point multiply by immediate (predicated).

Multiply by an immediate each active floating-point element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate may take the value +0.5 or +2.0 only. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	1	1	0	1	0	1	0	0	Pg	0	0	0	0	i1								Zdn

## SVE

FMUL <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <const>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
bits(esize) imm = if i1 == '0' then FPPointFive('0') else FPTwo('0');
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <const> Is the floating-point immediate value, encoded in "i1":

i1	<const>
0	#0.5
1	#2.0

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPMul(element1, imm, FPCR<31:0>);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# FMUL (vectors, predicated)

Floating-point multiply vectors (predicated).

Multiply active floating-point elements of the first source vector by corresponding floating-point elements of the second source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	0	1	0	1	0	0	Pg	Zm				Zdn								

## SVE

FMUL <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPMul(element1, element2, FPCR<31:0>);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# FMUL (vectors, unpredicated)

Floating-point multiply vectors (unpredicated).

Multiply all elements of the first source vector by corresponding floating-point elements of the second source vector and place the results in the corresponding elements of the destination vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size		0	Zm				0	0	0	0	1	0	Zn				Zd						

## SVE

FMUL <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = FPMul(element1, element2, FPCR<31:0>);

Z[d] = result;
```

# FMUL (indexed)

Floating-point multiply by indexed elements.

Multiply all floating-point elements within each 128-bit segment of the first source vector by the specified element in the corresponding second source vector segment. The results are placed in the corresponding elements of the destination vector.

The elements within the second source vector are specified using an immediate index which selects the same element position within each 128-bit vector segment. The index range is from 0 to one less than the number of elements per 128-bit segment, encoded in 1 to 3 bits depending on the size of the element. This instruction is unpredicated.

It has encodings from 3 classes: [Half-precision](#) , [Single-precision](#) and [Double-precision](#)

## Half-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	0	i3h	1	i3l	Zm				0	0	1	0	0	0	Zn				Zd					

## Half-precision

FMUL <Zd>.H, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer index = UInt(i3h:i3l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Single-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	1	0	1	i2	Zm				0	0	1	0	0	0	Zn				Zd					
size<1>size<0>																															

## Single-precision

FMUL <Zd>.S, <Zn>.S, <Zm>.S[<imm>]

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Double-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	1	1	i1	Zm				0	0	1	0	0	0	Zn				Zd						
								size<1>				size<0>																			

## Double-precision

FMUL <Zd>.D, <Zn>.D, <Zm>.D[<imm>]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer index = UInt(i1);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd>	Is the name of the destination scalable vector register, encoded in the "Zd" field.
<Zn>	Is the name of the first source scalable vector register, encoded in the "Zn" field.
<Zm>	For the half-precision and single-precision variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  For the double-precision variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
<imm>	For the half-precision variant: is the immediate index, in the range 0 to 7, encoded in the "i3h:i3l" fields.  For the single-precision variant: is the immediate index, in the range 0 to 3, encoded in the "i2" field.  For the double-precision variant: is the immediate index, in the range 0 to 1, encoded in the "i1" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer eltspersegment = 128 DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer segmentbase = e - (e MOD eltspersegment);
    integer s = segmentbase + index;
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, s, esize];
    Elem[result, e, esize] = FPMul(element1, element2, FPCR<31:0>);

Z[d] = result;
```

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FMULX

Floating-point multiply-extended vectors (predicated).

Multiply active floating-point elements of the first source vector by corresponding floating-point elements of the second source vector except that  $\infty \times 0.0$  gives 2.0 instead of NaN, and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

The instruction can be used with FRECPX to safely convert arbitrary elements in mathematical vector space to UNIT VECTORS or DIRECTION VECTORS with length 1.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	1	0	1	0	1	0	0	Pg	Zm				Zdn								

SVE

```
FMULX <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>
```

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPMuLX(element1, element2, FPCR<31:0>);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# FNEG

Floating-point negate (predicated).

Negate each active floating-point element of the source vector, and place the results in the corresponding elements of the destination vector. This inverts the sign bit and cannot signal a floating-point exception. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	1	0	1	1	0	1	Pg				Zn				Zd					

## SVE

FNEG <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    bits(esize) element = Elem[operand, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPNeg(element);

Z[d] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

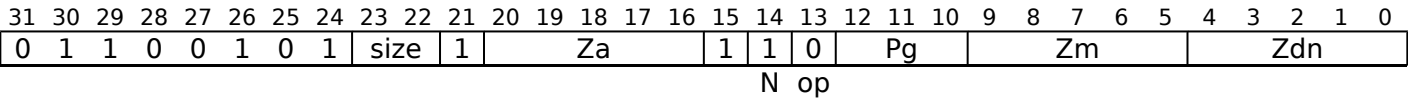
- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



FNMAD

Floating-point negated fused multiply-add vectors (predicated), writing multiplicand [ $Z_{dn} = -Z_a + -Z_{dn} * Z_m$ ].

Multiply the corresponding active floating-point elements of the first and second source vectors and add to elements of the third (addend) vector without intermediate rounding. Destructively place the negated results in the destination and first source (multiplicand) vector. Inactive elements in the destination vector register remain unmodified.



SVE

```
FNMAD <Zdn>.<T>, <Pg>/M, <Zm>.<T>, <Za>.<T>
```

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
integer a = UInt(Za);
boolean op1_neg = TRUE;
boolean op3_neg = TRUE;
```

Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <Za> Is the name of the third source scalable vector register, encoded in the "Za" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[a];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    bits(esize) element3 = Elem[operand3, e, esize];

    if ElemP[mask, e, esize] == '1' then
        if op1_neg then element1 = FPNeg(element1);
        if op3_neg then element3 = FPNeg(element3);
        Elem[result, e, esize] = FPMu1Add(element3, element1, element2, FPCR<31:0>);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

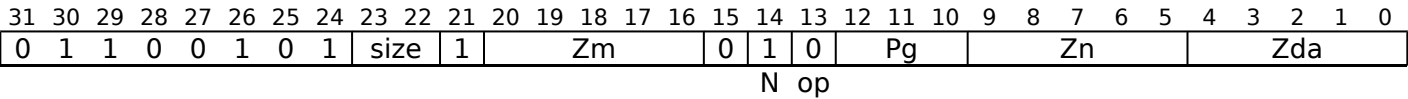
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FNMLA

Floating-point negated fused multiply-add vectors (predicated), writing addend [ $Zda = -Zda + -Zn * Zm$ ].

Multiply the corresponding active floating-point elements of the first and second source vectors and add to elements of the third source (addend) vector without intermediate rounding. Destructively place the negated results in the destination and third source (addend) vector. Inactive elements in the destination vector register remain unmodified.



SVE

```
FNMLA <Zda>.<T>, <Pg>/M, <Zn>.<T>, <Zm>.<T>
```

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean op1_neg = TRUE;
boolean op3_neg = TRUE;
```

Assembler Symbols

- <Zda>

Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D
- <Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn>

Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm>

Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    bits(esize) element3 = Elem[operand3, e, esize];

    if ElemP[mask, e, esize] == '1' then
        if op1_neg then element1 = FPNeg(element1);
        if op3_neg then element3 = FPNeg(element3);
        Elem[result, e, esize] = FPMu1Add(element3, element1, element2, FPCR<31:0>);
    else
        Elem[result, e, esize] = element3;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

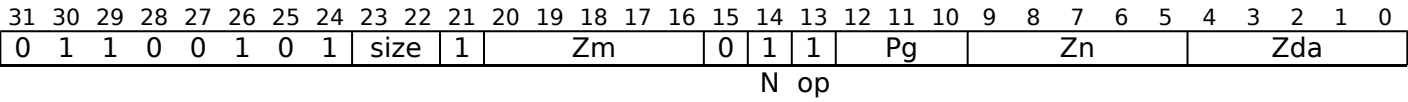
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FNMLS

Floating-point negated fused multiply-subtract vectors (predicated), writing addend [ $Zda = -Zda + Zn * Zm$ ].

Multiply the corresponding active floating-point elements of the first and second source vectors and subtract from elements of the third source (addend) vector without intermediate rounding. Destructively place the negated results in the destination and third source (addend) vector. Inactive elements in the destination vector register remain unmodified.



SVE

```
FNMLS <Zda>.<T>, <Pg>/M, <Zn>.<T>, <Zm>.<T>
```

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean op1_neg = FALSE;
boolean op3_neg = TRUE;
```

Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    bits(esize) element3 = Elem[operand3, e, esize];

    if ElemP[mask, e, esize] == '1' then
        if op1_neg then element1 = FPNeg(element1);
        if op3_neg then element3 = FPNeg(element3);
        Elem[result, e, esize] = FPMu1Add(element3, element1, element2, FPCR<31:0>);
    else
        Elem[result, e, esize] = element3;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

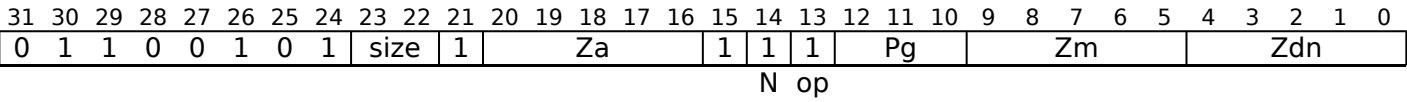
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FNMSB

Floating-point negated fused multiply-subtract vectors (predicated), writing multiplicand [ $Z_{dn} = -Z_a + Z_{dn} * Z_m$ ].

Multiply the corresponding active floating-point elements of the first and second source vectors and subtract from elements of the third (addend) vector without intermediate rounding. Destructively place the negated results in the destination and first source (multiplicand) vector. Inactive elements in the destination vector register remain unmodified.



SVE

FNMSB <Zdn>.<T>, <Pg>/M, <Zm>.<T>, <Za>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
integer a = UInt(Za);
boolean op1_neg = FALSE;
boolean op3_neg = TRUE;
```

Assembler Symbols

- <Zdn>

Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D
- <Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm>

Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <Za>

Is the name of the third source scalable vector register, encoded in the "Za" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[a];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    bits(esize) element3 = Elem[operand3, e, esize];

    if ElemP[mask, e, esize] == '1' then
        if op1_neg then element1 = FPNeg(element1);
        if op3_neg then element3 = FPNeg(element3);
        Elem[result, e, esize] = FPMu1Add(element3, element1, element2, FPCR<31:0>);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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FRECPE

Floating-point reciprocal estimate (unpredicated).

Find the approximate reciprocal of each floating-point element of the source vector, and place the results in the corresponding elements of the destination vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	1	1	1	0	0	0	1	1	0	0	Zn					Zd					

SVE

FRECPE <Zd>.<T>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand = Z[n];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPRecipEstimate(element, FPCR<31:0>);

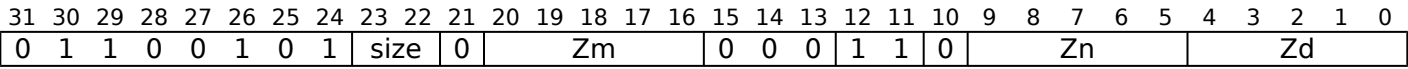
Z[d] = result;
```



FRECPS

Floating-point reciprocal step (unpredicated).

Multiply corresponding floating-point elements of the first and second source vectors, subtract the products from 2.0 without intermediate rounding and place the results in the corresponding elements of the destination vector. This instruction is unpredicated.  
This instruction can be used to perform a single Newton-Raphson iteration for calculating the reciprocal of a vector of floating-point values.



SVE

FRECPS <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = FPRecipStepFused(element1, element2);

Z[d] = result;
```

FRECPX

Floating-point reciprocal exponent (predicated).

Invert the exponent and zero the fractional part of each active floating-point element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

The result of this instruction can be used with FMULX to convert arbitrary elements in mathematical vector space to "unit vectors" or "direction vectors" of length 1.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	1	1	0	0	1	0	1	Pg			Zn				Zd						

SVE

FRECPX <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    bits(esize) element = Elem[operand, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPrecpX(element, FPCR<31:0>);

Z[d] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



FRINT<r>

Floating-point round to integral value (predicated).

Round to an integral floating-point value with the specified rounding option from each active floating-point element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

The <r> symbol specifies one of the following rounding options: N (to nearest, with ties to even), A (to nearest, with ties away from zero), M (toward minus Infinity), P (toward plus Infinity), Z (toward zero), I (current FPCR rounding mode), or X (current FPCR rounding mode, signalling inexact).

It has encodings from 7 classes: [Current mode](#) , [Current mode signalling inexact](#) , [Nearest with ties to away](#) , [Nearest with ties to even](#) , [Toward zero](#) , [Toward minus infinity](#) and [Toward plus infinity](#)

Current mode

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size			0	0	0	1	1	1	1	0	1	Pg			Zn			Zd					

Current mode

FRINTI <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean exact = FALSE;
FPRounding rounding = FPRoundingMode(FPCR<31:0>);
```

Current mode signalling inexact

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size			0	0	0	1	1	0	1	0	1	Pg			Zn			Zd					

Current mode signalling inexact

FRINTX <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean exact = TRUE;
FPRounding rounding = FPRoundingMode(FPCR<31:0>);
```

Nearest with ties to away

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size			0	0	0	1	0	0	1	0	1	Pg			Zn			Zd					

Nearest with ties to away

```
FRINTA <Zd>.<T>, <Pg>/M, <Zn>.<T>

if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean exact = FALSE;
FPRounding rounding = FPRounding_TIEAWAY;
```

Nearest with ties to even

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size		0	0	0	0	0	0	1	0	1	Pg			Zn				Zd					

Toward minus infinity

```
FRINTM <Zd>.<T>, <Pg>/M, <Zn>.<T>

if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean exact = FALSE;
FPRounding rounding = FPRounding_NEGINF;
```

Toward plus infinity

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size		0	0	0	0	0	1	1	0	1	Pg			Zn			Zd						

Toward plus infinity

```
FRINTP <Zd>.<T>, <Pg>/M, <Zn>.<T>

if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean exact = FALSE;
FPRounding rounding = FPRounding_POSINF;
```

Assembler Symbols

- <Zd>

Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D
- <Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn>

Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    bits(esize) element = Elem[operand, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPRoundInt(element, FPCR<31:0>, rounding, exact);

Z[d] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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FRSQRTE

Floating-point reciprocal square root estimate (unpredicated).

Find the approximate reciprocal square root of each active floating-point element of the source vector, and place the results in the corresponding elements of the destination vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size		0	0	1	1	1	1	0	0	1	1	0	0	Zn				Zd					

SVE

FRSQRTE <Zd>.<T>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand = Z[n];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element = Elem[operand, e, esize];
    Elem[result, e, esize] = FPRSqrtEstimate(element, FPCR<31:0>);

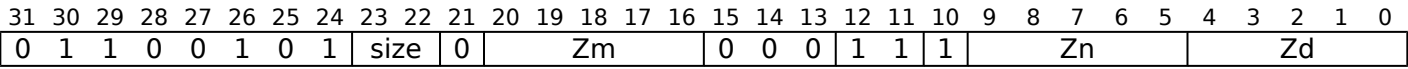
Z[d] = result;
```



FRSQRTS

Floating-point reciprocal square root step (unpredicated).

Multiply corresponding floating-point elements of the first and second source vectors, subtract the products from 3.0 and divide the results by 2.0 without any intermediate rounding and place the results in the corresponding elements of the destination vector. This instruction is unpredicated.  
This instruction can be used to perform a single Newton-Raphson iteration for calculating the reciprocal square root of a vector of floating-point values.



SVE

```
FRSQRTS <Zd>.<T>, <Zn>.<T>, <Zm>.<T>
```

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = FPRSqrtStepFused(element1, element2);

Z[d] = result;
```

# FSCALE

Floating-point adjust exponent by vector (predicated).

Multiply the active floating-point elements of the first source vector by 2.0 to the power of the signed integer values in the corresponding elements of the second source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	1	0	0	1	1	0	0	Pg				Zm				Zdn					

## SVE

FSCALE <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    integer element2 = SInt(Elem[operand2, e, esize]);
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPScale(element1, element2, FPCR<31:0>);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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FSQRT

Floating-point square root (predicated).

Calculate the square root of each active floating-point element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	1	1	0	1	1	0	1	Pg				Zn				Zd					

SVE

```
FSQRT <Zd>.<T>, <Pg>/M, <Zn>.<T>
```

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

Assembler Symbols

- <Zd>

Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D
- <Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn>

Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    bits(esize) element = Elem[operand, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPSqrt(element, FPCR<31:0>);

Z[d] = result;
```

Operational information

- This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:
- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
  - The MOVPRFX instruction must specify the same destination register as this instruction.
  - The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



# FSUB (immediate)

Floating-point subtract immediate (predicated).

Subtract an immediate from each active floating-point element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate may take the value +0.5 or +1.0 only. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	1	1	0	0	1	1	0	0	Pg	0	0	0	0	i1	Zdn							

## SVE

FSUB <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <const>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
bits(esize) imm = if i1 == '0' then FPPointFive('0') else FPOne('0');
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <const> Is the floating-point immediate value, encoded in "i1":

i1	<const>
0	#0.5
1	#1.0

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPSub(element1, imm, FPCR<31:0>);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# FSUB (vectors, predicated)

Floating-point subtract vectors (predicated).

Subtract active floating-point elements of the second source vector from corresponding floating-point elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	0	0	1	1	0	0	Pg				Zm				Zdn					

## SVE

FSUB <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPSub(element1, element2, FPCR<31:0>);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.



- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# FSUB (vectors, unpredicated)

Floating-point subtract vectors (unpredicated).

Subtract all floating-point elements of the second source vector from corresponding elements of the first source vector and place the results in the corresponding elements of the destination vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size		0	Zm					0	0	0	0	0	1	Zn					Zd				

## SVE

FSUB <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = FPSub(element1, element2, FPCR<31:0>);

Z[d] = result;
```

# FSUBR (immediate)

Floating-point reversed subtract from immediate (predicated).

Reversed subtract from an immediate each active floating-point element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate may take the value +0.5 or +1.0 only. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	1	1	0	1	1	1	0	0	Pg	0	0	0	0	i1	Zdn							

## SVE

FSUBR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <const>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
bits(esize) imm = if i1 == '0' then FPPointFive('0') else FPOne('0');
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <const> Is the floating-point immediate value, encoded in "i1":

i1	<const>
0	#0.5
1	#1.0

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPSub(imm, element1, FPCR<31:0>);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# FSUBR (vectors)

Floating-point reversed subtract vectors (predicated).

Reversed subtract active floating-point elements of the first source vector from corresponding floating-point elements of the second source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	0	1	1	1	0	0	Pg				Zm				Zdn					

## SVE

FSUBR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = FPSub(element2, element1, FPCR<31:0>);
    else
        Elem[result, e, esize] = element1;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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FTMAD

Floating-point trigonometric multiply-add coefficient.

The FTMAD instruction calculates the series terms for either SIN(x) or COS(x), where the argument x has been adjusted to be in the range  $-\pi/4 < x \leq \pi/4$ .

To calculate the series terms of SIN(x) and COS(x) the initial source operands of FTMAD should be zero in the first source vector and  $x^2$  in the second source vector. The FTMAD instruction is then executed eight times to calculate the sum of eight series terms, which gives a result of sufficient precision.

The FTMAD instruction multiplies each element of the first source vector by the absolute value of the corresponding element of the second source vector and performs a fused addition of each product with a value obtained from a table of hard-wired coefficients, and places the results destructively in the first source vector.

The coefficients are different for SIN(x) and COS(x), and are selected by a combination of the sign bit in the second source element and an immediate index in the range 0 to 7.

This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size		0	1	0	imm3		1	0	0	0	0	0	Zm				Zdn						

SVE

FTMAD <Zdn>.<T>, <Zdn>.<T>, <Zm>.<T>, #<imm>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
integer imm = UInt(imm3);
```

Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

<imm> Is the unsigned immediate operand, in the range 0 to 7, encoded in the "imm3" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = FPTrigMAdd(imm, element1, element2, FPCR<31:0>);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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FTSMUL

Floating-point trigonometric starting value.

The FTSMUL instruction calculates the initial value for the FTMAD instruction. The instruction squares each element in the first source vector and then sets the sign bit to a copy of bit 0 of the corresponding element in the second source register, and places the results in the destination vector. This instruction is unpredicated. To compute SIN(x) or COS(x) the instruction is executed with elements of the first source vector set to x, adjusted to be in the range  $-\pi/4 < x \leq \pi/4$ . The elements of the second source vector hold the corresponding value of the quadrant Q number as an integer not a floating-point value. The value Q satisfies the relationship  $(2q-1) \times \pi/4 < x \leq (2q+1) \times \pi/4$ .

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	Zm						0	0	0	0	1	1	Zn						Zd			

SVE

FTSMUL <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = FPTrigSMul(element1, element2, FPCR<31:0>);

Z[d] = result;
```

FTSSEL

Floating-point trigonometric select coefficient.

The FTSSEL instruction selects the coefficient for the final multiplication in the polynomial series approximation. The instruction places the value 1.0 or a copy of the first source vector element in the destination element, depending on bit 0 of the quadrant number Q held in the corresponding element of the second source vector. The sign bit of the destination element is copied from bit 1 of the corresponding value of Q. This instruction is unpredicated.

To compute SIN(x) or COS(x) the instruction is executed with elements of the first source vector set to x, adjusted to be in the range  $-\pi/4 < x \leq \pi/4$ .

The elements of the second source vector hold the corresponding value of the quadrant Q number as an integer not a floating-point value. The value Q satisfies the relationship  $(2q-1) \times \pi/4 < x \leq (2q+1) \times \pi/4$ .

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	0	0	0	0	1	0	0	size	1	Zm						1	0	1	1	0	0	Zn						Zd				

SVE

FTSSEL <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = FPTrigSSel(element1, element2);

Z[d] = result;
```

# HISTCNT

Count matching elements in vector.

This instruction compares each active 32 or 64-bit element of the first source vector with all active elements with an element number less than or equal to its own in the second source vector, and places the count of matching elements in the corresponding element of the destination vector. Inactive elements in the destination vector are set to zero.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	size	1	Zm						1	1	0	Pg			Zn				Zd					

## SVE2

HISTCNT <Zd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
if size == '0x' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer d = UInt(Zd);
integer n = UInt(Zn);
integer m = UInt(Zm);
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "size<0>":

size<0>	<T>
0	S
1	D
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer count = 0;
    if ElemP[mask, e, esize] == '1' then
        bits(esize) element1 = Elem[operand1, e, esize];
        for i = 0 to e
            if ElemP[mask, i, esize] == '1' then
                bits(esize) element2 = Elem[operand2, i, esize];
                if element1 == element2 then
                    count = count + 1;
        Elem[result, e, esize] = count<esize-1:0>;

Z[d] = result;
```

# HISTSEG

Count matching elements in vector segments.

This instruction compares each 8-bit byte element of the first source vector with all of the elements in the corresponding 128-bit segment of the second source vector and places the count of matching elements in the corresponding element of the destination vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	size	1	Zm						1	0	1	0	0	0	Zn						Zd			

## SVE2

HISTSEG <Zd>.B, <Zn>.B, <Zm>.B

```
if !HaveSVE2() then UNDEFINED;
if size != '00' then UNDEFINED;
integer esize = 8;
integer d = UInt(Zd);
integer n = UInt(Zn);
integer m = UInt(Zm);
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer segments = VL DIV 128;
integer eltspersegment = 128 DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for b = 0 to segments-1
  for s = 0 to eltspersegment-1
    integer count = 0;
    integer e = eltspersegment * b + s;
    bits(esize) element1 = Elem[operand1, e, esize];
    for i = 0 to eltspersegment-1
      integer e2 = eltspersegment * b + i;
      bits(esize) element2 = Elem[operand2, e2, esize];
      if element1 == element2 then
        count = count + 1;
    Elem[result, e, esize] = count<esize-1:0>;

Z[d] = result;
```

# INCB, INCD, INCH, INCW (scalar)

Increment scalar by multiple of predicate constraint element count.

Determines the number of active elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment the scalar destination.

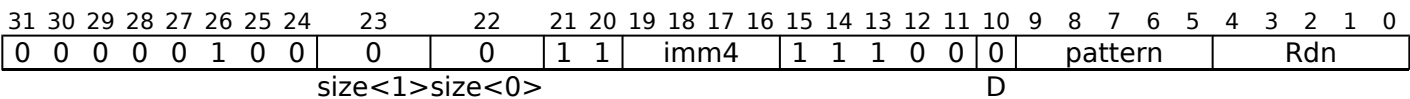
The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 4 classes: [Byte](#) , [Doubleword](#) , [Halfword](#) and [Word](#)

## Byte

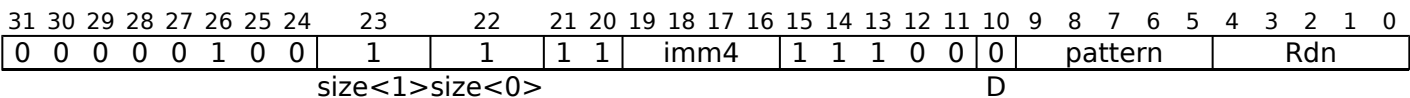


## Byte

INCB <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

## Doubleword

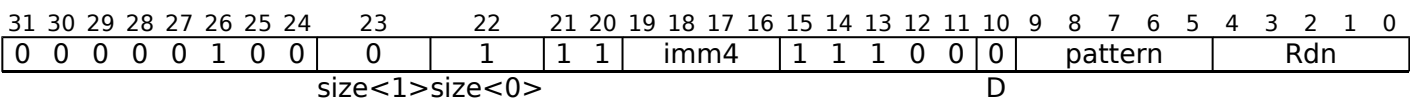


## Doubleword

INCD <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

## Halfword

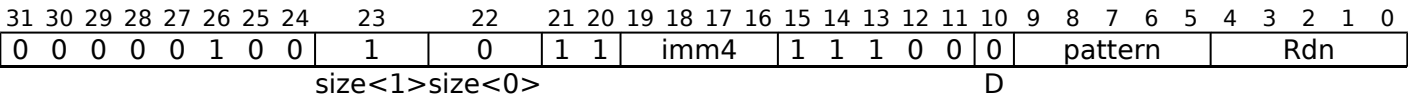


Halfword

```
INCH <Xdn>{, <pattern>{, MUL #<imm>}}
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

Word



Word

```
INCW <Xdn>{, <pattern>{, MUL #<imm>}}
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

Assembler Symbols

- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

Operation

```
CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(64) operand1 = X[dn];

X[dn] = operand1 + (count * imm);
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# INCD, INCH, INCW (vector)

Increment vector by multiple of predicate constraint element count.

Determines the number of active elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment all destination vector elements.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 3 classes: [Doubleword](#) , [Halfword](#) and [Word](#)

## Doubleword

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	1	1	1	imm4				1	1	0	0	0	0	0	pattern					Zdn			
size<1>size<0>																D															

## Doubleword

INCD <Zdn>.D{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

## Halfword

31	30	29	28	27	26	25	24	23		22		21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	1	1	1	1	imm4				1	1	0	0	0	0	0	pattern				Zdn				
size<1>size<0>																D																	

## Halfword

INCH <Zdn>.H{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

## Word

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	0	1	1	imm4				1	1	0	0	0	0	0	pattern					Zdn			
size<1>size<0>																D															



Word

```
INCW <Zdn>.S{, <pattern>{, MUL #<imm>}}
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
```

Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer count = DecodePredCount(pat, esize);
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    Elem[result, e, esize] = Elem[operand1, e, esize] + (count * imm);

Z[dn] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

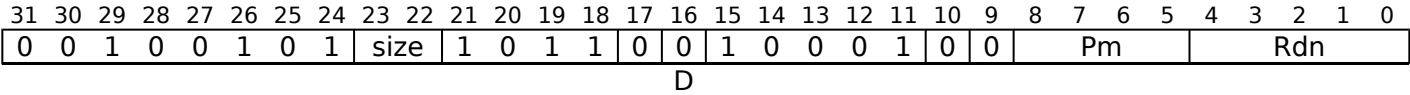
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# INCP (scalar)

Increment scalar by count of true predicate elements.

Counts the number of true elements in the source predicate and then uses the result to increment the scalar destination.



## SVE

INCP <Xdn>, <Pm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Rdn);
```

## Assembler Symbols

- <Xdn>Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Pm>Is the name of the source scalable predicate register, encoded in the "Pm" field.
- <T>Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) operand1 = X[dn];
bits(PL) operand2 = P[m];
integer count = 0;

for e = 0 to elements-1
    if ElemP[operand2, e, esize] == '1' then
        count = count + 1;

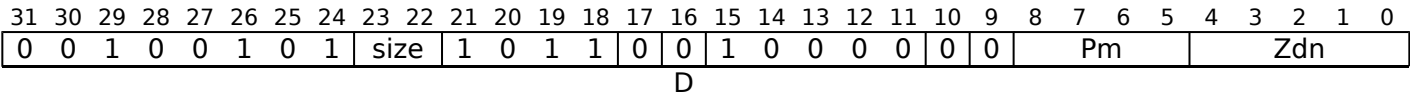
X[dn] = operand1 + count;
```

# INCP (vector)

Increment vector by count of true predicate elements.

Counts the number of true elements in the source predicate and then uses the result to increment all destination vector elements.

The predicate size specifier may be omitted in assembler source code, but this is deprecated and will be prohibited in a future release of the architecture.



## SVE

INCP <Zdn>.<T>, <Pm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Zdn);
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pm> Is the name of the source scalable predicate register, encoded in the "Pm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(PL) operand2 = P[m];
bits(VL) result;
integer count = 0;

for e = 0 to elements-1
    if ElemP[operand2, e, esize] == '1' then
        count = count + 1;

for e = 0 to elements-1
    Elem[result, e, esize] = Elem[operand1, e, esize] + count;

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



# INDEX (immediates)

Create index starting from and incremented by immediate.

Populates the destination vector by setting the first element to the first signed immediate integer operand and monotonically incrementing the value by the second signed immediate integer operand for each subsequent element. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	1	imm5b						0	1	0	0	0	0	imm5					Zd				

## SVE

INDEX <Zd>.<T>, #<imm1>, #<imm2>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer d = UInt(Zd);
integer imm1 = SInt(imm5);
integer imm2 = SInt(imm5b);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<imm1> Is the first signed immediate operand, in the range -16 to 15, encoded in the "imm5" field.

<imm2> Is the second signed immediate operand, in the range -16 to 15, encoded in the "imm5b" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) result;

for e = 0 to elements-1
    integer index = imm1 + e * imm2;
    Elem[result, e, esize] = index<esize-1:0>;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# INDEX (immediate, scalar)

Create index starting from immediate and incremented by general-purpose register.

Populates the destination vector by setting the first element to the first signed immediate integer operand and monotonically incrementing the value by the second signed scalar integer operand for each subsequent element. The scalar source operand is a general-purpose register in which only the least significant bits corresponding to the vector element size are used and any remaining bits are ignored. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	1	Rm						0	1	0	0	1	0	imm5					Zd				

## SVE

INDEX <Zd>.<T>, #<imm>, <R><m>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Rm);
integer d = UInt(Zd);
integer imm = SInt(imm5);
```

## Assembler Symbols

- <Zd>

Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <imm>

Is the signed immediate operand, in the range -16 to 15, encoded in the "imm5" field.
- <R>

Is a width specifier, encoded in "size":

size	<R>
01	W
x0	W
11	X
- <m>

Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(esize) operand2 = X[m];
integer element2 = SInt(operand2);
bits(VL) result;

for e = 0 to elements-1
    integer index = imm + e * element2;
    Elem[result, e, esize] = index<esize-1:0>;

Z[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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INDEX (scalar, immediate)

Create index starting from general-purpose register and incremented by immediate.

Populates the destination vector by setting the first element to the first signed scalar integer operand and monotonically incrementing the value by the second signed immediate integer operand for each subsequent element. The scalar source operand is a general-purpose register in which only the least significant bits corresponding to the vector element size are used and any remaining bits are ignored. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	1				imm5			0	1	0	0	0	1				Rn				Zd		

SVE

INDEX <Zd>.<T>, <R><n>, #<imm>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Rn);
integer d = UInt(Zd);
integer imm = SInt(imm5);
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <R> Is a width specifier, encoded in "size":

size	<R>
01	W
x0	W
11	X
- <n> Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rn" field.
- <imm> Is the signed immediate operand, in the range -16 to 15, encoded in the "imm5" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(esize) operand1 = X[n];
integer element1 = SInt(operand1);
bits(VL) result;

for e = 0 to elements-1
    integer index = element1 + e * imm;
    Elem[result, e, esize] = index<esize-1:0>;

Z[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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INDEX (scalars)

Create index starting from and incremented by general-purpose register.

Populates the destination vector by setting the first element to the first signed scalar integer operand and monotonically incrementing the value by the second signed scalar integer operand for each subsequent element. The scalar source operands are general-purpose registers in which only the least significant bits corresponding to the vector element size are used and any remaining bits are ignored. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	0	0	0	0	1	0	0	size	1	Rm						0	1	0	0	1	1	Rn						Zd					

SVE

INDEX <Zd>.<T>, <R><n>, <R><m>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Zd);
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <R> Is a width specifier, encoded in "size":

size	<R>
01	W
x0	W
11	X
- <n> Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rn" field.
- <m> Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(esize) operand1 = X[n];
integer element1 = SInt(operand1);
bits(esize) operand2 = X[m];
integer element2 = SInt(operand2);
bits(VL) result;

for e = 0 to elements-1
    integer index = element1 + e * element2;
    Elem[result, e, esize] = index<esize-1:0>;

Z[d] = result;
```

Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# INSR (scalar)

Insert general-purpose register in shifted vector.

Shift the destination vector left by one element, and then place a copy of the least-significant bits of the general-purpose register in element 0 of the destination vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size		1	0	0	1	0	0	0	0	1	1	1	0	Rm				Zdn					

## SVE

INSR <Zdn>.<T>, <R><m>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer dn = UInt(Zdn);
integer m = UInt(Rm);
```

## Assembler Symbols

- <Zdn>

Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <R>

Is a width specifier, encoded in "size":

size	<R>
01	W
x0	W
11	X
- <m>

Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
bits(VL) dest = Z[dn];
bits(esize) src = X[m];
Z[dn] = dest<VL-esize-1:0> : src;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



# INSR (SIMD&FP scalar)

Insert SIMD&FP scalar register in shifted vector.

Shift the destination vector left by one element, and then place a copy of the SIMD&FP scalar register in element 0 of the destination vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size		1	1	0	1	0	0	0	0	1	1	1	0	Vm				Zdn					

## SVE

INSR <Zdn>.<T>, <V><m>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer dn = UInt(Zdn);
integer m = UInt(Vm);
```

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<V> Is a width specifier, encoded in "size":

size	<V>
00	B
01	H
10	S
11	D

<m> Is the number [0-31] of the source SIMD&FP register, encoded in the "Vm" field.

## Operation

```
CheckSVEEnabled();
bits(VL) dest = Z[dn];
bits(esize) src = V[m];
Z[dn] = dest<VL-esize-1:0> : src;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

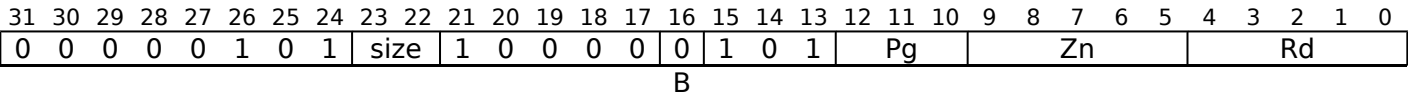




# LASTA (scalar)

Extract element after last to general-purpose register.

If there is an active element then extract the element after the last active element modulo the number of elements from the final source vector register. If there are no active elements, extract element zero. Then zero-extend and place the extracted element in the destination general-purpose register.



## SVE

LASTA <R><d>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer rsize = if esize < 64 then 32 else 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Rd);
boolean isBefore = FALSE;
```

## Assembler Symbols

- <R>

Is a width specifier, encoded in "size":

size	<R>
01	W
x0	W
11	X
- <d>

Is the number [0-30] of the destination general-purpose register or the name ZR (31), encoded in the "Rd" field.
- <Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn>

Is the name of the source scalable vector register, encoded in the "Zn" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(rsize) result;
integer last = LastActiveElement(mask, esize);

if isBefore then
    if last < 0 then last = elements - 1;
else
    last = last + 1;
    if last >= elements then last = 0;
result = ZeroExtend(Elem[operand, last, esize]);

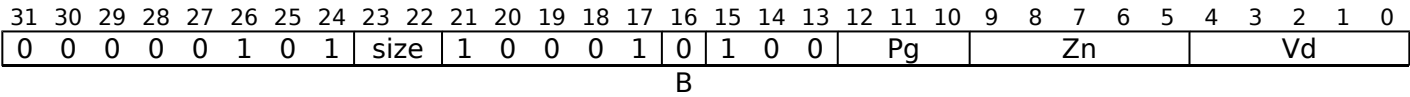
X[d] = result;
```



LASTA (SIMD&FP scalar)

Extract element after last to SIMD&FP scalar register.

If there is an active element then extract the element after the last active element modulo the number of elements from the final source vector register. If there are no active elements, extract element zero. Then place the extracted element in the destination SIMD&FP scalar register.



SVE

LASTA <V><d>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);
boolean isBefore = FALSE;
```

Assembler Symbols

- <V>

Is a width specifier, encoded in "size":

size	<V>
00	B
01	H
10	S
11	D
- <d>

Is the number [0-31] of the destination SIMD&FP register, encoded in the "Vd" field.
- <Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn>

Is the name of the source scalable vector register, encoded in the "Zn" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

Operation

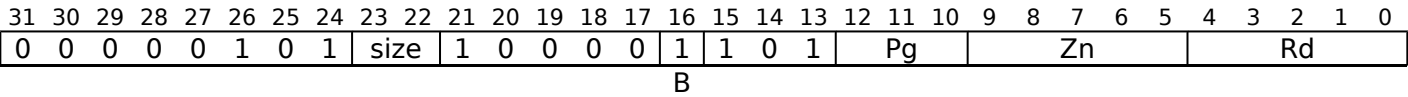
```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
integer last = LastActiveElement(mask, esize);

if isBefore then
    if last < 0 then last = elements - 1;
else
    last = last + 1;
    if last >= elements then last = 0;
V[d] = Elem[operand, last, esize];
```

# LASTB (scalar)

Extract last element to general-purpose register.

If there is an active element then extract the last active element from the final source vector register. If there are no active elements, extract the highest-numbered element. Then zero-extend and place the extracted element in the destination general-purpose register.



## SVE

LASTB <R><d>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer rsize = if esize < 64 then 32 else 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Rd);
boolean isBefore = TRUE;
```

## Assembler Symbols

<R>

Is a width specifier, encoded in "size":

size	<R>
01	W
x0	W
11	X

<d>

Is the number [0-30] of the destination general-purpose register or the name ZR (31), encoded in the "Rd" field.

<Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn>

Is the name of the source scalable vector register, encoded in the "Zn" field.

<T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(rsize) result;
integer last = LastActiveElement(mask, esize);

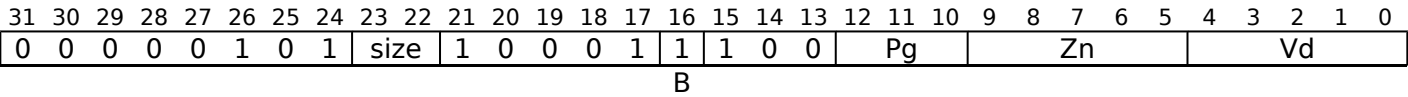
if isBefore then
    if last < 0 then last = elements - 1;
else
    last = last + 1;
    if last >= elements then last = 0;
result = ZeroExtend(Elem[operand, last, esize]);
X[d] = result;
```



# LASTB (SIMD&FP scalar)

Extract last element to SIMD&FP scalar register.

If there is an active element then extract the last active element from the final source vector register. If there are no active elements, extract the highest-numbered element. Then place the extracted element in the destination SIMD&FP register.



## SVE

LASTB <V><d>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);
boolean isBefore = TRUE;
```

## Assembler Symbols

- <V>

Is a width specifier, encoded in "size":

size	<V>
00	B
01	H
10	S
11	D
- <d>

Is the number [0-31] of the destination SIMD&FP register, encoded in the "Vd" field.
- <Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn>

Is the name of the source scalable vector register, encoded in the "Zn" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
integer last = LastActiveElement(mask, esize);

if isBefore then
    if last < 0 then last = elements - 1;
else
    last = last + 1;
    if last >= elements then last = 0;
V[d] = Elem[operand, last, esize];
```

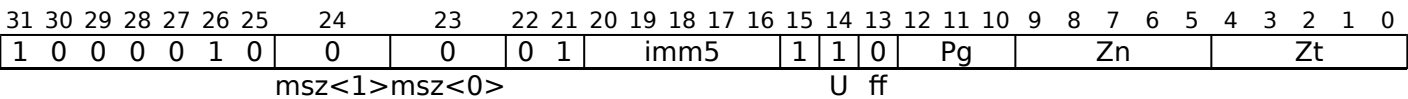
## LD1B (vector plus immediate)

Gather load unsigned bytes to vector (immediate index).

Gather load of unsigned bytes to active elements of a vector register from memory addresses generated by a vector base plus immediate index. The index is in the range 0 to 31. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

### 32-bit element

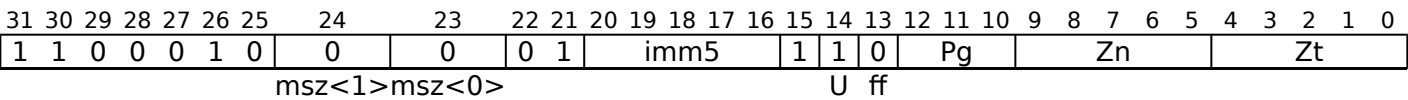


### 32-bit element

LD1B { <Zt>.S }, <Pg>/Z, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = UInt(imm5);
```

### 64-bit element



### 64-bit element

LD1B { <Zt>.D }, <Pg>/Z, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = UInt(imm5);
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, in the range 0 to 31, defaulting to 0, encoded in the "imm5" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) base = Z[n];
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();
Z[t] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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## LD1B (scalar plus immediate)

Contiguous load unsigned bytes to vector (immediate index).

Contiguous load of unsigned bytes to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 4 classes: [8-bit element](#) , [16-bit element](#) , [32-bit element](#) and [64-bit element](#)

### 8-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	0	0	0	0	imm4			1		0	1	Pg		Rn				Zt						
dtype<3:1>dtype<0>																															

### 8-bit element

LD1B { <Zt>.B }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

### 16-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	0	0	1	0	imm4			1	0	1	Pg			Rn			Zt							
dtype<3:1>dtype<0>																															

### 16-bit element

LD1B { <Zt>.H }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

### 32-bit element

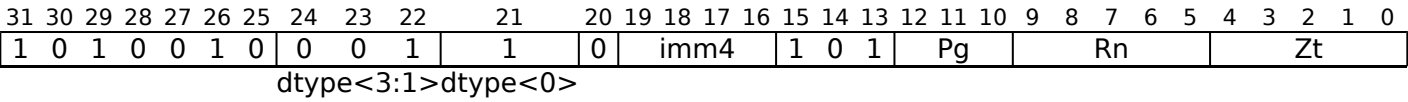
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	0	1	0	0	imm4		1	0	1	Pg		Rn			Zt									
dtype<3:1>dtype<0>																															

32-bit element

```
LD1B { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

64-bit element



64-bit element

```
LD1B { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

addr = base + offset * elements * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();
    addr = addr + mbytes;

Z[t] = result;
```

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## LD1B (scalar plus scalar)

Contiguous load unsigned bytes to vector (scalar index).

Contiguous load of unsigned bytes to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 4 classes: [8-bit element](#) , [16-bit element](#) , [32-bit element](#) and [64-bit element](#)

### 8-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	0	0	0	Rm				0	1	0	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

### 8-bit element

LD1B { <Zt>.B }, <Pg>/Z, [<Xn|SP>, <Xm>]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 8;
integer msize = 8;
boolean unsigned = TRUE;
```

### 16-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	0	0	1	Rm				0	1	0	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

### 16-bit element

LD1B { <Zt>.H }, <Pg>/Z, [<Xn|SP>, <Xm>]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
integer msize = 8;
boolean unsigned = TRUE;
```

### 32-bit element

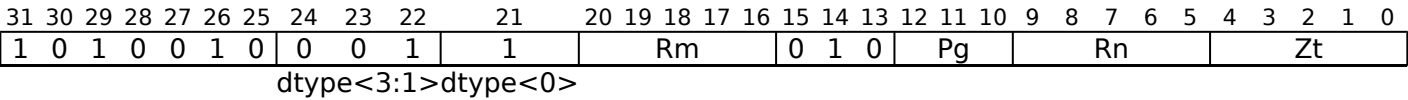
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	0	1	0	Rm				0	1	0	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

32-bit element

```
LD1B { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Xm>]
```

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
boolean unsigned = TRUE;
```

64-bit element



64-bit element

```
LD1B { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Xm>]
```

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
boolean unsigned = TRUE;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
bits(64) offset = X[m];
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    if ElemP[mask, e, esize] == '1' then
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();
    offset = offset + 1;

Z[t] = result;
```

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## LD1B (scalar plus vector)

Gather load unsigned bytes to vector (vector index).

Gather load of unsigned bytes to active elements of a vector register from memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally sign or zero-extended from 32 to 64 bits. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 3 classes: [32-bit unpacked unscaled offset](#) , [32-bit unscaled offset](#) and [64-bit unscaled offset](#)

### 32-bit unpacked unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	xs	0	Zm				0	1	0	Pg			Rn				Zt						
msz<1>msz<0>										U ff																					

### 32-bit unpacked unscaled offset

LD1B { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

### 32-bit unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	0	xs	0	Zm				0	1	0	Pg			Rn				Zt						
										U										ff											

### 32-bit unscaled offset

LD1B { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

### 64-bit unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	1	0	Zm				1	1	0	Pg			Rn				Zt						
msz<1>msz<0>										U										ff											

## 64-bit unscaled offset

LD1B { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
integer offs_size = 64;
boolean unsigned = TRUE;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(VL) offset = Z[m];
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        addr = base + (off << scale);
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

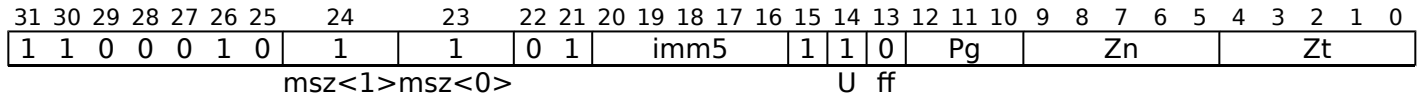
Z[t] = result;
```



## LD1D (vector plus immediate)

Gather load doublewords to vector (immediate index).

Gather load of doublewords to active elements of a vector register from memory addresses generated by a vector base plus immediate index. The index is a multiple of 8 in the range 0 to 248. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.



### SVE

LD1D { <Zt>.D }, <Pg>/Z, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
boolean unsigned = TRUE;
integer offset = UInt(imm5);
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 8 in the range 0 to 248, defaulting to 0, encoded in the "imm5" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) base = Z[n];
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

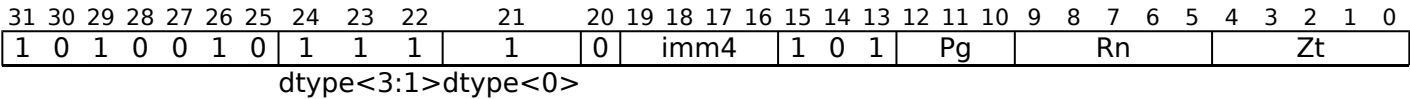
Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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## LD1D (scalar plus immediate)

Contiguous load doublewords to vector (immediate index).

Contiguous load of doublewords to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.



### SVE

LD1D { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

addr = base + offset * elements * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();
    addr = addr + mbytes;

Z[t] = result;
```

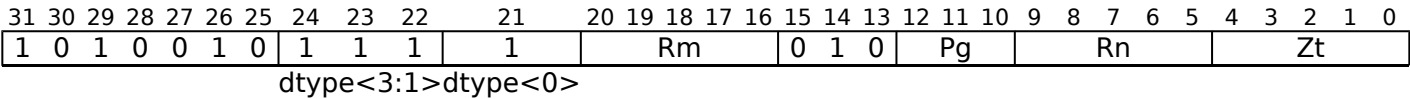
Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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## LD1D (scalar plus scalar)

Contiguous load doublewords to vector (scalar index).

Contiguous load of doublewords to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 8 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.



### SVE

LD1D { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #3]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
boolean unsigned = TRUE;
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
bits(64) offset = X[m];
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    if ElemP[mask, e, esize] == '1' then
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();
    offset = offset + 1;

Z[t] = result;
```

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## LD1D (scalar plus vector)

Gather load doublewords to vector (vector index).

Gather load of doublewords to active elements of a vector register from memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then optionally multiplied by 8. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 4 classes: [32-bit unpacked scaled offset](#) , [32-bit unpacked unscaled offset](#) , [64-bit scaled offset](#) and [64-bit unscaled offset](#)

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	1	1	xs	1	Zm					0	1	0	Pg			Rn				Zt					
																U ff															

### 32-bit unpacked scaled offset

LD1D { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod> #3]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 3;
```

### 32-bit unpacked unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	1	1	xs	0	Zm					0	1	0	Pg			Rn				Zt					
msz<1>msz<0>																U ff															

### 32-bit unpacked unscaled offset

LD1D { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

### 64-bit scaled offset

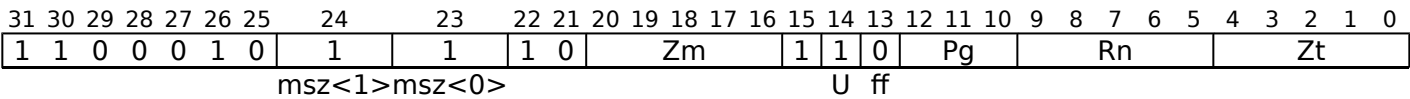
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	1	1	1	1	Zm					1	1	0	Pg			Rn				Zt					
																U ff															

64-bit scaled offset

```
LD1D { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, LSL #3]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
integer offs_size = 64;
boolean unsigned = TRUE;
boolean offs_unsigned = TRUE;
integer scale = 3;
```

64-bit unscaled offset



64-bit unscaled offset

```
LD1D { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
integer offs_size = 64;
boolean unsigned = TRUE;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(VL) offset = Z[m];
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        addr = base + (off << scale);
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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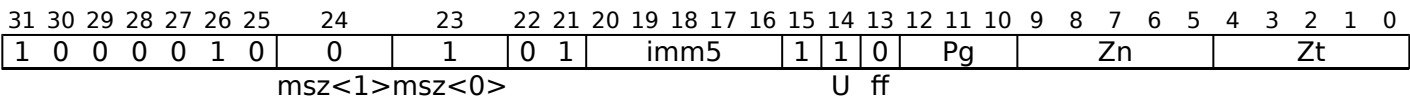
# LD1H (vector plus immediate)

Gather load unsigned halfwords to vector (immediate index).

Gather load of unsigned halfwords to active elements of a vector register from memory addresses generated by a vector base plus immediate index. The index is a multiple of 2 in the range 0 to 62. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

## 32-bit element

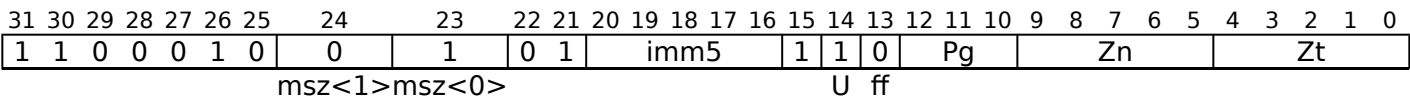


## 32-bit element

LD1H { <Zt>.S }, <Pg>/Z, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
boolean unsigned = TRUE;
integer offset = UInt(imm5);
```

## 64-bit element



## 64-bit element

LD1H { <Zt>.D }, <Pg>/Z, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
boolean unsigned = TRUE;
integer offset = UInt(imm5);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 2 in the range 0 to 62, defaulting to 0, encoded in the "imm5" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) base = Z[n];
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();
Z[t] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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## LD1H (scalar plus immediate)

Contiguous load unsigned halfwords to vector (immediate index).

Contiguous load of unsigned halfwords to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 3 classes: [16-bit element](#) , [32-bit element](#) and [64-bit element](#)

### 16-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	1	0	1	0	imm4			1	0	1	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

### 16-bit element

LD1H { <Zt>.H }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer msize = 16;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

### 32-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	1	1	0	0	imm4			1	0	1	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

### 32-bit element

LD1H { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

### 64-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	1	1	1	0	imm4			1	0	1	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

## 64-bit element

```
LD1H { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

## Assembler Symbols

<Zt>	Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<imm>	Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
       ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
        base = SP[];
    else
        if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
        base = X[n];

addr = base + offset * elements * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();
    addr = addr + mbytes;

Z[t] = result;
```

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## LD1H (scalar plus scalar)

Contiguous load unsigned halfwords to vector (scalar index).

Contiguous load of unsigned halfwords to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 2 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 3 classes: [16-bit element](#) , [32-bit element](#) and [64-bit element](#)

### 16-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	1	0	1	Rm				0	1	0	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

### 16-bit element

LD1H { <Zt>.H }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
integer msize = 16;
boolean unsigned = TRUE;
```

### 32-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	1	1	0	Rm				0	1	0	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

### 32-bit element

LD1H { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
boolean unsigned = TRUE;
```

### 64-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	1	1	1	Rm				0	1	0	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

## 64-bit element

```
LD1H { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #1]
```

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
boolean unsigned = TRUE;
```

## Assembler Symbols

<Zt>	Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
bits(64) offset = X[m];
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        base = SP[];
    else
        base = X[n];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    if ElemP[mask, e, esize] == '1' then
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();
    offset = offset + 1;

Z[t] = result;
```

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## LD1H (scalar plus vector)

Gather load unsigned halfwords to vector (vector index).

Gather load of unsigned halfwords to active elements of a vector register from memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then optionally multiplied by 2. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 6 classes: [32-bit scaled offset](#) , [32-bit unpacked scaled offset](#) , [32-bit unpacked unscaled offset](#) , [32-bit unscaled offset](#) , [64-bit scaled offset](#) and [64-bit unscaled offset](#)

### 32-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	1	xs	1	Zm					0	1	0	Pg			Rn					Zt				
																U ff															

### 32-bit scaled offset

LD1H { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod> #1]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 1;
```

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	1	xs	1	Zm					0	1	0	Pg			Rn					Zt				
																U ff															

### 32-bit unpacked scaled offset

LD1H { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod> #1]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 1;
```

### 32-bit unpacked unscaled offset

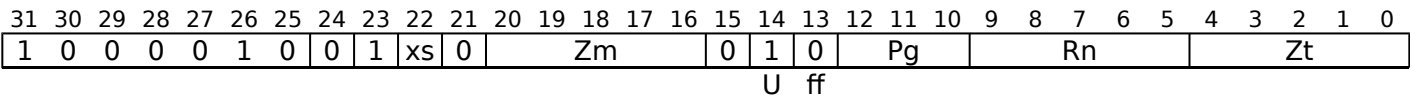
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	1	xs	0	Zm					0	1	0	Pg			Rn					Zt				
msz<1>msz<0>																U ff															

32-bit unpacked unscaled offset

LD1H { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

32-bit unscaled offset

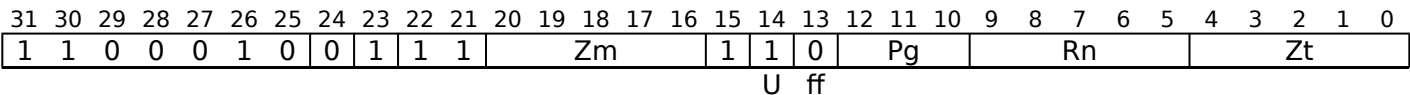


32-bit unscaled offset

LD1H { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

64-bit scaled offset

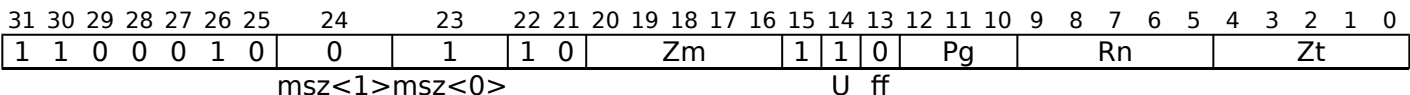


64-bit scaled offset

LD1H { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, LSL #1]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 64;
boolean unsigned = TRUE;
boolean offs_unsigned = TRUE;
integer scale = 1;
```

64-bit unscaled offset





## 64-bit unscaled offset

LD1H { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 64;
boolean unsigned = TRUE;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(VL) offset = Z[m];
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        base = SP[];
    else
        base = X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        addr = base + (off << scale);
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

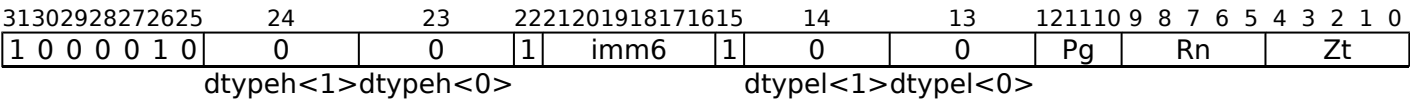
# LD1RB

Load and broadcast unsigned byte to vector.

Load a single unsigned byte from a memory address generated by a 64-bit scalar base address plus an immediate offset which is in the range 0 to 63.  
Broadcast the loaded data into all active elements of the destination vector, setting the inactive elements to zero. If all elements are inactive then the instruction will not perform a read from Device memory or cause a data abort.

It has encodings from 4 classes: [8-bit element](#) , [16-bit element](#) , [32-bit element](#) and [64-bit element](#)

## 8-bit element

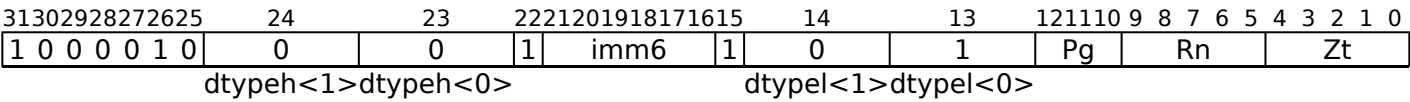


## 8-bit element

LD1RB { <Zt>.B }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = UInt(imm6);
```

## 16-bit element

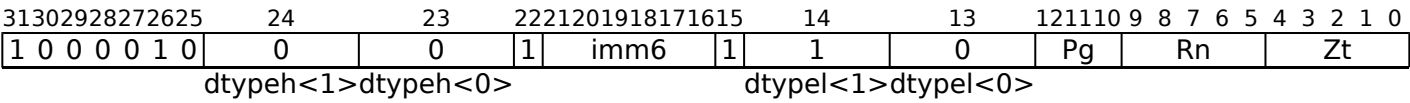


## 16-bit element

LD1RB { <Zt>.H }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = UInt(imm6);
```

## 32-bit element

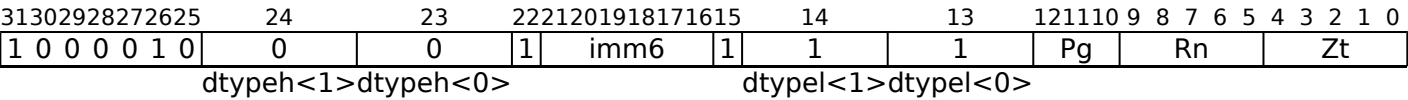


32-bit element

```
LD1RB { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>}]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = UInt(imm6);
```

64-bit element



64-bit element

```
LD1RB { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>}]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = UInt(imm6);
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional unsigned immediate byte offset, in the range 0 to 63, defaulting to 0, encoded in the "imm6" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

integer last = LastActiveElement(mask, esize);
if last >= 0 then
    addr = base + offset * mbytes;
    data = Mem[addr, mbytes, AccType_NORMAL];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

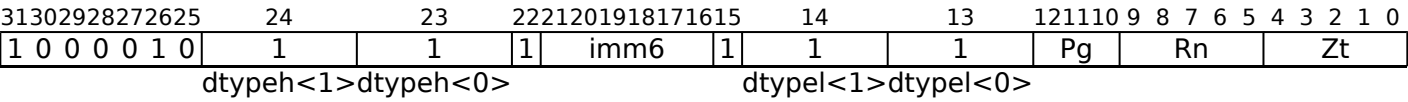
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LD1RD

Load and broadcast doubleword to vector.

Load a single doubleword from a memory address generated by a 64-bit scalar base address plus an immediate offset which is a multiple of 8 in the range 0 to 504.

Broadcast the loaded data into all active elements of the destination vector, setting the inactive elements to zero. If all elements are inactive then the instruction will not perform a read from Device memory or cause a data abort.



SVE

```
LD1RD { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>}]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
boolean unsigned = TRUE;
integer offset = UInt(imm6);
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 8 in the range 0 to 504, defaulting to 0, encoded in the "imm6" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

integer last = LastActiveElement(mask, esize);
if last >= 0 then
    addr = base + offset * mbytes;
    data = Mem[addr, mbytes, AccType_NORMAL];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

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# LD1RH

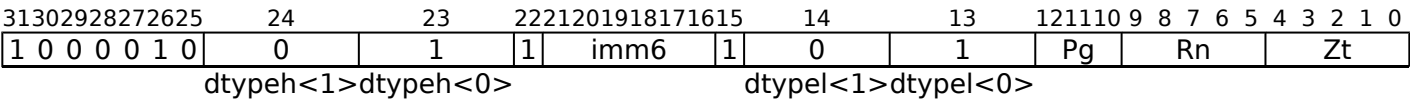
Load and broadcast unsigned halfword to vector.

Load a single unsigned halfword from a memory address generated by a 64-bit scalar base address plus an immediate offset which is a multiple of 2 in the range 0 to 126.

Broadcast the loaded data into all active elements of the destination vector, setting the inactive elements to zero. If all elements are inactive then the instruction will not perform a read from Device memory or cause a data abort.

It has encodings from 3 classes: [16-bit element](#) , [32-bit element](#) and [64-bit element](#)

## 16-bit element

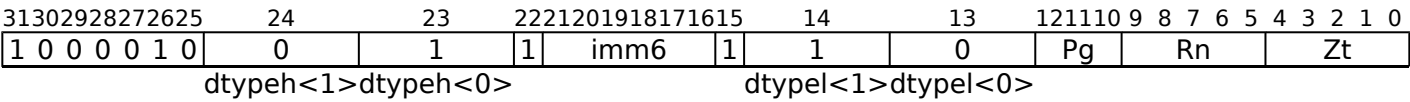


## 16-bit element

LD1RH { <Zt>.H }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer msize = 16;
boolean unsigned = TRUE;
integer offset = UInt(imm6);
```

## 32-bit element

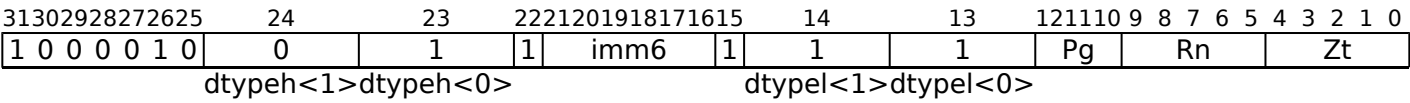


## 32-bit element

LD1RH { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
boolean unsigned = TRUE;
integer offset = UInt(imm6);
```

## 64-bit element



## 64-bit element

LD1RH { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
boolean unsigned = TRUE;
integer offset = UInt(imm6);
```

## Assembler Symbols

<Zt>	Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<imm>	Is the optional unsigned immediate byte offset, a multiple of 2 in the range 0 to 126, defaulting to 0, encoded in the "imm6" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
       ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        base = SP[];
    else
        base = X[n];

integer last = LastActiveElement(mask, esize);
if last >= 0 then
    addr = base + offset * mbytes;
    data = Mem[addr, mbytes, AccType_NORMAL];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

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# LD1ROB (scalar plus immediate)

Contiguous load and replicate thirty-two bytes (immediate index).

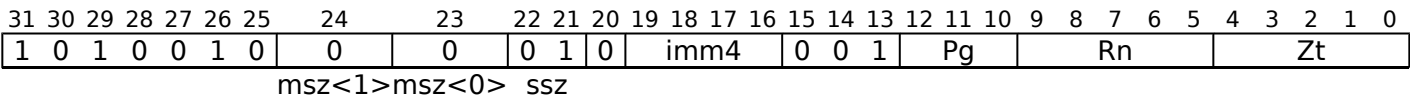
Load thirty-two contiguous bytes to elements of a 256-bit (octaword) vector from the memory address generated by a 64-bit scalar base address and immediate index that is a multiple of 32 in the range -256 to +224 added to the base address.

Inactive elements will not read Device memory or signal a fault, and are set to zero.

The resulting 256-bit vector is then replicated to fill the destination vector. The instruction requires that the current vector length is at least 256 bits, and if the current vector length is not an integer multiple of 256 bits then the trailing bits in the destination vector are set to zero.

Only the first thirty-two predicate elements are used and higher numbered predicate elements are ignored.

ID\_AA64ZFR0\_EL1.F64MM indicates whether this instruction is implemented.



## SVE

LD1ROB { <Zt>.B }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVEFP64MatMulExt() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8;
integer offset = SInt(imm4);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate byte offset, a multiple of 32 in the range -256 to 224, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
if VL < 256 then UNDEFINED;
integer elements = 256 DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g]; // low bits only
bits(256) result;
constant integer mbytes = esize DIV 8;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

addr = base + offset * 32;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();
    addr = addr + mbytes;

Z[t] = ZeroExtend(Replicate(result, VL DIV 256), VL);
```

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LD1ROB (scalar plus scalar)

Contiguous load and replicate thirty-two bytes (scalar index).

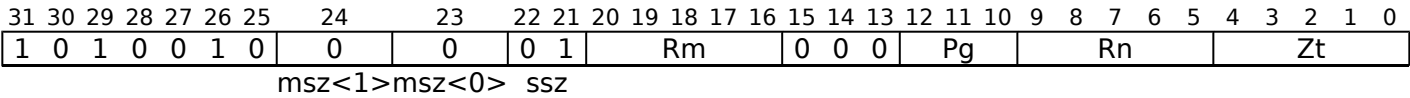
Load thirty-two contiguous bytes to elements of a 256-bit (octaword) vector from the memory address generated by a 64-bit scalar base address and scalar index which is added to the base address.

Inactive elements will not read Device memory or signal a fault, and are set to zero.

The resulting 256-bit vector is then replicated to fill the destination vector. The instruction requires that the current vector length is at least 256 bits, and if the current vector length is not an integer multiple of 256 bits then the trailing bits in the destination vector are set to zero.

Only the first thirty-two predicate elements are used and higher numbered predicate elements are ignored.

ID\_AA64ZFR0\_EL1.F64MM indicates whether this instruction is implemented.



SVE

LD1ROB { <Zt>.B }, <Pg>/Z, [<Xn|SP>, <Xm>]

```
if !HaveSVEFP64MatMulExt() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 8;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
if VL < 256 then UNDEFINED;
integer elements = 256 DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g]; // low bits only
bits(64) offset;
bits(256) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

offset = X[m];

addr = base + UInt(offset) * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();
    addr = addr + mbytes;

Z[t] = ZeroExtend(Replicate(result, VL DIV 256), VL);
```

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LD1ROD (scalar plus immediate)

Contiguous load and replicate four doublewords (immediate index).

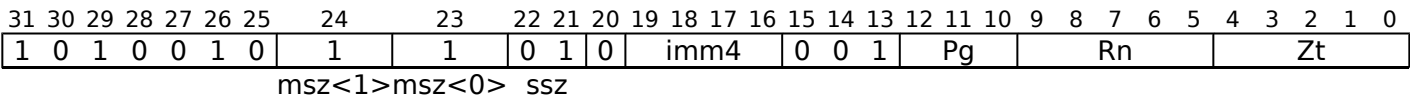
Load four contiguous doublewords to elements of a 256-bit (octaword) vector from the memory address generated by a 64-bit scalar base address and immediate index that is a multiple of 32 in the range -256 to +224 added to the base address.

Inactive elements will not read Device memory or signal a fault, and are set to zero.

The resulting 256-bit vector is then replicated to fill the destination vector. The instruction requires that the current vector length is at least 256 bits, and if the current vector length is not an integer multiple of 256 bits then the trailing bits in the destination vector are set to zero.

Only the first four predicate elements are used and higher numbered predicate elements are ignored.

ID\_AA64ZFR0\_EL1.F64MM indicates whether this instruction is implemented.



SVE

LD1ROD { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVEFP64MatMulExt() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer offset = SInt(imm4);
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate byte offset, a multiple of 32 in the range -256 to 224, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
if VL < 256 then UNDEFINED;
integer elements = 256 DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g]; // low bits only
bits(256) result;
constant integer mbytes = esize DIV 8;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

addr = base + offset * 32;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();
    addr = addr + mbytes;

Z[t] = ZeroExtend(Replicate(result, VL DIV 256), VL);
```

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# LD1ROD (scalar plus scalar)

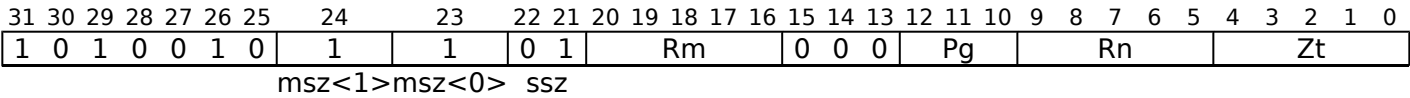
Contiguous load and replicate four doublewords (scalar index).

Load four contiguous doublewords to elements of a 256-bit (octaword) vector from the memory address generated by a 64-bit scalar base address and scalar index which is multiplied by 8 and added to the base address. Inactive elements will not read Device memory or signal a fault, and are set to zero.

The resulting 256-bit vector is then replicated to fill the destination vector. The instruction requires that the current vector length is at least 256 bits, and if the current vector length is not an integer multiple of 256 bits then the trailing bits in the destination vector are set to zero.

Only the first four predicate elements are used and higher numbered predicate elements are ignored.

ID\_AA64ZFR0\_EL1.F64MM indicates whether this instruction is implemented.



## SVE

```
LD1ROD { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #3]

if !HaveSVEFP64MatMulExt() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
if VL < 256 then UNDEFINED;
integer elements = 256 DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g]; // low bits only
bits(64) offset;
bits(256) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

offset = X[m];

addr = base + UInt(offset) * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();
    addr = addr + mbytes;

Z[t] = ZeroExtend(Replicate(result, VL DIV 256), VL);
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# LD1ROH (scalar plus immediate)

Contiguous load and replicate sixteen halfwords (immediate index).

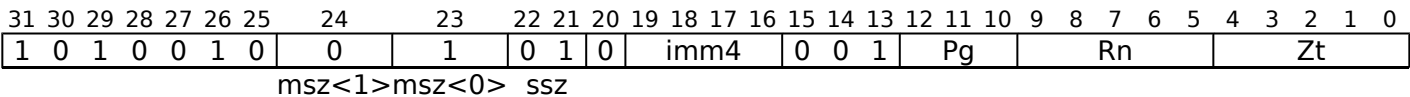
Load sixteen contiguous halfwords to elements of a 256-bit (octaword) vector from the memory address generated by a 64-bit scalar base address and immediate index that is a multiple of 32 in the range -256 to +224 added to the base address.

Inactive elements will not read Device memory or signal a fault, and are set to zero.

The resulting 256-bit vector is then replicated to fill the destination vector. The instruction requires that the current vector length is at least 256 bits, and if the current vector length is not an integer multiple of 256 bits then the trailing bits in the destination vector are set to zero.

Only the first sixteen predicate elements are used and higher numbered predicate elements are ignored.

ID\_AA64ZFR0\_EL1.F64MM indicates whether this instruction is implemented.



## SVE

LD1ROH { <Zt>.H }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVEFP64MatMulExt() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer offset = SInt(imm4);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate byte offset, a multiple of 32 in the range -256 to 224, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
if VL < 256 then UNDEFINED;
integer elements = 256 DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g]; // low bits only
bits(256) result;
constant integer mbytes = esize DIV 8;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

addr = base + offset * 32;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();
    addr = addr + mbytes;

Z[t] = ZeroExtend(Replicate(result, VL DIV 256), VL);
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# LD1ROH (scalar plus scalar)

Contiguous load and replicate sixteen halfwords (scalar index).

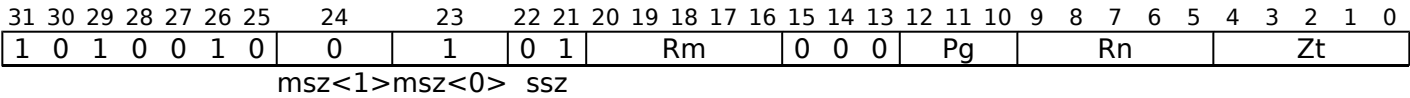
Load sixteen contiguous halfwords to elements of a 256-bit (octaword) vector from the memory address generated by a 64-bit scalar base address and scalar index which is multiplied by 2 and added to the base address.

Inactive elements will not read Device memory or signal a fault, and are set to zero.

The resulting 256-bit vector is then replicated to fill the destination vector. The instruction requires that the current vector length is at least 256 bits, and if the current vector length is not an integer multiple of 256 bits then the trailing bits in the destination vector are set to zero.

Only the first sixteen predicate elements are used and higher numbered predicate elements are ignored.

ID\_AA64ZFR0\_EL1.F64MM indicates whether this instruction is implemented.



## SVE

LD1ROH { <Zt>.H }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVEFP64MatMulExt() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
if VL < 256 then UNDEFINED;
integer elements = 256 DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g]; // low bits only
bits(64) offset;
bits(256) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

offset = X[m];

addr = base + UInt(offset) * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();
    addr = addr + mbytes;

Z[t] = ZeroExtend(Replicate(result, VL DIV 256), VL);
```

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LD1ROW (scalar plus immediate)

Contiguous load and replicate eight words (immediate index).

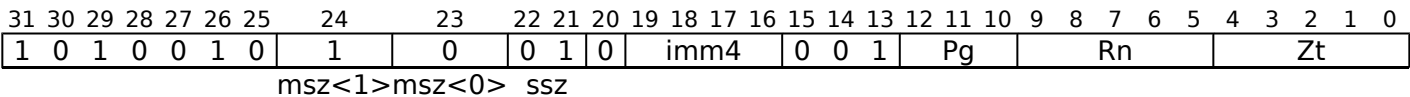
Load eight contiguous words to elements of a 256-bit (octaword) vector from the memory address generated by a 64-bit scalar base address and immediate index that is a multiple of 32 in the range -256 to +224 added to the base address.

Inactive elements will not read Device memory or signal a fault, and are set to zero.

The resulting 256-bit vector is then replicated to fill the destination vector. The instruction requires that the current vector length is at least 256 bits, and if the current vector length is not an integer multiple of 256 bits then the trailing bits in the destination vector are set to zero.

Only the first eight predicate elements are used and higher numbered predicate elements are ignored.

ID\_AA64ZFR0\_EL1.F64MM indicates whether this instruction is implemented.



SVE

LD1ROW { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVEFP64MatMulExt() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer offset = SInt(imm4);
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate byte offset, a multiple of 32 in the range -256 to 224, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
if VL < 256 then UNDEFINED;
integer elements = 256 DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g]; // low bits only
bits(256) result;
constant integer mbytes = esize DIV 8;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

addr = base + offset * 32;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();
    addr = addr + mbytes;

Z[t] = ZeroExtend(Replicate(result, VL DIV 256), VL);
```

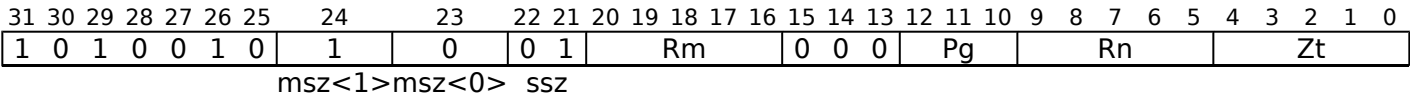
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# LD1ROW (scalar plus scalar)

Contiguous load and replicate eight words (scalar index).

Load eight contiguous words to elements of a 256-bit (octaword) vector from the memory address generated by a 64-bit scalar base address and scalar index which is multiplied by 4 and added to the base address. Inactive elements will not read Device memory or signal a fault, and are set to zero. The resulting 256-bit vector is then replicated to fill the destination vector. The instruction requires that the current vector length is at least 256 bits, and if the current vector length is not an integer multiple of 256 bits then the trailing bits in the destination vector are set to zero. Only the first eight predicate elements are used and higher numbered predicate elements are ignored. ID\_AA64ZFR0\_EL1.F64MM indicates whether this instruction is implemented.



## SVE

LD1ROW { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #2]

```
if !HaveSVEFP64MatMulExt() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
if VL < 256 then UNDEFINED;
integer elements = 256 DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g]; // low bits only
bits(64) offset;
bits(256) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

offset = X[m];

addr = base + UInt(offset) * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();
    addr = addr + mbytes;

Z[t] = ZeroExtend(Replicate(result, VL DIV 256), VL);
```

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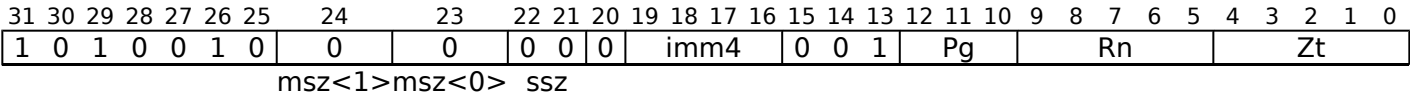


LD1RQB (scalar plus immediate)

Contiguous load and replicate sixteen bytes (immediate index).

Load sixteen contiguous bytes to elements of a short, 128-bit (quadword) vector from the memory address generated by a 64-bit scalar base address and immediate index that is a multiple of 16 in the range -128 to +112 added to the base address.

Inactive elements will not read Device memory or signal a fault, and are set to zero. The resulting short vector is then replicated to fill the long destination vector. Only the first sixteen predicate elements are used and higher numbered predicate elements are ignored.



SVE

```
LD1RQB { <Zt>.B }, <Pg>/Z, [<Xn|SP>{, #<imm>}]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8;
integer offset = SInt(imm4);
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate byte offset, a multiple of 16 in the range -128 to 112, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = 128 DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g]; // low 16 bits only
bits(128) result;
constant integer mbytes = esize DIV 8;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

addr = base + offset * 16;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();
    addr = addr + mbytes;

Z[t] = Replicate(result, VL DIV 128);
```

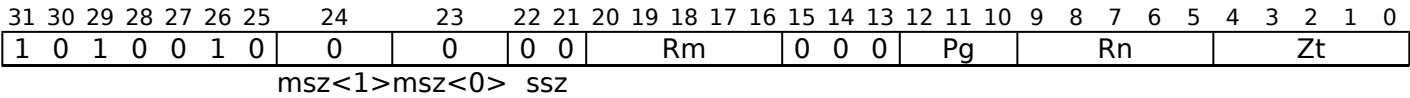
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LD1RQB (scalar plus scalar)

Contiguous load and replicate sixteen bytes (scalar index).

Load sixteen contiguous bytes to elements of a short, 128-bit (quadword) vector from the memory address generated by a 64-bit scalar base address and scalar index which is added to the base address.  
Inactive elements will not read Device memory or signal a fault, and are set to zero. The resulting short vector is then replicated to fill the long destination vector. Only the first sixteen predicate elements are used and higher numbered predicate elements are ignored.



SVE

LD1RQB { <Zt>.B }, <Pg>/Z, [<Xn|SP>, <Xm>]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 8;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = 128 DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g]; // low 16 bits only
bits(64) offset;
bits(128) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];
offset = X[m];

addr = base + UInt(offset) * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();
    addr = addr + mbytes;

Z[t] = Replicate(result, VL DIV 128);
```

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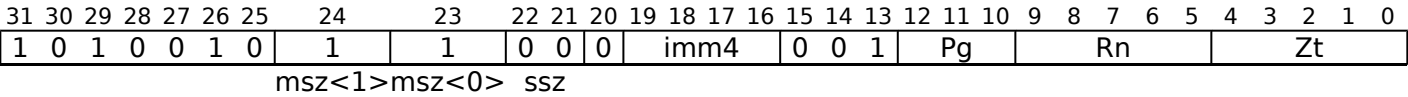
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# LD1RQD (scalar plus immediate)

Contiguous load and replicate two doublewords (immediate index).

Load two contiguous doublewords to elements of a short, 128-bit (quadword) vector from the memory address generated by a 64-bit scalar base address and immediate index that is a multiple of 16 in the range -128 to +112 added to the base address.

Inactive elements will not read Device memory or signal a fault, and are set to zero. The resulting short vector is then replicated to fill the long destination vector. Only the first two predicate elements are used and higher numbered predicate elements are ignored.



## SVE

```
LD1RQD { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>}]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer offset = SInt(imm4);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate byte offset, a multiple of 16 in the range -128 to 112, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = 128 DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g]; // low 16 bits only
bits(128) result;
constant integer mbytes = esize DIV 8;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

addr = base + offset * 16;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();
    addr = addr + mbytes;

Z[t] = Replicate(result, VL DIV 128);
```

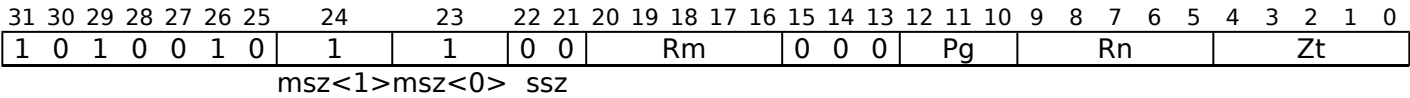
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LD1RQD (scalar plus scalar)

Contiguous load and replicate two doublewords (scalar index).

Load two contiguous doublewords to elements of a short, 128-bit (quadword) vector from the memory address generated by a 64-bit scalar base address and scalar index which is multiplied by 8 and added to the base address. Inactive elements will not read Device memory or signal a fault, and are set to zero. The resulting short vector is then replicated to fill the long destination vector. Only the first two predicate elements are used and higher numbered predicate elements are ignored.



SVE

LD1RQD { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #3]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = 128 DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g]; // low 16 bits only
bits(64) offset;
bits(128) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        base = SP[];
    else
        base = X[n];
    offset = X[m];

addr = base + UInt(offset) * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();
    addr = addr + mbytes;

Z[t] = Replicate(result, VL DIV 128);
```

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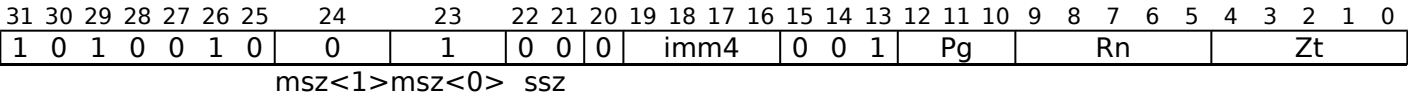


# LD1RQH (scalar plus immediate)

Contiguous load and replicate eight halfwords (immediate index).

Load eight contiguous halfwords to elements of a short, 128-bit (quadword) vector from the memory address generated by a 64-bit scalar base address and immediate index that is a multiple of 16 in the range -128 to +112 added to the base address.

Inactive elements will not read Device memory or signal a fault, and are set to zero. The resulting short vector is then replicated to fill the long destination vector. Only the first eight predicate elements are used and higher numbered predicate elements are ignored.



## SVE

LD1RQH { <Zt>.H }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer offset = SInt(imm4);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate byte offset, a multiple of 16 in the range -128 to 112, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = 128 DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g]; // low 16 bits only
bits(128) result;
constant integer mbytes = esize DIV 8;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

addr = base + offset * 16;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();
    addr = addr + mbytes;

Z[t] = Replicate(result, VL DIV 128);
```

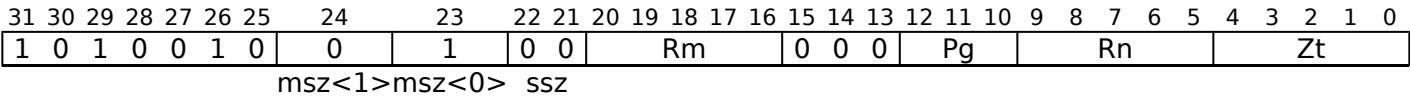
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# LD1RQH (scalar plus scalar)

Contiguous load and replicate eight halfwords (scalar index).

Load eight contiguous halfwords to elements of a short, 128-bit (quadword) vector from the memory address generated by a 64-bit scalar base address and scalar index which is multiplied by 2 and added to the base address. Inactive elements will not read Device memory or signal a fault, and are set to zero. The resulting short vector is then replicated to fill the long destination vector. Only the first eight predicate elements are used and higher numbered predicate elements are ignored.



## SVE

LD1RQH { <Zt>.H }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = 128 DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g]; // low 16 bits only
bits(64) offset;
bits(128) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];
offset = X[m];

addr = base + UInt(offset) * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();
    addr = addr + mbytes;

Z[t] = Replicate(result, VL DIV 128);
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

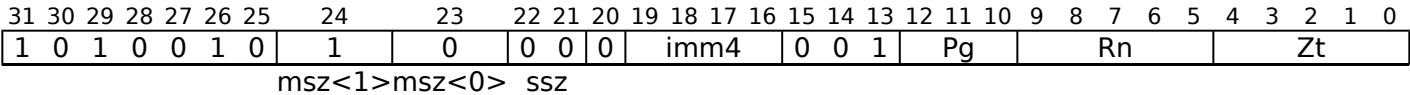
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LD1RQW (scalar plus immediate)

Contiguous load and replicate four words (immediate index).

Load four contiguous words to elements of a short, 128-bit (quadword) vector from the memory address generated by a 64-bit scalar base address and immediate index that is a multiple of 16 in the range -128 to +112 added to the base address.

Inactive elements will not read Device memory or signal a fault, and are set to zero. The resulting short vector is then replicated to fill the long destination vector. Only the first four predicate elements are used and higher numbered predicate elements are ignored.



SVE

```
LD1RQW { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>}]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer offset = SInt(imm4);
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate byte offset, a multiple of 16 in the range -128 to 112, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = 128 DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g]; // low 16 bits only
bits(128) result;
constant integer mbytes = esize DIV 8;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

addr = base + offset * 16;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();
    addr = addr + mbytes;

Z[t] = Replicate(result, VL DIV 128);
```

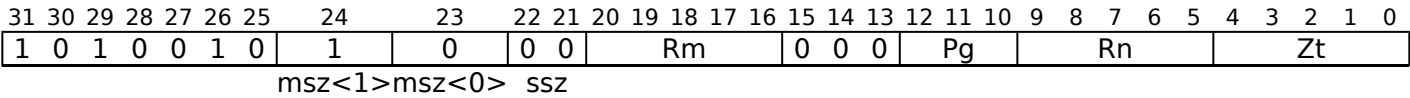
Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# LD1RQW (scalar plus scalar)

Contiguous load and replicate four words (scalar index).

Load four contiguous words to elements of a short, 128-bit (quadword) vector from the memory address generated by a 64-bit scalar base address and scalar index which is multiplied by 4 and added to the base address. Inactive elements will not read Device memory or signal a fault, and are set to zero. The resulting short vector is then replicated to fill the long destination vector. Only the first four predicate elements are used and higher numbered predicate elements are ignored.



## SVE

LD1RQW { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #2]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = 128 DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g]; // low 16 bits only
bits(64) offset;
bits(128) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];
offset = X[m];

addr = base + UInt(offset) * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_NORMAL];
    else
        Elem[result, e, esize] = Zeros();
    addr = addr + mbytes;

Z[t] = Replicate(result, VL DIV 128);
```

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# LD1RSB

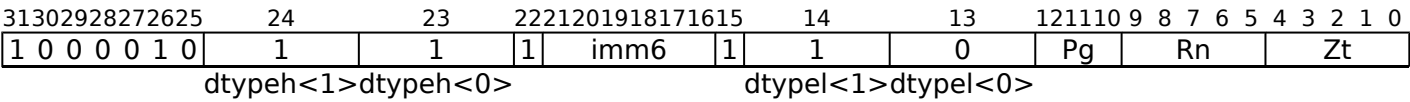
Load and broadcast signed byte to vector.

Load a single signed byte from a memory address generated by a 64-bit scalar base address plus an immediate offset which is in the range 0 to 63.

Broadcast the loaded data into all active elements of the destination vector, setting the inactive elements to zero. If all elements are inactive then the instruction will not perform a read from Device memory or cause a data abort.

It has encodings from 3 classes: [16-bit element](#) , [32-bit element](#) and [64-bit element](#)

## 16-bit element

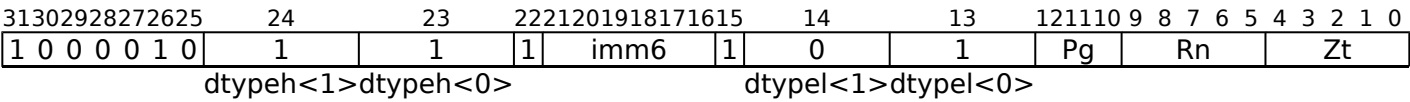


## 16-bit element

LD1RSB { <Zt>.H }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer msize = 8;
boolean unsigned = FALSE;
integer offset = UInt(imm6);
```

## 32-bit element

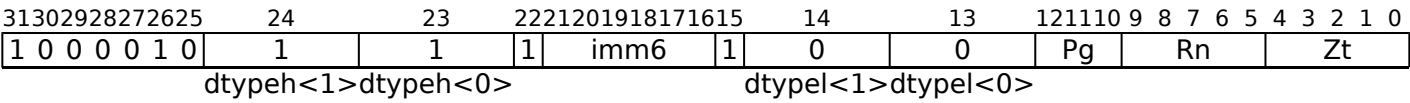


## 32-bit element

LD1RSB { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
boolean unsigned = FALSE;
integer offset = UInt(imm6);
```

## 64-bit element



## 64-bit element

```
LD1RSB { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>}]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
boolean unsigned = FALSE;
integer offset = UInt(imm6);
```

## Assembler Symbols

<Zt>	Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<imm>	Is the optional unsigned immediate byte offset, in the range 0 to 63, defaulting to 0, encoded in the "imm6" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        base = SP[];
    else
        base = X[n];

integer last = LastActiveElement(mask, esize);
if last >= 0 then
    addr = base + offset * mbytes;
    data = Mem[addr, mbytes, AccType_NORMAL];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

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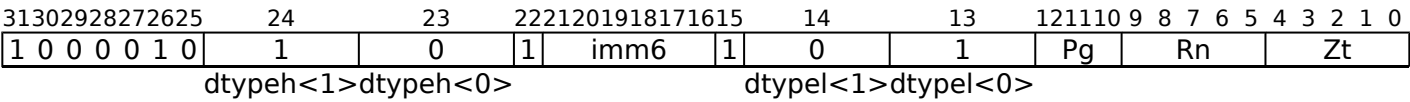
# LD1RSH

Load and broadcast signed halfword to vector.

Load a single signed halfword from a memory address generated by a 64-bit scalar base address plus an immediate offset which is a multiple of 2 in the range 0 to 126.  
Broadcast the loaded data into all active elements of the destination vector, setting the inactive elements to zero. If all elements are inactive then the instruction will not perform a read from Device memory or cause a data abort.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

## 32-bit element

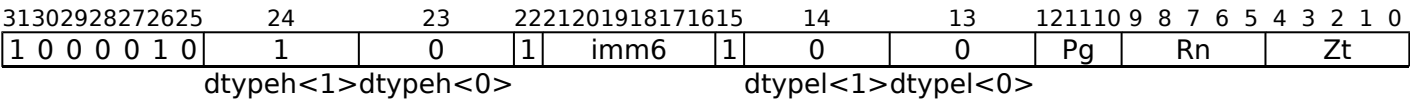


## 32-bit element

LD1RSH { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
boolean unsigned = FALSE;
integer offset = UInt(imm6);
```

## 64-bit element



## 64-bit element

LD1RSH { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
boolean unsigned = FALSE;
integer offset = UInt(imm6);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 2 in the range 0 to 126, defaulting to 0, encoded in the "imm6" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

integer last = LastActiveElement(mask, esize);
if last >= 0 then
    addr = base + offset * mbytes;
    data = Mem[addr, mbytes, AccType_NORMAL];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

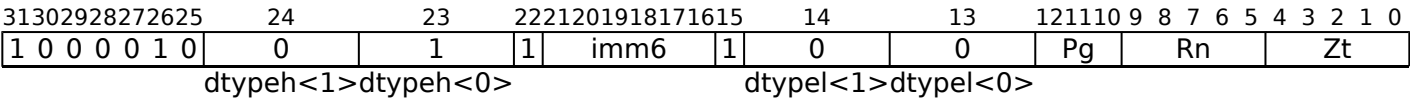
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# LD1RSW

Load and broadcast signed word to vector.

Load a single signed word from a memory address generated by a 64-bit scalar base address plus an immediate offset which is a multiple of 4 in the range 0 to 252.

Broadcast the loaded data into all active elements of the destination vector, setting the inactive elements to zero. If all elements are inactive then the instruction will not perform a read from Device memory or cause a data abort.



## SVE

```
LD1RSW { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>}]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
boolean unsigned = FALSE;
integer offset = UInt(imm6);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 4 in the range 0 to 252, defaulting to 0, encoded in the "imm6" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

integer last = LastActiveElement(mask, esize);
if last >= 0 then
    addr = base + offset * mbytes;
    data = Mem[addr, mbytes, AccType_NORMAL];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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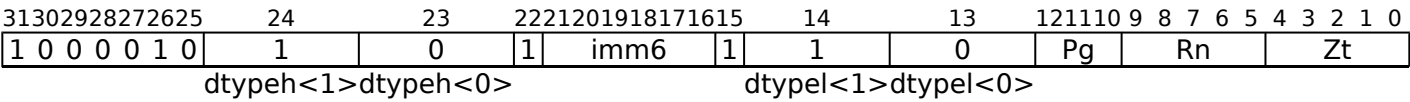
# LD1RW

Load and broadcast unsigned word to vector.

Load a single unsigned word from a memory address generated by a 64-bit scalar base address plus an immediate offset which is a multiple of 4 in the range 0 to 252.  
Broadcast the loaded data into all active elements of the destination vector, setting the inactive elements to zero. If all elements are inactive then the instruction will not perform a read from Device memory or cause a data abort.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

## 32-bit element

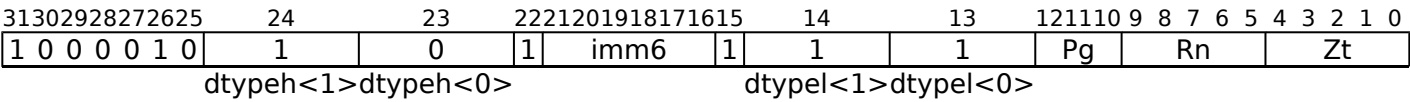


## 32-bit element

LD1RW { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 32;
boolean unsigned = TRUE;
integer offset = UInt(imm6);
```

## 64-bit element



## 64-bit element

LD1RW { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
boolean unsigned = TRUE;
integer offset = UInt(imm6);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 4 in the range 0 to 252, defaulting to 0, encoded in the "imm6" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

integer last = LastActiveElement(mask, esize);
if last >= 0 then
    addr = base + offset * mbytes;
    data = Mem[addr, mbytes, AccType_NORMAL];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

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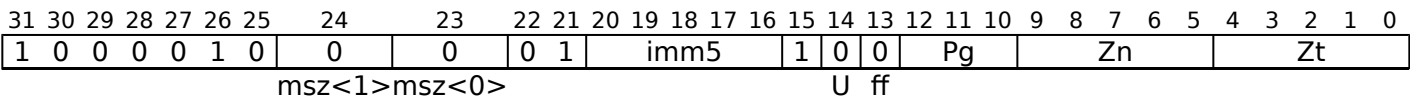
# LD1SB (vector plus immediate)

Gather load signed bytes to vector (immediate index).

Gather load of signed bytes to active elements of a vector register from memory addresses generated by a vector base plus immediate index. The index is in the range 0 to 31. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

## 32-bit element

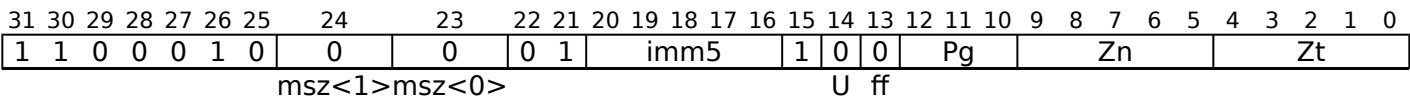


## 32-bit element

LD1SB { <Zt>.S }, <Pg>/Z, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
boolean unsigned = FALSE;
integer offset = UInt(imm5);
```

## 64-bit element



## 64-bit element

LD1SB { <Zt>.D }, <Pg>/Z, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
boolean unsigned = FALSE;
integer offset = UInt(imm5);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, in the range 0 to 31, defaulting to 0, encoded in the "imm5" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) base = Z[n];
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();
Z[t] = result;
```

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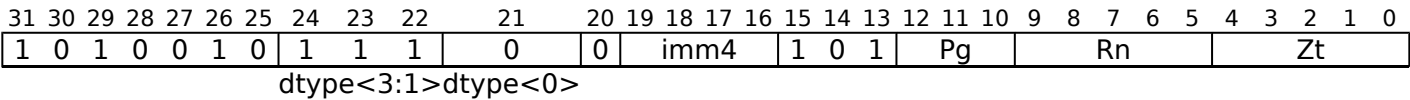
# LD1SB (scalar plus immediate)

Contiguous load signed bytes to vector (immediate index).

Contiguous load of signed bytes to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 3 classes: [16-bit element](#) , [32-bit element](#) and [64-bit element](#)

## 16-bit element

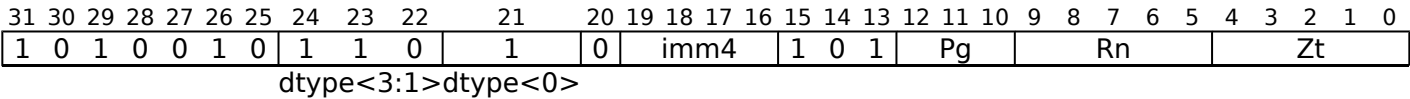


## 16-bit element

LD1SB { <Zt>.H }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer msize = 8;
boolean unsigned = FALSE;
integer offset = SInt(imm4);
```

## 32-bit element

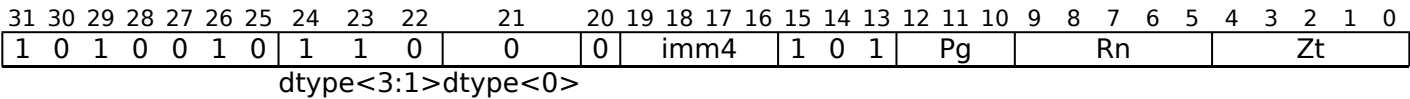


## 32-bit element

LD1SB { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
boolean unsigned = FALSE;
integer offset = SInt(imm4);
```

## 64-bit element



## 64-bit element

LD1SB { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
boolean unsigned = FALSE;
integer offset = SInt(imm4);
```

## Assembler Symbols

<Zt>	Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<imm>	Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
       ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
        base = SP[];
    else
        if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
        base = X[n];

addr = base + offset * elements * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();
    addr = addr + mbytes;

Z[t] = result;
```

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## LD1SB (scalar plus scalar)

Contiguous load signed bytes to vector (scalar index).

Contiguous load of signed bytes to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 3 classes: [16-bit element](#) , [32-bit element](#) and [64-bit element](#)

### 16-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	1	1	1	0	Rm				0	1	0	Pg				Rn				Zt					
dtype<3:1>dtype<0>																															

### 16-bit element

LD1SB { <Zt>.H }, <Pg>/Z, [<Xn|SP>, <Xm>]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
integer msize = 8;
boolean unsigned = FALSE;
```

### 32-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	1	1	0	1	Rm				0	1	0	Pg				Rn				Zt					
dtype<3:1>dtype<0>																															

### 32-bit element

LD1SB { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Xm>]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
boolean unsigned = FALSE;
```

### 64-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	1	1	0	0	Rm				0	1	0	Pg				Rn				Zt					
dtype<3:1>dtype<0>																															

## 64-bit element

LD1SB { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Xm>]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
boolean unsigned = FALSE;
```

## Assembler Symbols

<Zt>	Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<Xm>	Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
bits(64) offset = X[m];
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    if ElemP[mask, e, esize] == '1' then
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();
    offset = offset + 1;

Z[t] = result;
```

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## LD1SB (scalar plus vector)

Gather load signed bytes to vector (vector index).

Gather load of signed bytes to active elements of a vector register from memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally sign or zero-extended from 32 to 64 bits. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 3 classes: [32-bit unpacked unscaled offset](#) , [32-bit unscaled offset](#) and [64-bit unscaled offset](#)

### 32-bit unpacked unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	xs	0	Zm				0	0	0	Pg			Rn				Zt						
msz<1>msz<0>										U ff																					

### 32-bit unpacked unscaled offset

LD1SB { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

### 32-bit unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	0	xs	0	Zm				0	0	0	Pg			Rn				Zt						
										U										ff											

### 32-bit unscaled offset

LD1SB { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

### 64-bit unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	1	0	Zm				1	0	0	Pg			Rn				Zt						
msz<1>msz<0>										U ff																					

## 64-bit unscaled offset

LD1SB { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
integer offs_size = 64;
boolean unsigned = FALSE;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(VL) offset = Z[m];
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        base = SP[];
    else
        base = X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        addr = base + (off << scale);
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```



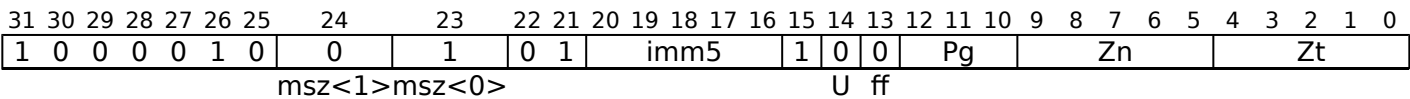
# LD1SH (vector plus immediate)

Gather load signed halfwords to vector (immediate index).

Gather load of signed halfwords to active elements of a vector register from memory addresses generated by a vector base plus immediate index. The index is a multiple of 2 in the range 0 to 62. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

## 32-bit element

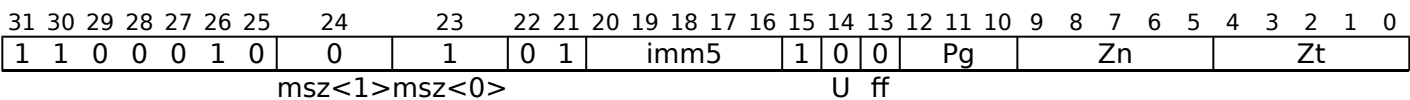


## 32-bit element

LD1SH { <Zt>.S }, <Pg>/Z, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
boolean unsigned = FALSE;
integer offset = UInt(imm5);
```

## 64-bit element



## 64-bit element

LD1SH { <Zt>.D }, <Pg>/Z, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
boolean unsigned = FALSE;
integer offset = UInt(imm5);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 2 in the range 0 to 62, defaulting to 0, encoded in the "imm5" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) base = Z[n];
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();
Z[t] = result;
```

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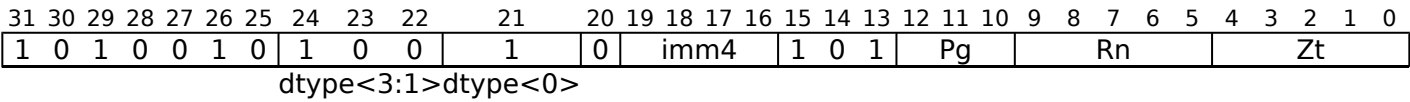
# LD1SH (scalar plus immediate)

Contiguous load signed halfwords to vector (immediate index).

Contiguous load of signed halfwords to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

## 32-bit element

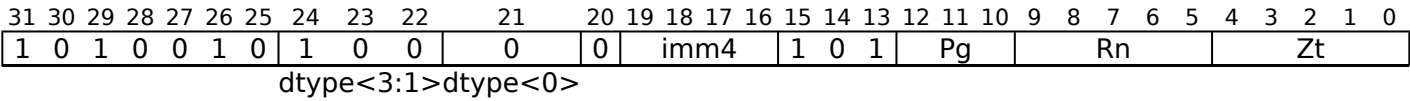


## 32-bit element

LD1SH { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
boolean unsigned = FALSE;
integer offset = SInt(imm4);
```

## 64-bit element



## 64-bit element

LD1SH { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
boolean unsigned = FALSE;
integer offset = SInt(imm4);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

addr = base + offset * elements * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();
    addr = addr + mbytes;

Z[t] = result;
```

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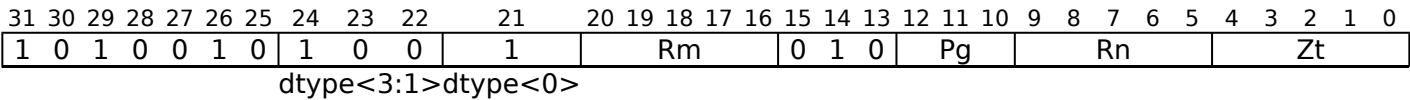
# LD1SH (scalar plus scalar)

Contiguous load signed halfwords to vector (scalar index).

Contiguous load of signed halfwords to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 2 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

## 32-bit element

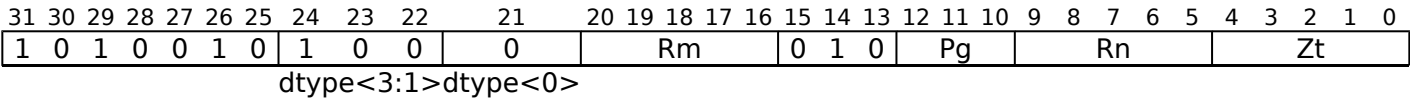


## 32-bit element

LD1SH { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
boolean unsigned = FALSE;
```

## 64-bit element



## 64-bit element

LD1SH { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
boolean unsigned = FALSE;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
bits(64) offset = X[m];
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    if ElemP[mask, e, esize] == '1' then
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();
    offset = offset + 1;

Z[t] = result;
```

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## LD1SH (scalar plus vector)

Gather load signed halfwords to vector (vector index).

Gather load of signed halfwords to active elements of a vector register from memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then optionally multiplied by 2. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 6 classes: [32-bit scaled offset](#) , [32-bit unpacked scaled offset](#) , [32-bit unpacked unscaled offset](#) , [32-bit unscaled offset](#) , [64-bit scaled offset](#) and [64-bit unscaled offset](#)

### 32-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	1	xs	1	Zm				0	0	0	Pg			Rn				Zt						
																U ff															

### 32-bit scaled offset

LD1SH { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod> #1]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 1;
```

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	1	xs	1	Zm				0	0	0	Pg			Rn				Zt						
																U ff															

### 32-bit unpacked scaled offset

LD1SH { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod> #1]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 1;
```

### 32-bit unpacked unscaled offset

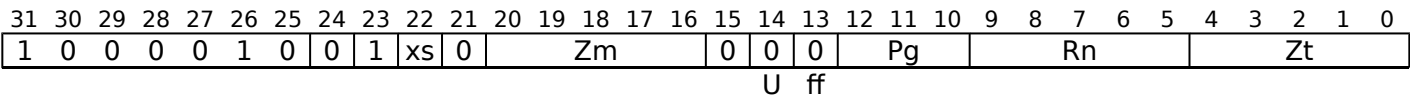
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	1	xs	0	Zm				0	0	0	Pg			Rn				Zt						
msz<1>msz<0>										U ff																					

32-bit unpacked unscaled offset

```
LD1SH { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod>]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

32-bit unscaled offset

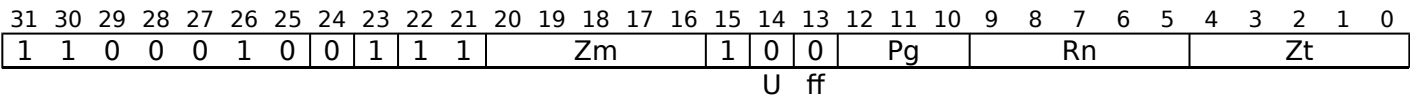


32-bit unscaled offset

```
LD1SH { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod>]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

64-bit scaled offset

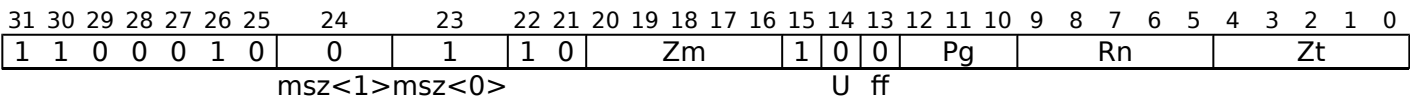


64-bit scaled offset

```
LD1SH { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, LSL #1]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 64;
boolean unsigned = FALSE;
boolean offs_unsigned = TRUE;
integer scale = 1;
```

64-bit unscaled offset





## 64-bit unscaled offset

LD1SH { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 64;
boolean unsigned = FALSE;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(VL) offset = Z[m];
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        base = SP[];
    else
        base = X[n];

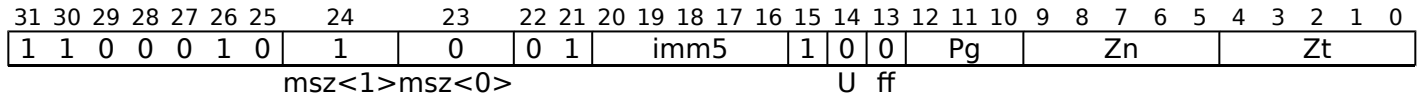
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        addr = base + (off << scale);
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

## LD1SW (vector plus immediate)

Gather load signed words to vector (immediate index).

Gather load of signed words to active elements of a vector register from memory addresses generated by a vector base plus immediate index. The index is a multiple of 4 in the range 0 to 124. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.



### SVE

LD1SW { <Zt>.D }, <Pg>/Z, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
boolean unsigned = FALSE;
integer offset = UInt(imm5);
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 4 in the range 0 to 124, defaulting to 0, encoded in the "imm5" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) base = Z[n];
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

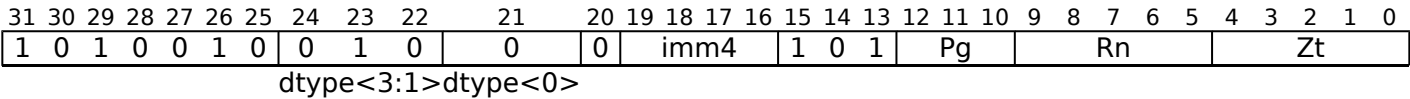
Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# LD1SW (scalar plus immediate)

Contiguous load signed words to vector (immediate index).

Contiguous load of signed words to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.



## SVE

LD1SW { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
boolean unsigned = FALSE;
integer offset = SInt(imm4);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

addr = base + offset * elements * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();
    addr = addr + mbytes;

Z[t] = result;
```

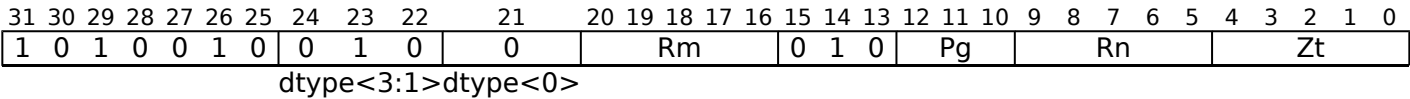
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## LD1SW (scalar plus scalar)

Contiguous load signed words to vector (scalar index).

Contiguous load of signed words to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 4 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.



### SVE

LD1SW { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #2]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
boolean unsigned = FALSE;
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
bits(64) offset = X[m];
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    if ElemP[mask, e, esize] == '1' then
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();
    offset = offset + 1;

Z[t] = result;
```

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## LD1SW (scalar plus vector)

Gather load signed words to vector (vector index).

Gather load of signed words to active elements of a vector register from memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then optionally multiplied by 4. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 4 classes: [32-bit unpacked scaled offset](#) , [32-bit unpacked unscaled offset](#) , [64-bit scaled offset](#) and [64-bit unscaled offset](#)

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	1	0	xs	1	Zm				0	0	0	Pg			Rn				Zt						
																U ff															

### 32-bit unpacked scaled offset

LD1SW { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod> #2]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 2;
```

### 32-bit unpacked unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	1	0	xs	0	Zm				0	0	0	Pg			Rn				Zt						
msz<1>msz<0>																U ff															

### 32-bit unpacked unscaled offset

LD1SW { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

### 64-bit scaled offset

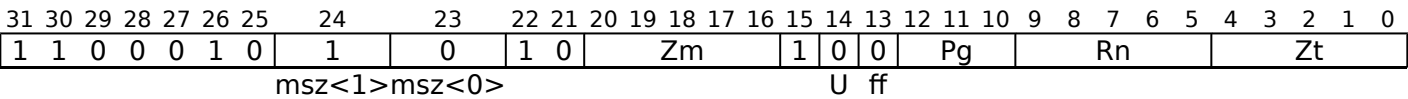
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	1	0	1	1	Zm				1	0	0	Pg			Rn				Zt						
																U ff															

64-bit scaled offset

```
LD1SW { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, LSL #2]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 64;
boolean unsigned = FALSE;
boolean offs_unsigned = TRUE;
integer scale = 2;
```

64-bit unscaled offset



64-bit unscaled offset

```
LD1SW { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 64;
boolean unsigned = FALSE;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(VL) offset = Z[m];
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        addr = base + (off << scale);
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

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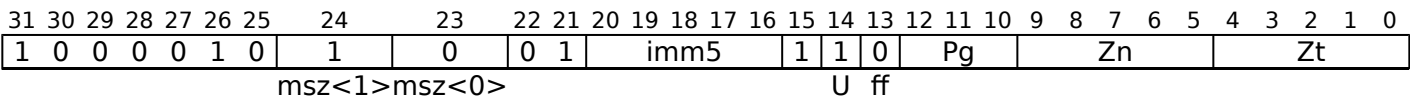
# LD1W (vector plus immediate)

Gather load unsigned words to vector (immediate index).

Gather load of unsigned words to active elements of a vector register from memory addresses generated by a vector base plus immediate index. The index is a multiple of 4 in the range 0 to 124. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

## 32-bit element

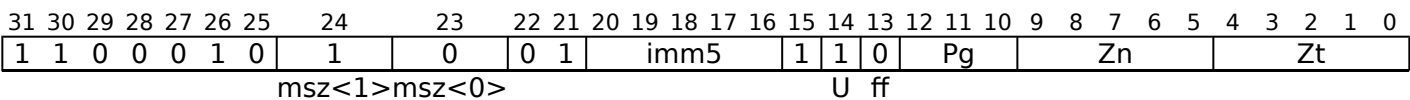


## 32-bit element

LD1W { <Zt>.S }, <Pg>/Z, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 32;
boolean unsigned = TRUE;
integer offset = UInt(imm5);
```

## 64-bit element



## 64-bit element

LD1W { <Zt>.D }, <Pg>/Z, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
boolean unsigned = TRUE;
integer offset = UInt(imm5);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 4 in the range 0 to 124, defaulting to 0, encoded in the "imm5" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) base = Z[n];
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();
Z[t] = result;
```

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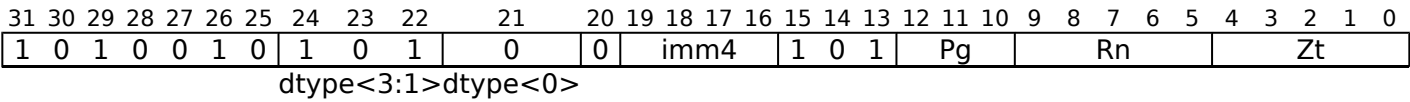
# LD1W (scalar plus immediate)

Contiguous load unsigned words to vector (immediate index).

Contiguous load of unsigned words to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

## 32-bit element

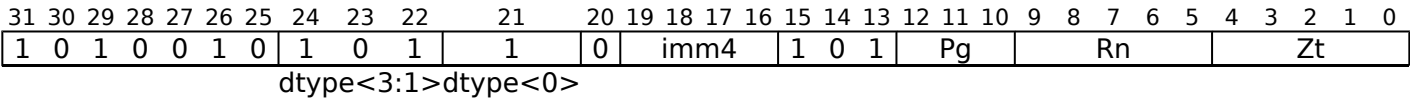


## 32-bit element

LD1W { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 32;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

## 64-bit element



## 64-bit element

LD1W { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

addr = base + offset * elements * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();
    addr = addr + mbytes;

Z[t] = result;
```

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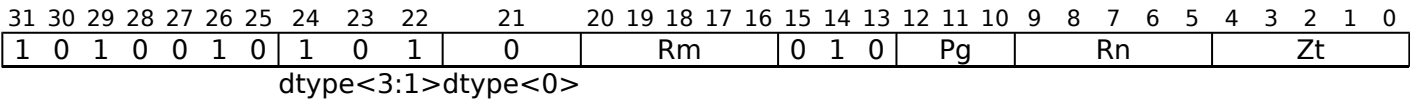
# LD1W (scalar plus scalar)

Contiguous load unsigned words to vector (scalar index).

Contiguous load of unsigned words to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 4 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

## 32-bit element

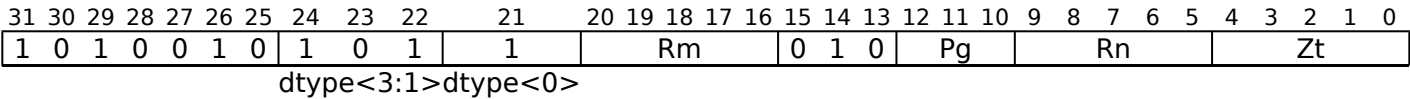


## 32-bit element

LD1W { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #2]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 32;
boolean unsigned = TRUE;
```

## 64-bit element



## 64-bit element

LD1W { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #2]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
boolean unsigned = TRUE;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
bits(64) offset = X[m];
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    if ElemP[mask, e, esize] == '1' then
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();
    offset = offset + 1;

Z[t] = result;
```

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## LD1W (scalar plus vector)

Gather load unsigned words to vector (vector index).

Gather load of unsigned words to active elements of a vector register from memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then optionally multiplied by 4. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 6 classes: [32-bit scaled offset](#) , [32-bit unpacked scaled offset](#) , [32-bit unpacked unscaled offset](#) , [32-bit unscaled offset](#) , [64-bit scaled offset](#) and [64-bit unscaled offset](#)

### 32-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	1	0	xs	1	Zm				0	1	0	Pg			Rn				Zt						
																U ff															

### 32-bit scaled offset

LD1W { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod> #2]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 32;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 2;
```

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	1	0	xs	1	Zm				0	1	0	Pg			Rn				Zt						
																U ff															

### 32-bit unpacked scaled offset

LD1W { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod> #2]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 2;
```

### 32-bit unpacked unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	1	0	xs	0	Zm				0	1	0	Pg			Rn				Zt						
msz<1>msz<0>										U ff																					

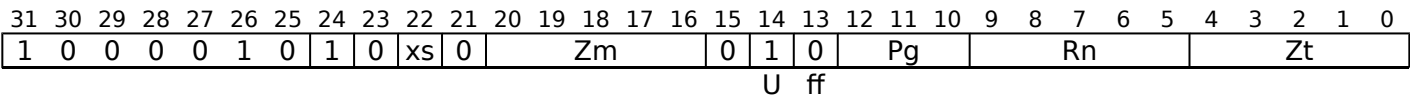


32-bit unpacked unscaled offset

```
LD1W { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod>]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

32-bit unscaled offset

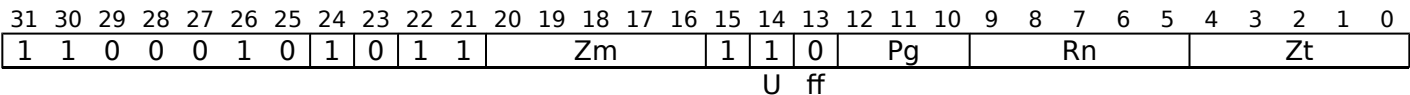


32-bit unscaled offset

```
LD1W { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod>]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 32;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

64-bit scaled offset

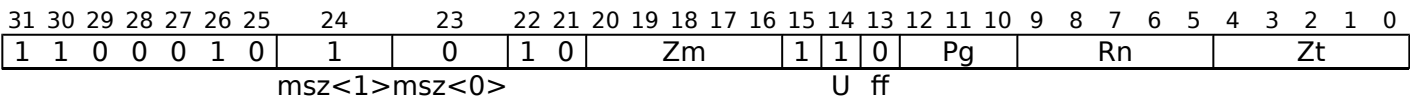


64-bit scaled offset

```
LD1W { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, LSL #2]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 64;
boolean unsigned = TRUE;
boolean offs_unsigned = TRUE;
integer scale = 2;
```

64-bit unscaled offset



## 64-bit unscaled offset

LD1W { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 64;
boolean unsigned = TRUE;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(VL) offset = Z[m];
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

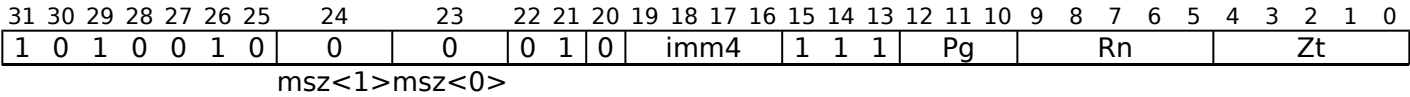
if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        base = SP[];
    else
        base = X[n];
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        addr = base + (off << scale);
        data = Mem[addr, mbytes, AccType_NORMAL];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();
Z[t] = result;
```

## LD2B (scalar plus immediate)

Contiguous load two-byte structures to two vectors (immediate index).

Contiguous load two-byte structures, each to the same element number in two vector registers from the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 2 in the range -16 to 14 that is multiplied by the vector's in-memory size, irrespective of predication,  
Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive bytes in memory which make up each structure. Inactive elements will not read Device memory or signal a fault, and the corresponding element is set to zero in each of the two destination vector registers.



### SVE

LD2B { <Zt1>.B, <Zt2>.B }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8;
integer offset = SInt(imm4);
integer nreg = 2;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 2 in the range -16 to 14, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

addr = base + offset * elements * nreg * mbytes;
for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();
        addr = addr + mbytes;

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

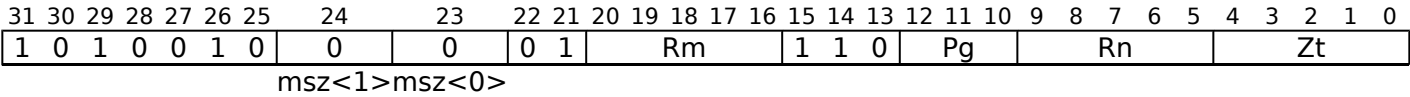
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## LD2B (scalar plus scalar)

Contiguous load two-byte structures to two vectors (scalar index).

Contiguous load two-byte structures, each to the same element number in two vector registers from the memory address generated by a 64-bit scalar base and a 64-bit scalar index register and added to the base address. After each structure access the index value is incremented by two. The index register is not updated by the instruction. Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive bytes in memory which make up each structure. Inactive elements will not read Device memory or signal a fault, and the corresponding element is set to zero in each of the two destination vector registers.



### SVE

LD2B { <Zt1>.B, <Zt2>.B }, <Pg>/Z, [<Xn|SP>, <Xm>]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 8;
integer nreg = 2;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(64) offset = X[m];
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();
        addr = addr + mbytes;
    offset = offset + nreg;

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

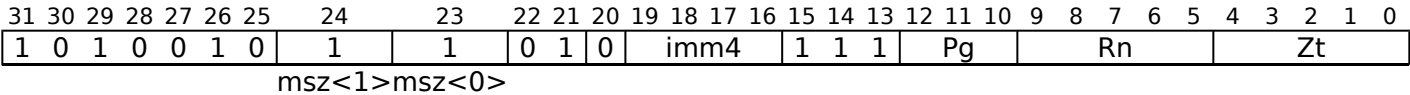
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## LD2D (scalar plus immediate)

Contiguous load two-doubleword structures to two vectors (immediate index).

Contiguous load two-doubleword structures, each to the same element number in two vector registers from the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 2 in the range -16 to 14 that is multiplied by the vector's in-memory size, irrespective of predication, Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive doublewords in memory which make up each structure. Inactive elements will not read Device memory or signal a fault, and the corresponding element is set to zero in each of the two destination vector registers.



### SVE

LD2D { <Zt1>.D, <Zt2>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer offset = SInt(imm4);
integer nreg = 2;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 2 in the range -16 to 14, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

addr = base + offset * elements * nreg * mbytes;
for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();
        addr = addr + mbytes;

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

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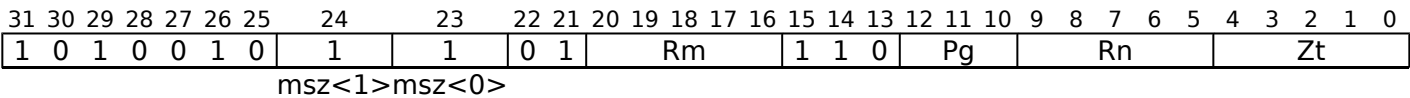


LD2D (scalar plus scalar)

Contiguous load two-doubleword structures to two vectors (scalar index).

Contiguous load two-doubleword structures, each to the same element number in two vector registers from the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by two. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive doublewords in memory which make up each structure. Inactive elements will not read Device memory or signal a fault, and the corresponding element is set to zero in each of the two destination vector registers.



SVE

LD2D { <Zt1>.D, <Zt2>.D }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #3]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer nreg = 2;
```

Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(64) offset = X[m];
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();
        addr = addr + mbytes;
    offset = offset + nreg;

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

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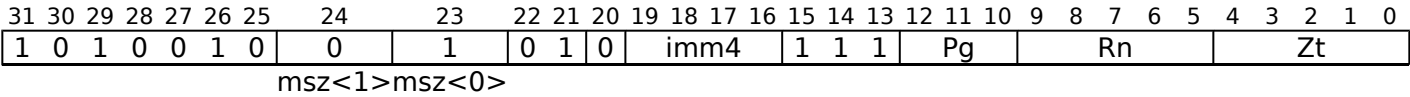
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## LD2H (scalar plus immediate)

Contiguous load two-halfword structures to two vectors (immediate index).

Contiguous load two-halfword structures, each to the same element number in two vector registers from the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 2 in the range -16 to 14 that is multiplied by the vector's in-memory size, irrespective of predication,

Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive halfwords in memory which make up each structure. Inactive elements will not read Device memory or signal a fault, and the corresponding element is set to zero in each of the two destination vector registers.



### SVE

LD2H { <Zt1>.H, <Zt2>.H }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer offset = SInt(imm4);
integer nreg = 2;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 2 in the range -16 to 14, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

addr = base + offset * elements * nreg * mbytes;
for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();
        addr = addr + mbytes;

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

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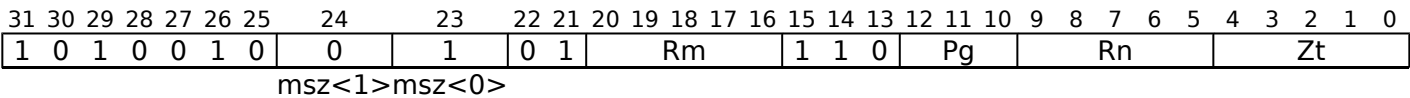
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## LD2H (scalar plus scalar)

Contiguous load two-halfword structures to two vectors (scalar index).

Contiguous load two-halfword structures, each to the same element number in two vector registers from the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by two. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive halfwords in memory which make up each structure. Inactive elements will not read Device memory or signal a fault, and the corresponding element is set to zero in each of the two destination vector registers.



### SVE

LD2H { <Zt1>.H, <Zt2>.H }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
integer nreg = 2;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(64) offset = X[m];
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();
        addr = addr + mbytes;
    offset = offset + nreg;

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

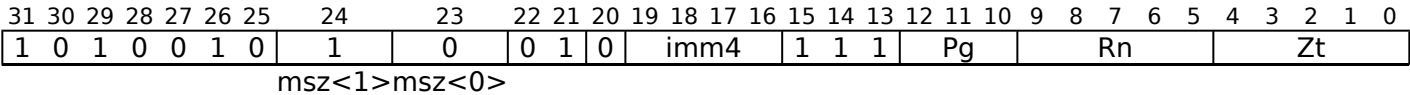
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## LD2W (scalar plus immediate)

Contiguous load two-word structures to two vectors (immediate index).

Contiguous load two-word structures, each to the same element number in two vector registers from the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 2 in the range -16 to 14 that is multiplied by the vector's in-memory size, irrespective of predication, Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive words in memory which make up each structure. Inactive elements will not read Device memory or signal a fault, and the corresponding element is set to zero in each of the two destination vector registers.



### SVE

LD2W { <Zt1>.S, <Zt2>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer offset = SInt(imm4);
integer nreg = 2;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 2 in the range -16 to 14, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

addr = base + offset * elements * nreg * mbytes;
for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();
        addr = addr + mbytes;

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

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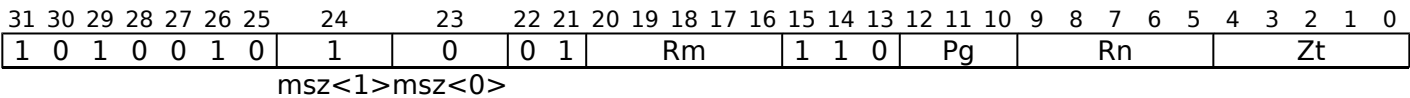


## LD2W (scalar plus scalar)

Contiguous load two-word structures to two vectors (scalar index).

Contiguous load two-word structures, each to the same element number in two vector registers from the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by two. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive words in memory which make up each structure. Inactive elements will not read Device memory or signal a fault, and the corresponding element is set to zero in each of the two destination vector registers.



### SVE

LD2W { <Zt1>.S, <Zt2>.S }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #2]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer nreg = 2;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(64) offset = X[m];
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();
        addr = addr + mbytes;
    offset = offset + nreg;

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

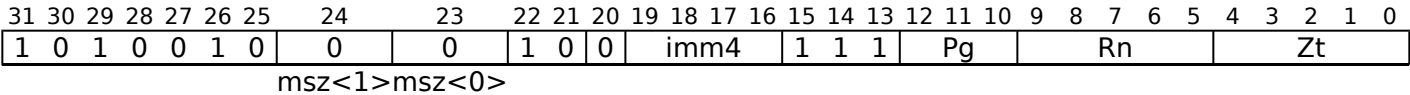
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LD3B (scalar plus immediate)

Contiguous load three-byte structures to three vectors (immediate index).

Contiguous load three-byte structures, each to the same element number in three vector registers from the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 3 in the range -24 to 21 that is multiplied by the vector's in-memory size, irrespective of predication,  
Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive bytes in memory which make up each structure. Inactive elements will not read Device memory or signal a fault, and the corresponding element is set to zero in each of the three destination vector registers.



SVE

LD3B { <Zt1>.B, <Zt2>.B, <Zt3>.B }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8;
integer offset = SInt(imm4);
integer nreg = 3;
```

Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 3 in the range -24 to 21, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

addr = base + offset * elements * nreg * mbytes;
for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();
        addr = addr + mbytes;

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

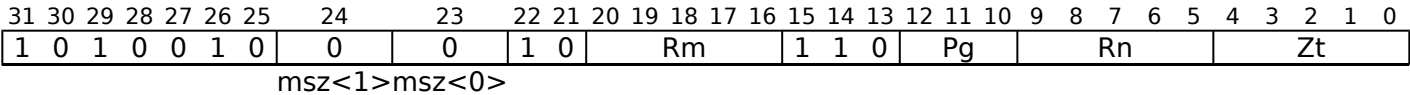
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## LD3B (scalar plus scalar)

Contiguous load three-byte structures to three vectors (scalar index).

Contiguous load three-byte structures, each to the same element number in three vector registers from the memory address generated by a 64-bit scalar base and a 64-bit scalar index register and added to the base address. After each structure access the index value is incremented by three. The index register is not updated by the instruction. Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive bytes in memory which make up each structure. Inactive elements will not read Device memory or signal a fault, and the corresponding element is set to zero in each of the three destination vector registers.



### SVE

LD3B { <Zt1>.B, <Zt2>.B, <Zt3>.B }, <Pg>/Z, [<Xn|SP>, <Xm>]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 8;
integer nreg = 3;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(64) offset = X[m];
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();
        addr = addr + mbytes;
    offset = offset + nreg;

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

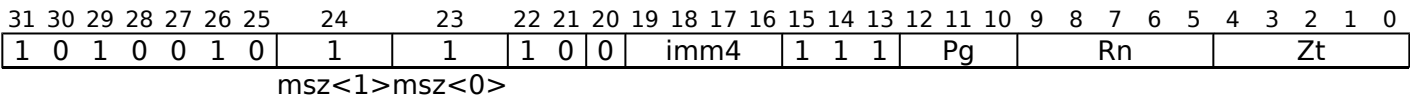
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## LD3D (scalar plus immediate)

Contiguous load three-doubleword structures to three vectors (immediate index).

Contiguous load three-doubleword structures, each to the same element number in three vector registers from the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 3 in the range -24 to 21 that is multiplied by the vector's in-memory size, irrespective of predication, Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive doublewords in memory which make up each structure. Inactive elements will not read Device memory or signal a fault, and the corresponding element is set to zero in each of the three destination vector registers.



### SVE

LD3D { <Zt1>.D, <Zt2>.D, <Zt3>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer offset = SInt(imm4);
integer nreg = 3;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 3 in the range -24 to 21, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

addr = base + offset * elements * nreg * mbytes;
for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();
        addr = addr + mbytes;

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

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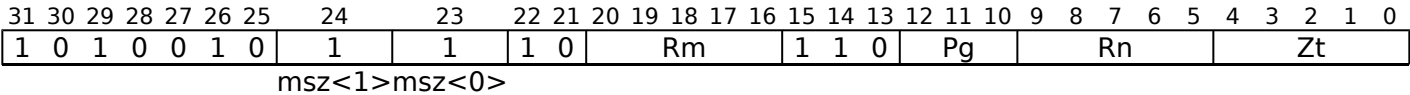


## LD3D (scalar plus scalar)

Contiguous load three-doubleword structures to three vectors (scalar index).

Contiguous load three-doubleword structures, each to the same element number in three vector registers from the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by three. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive doublewords in memory which make up each structure. Inactive elements will not read Device memory or signal a fault, and the corresponding element is set to zero in each of the three destination vector registers.



### SVE

LD3D { <Zt1>.D, <Zt2>.D, <Zt3>.D }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #3]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer nreg = 3;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(64) offset = X[m];
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();
        addr = addr + mbytes;
    offset = offset + nreg;

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

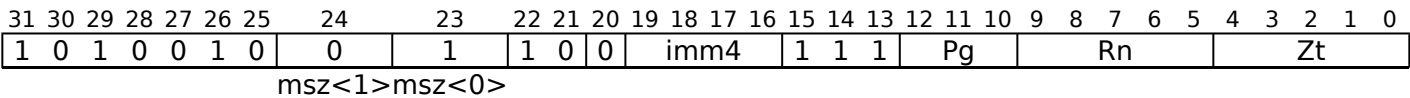
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LD3H (scalar plus immediate)

Contiguous load three-halfword structures to three vectors (immediate index).

Contiguous load three-halfword structures, each to the same element number in three vector registers from the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 3 in the range -24 to 21 that is multiplied by the vector's in-memory size, irrespective of predication, Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive halfwords in memory which make up each structure. Inactive elements will not read Device memory or signal a fault, and the corresponding element is set to zero in each of the three destination vector registers.



SVE

LD3H { <Zt1>.H, <Zt2>.H, <Zt3>.H }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer offset = SInt(imm4);
integer nreg = 3;
```

Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 3 in the range -24 to 21, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

addr = base + offset * elements * nreg * mbytes;
for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();
        addr = addr + mbytes;

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

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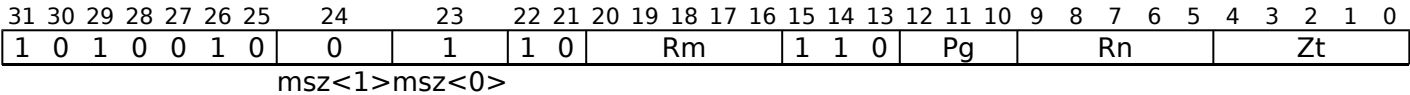
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## LD3H (scalar plus scalar)

Contiguous load three-halfword structures to three vectors (scalar index).

Contiguous load three-halfword structures, each to the same element number in three vector registers from the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by three. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive halfwords in memory which make up each structure. Inactive elements will not read Device memory or signal a fault, and the corresponding element is set to zero in each of the three destination vector registers.



### SVE

LD3H { <Zt1>.H, <Zt2>.H, <Zt3>.H }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
integer nreg = 3;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(64) offset = X[m];
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();
        addr = addr + mbytes;
    offset = offset + nreg;

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

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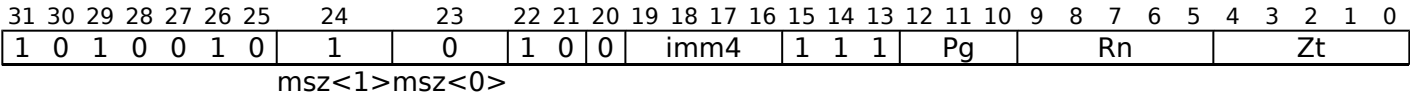
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# LD3W (scalar plus immediate)

Contiguous load three-word structures to three vectors (immediate index).

Contiguous load three-word structures, each to the same element number in three vector registers from the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 3 in the range -24 to 21 that is multiplied by the vector's in-memory size, irrespective of predication,

Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive words in memory which make up each structure. Inactive elements will not read Device memory or signal a fault, and the corresponding element is set to zero in each of the three destination vector registers.



## SVE

LD3W { <Zt1>.S, <Zt2>.S, <Zt3>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer offset = SInt(imm4);
integer nreg = 3;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 3 in the range -24 to 21, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

addr = base + offset * elements * nreg * mbytes;
for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();
        addr = addr + mbytes;

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

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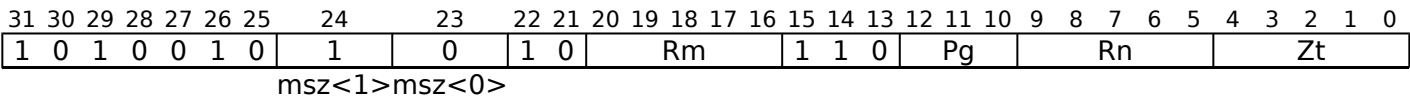


## LD3W (scalar plus scalar)

Contiguous load three-word structures to three vectors (scalar index).

Contiguous load three-word structures, each to the same element number in three vector registers from the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by three. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive words in memory which make up each structure. Inactive elements will not read Device memory or signal a fault, and the corresponding element is set to zero in each of the three destination vector registers.



### SVE

LD3W { <Zt1>.S, <Zt2>.S, <Zt3>.S }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #2]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer nreg = 3;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(64) offset = X[m];
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();
        addr = addr + mbytes;
    offset = offset + nreg;

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

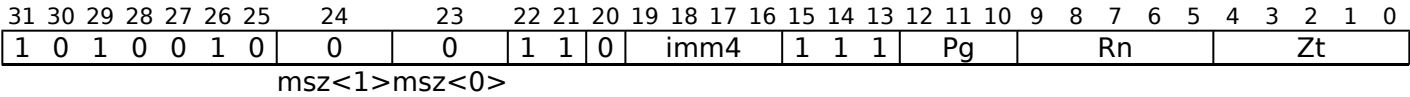
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LD4B (scalar plus immediate)

Contiguous load four-byte structures to four vectors (immediate index).

Contiguous load four-byte structures, each to the same element number in four vector registers from the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 4 in the range -32 to 28 that is multiplied by the vector's in-memory size, irrespective of predication,  
Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive bytes in memory which make up each structure. Inactive elements will not read Device memory or signal a fault, and the corresponding element is set to zero in each of the four destination vector registers.



SVE

LD4B { <Zt1>.B, <Zt2>.B, <Zt3>.B, <Zt4>.B }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8;
integer offset = SInt(imm4);
integer nreg = 4;
```

Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 4 in the range -32 to 28, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

addr = base + offset * elements * nreg * mbytes;
for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();
        addr = addr + mbytes;

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

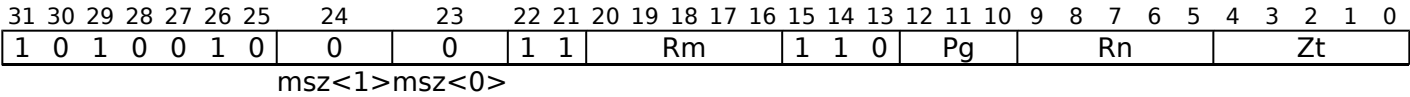
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## LD4B (scalar plus scalar)

Contiguous load four-byte structures to four vectors (scalar index).

Contiguous load four-byte structures, each to the same element number in four vector registers from the memory address generated by a 64-bit scalar base and a 64-bit scalar index register and added to the base address. After each structure access the index value is incremented by four. The index register is not updated by the instruction. Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive bytes in memory which make up each structure. Inactive elements will not read Device memory or signal a fault, and the corresponding element is set to zero in each of the four destination vector registers.



### SVE

LD4B { <Zt1>.B, <Zt2>.B, <Zt3>.B, <Zt4>.B }, <Pg>/Z, [<Xn|SP>, <Xm>]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 8;
integer nreg = 4;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(64) offset = X[m];
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();
        addr = addr + mbytes;
    offset = offset + nreg;

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

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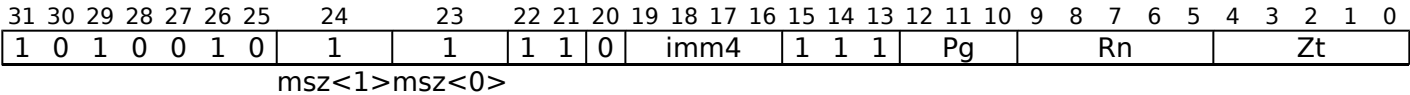
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# LD4D (scalar plus immediate)

Contiguous load four-doubleword structures to four vectors (immediate index).

Contiguous load four-doubleword structures, each to the same element number in four vector registers from the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 4 in the range -32 to 28 that is multiplied by the vector's in-memory size, irrespective of predication,

Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive doublewords in memory which make up each structure. Inactive elements will not read Device memory or signal a fault, and the corresponding element is set to zero in each of the four destination vector registers.



## SVE

LD4D { <Zt1>.D, <Zt2>.D, <Zt3>.D, <Zt4>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer offset = SInt(imm4);
integer nreg = 4;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 4 in the range -32 to 28, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

addr = base + offset * elements * nreg * mbytes;
for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();
        addr = addr + mbytes;

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

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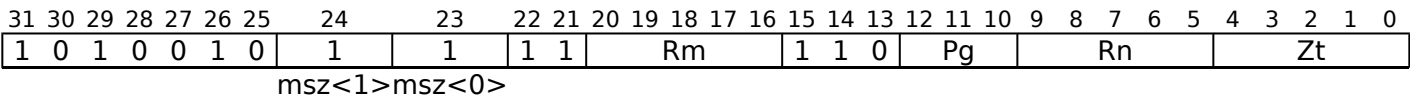


## LD4D (scalar plus scalar)

Contiguous load four-doubleword structures to four vectors (scalar index).

Contiguous load four-doubleword structures, each to the same element number in four vector registers from the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by four. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive doublewords in memory which make up each structure. Inactive elements will not read Device memory or signal a fault, and the corresponding element is set to zero in each of the four destination vector registers.



### SVE

LD4D { <Zt1>.D, <Zt2>.D, <Zt3>.D, <Zt4>.D }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #3]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer nreg = 4;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(64) offset = X[m];
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();
        addr = addr + mbytes;
    offset = offset + nreg;

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

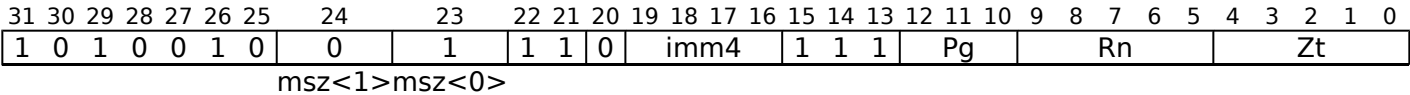
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# LD4H (scalar plus immediate)

Contiguous load four-halfword structures to four vectors (immediate index).

Contiguous load four-halfword structures, each to the same element number in four vector registers from the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 4 in the range -32 to 28 that is multiplied by the vector's in-memory size, irrespective of predication,  
Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive halfwords in memory which make up each structure. Inactive elements will not read Device memory or signal a fault, and the corresponding element is set to zero in each of the four destination vector registers.



## SVE

LD4H { <Zt1>.H, <Zt2>.H, <Zt3>.H, <Zt4>.H }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer offset = SInt(imm4);
integer nreg = 4;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 4 in the range -32 to 28, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

addr = base + offset * elements * nreg * mbytes;
for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();
        addr = addr + mbytes;

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

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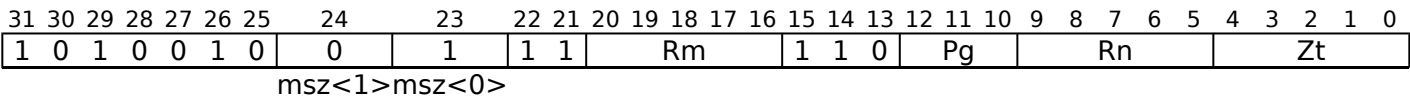
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## LD4H (scalar plus scalar)

Contiguous load four-halfword structures to four vectors (scalar index).

Contiguous load four-halfword structures, each to the same element number in four vector registers from the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by four. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive halfwords in memory which make up each structure. Inactive elements will not read Device memory or signal a fault, and the corresponding element is set to zero in each of the four destination vector registers.



### SVE

LD4H { <Zt1>.H, <Zt2>.H, <Zt3>.H, <Zt4>.H }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
integer nreg = 4;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(64) offset = X[m];
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();
        addr = addr + mbytes;
    offset = offset + nreg;

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

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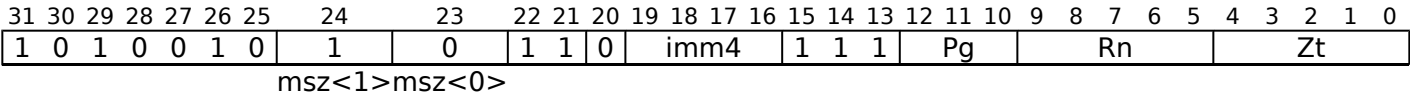
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# LD4W (scalar plus immediate)

Contiguous load four-word structures to four vectors (immediate index).

Contiguous load four-word structures, each to the same element number in four vector registers from the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 4 in the range -32 to 28 that is multiplied by the vector's in-memory size, irrespective of predication,

Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive words in memory which make up each structure. Inactive elements will not read Device memory or signal a fault, and the corresponding element is set to zero in each of the four destination vector registers.



## SVE

LD4W { <Zt1>.S, <Zt2>.S, <Zt3>.S, <Zt4>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer offset = SInt(imm4);
integer nreg = 4;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 4 in the range -32 to 28, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

addr = base + offset * elements * nreg * mbytes;
for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();
        addr = addr + mbytes;

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

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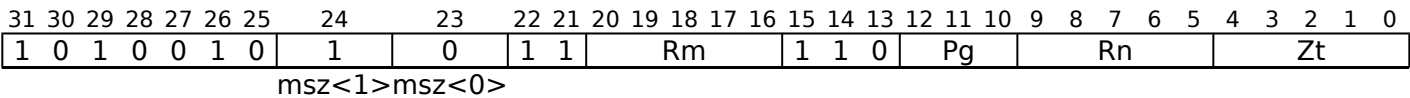


## LD4W (scalar plus scalar)

Contiguous load four-word structures to four vectors (scalar index).

Contiguous load four-word structures, each to the same element number in four vector registers from the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by four. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive words in memory which make up each structure. Inactive elements will not read Device memory or signal a fault, and the corresponding element is set to zero in each of the four destination vector registers.



### SVE

LD4W { <Zt1>.S, <Zt2>.S, <Zt3>.S, <Zt4>.S }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #2]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer nreg = 4;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(64) offset = X[m];
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Elem[values[r], e, esize] = Mem[addr, mbytes, AccType_NORMAL];
        else
            Elem[values[r], e, esize] = Zeros();
        addr = addr + mbytes;
    offset = offset + nreg;

for r = 0 to nreg-1
    Z[(t+r) MOD 32] = values[r];
```

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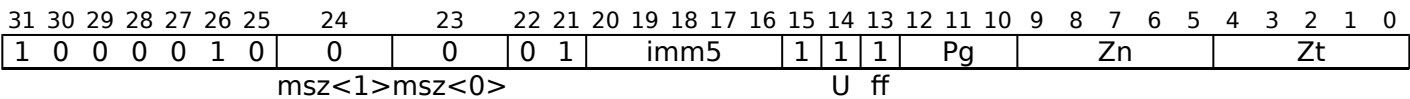
# LDFF1B (vector plus immediate)

Gather load first-fault unsigned bytes to vector (immediate index).

Gather load with first-faulting behavior of unsigned bytes to active elements of a vector register from memory addresses generated by a vector base plus immediate index. The index is in the range 0 to 31. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

## 32-bit element

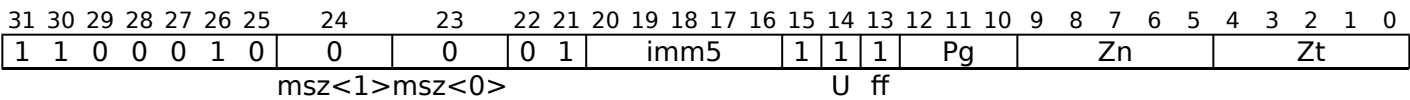


## 32-bit element

LDFF1B { <Zt>.S }, <Pg>/Z, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = UInt(imm5);
```

## 64-bit element



## 64-bit element

LDFF1B { <Zt>.D }, <Pg>/Z, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = UInt(imm5);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, in the range 0 to 31, defaulting to 0, encoded in the "imm5" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) base = Z[n];
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
    if first then
      // Mem[] will not return if a fault is detected for the first active element
      data = Mem[addr, mbytes, AccType_NORMAL];
      first = FALSE;
    else
      // MemNF[] will return fault=TRUE if access is not performed for any reason
      (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
  else
    (data, fault) = (Zeros(msize), FALSE);

  // FFR elements set to FALSE following a suppressed access/fault
  faulted = faulted || fault;
  if faulted then
    ElemFFR[e, esize] = '0';

  // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
  unknown = unknown || ElemFFR[e, esize] == '0';
  if unknown then
    if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
      Elem[result, e, esize] = Extend(data, esize, unsigned);
    elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
      Elem[result, e, esize] = Zeros();
    else // merge
      Elem[result, e, esize] = Elem[orig, e, esize];
  else
    Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

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## LDFF1B (scalar plus scalar)

Contiguous load first-fault unsigned bytes to vector (scalar index).

Contiguous load with first-faulting behavior of unsigned bytes to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 4 classes: [8-bit element](#) , [16-bit element](#) , [32-bit element](#) and [64-bit element](#)

### 8-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	0	0	0	Rm				0	1	1	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

### 8-bit element

LDFF1B { <Zt>.B }, <Pg>/Z, [<Xn|SP>{, <Xm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 8;
integer msize = 8;
boolean unsigned = TRUE;
```

### 16-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	0	0	1	Rm				0	1	1	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

### 16-bit element

LDFF1B { <Zt>.H }, <Pg>/Z, [<Xn|SP>{, <Xm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
integer msize = 8;
boolean unsigned = TRUE;
```

### 32-bit element

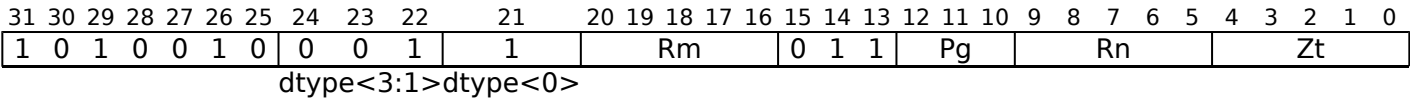
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	0	1	0	Rm				0	1	1	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

32-bit element

```
LDFF1B { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, <Xm>}]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
boolean unsigned = TRUE;
```

64-bit element



64-bit element

```
LDFF1B { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, <Xm>}]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
boolean unsigned = TRUE;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the optional 64-bit name of the general-purpose offset register, defaulting to XZR, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
bits(64) offset = X[m];
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = base + UInt(offset) * mbytes;
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_CNOTEFIRST];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

    offset = offset + 1;

Z[t] = result;
```

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## LDFF1B (scalar plus vector)

Gather load first-fault unsigned bytes to vector (vector index).

Gather load with first-faulting behavior of unsigned bytes to active elements of a vector register from memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally sign or zero-extended from 32 to 64 bits. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 3 classes: [32-bit unpacked unscaled offset](#) , [32-bit unscaled offset](#) and [64-bit unscaled offset](#)

### 32-bit unpacked unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	xs	0	Zm				0	1	1	Pg			Rn				Zt						
msz<1>msz<0>										U ff																					

### 32-bit unpacked unscaled offset

LDFF1B { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

### 32-bit unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	0	xs	0	Zm				0	1	1	Pg			Rn				Zt						
										U										ff											

### 32-bit unscaled offset

LDFF1B { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

### 64-bit unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	1	0	Zm				1	1	1	Pg			Rn				Zt						
msz<1>msz<0>										U										ff											



64-bit unscaled offset

```
LDFF1B { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
integer offs_size = 64;
boolean unsigned = TRUE;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(VL) offset;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        base = SP[];
else
    base = X[n];
offset = Z[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        addr = base + (off << scale);
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

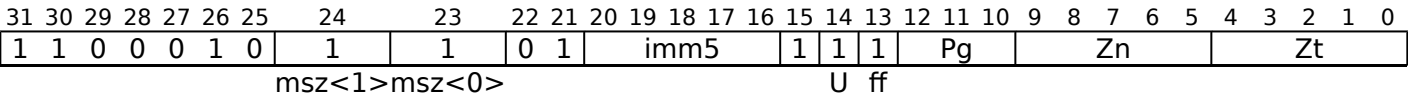
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## LDFF1D (vector plus immediate)

Gather load first-fault doublewords to vector (immediate index).

Gather load with first-faulting behavior of doublewords to active elements of a vector register from memory addresses generated by a vector base plus immediate index. The index is a multiple of 8 in the range 0 to 248. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.



### SVE

LDFF1D { <Zt>.D }, <Pg>/Z, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
boolean unsigned = TRUE;
integer offset = UInt(imm5);
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 8 in the range 0 to 248, defaulting to 0, encoded in the "imm5" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) base = Z[n];
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
    if first then
      // Mem[] will not return if a fault is detected for the first active element
      data = Mem[addr, mbytes, AccType_NORMAL];
      first = FALSE;
    else
      // MemNF[] will return fault=TRUE if access is not performed for any reason
      (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
  else
    (data, fault) = (Zeros(msize), FALSE);

  // FFR elements set to FALSE following a suppressed access/fault
  faulted = faulted || fault;
  if faulted then
    ElemFFR[e, esize] = '0';

  // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
  unknown = unknown || ElemFFR[e, esize] == '0';
  if unknown then
    if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
      Elem[result, e, esize] = Extend(data, esize, unsigned);
    elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
      Elem[result, e, esize] = Zeros();
    else // merge
      Elem[result, e, esize] = Elem[orig, e, esize];
  else
    Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

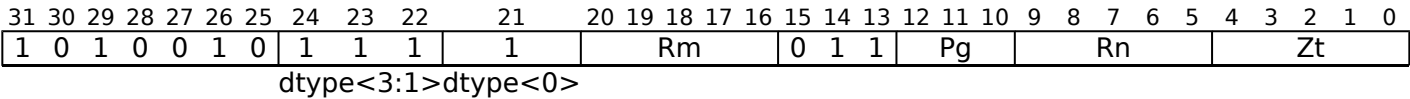
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## LDFF1D (scalar plus scalar)

Contiguous load first-fault doublewords to vector (scalar index).

Contiguous load with first-faulting behavior of doublewords to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 8 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.



### SVE

LDFF1D { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, <Xm>, LSL #3}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
boolean unsigned = TRUE;
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the optional 64-bit name of the general-purpose offset register, defaulting to XZR, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
bits(64) offset = X[m];
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = base + UInt(offset) * mbytes;
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_CNOTEFIRST];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

    offset = offset + 1;

Z[t] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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## LDFF1D (scalar plus vector)

Gather load first-fault doublewords to vector (vector index).

Gather load with first-faulting behavior of doublewords to active elements of a vector register from memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then optionally multiplied by 8. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 4 classes: [32-bit unpacked scaled offset](#) , [32-bit unpacked unscaled offset](#) , [64-bit scaled offset](#) and [64-bit unscaled offset](#)

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	1	1	xs	1	Zm				0	1	1	Pg			Rn				Zt						
																U ff															

### 32-bit unpacked scaled offset

LDFF1D { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod> #3]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 3;
```

### 32-bit unpacked unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	1	1	xs	0	Zm				0	1	1	Pg			Rn				Zt						
msz<1>msz<0>																U ff															

### 32-bit unpacked unscaled offset

LDFF1D { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

### 64-bit scaled offset

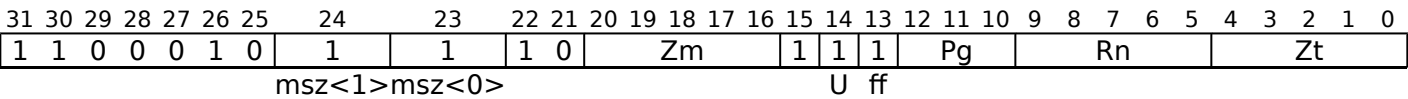
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	1	1	1	1	Zm				1	1	1	Pg			Rn				Zt						
U ff																															

64-bit scaled offset

```
LDFF1D { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, LSL #3]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
integer offs_size = 64;
boolean unsigned = TRUE;
boolean offs_unsigned = TRUE;
integer scale = 3;
```

64-bit unscaled offset



64-bit unscaled offset

```
LDFF1D { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
integer offs_size = 64;
boolean unsigned = TRUE;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(VL) offset;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        base = SP[];
else
    base = X[n];
offset = Z[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        addr = base + (off << scale);
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

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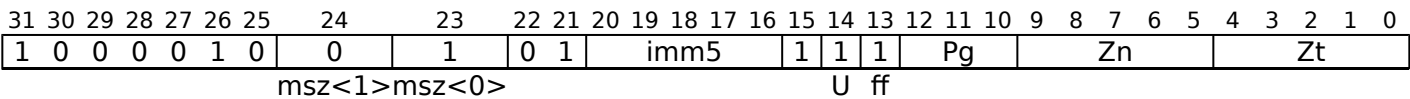
# LDFF1H (vector plus immediate)

Gather load first-fault unsigned halfwords to vector (immediate index).

Gather load with first-faulting behavior of unsigned halfwords to active elements of a vector register from memory addresses generated by a vector base plus immediate index. The index is a multiple of 2 in the range 0 to 62. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

## 32-bit element

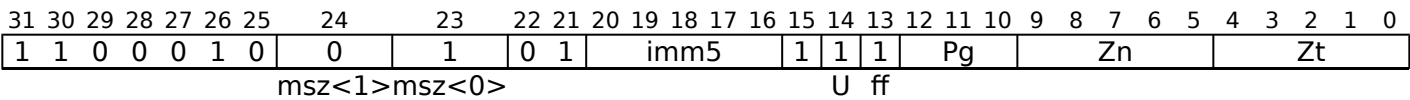


## 32-bit element

LDFF1H { <Zt>.S }, <Pg>/Z, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
boolean unsigned = TRUE;
integer offset = UInt(imm5);
```

## 64-bit element



## 64-bit element

LDFF1H { <Zt>.D }, <Pg>/Z, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
boolean unsigned = TRUE;
integer offset = UInt(imm5);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 2 in the range 0 to 62, defaulting to 0, encoded in the "imm5" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) base = Z[n];
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
    if first then
      // Mem[] will not return if a fault is detected for the first active element
      data = Mem[addr, mbytes, AccType_NORMAL];
      first = FALSE;
    else
      // MemNF[] will return fault=TRUE if access is not performed for any reason
      (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
  else
    (data, fault) = (Zeros(msize), FALSE);

  // FFR elements set to FALSE following a suppressed access/fault
  faulted = faulted || fault;
  if faulted then
    ElemFFR[e, esize] = '0';

  // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
  unknown = unknown || ElemFFR[e, esize] == '0';
  if unknown then
    if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
      Elem[result, e, esize] = Extend(data, esize, unsigned);
    elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
      Elem[result, e, esize] = Zeros();
    else // merge
      Elem[result, e, esize] = Elem[orig, e, esize];
  else
    Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

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## LDFF1H (scalar plus scalar)

Contiguous load first-fault unsigned halfwords to vector (scalar index).

Contiguous load with first-faulting behavior of unsigned halfwords to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 2 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 3 classes: [16-bit element](#) , [32-bit element](#) and [64-bit element](#)

### 16-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	1	0	1	Rm				0	1	1	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

### 16-bit element

LDFF1H { <Zt>.H }, <Pg>/Z, [<Xn|SP>{, <Xm>, LSL #1}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
integer msize = 16;
boolean unsigned = TRUE;
```

### 32-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	1	1	0	Rm				0	1	1	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

### 32-bit element

LDFF1H { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, <Xm>, LSL #1}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
boolean unsigned = TRUE;
```

### 64-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	1	1	1	Rm				0	1	1	Pg			Rn				Zt						
dtype<3:1>dtype<0>																															

**64-bit element**

```
LDDFF1H { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, <Xm>, LSL #1}]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
boolean unsigned = TRUE;
```

**Assembler Symbols**

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the optional 64-bit name of the general-purpose offset register, defaulting to XZR, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
bits(64) offset = X[m];
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = base + UInt(offset) * mbytes;
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_CNOTEFIRST];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

    offset = offset + 1;

Z[t] = result;
```

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## LDFF1H (scalar plus vector)

Gather load first-fault unsigned halfwords to vector (vector index).

Gather load with first-faulting behavior of unsigned halfwords to active elements of a vector register from memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then optionally multiplied by 2. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 6 classes: [32-bit scaled offset](#) , [32-bit unpacked scaled offset](#) , [32-bit unpacked unscaled offset](#) , [32-bit unscaled offset](#) , [64-bit scaled offset](#) and [64-bit unscaled offset](#)

### 32-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	1	xs	1	Zm					0	1	1	Pg			Rn					Zt				
																U ff															

### 32-bit scaled offset

LDFF1H { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod> #1]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 1;
```

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	1	xs	1	Zm					0	1	1	Pg			Rn					Zt				
																U ff															

### 32-bit unpacked scaled offset

LDFF1H { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod> #1]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 1;
```

### 32-bit unpacked unscaled offset

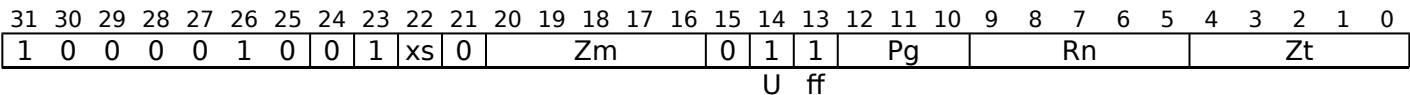
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	1	xs	0	Zm					0	1	1	Pg			Rn					Zt				
msz<1>msz<0>										U ff																					

32-bit unpacked unscaled offset

```
LDFF1H { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod>]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

32-bit unscaled offset

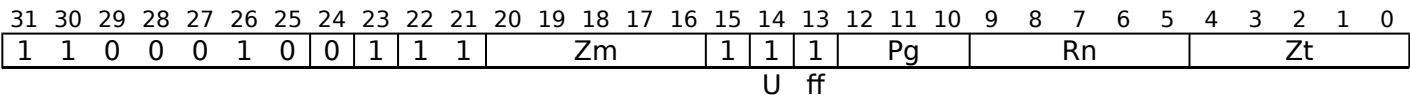


32-bit unscaled offset

```
LDFF1H { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod>]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

64-bit scaled offset

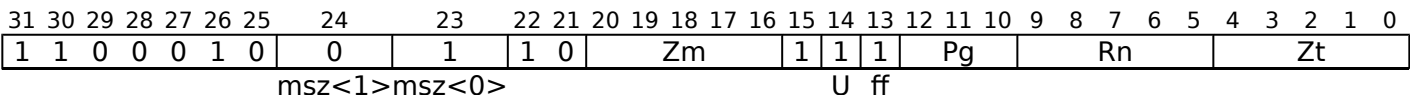


64-bit scaled offset

```
LDFF1H { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, LSL #1]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 64;
boolean unsigned = TRUE;
boolean offs_unsigned = TRUE;
integer scale = 1;
```

64-bit unscaled offset





64-bit unscaled offset

```
LDFF1H { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 64;
boolean unsigned = TRUE;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(VL) offset;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        base = SP[];
else
    base = X[n];
offset = Z[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        addr = base + (off << scale);
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

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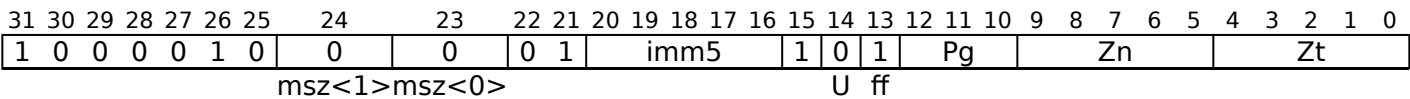
# LDFF1SB (vector plus immediate)

Gather load first-fault signed bytes to vector (immediate index).

Gather load with first-faulting behavior of signed bytes to active elements of a vector register from memory addresses generated by a vector base plus immediate index. The index is in the range 0 to 31. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

## 32-bit element

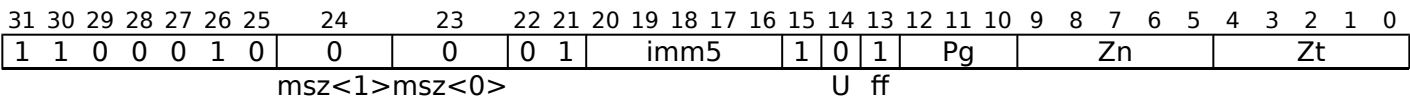


## 32-bit element

LDFF1SB { <Zt>.S }, <Pg>/Z, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
boolean unsigned = FALSE;
integer offset = UInt(imm5);
```

## 64-bit element



## 64-bit element

LDFF1SB { <Zt>.D }, <Pg>/Z, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
boolean unsigned = FALSE;
integer offset = UInt(imm5);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, in the range 0 to 31, defaulting to 0, encoded in the "imm5" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) base = Z[n];
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
    if first then
      // Mem[] will not return if a fault is detected for the first active element
      data = Mem[addr, mbytes, AccType_NORMAL];
      first = FALSE;
    else
      // MemNF[] will return fault=TRUE if access is not performed for any reason
      (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
  else
    (data, fault) = (Zeros(msize), FALSE);

  // FFR elements set to FALSE following a suppressed access/fault
  faulted = faulted || fault;
  if faulted then
    ElemFFR[e, esize] = '0';

  // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
  unknown = unknown || ElemFFR[e, esize] == '0';
  if unknown then
    if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
      Elem[result, e, esize] = Extend(data, esize, unsigned);
    elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
      Elem[result, e, esize] = Zeros();
    else // merge
      Elem[result, e, esize] = Elem[orig, e, esize];
  else
    Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

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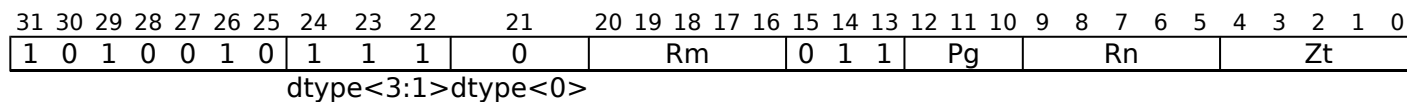
## LDFF1SB (scalar plus scalar)

Contiguous load first-fault signed bytes to vector (scalar index).

Contiguous load with first-faulting behavior of signed bytes to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 3 classes: [16-bit element](#) , [32-bit element](#) and [64-bit element](#)

### 16-bit element

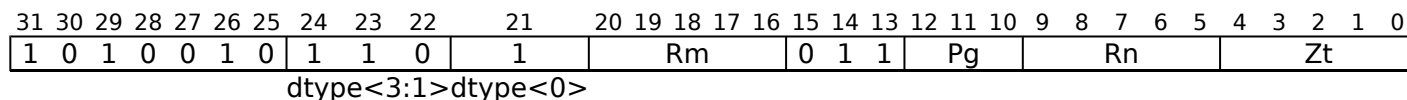


### 16-bit element

LDFF1SB { <Zt>.H }, <Pg>/Z, [<Xn|SP>{, <Xm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
integer msize = 8;
boolean unsigned = FALSE;
```

### 32-bit element

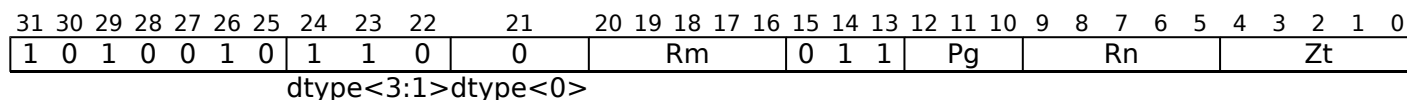


### 32-bit element

LDFF1SB { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, <Xm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
boolean unsigned = FALSE;
```

### 64-bit element



64-bit element

```
LDDFF1SB { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, <Xm>}]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
boolean unsigned = FALSE;
```

Assembler Symbols

<Zt>	Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<Xm>	Is the optional 64-bit name of the general-purpose offset register, defaulting to XZR, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
bits(64) offset = X[m];
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = base + UInt(offset) * mbytes;
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_CNOTFIRST];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

    offset = offset + 1;

Z[t] = result;
```

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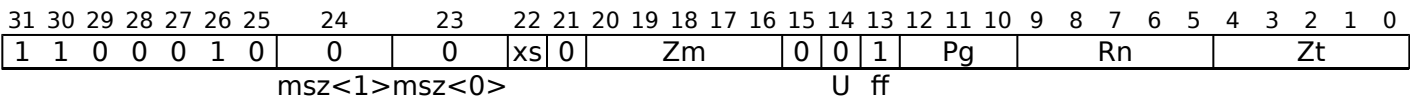
# LDFF1SB (scalar plus vector)

Gather load first-fault signed bytes to vector (vector index).

Gather load with first-faulting behavior of signed bytes to active elements of a vector register from memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally sign or zero-extended from 32 to 64 bits. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 3 classes: [32-bit unpacked unscaled offset](#) , [32-bit unscaled offset](#) and [64-bit unscaled offset](#)

## 32-bit unpacked unscaled offset

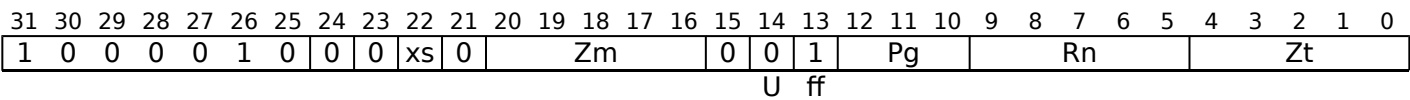


## 32-bit unpacked unscaled offset

LDFF1SB { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

## 32-bit unscaled offset

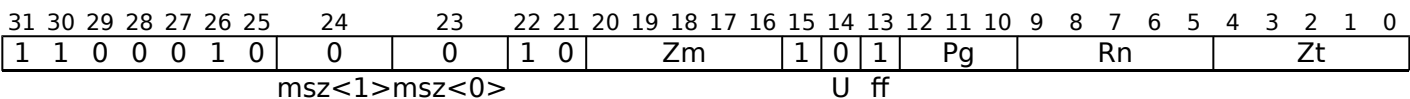


## 32-bit unscaled offset

LDFF1SB { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

## 64-bit unscaled offset





64-bit unscaled offset

```
LDF1SB { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
integer offs_size = 64;
boolean unsigned = FALSE;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(VL) offset;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        base = SP[];
else
    base = X[n];
offset = Z[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        addr = base + (off << scale);
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

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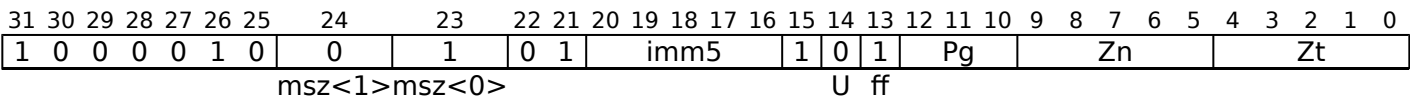
# LDFF1SH (vector plus immediate)

Gather load first-fault signed halfwords to vector (immediate index).

Gather load with first-faulting behavior of signed halfwords to active elements of a vector register from memory addresses generated by a vector base plus immediate index. The index is a multiple of 2 in the range 0 to 62. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

## 32-bit element

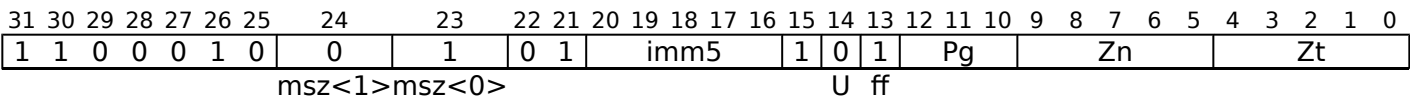


## 32-bit element

LDFF1SH { <Zt>.S }, <Pg>/Z, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
boolean unsigned = FALSE;
integer offset = UInt(imm5);
```

## 64-bit element



## 64-bit element

LDFF1SH { <Zt>.D }, <Pg>/Z, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
boolean unsigned = FALSE;
integer offset = UInt(imm5);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 2 in the range 0 to 62, defaulting to 0, encoded in the "imm5" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) base = Z[n];
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
    if first then
      // Mem[] will not return if a fault is detected for the first active element
      data = Mem[addr, mbytes, AccType_NORMAL];
      first = FALSE;
    else
      // MemNF[] will return fault=TRUE if access is not performed for any reason
      (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
  else
    (data, fault) = (Zeros(msize), FALSE);

  // FFR elements set to FALSE following a suppressed access/fault
  faulted = faulted || fault;
  if faulted then
    ElemFFR[e, esize] = '0';

  // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
  unknown = unknown || ElemFFR[e, esize] == '0';
  if unknown then
    if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
      Elem[result, e, esize] = Extend(data, esize, unsigned);
    elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
      Elem[result, e, esize] = Zeros();
    else // merge
      Elem[result, e, esize] = Elem[orig, e, esize];
  else
    Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

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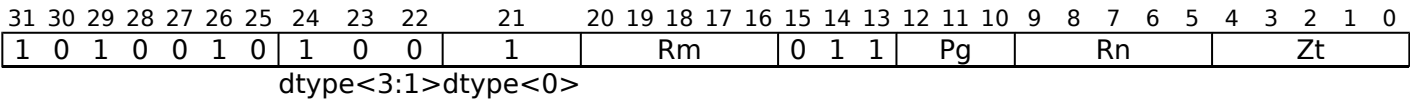
# LDFF1SH (scalar plus scalar)

Contiguous load first-fault signed halfwords to vector (scalar index).

Contiguous load with first-faulting behavior of signed halfwords to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 2 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

## 32-bit element

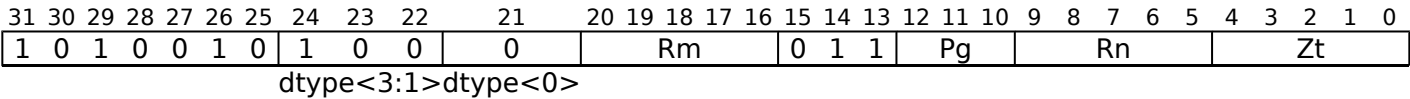


## 32-bit element

LDFF1SH { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, <Xm>, LSL #1}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
boolean unsigned = FALSE;
```

## 64-bit element



## 64-bit element

LDFF1SH { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, <Xm>, LSL #1}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
boolean unsigned = FALSE;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the optional 64-bit name of the general-purpose offset register, defaulting to XZR, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
bits(64) offset = X[m];
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = base + UInt(offset) * mbytes;
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_CNOTFIRST];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

    offset = offset + 1;

Z[t] = result;
```

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## LDFF1SH (scalar plus vector)

Gather load first-fault signed halfwords to vector (vector index).

Gather load with first-faulting behavior of signed halfwords to active elements of a vector register from memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then optionally multiplied by 2. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 6 classes: [32-bit scaled offset](#) , [32-bit unpacked scaled offset](#) , [32-bit unpacked unscaled offset](#) , [32-bit unscaled offset](#) , [64-bit scaled offset](#) and [64-bit unscaled offset](#)

### 32-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	1	xs	1	Zm					0	0	1	Pg			Rn					Zt				
																U ff															

### 32-bit scaled offset

LDFF1SH { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod> #1]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 1;
```

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	1	xs	1	Zm					0	0	1	Pg			Rn					Zt				
																U ff															

### 32-bit unpacked scaled offset

LDFF1SH { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod> #1]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 1;
```

### 32-bit unpacked unscaled offset

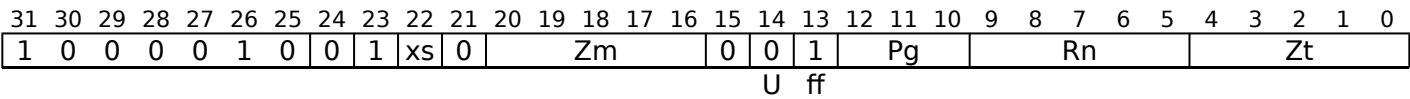
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	1	xs	0	Zm					0	0	1	Pg			Rn					Zt				
msz<1>msz<0>										U ff																					

32-bit unpacked unscaled offset

```
LDFF1SH { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod>]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

32-bit unscaled offset

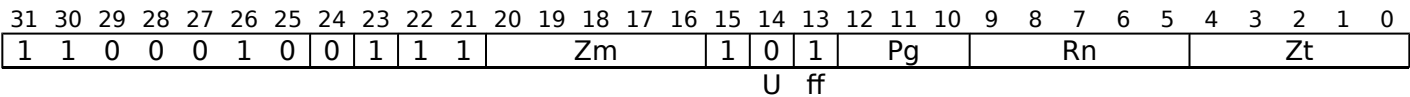


32-bit unscaled offset

```
LDFF1SH { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod>]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

64-bit scaled offset

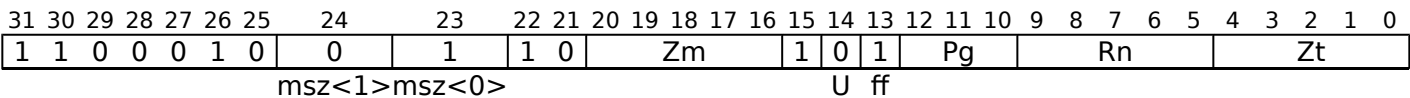


64-bit scaled offset

```
LDFF1SH { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, LSL #1]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 64;
boolean unsigned = FALSE;
boolean offs_unsigned = TRUE;
integer scale = 1;
```

64-bit unscaled offset





64-bit unscaled offset

```
LDDFF1SH { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 64;
boolean unsigned = FALSE;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(VL) offset;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        base = SP[];
else
    base = X[n];
offset = Z[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        addr = base + (off << scale);
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

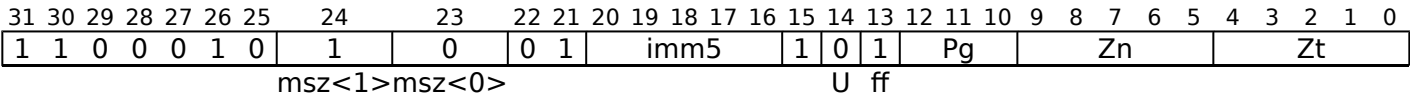
Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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LDFF1SW (vector plus immediate)

Gather load first-fault signed words to vector (immediate index).

Gather load with first-faulting behavior of signed words to active elements of a vector register from memory addresses generated by a vector base plus immediate index. The index is a multiple of 4 in the range 0 to 124. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.



SVE

```
LDFF1SW { <Zt>.D }, <Pg>/Z, [<Zn>.D{, #<imm>}]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
boolean unsigned = FALSE;
integer offset = UInt(imm5);
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 4 in the range 0 to 124, defaulting to 0, encoded in the "imm5" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) base = Z[n];
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
    if first then
      // Mem[] will not return if a fault is detected for the first active element
      data = Mem[addr, mbytes, AccType_NORMAL];
      first = FALSE;
    else
      // MemNF[] will return fault=TRUE if access is not performed for any reason
      (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
  else
    (data, fault) = (Zeros(msize), FALSE);

  // FFR elements set to FALSE following a suppressed access/fault
  faulted = faulted || fault;
  if faulted then
    ElemFFR[e, esize] = '0';

  // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
  unknown = unknown || ElemFFR[e, esize] == '0';
  if unknown then
    if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
      Elem[result, e, esize] = Extend(data, esize, unsigned);
    elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
      Elem[result, e, esize] = Zeros();
    else // merge
      Elem[result, e, esize] = Elem[orig, e, esize];
  else
    Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

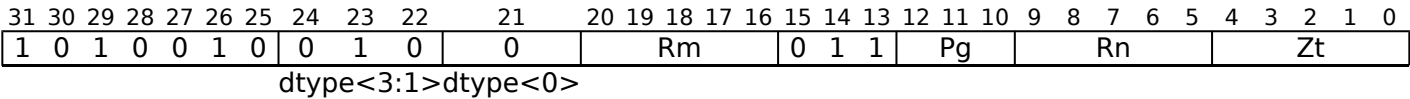
Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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LDFF1SW (scalar plus scalar)

Contiguous load first-fault signed words to vector (scalar index).

Contiguous load with first-faulting behavior of signed words to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 4 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.



SVE

LDFF1SW { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, <Xm>, LSL #2}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
boolean unsigned = FALSE;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the optional 64-bit name of the general-purpose offset register, defaulting to XZR, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
bits(64) offset = X[m];
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = base + UInt(offset) * mbytes;
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_CNOTEFIRST];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

    offset = offset + 1;

Z[t] = result;
```

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## LDFF1SW (scalar plus vector)

Gather load first-fault signed words to vector (vector index).

Gather load with first-faulting behavior of signed words to active elements of a vector register from memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then optionally multiplied by 4. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 4 classes: [32-bit unpacked scaled offset](#) , [32-bit unpacked unscaled offset](#) , [64-bit scaled offset](#) and [64-bit unscaled offset](#)

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	1	0	xs	1	Zm				0	0	1	Pg			Rn				Zt						
																U ff															

### 32-bit unpacked scaled offset

```
LDFF1SW { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod> #2]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 2;
```

### 32-bit unpacked unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	1	0	xs	0	Zm				0	0	1	Pg			Rn				Zt						
msz<1>msz<0>																U ff															

### 32-bit unpacked unscaled offset

```
LDFF1SW { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod>]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 32;
boolean unsigned = FALSE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

### 64-bit scaled offset

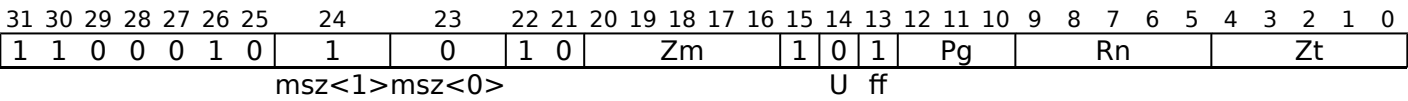
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	1	0	1	1	Zm				1	0	1	Pg			Rn				Zt						
																U ff															

64-bit scaled offset

```
LDFF1SW { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, LSL #2]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 64;
boolean unsigned = FALSE;
boolean offs_unsigned = TRUE;
integer scale = 2;
```

64-bit unscaled offset



64-bit unscaled offset

```
LDFF1SW { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 64;
boolean unsigned = FALSE;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(VL) offset;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        base = SP[];
else
    base = X[n];
offset = Z[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        addr = base + (off << scale);
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

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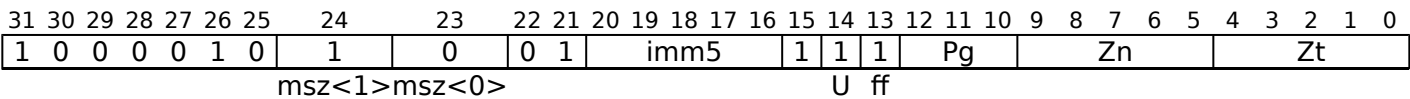
# LDF1W (vector plus immediate)

Gather load first-fault unsigned words to vector (immediate index).

Gather load with first-faulting behavior of unsigned words to active elements of a vector register from memory addresses generated by a vector base plus immediate index. The index is a multiple of 4 in the range 0 to 124. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

## 32-bit element

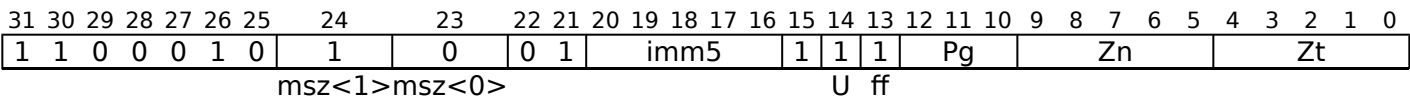


## 32-bit element

LDF1W { <Zt>.S }, <Pg>/Z, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 32;
boolean unsigned = TRUE;
integer offset = UInt(imm5);
```

## 64-bit element



## 64-bit element

LDF1W { <Zt>.D }, <Pg>/Z, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
boolean unsigned = TRUE;
integer offset = UInt(imm5);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 4 in the range 0 to 124, defaulting to 0, encoded in the "imm5" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) base = Z[n];
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
    if first then
      // Mem[] will not return if a fault is detected for the first active element
      data = Mem[addr, mbytes, AccType_NORMAL];
      first = FALSE;
    else
      // MemNF[] will return fault=TRUE if access is not performed for any reason
      (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
  else
    (data, fault) = (Zeros(msize), FALSE);

  // FFR elements set to FALSE following a suppressed access/fault
  faulted = faulted || fault;
  if faulted then
    ElemFFR[e, esize] = '0';

  // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
  unknown = unknown || ElemFFR[e, esize] == '0';
  if unknown then
    if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
      Elem[result, e, esize] = Extend(data, esize, unsigned);
    elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
      Elem[result, e, esize] = Zeros();
    else // merge
      Elem[result, e, esize] = Elem[orig, e, esize];
  else
    Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

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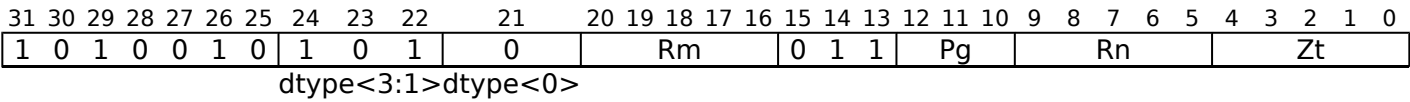
# LDFF1W (scalar plus scalar)

Contiguous load first-fault unsigned words to vector (scalar index).

Contiguous load with first-faulting behavior of unsigned words to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 4 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

## 32-bit element

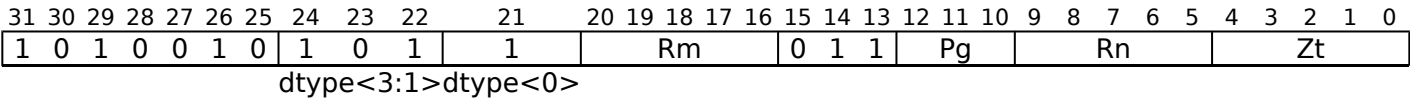


## 32-bit element

LDFF1W { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, <Xm>, LSL #2}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 32;
boolean unsigned = TRUE;
```

## 64-bit element



## 64-bit element

LDFF1W { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, <Xm>, LSL #2}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
boolean unsigned = TRUE;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the optional 64-bit name of the general-purpose offset register, defaulting to XZR, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
bits(64) offset = X[m];
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = base + UInt(offset) * mbytes;
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_CNOTEFIRST];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

    offset = offset + 1;

Z[t] = result;
```

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## LDFF1W (scalar plus vector)

Gather load first-fault unsigned words to vector (vector index).

Gather load with first-faulting behavior of unsigned words to active elements of a vector register from memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then optionally multiplied by 4. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.

It has encodings from 6 classes: [32-bit scaled offset](#) , [32-bit unpacked scaled offset](#) , [32-bit unpacked unscaled offset](#) , [32-bit unscaled offset](#) , [64-bit scaled offset](#) and [64-bit unscaled offset](#)

### 32-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	1	0	xs	1	Zm				0	1	1	Pg			Rn				Zt						
																U ff															

### 32-bit scaled offset

LDFF1W { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod> #2]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 32;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 2;
```

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	1	0	xs	1	Zm				0	1	1	Pg			Rn				Zt						
																U ff															

### 32-bit unpacked scaled offset

LDFF1W { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod> #2]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 2;
```

### 32-bit unpacked unscaled offset

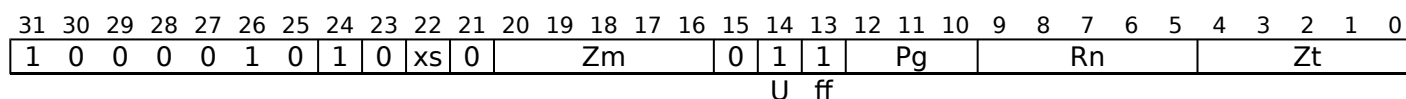
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	1	0	xs	0	Zm				0	1	1	Pg			Rn				Zt						
msz<1>msz<0>										U ff																					

### 32-bit unpacked unscaled offset

LDFF1W { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

### 32-bit unscaled offset

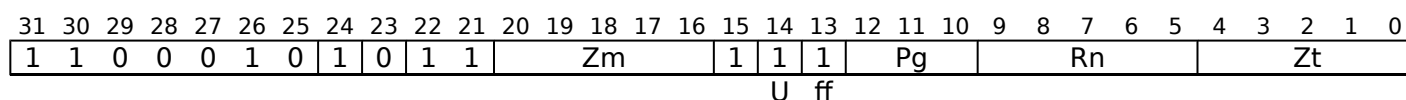


### 32-bit unscaled offset

LDFF1W { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Zm>.S, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 32;
integer offs_size = 32;
boolean unsigned = TRUE;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

### 64-bit scaled offset

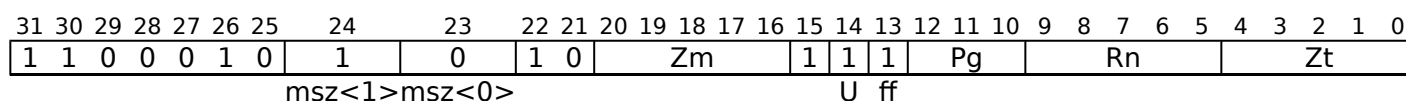


### 64-bit scaled offset

LDFF1W { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D, LSL #2]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 64;
boolean unsigned = TRUE;
boolean offs_unsigned = TRUE;
integer scale = 2;
```

### 64-bit unscaled offset



64-bit unscaled offset

```
LDFF1W { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Zm>.D]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 64;
boolean unsigned = TRUE;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(VL) offset;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean first = TRUE;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        base = SP[];
else
    base = X[n];
offset = Z[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        addr = base + (off << scale);
        if first then
            // Mem[] will not return if a fault is detected for the first active element
            data = Mem[addr, mbytes, AccType_NORMAL];
            first = FALSE;
        else
            // MemNF[] will return fault=TRUE if access is not performed for any reason
            (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elsif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

Z[t] = result;
```

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## LDNF1B

Contiguous load non-fault unsigned bytes to vector (immediate index).

Contiguous load with non-faulting behavior of unsigned bytes to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 4 classes: [8-bit element](#) , [16-bit element](#) , [32-bit element](#) and [64-bit element](#)

### 8-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	0	0	0	1	imm4				1	0	1	Pg			Rn				Zt					
dtype<3:1>dtype<0>																															

### 8-bit element

LDNF1B { <Zt>.B }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

### 16-bit element

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	0		1	1	imm4				1	0	1	Pg			Rn				Zt					
dtype<3:1>dtype<0>																															

### 16-bit element

LDNF1B { <Zt>.H }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

### 32-bit element

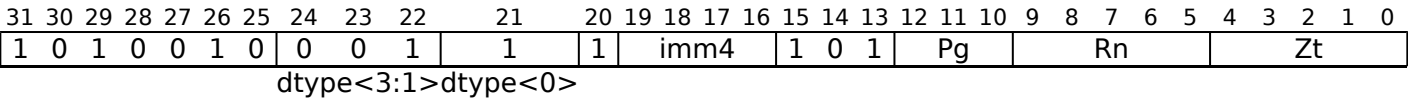
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	0	0	1	0	1	imm4				1	0	1	Pg			Rn				Zt					
dtype<3:1>dtype<0>																															

32-bit element

```
LDNF1B { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

64-bit element



64-bit element

```
LDNF1B { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if n == 31 then
    if ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
        base = SP[];
    else
        if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
        base = X[n];

addr = base + offset * elements * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        // MemNF[] will return fault=TRUE if access is not performed for any reason
        (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elseif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

    addr = addr + mbytes;

Z[t] = result;
```

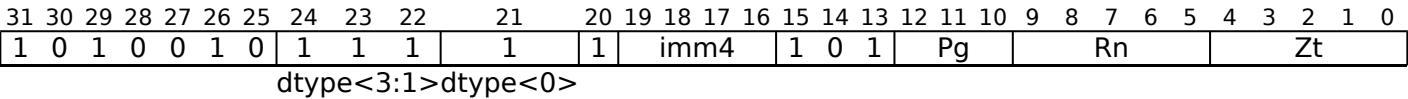
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LDNF1D

Contiguous load non-fault doublewords to vector (immediate index).

Contiguous load with non-faulting behavior of doublewords to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.



SVE

LDNF1D { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if n == 31 then
    if ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
        base = SP[];
    else
        if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
        base = X[n];

addr = base + offset * elements * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        // MemNF[] will return fault=TRUE if access is not performed for any reason
        (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elseif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

    addr = addr + mbytes;

Z[t] = result;
```

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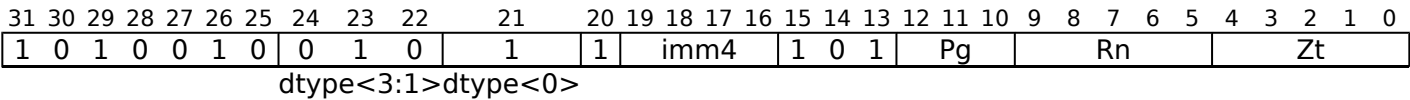
# LDNF1H

Contiguous load non-fault unsigned halfwords to vector (immediate index).

Contiguous load with non-faulting behavior of unsigned halfwords to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 3 classes: [16-bit element](#) , [32-bit element](#) and [64-bit element](#)

## 16-bit element

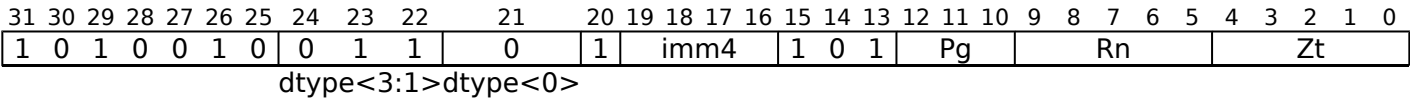


## 16-bit element

LDNF1H { <Zt>.H }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer msize = 16;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

## 32-bit element

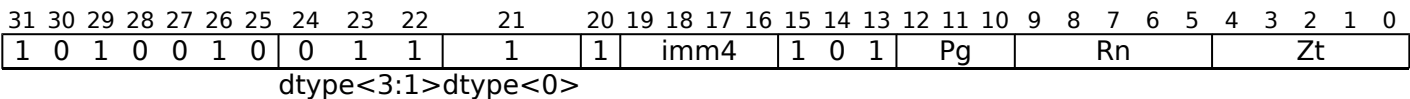


## 32-bit element

LDNF1H { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

## 64-bit element



**64-bit element**

```
LDNF1H { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

**Assembler Symbols**

<Zt>	Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<imm>	Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if n == 31 then
    if ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
        base = SP[];
    else
        if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
        base = X[n];

addr = base + offset * elements * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        // MemNF[] will return fault=TRUE if access is not performed for any reason
        (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elseif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

    addr = addr + mbytes;

Z[t] = result;
```

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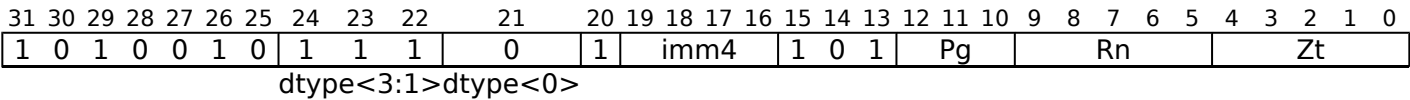
# LDNF1SB

Contiguous load non-fault signed bytes to vector (immediate index).

Contiguous load with non-faulting behavior of signed bytes to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 3 classes: [16-bit element](#) , [32-bit element](#) and [64-bit element](#)

## 16-bit element

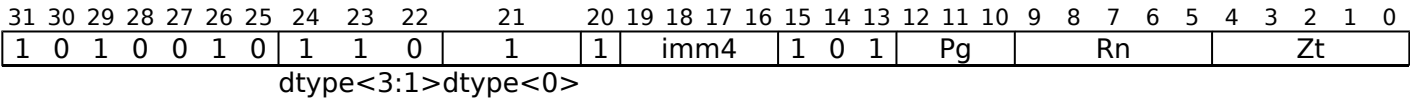


## 16-bit element

LDNF1SB { <Zt>.H }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer msize = 8;
boolean unsigned = FALSE;
integer offset = SInt(imm4);
```

## 32-bit element

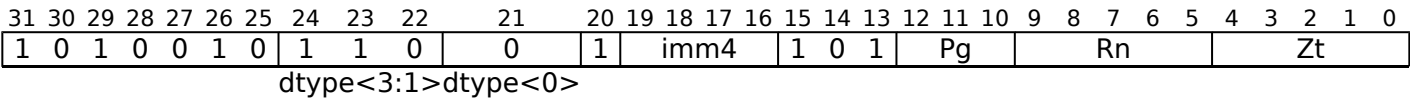


## 32-bit element

LDNF1SB { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
boolean unsigned = FALSE;
integer offset = SInt(imm4);
```

## 64-bit element



**64-bit element**

```
LDNF1SB { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
boolean unsigned = FALSE;
integer offset = SInt(imm4);
```

**Assembler Symbols**

<Zt>	Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<imm>	Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if n == 31 then
    if ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
        base = SP[];
    else
        if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
        base = X[n];

addr = base + offset * elements * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        // MemNF[] will return fault=TRUE if access is not performed for any reason
        (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elseif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

    addr = addr + mbytes;

Z[t] = result;
```

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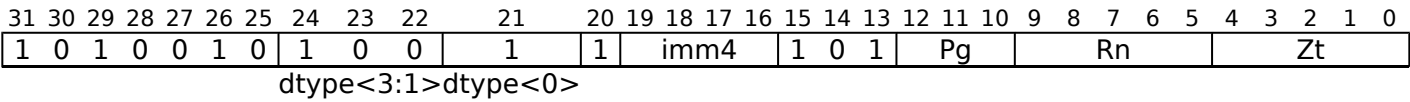
# LDNF1SH

Contiguous load non-fault signed halfwords to vector (immediate index).

Contiguous load with non-faulting behavior of signed halfwords to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

## 32-bit element

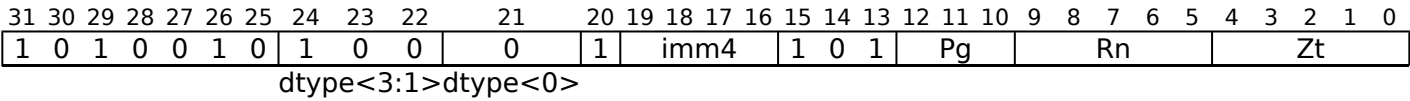


## 32-bit element

LDNF1SH { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
boolean unsigned = FALSE;
integer offset = SInt(imm4);
```

## 64-bit element



## 64-bit element

LDNF1SH { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
boolean unsigned = FALSE;
integer offset = SInt(imm4);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if n == 31 then
    if ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
        base = SP[];
    else
        if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
        base = X[n];

addr = base + offset * elements * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        // MemNF[] will return fault=TRUE if access is not performed for any reason
        (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elseif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

    addr = addr + mbytes;

Z[t] = result;
```

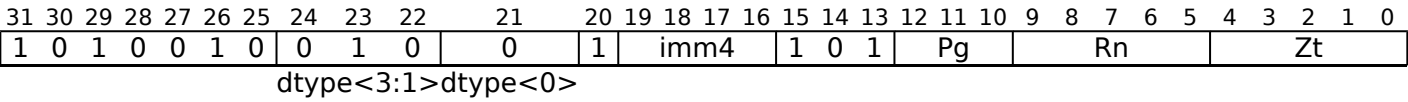
Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# LDNF1SW

Contiguous load non-fault signed words to vector (immediate index).

Contiguous load with non-faulting behavior of signed words to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.



## SVE

LDNF1SW { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
boolean unsigned = FALSE;
integer offset = SInt(imm4);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if n == 31 then
    if ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
        base = SP[];
    else
        if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
        base = X[n];

addr = base + offset * elements * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        // MemNF[] will return fault=TRUE if access is not performed for any reason
        (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elseif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

    addr = addr + mbytes;

Z[t] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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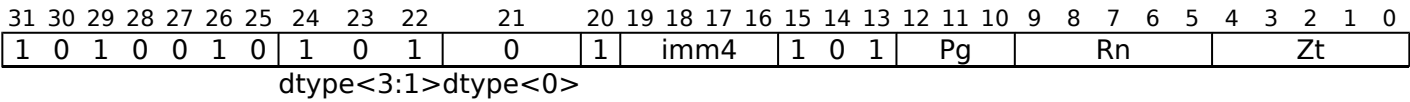
# LDNF1W

Contiguous load non-fault unsigned words to vector (immediate index).

Contiguous load with non-faulting behavior of unsigned words to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

## 32-bit element

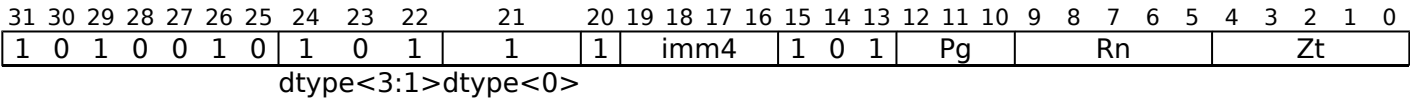


## 32-bit element

LDNF1W { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 32;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

## 64-bit element



## 64-bit element

LDNF1W { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
boolean unsigned = TRUE;
integer offset = SInt(imm4);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(VL) orig = Z[t];
bits(msize) data;
constant integer mbytes = msize DIV 8;
boolean fault = FALSE;
boolean faulted = FALSE;
boolean unknown = FALSE;

if n == 31 then
    if ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
        base = SP[];
    else
        if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
        base = X[n];

addr = base + offset * elements * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        // MemNF[] will return fault=TRUE if access is not performed for any reason
        (data, fault) = MemNF[addr, mbytes, AccType_NONFAULT];
    else
        (data, fault) = (Zeros(msize), FALSE);

    // FFR elements set to FALSE following a suppressed access/fault
    faulted = faulted || fault;
    if faulted then
        ElemFFR[e, esize] = '0';

    // Value becomes CONSTRAINED UNPREDICTABLE after an FFR element is FALSE
    unknown = unknown || ElemFFR[e, esize] == '0';
    if unknown then
        if !fault && ConstrainUnpredictableBool(Unpredictable_SVELDNFDATA) then
            Elem[result, e, esize] = Extend(data, esize, unsigned);
        elseif ConstrainUnpredictableBool(Unpredictable_SVELDNFZERO) then
            Elem[result, e, esize] = Zeros();
        else // merge
            Elem[result, e, esize] = Elem[orig, e, esize];
    else
        Elem[result, e, esize] = Extend(data, esize, unsigned);

    addr = addr + mbytes;

Z[t] = result;
```

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# LDNT1B (vector plus scalar)

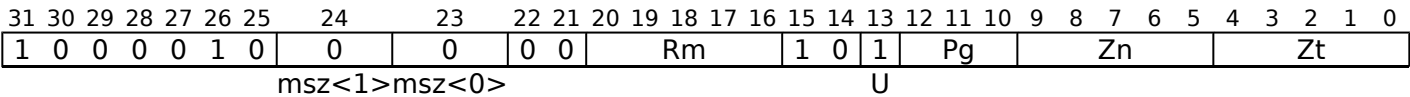
Gather load non-temporal unsigned bytes.

Gather load non-temporal of unsigned bytes to active elements of a vector register from memory addresses generated by a vector base plus a 64-bit unscaled scalar register offset. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.

A non-temporal load is a hint to the system that this data is unlikely to be referenced again soon.

It has encodings from 2 classes: [32-bit unscaled offset](#) and [64-bit unscaled offset](#)

## 32-bit unscaled offset

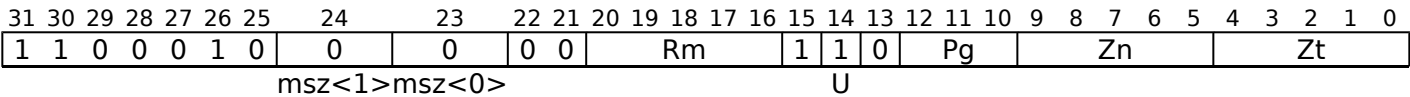


## 32-bit unscaled offset

LDNT1B { <Zt>.S }, <Pg>/Z, [<Zn>.S{, <Xm>}]

```
if !HaveSVE2() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
boolean unsigned = TRUE;
```

## 64-bit unscaled offset



## 64-bit unscaled offset

LDNT1B { <Zt>.D }, <Pg>/Z, [<Zn>.D{, <Xm>}]

```
if !HaveSVE2() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
boolean unsigned = TRUE;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <Xm> Is the optional 64-bit name of the general-purpose offset register, defaulting to XZR, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) base = Z[n];
bits(64) offset = X[m];
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = ZeroExtend(Elem[base, e, esize], 64) + offset;
        data = Mem[addr, mbytes, AccType_STREAM];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();
Z[t] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

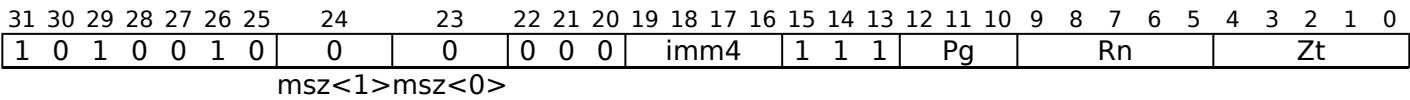
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# LDNT1B (scalar plus immediate)

Contiguous load non-temporal bytes to vector (immediate index).

Contiguous load non-temporal of bytes to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.

A non-temporal load is a hint to the system that this data is unlikely to be referenced again soon.



## SVE

```
LDNT1B { <Zt>.B }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8;
integer offset = SInt(imm4);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
constant integer mbytes = esize DIV 8;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        if HaveMTEEExt() then SetTagCheckedInstruction(FALSE);
        base = SP[];
    else
        if HaveMTEEExt() then SetTagCheckedInstruction(TRUE);
        base = X[n];

addr = base + offset * elements * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_STREAM];
    else
        Elem[result, e, esize] = Zeros();
    addr = addr + mbytes;

Z[t] = result;
```

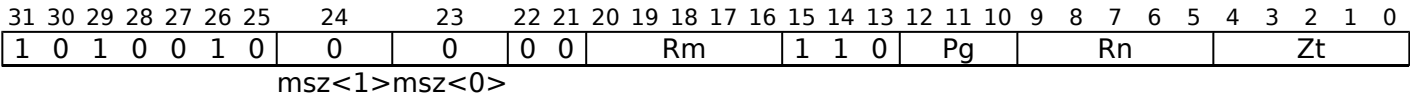


LDNT1B (scalar plus scalar)

Contiguous load non-temporal bytes to vector (scalar index).

Contiguous load non-temporal of bytes to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.

A non-temporal load is a hint to the system that this data is unlikely to be referenced again soon.



SVE

```
LDNT1B { <Zt>.B }, <Pg>/Z, [<Xn|SP>, <Xm>]
```

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 8;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(64) offset;
bits(PL) mask = P[g];
bits(VL) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];
offset = X[m];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_STREAM];
    else
        Elem[result, e, esize] = Zeros();
    offset = offset + 1;

Z[t] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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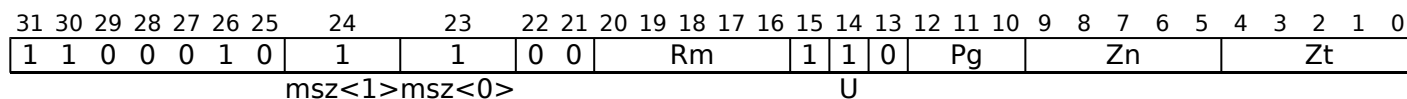


## LDNT1D (vector plus scalar)

Gather load non-temporal unsigned doublewords.

Gather load non-temporal of doublewords to active elements of a vector register from memory addresses generated by a vector base plus a 64-bit unscaled scalar register offset. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.

A non-temporal load is a hint to the system that this data is unlikely to be referenced again soon.



## SVE2

```
LDNT1D { <Zt>.D }, <Pg>/Z, [<Zn>.D{, <Xm>}]
```

```
if !HaveSVE2() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
boolean unsigned = TRUE;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <Xm> Is the optional 64-bit name of the general-purpose offset register, defaulting to XZR, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) base = Z[n];
bits(64) offset = X[m];
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    addr = ZeroExtend(Elem[base, e, esize], 64) + offset;
    data = Mem[addr, mbytes, AccType_STREAM];
    Elem[result, e, esize] = Extend(data, esize, unsigned);
  else
    Elem[result, e, esize] = Zeros();

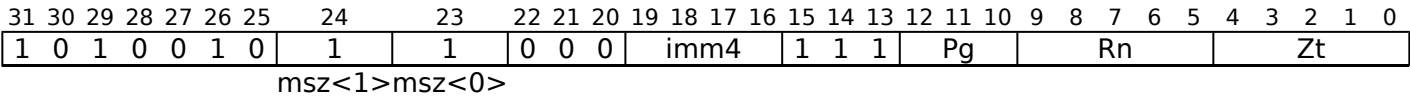
Z[t] = result;
```

# LDNT1D (scalar plus immediate)

Contiguous load non-temporal doublewords to vector (immediate index).

Contiguous load non-temporal of doublewords to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.

A non-temporal load is a hint to the system that this data is unlikely to be referenced again soon.



## SVE

LDNT1D { <Zt>.D }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer offset = SInt(imm4);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
constant integer mbytes = esize DIV 8;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
        base = SP[];
    else
        if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
        base = X[n];

addr = base + offset * elements * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_STREAM];
    else
        Elem[result, e, esize] = Zeros();
    addr = addr + mbytes;

Z[t] = result;
```

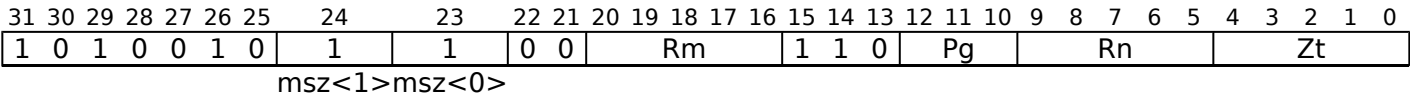


LDNT1D (scalar plus scalar)

Contiguous load non-temporal doublewords to vector (scalar index).

Contiguous load non-temporal of doublewords to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 8 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.

A non-temporal load is a hint to the system that this data is unlikely to be referenced again soon.



SVE

LDNT1D { <Zt>.D }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #3]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(64) offset;
bits(PL) mask = P[g];
bits(VL) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];
offset = X[m];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_STREAM];
    else
        Elem[result, e, esize] = Zeros();
    offset = offset + 1;

Z[t] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# LDNT1H (vector plus scalar)

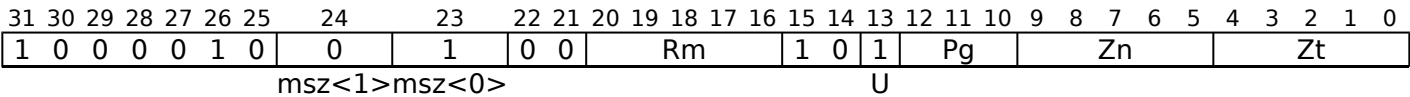
Gather load non-temporal unsigned halfwords.

Gather load non-temporal of unsigned halfwords to active elements of a vector register from memory addresses generated by a vector base plus a 64-bit unscaled scalar register offset. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.

A non-temporal load is a hint to the system that this data is unlikely to be referenced again soon.

It has encodings from 2 classes: [32-bit unscaled offset](#) and [64-bit unscaled offset](#)

## 32-bit unscaled offset

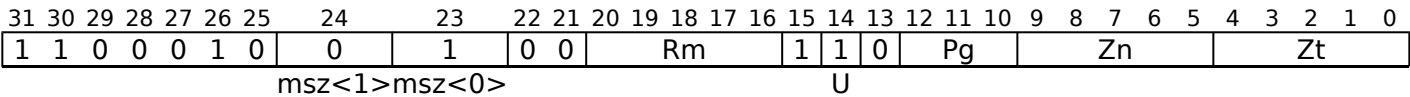


## 32-bit unscaled offset

LDNT1H { <Zt>.S }, <Pg>/Z, [<Zn>.S{, <Xm>}]

```
if !HaveSVE2() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
boolean unsigned = TRUE;
```

## 64-bit unscaled offset



## 64-bit unscaled offset

LDNT1H { <Zt>.D }, <Pg>/Z, [<Zn>.D{, <Xm>}]

```
if !HaveSVE2() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
boolean unsigned = TRUE;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <Xm> Is the optional 64-bit name of the general-purpose offset register, defaulting to XZR, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) base = Z[n];
bits(64) offset = X[m];
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = ZeroExtend(Elem[base, e, esize], 64) + offset;
        data = Mem[addr, mbytes, AccType_STREAM];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

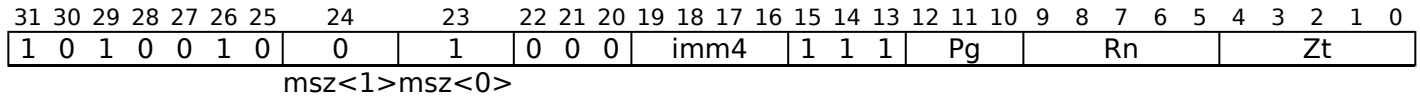
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## LDNT1H (scalar plus immediate)

Contiguous load non-temporal halfwords to vector (immediate index).

Contiguous load non-temporal of halfwords to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.

A non-temporal load is a hint to the system that this data is unlikely to be referenced again soon.



### SVE

```
LDNT1H { <Zt>.H }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer offset = SInt(imm4);
```

### Assembler Symbols

<Zt>	Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
<Xn SP>	Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
<imm>	Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
constant integer mbytes = esize DIV 8;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        if HaveMTEEExt() then SetTagCheckedInstruction(FALSE);
        base = SP[];
    else
        if HaveMTEEExt() then SetTagCheckedInstruction(TRUE);
        base = X[n];

addr = base + offset * elements * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_STREAM];
    else
        Elem[result, e, esize] = Zeros();
    addr = addr + mbytes;

Z[t] = result;
```



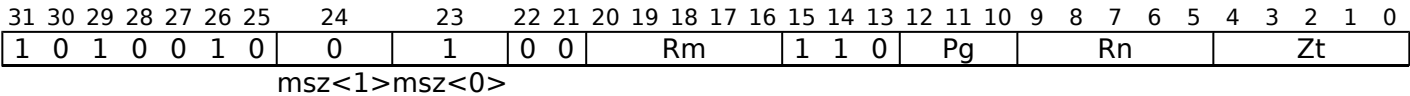


# LDNT1H (scalar plus scalar)

Contiguous load non-temporal halfwords to vector (scalar index).

Contiguous load non-temporal of halfwords to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 2 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.

A non-temporal load is a hint to the system that this data is unlikely to be referenced again soon.



## SVE

LDNT1H { <Zt>.H }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(64) offset;
bits(PL) mask = P[g];
bits(VL) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];
offset = X[m];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_STREAM];
    else
        Elem[result, e, esize] = Zeros();
    offset = offset + 1;

Z[t] = result;
```

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# LDNT1SB

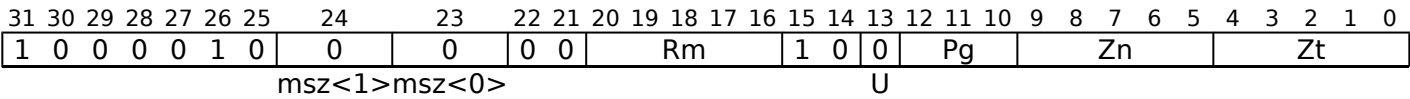
Gather load non-temporal signed bytes.

Gather load non-temporal of signed bytes to active elements of a vector register from memory addresses generated by a vector base plus a 64-bit unscaled scalar register offset. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.

A non-temporal load is a hint to the system that this data is unlikely to be referenced again soon.

It has encodings from 2 classes: [32-bit unscaled offset](#) and [64-bit unscaled offset](#)

## 32-bit unscaled offset

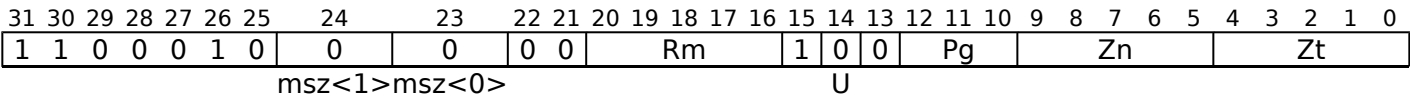


## 32-bit unscaled offset

LDNT1SB { <Zt>.S }, <Pg>/Z, [<Zn>.S{, <Xm>}]

```
if !HaveSVE2() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
boolean unsigned = FALSE;
```

## 64-bit unscaled offset



## 64-bit unscaled offset

LDNT1SB { <Zt>.D }, <Pg>/Z, [<Zn>.D{, <Xm>}]

```
if !HaveSVE2() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
boolean unsigned = FALSE;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <Xm> Is the optional 64-bit name of the general-purpose offset register, defaulting to XZR, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) base = Z[n];
bits(64) offset = X[m];
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = ZeroExtend(Elem[base, e, esize], 64) + offset;
        data = Mem[addr, mbytes, AccType_STREAM];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

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# LDNT1SH

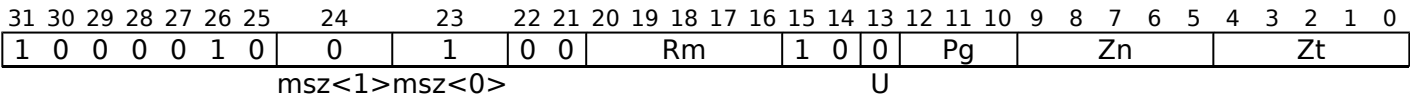
Gather load non-temporal signed halfwords.

Gather load non-temporal of signed halfwords to active elements of a vector register from memory addresses generated by a vector base plus a 64-bit unscaled scalar register offset. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.

A non-temporal load is a hint to the system that this data is unlikely to be referenced again soon.

It has encodings from 2 classes: [32-bit unscaled offset](#) and [64-bit unscaled offset](#)

## 32-bit unscaled offset

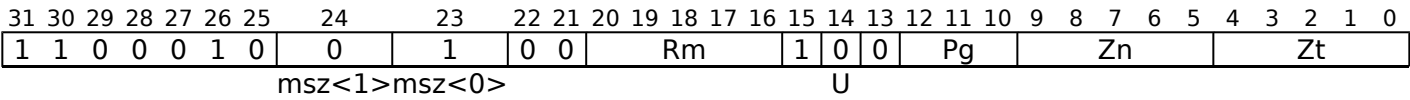


## 32-bit unscaled offset

LDNT1SH { <Zt>.S }, <Pg>/Z, [<Zn>.S{, <Xm>}]

```
if !HaveSVE2() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
boolean unsigned = FALSE;
```

## 64-bit unscaled offset



## 64-bit unscaled offset

LDNT1SH { <Zt>.D }, <Pg>/Z, [<Zn>.D{, <Xm>}]

```
if !HaveSVE2() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
boolean unsigned = FALSE;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <Xm> Is the optional 64-bit name of the general-purpose offset register, defaulting to XZR, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) base = Z[n];
bits(64) offset = X[m];
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = ZeroExtend(Elem[base, e, esize], 64) + offset;
        data = Mem[addr, mbytes, AccType_STREAM];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

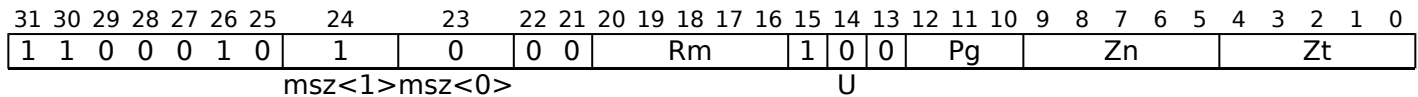
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## LDNT1SW

Gather load non-temporal signed words.

Gather load non-temporal of signed words to active elements of a vector register from memory addresses generated by a vector base plus a 64-bit unscaled scalar register offset. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.

A non-temporal load is a hint to the system that this data is unlikely to be referenced again soon.



## SVE2

```
LDNT1SW { <Zt>.D }, <Pg>/Z, [<Zn>.D{, <Xm>}]
```

```
if !HaveSVE2() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
boolean unsigned = FALSE;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <Xm> Is the optional 64-bit name of the general-purpose offset register, defaulting to XZR, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) base = Z[n];
bits(64) offset = X[m];
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    addr = ZeroExtend(Elem[base, e, esize], 64) + offset;
    data = Mem[addr, mbytes, AccType_STREAM];
    Elem[result, e, esize] = Extend(data, esize, unsigned);
  else
    Elem[result, e, esize] = Zeros();

Z[t] = result;
```



# LDNT1W (vector plus scalar)

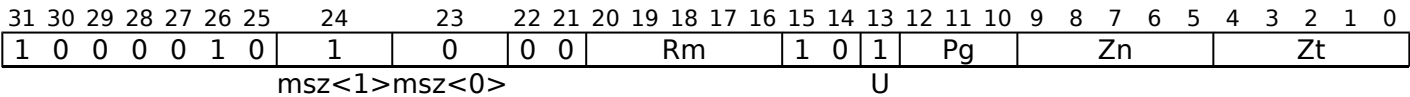
Gather load non-temporal unsigned words.

Gather load non-temporal of unsigned words to active elements of a vector register from memory addresses generated by a vector base plus a 64-bit unscaled scalar register offset. Inactive elements will not read Device memory or signal faults, and are set to zero in the destination vector.

A non-temporal load is a hint to the system that this data is unlikely to be referenced again soon.

It has encodings from 2 classes: [32-bit unscaled offset](#) and [64-bit unscaled offset](#)

## 32-bit unscaled offset

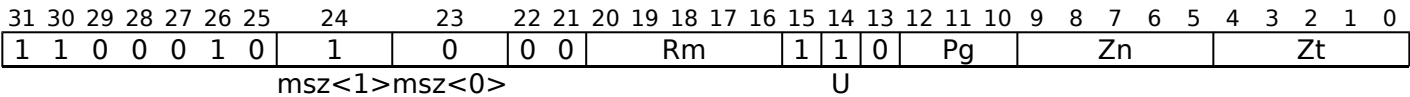


## 32-bit unscaled offset

LDNT1W { <Zt>.S }, <Pg>/Z, [<Zn>.S{, <Xm>}]

```
if !HaveSVE2() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 32;
boolean unsigned = TRUE;
```

## 64-bit unscaled offset



## 64-bit unscaled offset

LDNT1W { <Zt>.D }, <Pg>/Z, [<Zn>.D{, <Xm>}]

```
if !HaveSVE2() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
boolean unsigned = TRUE;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <Xm> Is the optional 64-bit name of the general-purpose offset register, defaulting to XZR, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) base = Z[n];
bits(64) offset = X[m];
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
bits(msize) data;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = ZeroExtend(Elem[base, e, esize], 64) + offset;
        data = Mem[addr, mbytes, AccType_STREAM];
        Elem[result, e, esize] = Extend(data, esize, unsigned);
    else
        Elem[result, e, esize] = Zeros();

Z[t] = result;
```

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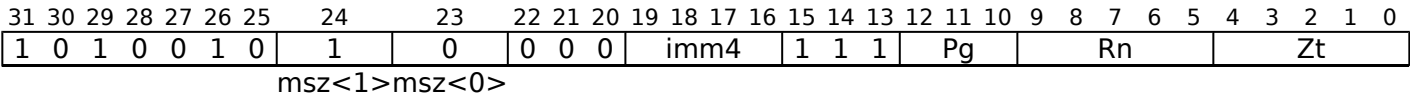
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# LDNT1W (scalar plus immediate)

Contiguous load non-temporal words to vector (immediate index).

Contiguous load non-temporal of words to elements of a vector register from the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.

A non-temporal load is a hint to the system that this data is unlikely to be referenced again soon.



## SVE

LDNT1W { <Zt>.S }, <Pg>/Z, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer offset = SInt(imm4);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) result;
constant integer mbytes = esize DIV 8;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
        base = SP[];
    else
        if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
        base = X[n];

addr = base + offset * elements * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_STREAM];
    else
        Elem[result, e, esize] = Zeros();
    addr = addr + mbytes;

Z[t] = result;
```

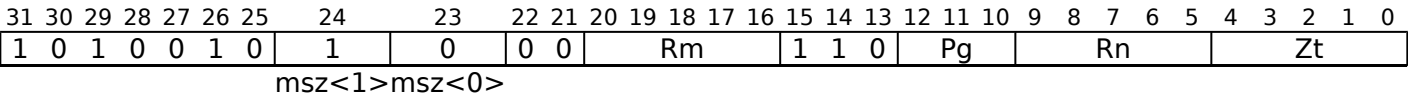


## LDNT1W (scalar plus scalar)

Contiguous load non-temporal words to vector (scalar index).

Contiguous load non-temporal of words to elements of a vector register from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 4 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements will not read Device memory or signal a fault, and are set to zero in the destination vector.

A non-temporal load is a hint to the system that this data is unlikely to be referenced again soon.



### SVE

LDNT1W { <Zt>.S }, <Pg>/Z, [<Xn|SP>, <Xm>, LSL #2]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(64) offset;
bits(PL) mask = P[g];
bits(VL) result;
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];
offset = X[m];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Mem[addr, mbytes, AccType_STREAM];
    else
        Elem[result, e, esize] = Zeros();
    offset = offset + 1;

Z[t] = result;
```

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# LDR (predicate)

Load predicate register.

Load a predicate register from a memory address generated by a 64-bit scalar base, plus an immediate offset in the range -256 to 255 which is multiplied by the current predicate register size in bytes. This instruction is unpredicated. The load is performed as a stream of bytes containing 8 consecutive predicate bits in ascending element order, without any endian conversion.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	1	1	0	imm9h						0	0	0	imm9l			Rn			0	Pt					

## SVE

LDR <Pt>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Pt);
integer n = UInt(Rn);
integer imm = SInt(imm9h:imm9l);
```

## Assembler Symbols

- <Pt> Is the name of the destination scalable predicate register, encoded in the "Pt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -256 to 255, defaulting to 0, encoded in the "imm9h:imm9l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = PL DIV 8;
bits(64) base;
integer offset = imm * elements;
bits(PL) result;

if n == 31 then
    CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

boolean aligned = AArch64.CheckAlignment(base + offset, 2, AccType_NORMAL, FALSE);
for e = 0 to elements-1
    Elem[result, e, 8] = AArch64.MemSingle(base + offset, 1, AccType_NORMAL, aligned);
    offset = offset + 1;

P[t] = result;
```

# LDR (vector)

Load vector register.

Load a vector register from a memory address generated by a 64-bit scalar base, plus an immediate offset in the range -256 to 255 which is multiplied by the current vector register size in bytes. This instruction is unpredicated. The load is performed as a stream of byte elements in ascending element order, without any endian conversion.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	1	1	0	imm9h						0	1	0	imm9l			Rn				Zt					

## SVE

LDR <Zt>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer imm = SInt(imm9h:imm9l);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -256 to 255, defaulting to 0, encoded in the "imm9h:imm9l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV 8;
bits(64) base;
integer offset = imm * elements;
bits(VL) result;

if n == 31 then
    CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

boolean aligned = AArch64.CheckAlignment(base + offset, 16, AccType_NORMAL, FALSE);
for e = 0 to elements-1
    Elem[result, e, 8] = AArch64.MemSingle(base + offset, 1, AccType_NORMAL, aligned);
    offset = offset + 1;

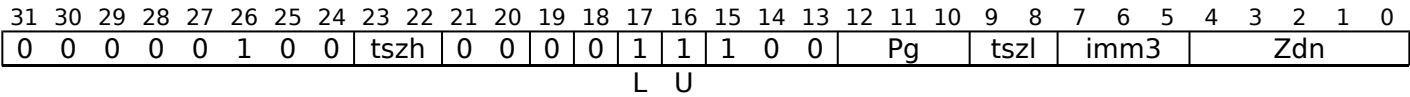
Z[t] = result;
```



# LSL (immediate, predicated)

Logical shift left by immediate (predicated).

Shift left by immediate each active element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate shift amount is an unsigned value in the range 0 to number of bits per element minus 1. Inactive elements in the destination vector register remain unmodified.



## SVE

LSL <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, #<const>

```
if !HaveSVE() then UNDEFINED;
bits(4) tsize = tszh:tszl;
case tsize of
    when '0000' UNDEFINED;
    when '0001' esize = 8;
    when '001x' esize = 16;
    when '01xx' esize = 32;
    when '1xxx' esize = 64;
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer shift = UInt(tsize:imm3) - esize;
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
00	00	RESERVED
00	01	B
00	1x	H
01	xx	S
1x	xx	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <const> Is the immediate shift amount, in the range 0 to number of bits per element minus 1, encoded in "tsz:imm3".

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(PL) mask = P[g];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = LSL(element1, shift);
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

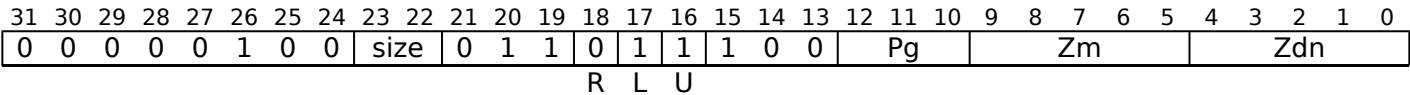
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LSL (wide elements, predicated)

Logical shift left by 64-bit wide elements (predicated).

Shift left active elements of the first source vector by corresponding overlapping 64-bit elements of the second source vector and destructively place the results in the corresponding elements of the first source vector. The shift amount is a vector of unsigned 64-bit doubleword elements in which all bits are significant, and not used modulo the destination element size. Inactive elements in the destination vector register remain unmodified.



SVE

LSL <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.D

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	RESERVED

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(64) element2 = Elem[operand2, (e * esize) DIV 64, 64];
    integer shift = Min(UInt(element2), esize);
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = LSL(element1, shift);
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];
Z[dn] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:

- The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and destination element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

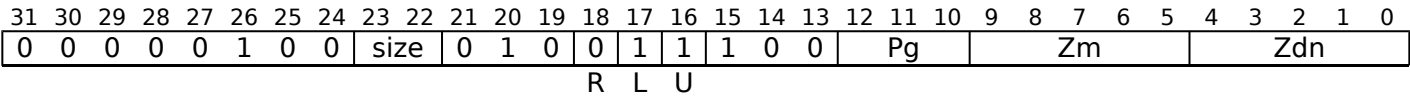
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# LSL (vectors)

Logical shift left by vector (predicated).

Shift left active elements of the first source vector by corresponding elements of the second source vector and destructively place the results in the corresponding elements of the first source vector. The shift amount operand is a vector of unsigned elements in which all bits are significant, and not used modulo the element size. Inactive elements in the destination vector register remain unmodified.



## SVE

LSL <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    integer shift = Min(UInt(element2), esize);
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = LSL(element1, shift);
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];
Z[dn] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.

- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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LSL (immediate, unpredicated)

Logical shift left by immediate (unpredicated).

Shift left by immediate each element of the source vector, and place the results in the corresponding elements of the destination vector. The immediate shift amount is an unsigned value in the range 0 to number of bits per element minus 1. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	tszh	1	tszl	imm3	1	0	0	1	1	1	Zn						Zd							

SVE

LSL <Zd>.<T>, <Zn>.<T>, #<const>

```
if !HaveSVE() then UNDEFINED;
bits(4) tsize = tszh:tszl;
case tsize of
  when '0000' UNDEFINED;
  when '0001' esize = 8;
  when '001x' esize = 16;
  when '01xx' esize = 32;
  when '1xxx' esize = 64;
integer n = UInt(Zn);
integer d = UInt(Zd);
integer shift = UInt(tsize:imm3) - esize;
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
00	00	RESERVED
00	01	B
00	1x	H
01	xx	S
1x	xx	D

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<const> Is the immediate shift amount, in the range 0 to number of bits per element minus 1, encoded in "tsz:imm3".

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) result;

for e = 0 to elements-1
  bits(esize) element1 = Elem[operand1, e, esize];
  Elem[result, e, esize] = LSL(element1, shift);

Z[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:

- The values of the data supplied in any of its registers.
- The values of the NZCV flags.

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LSL (wide elements, unpredicated)

Logical shift left by 64-bit wide elements (unpredicated).

Shift left all elements of the first source vector by corresponding overlapping 64-bit elements of the second source vector and place the first in the corresponding elements of the destination vector. The shift amount is a vector of unsigned 64-bit doubleword elements in which all bits are significant, and not used modulo the destination element size. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	1	Zm						1	0	0	0	1	1	Zn						Zd			

SVE

LSL <Zd>.<T>, <Zn>.<T>, <Zm>.D

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	RESERVED

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(64) element2 = Elem[operand2, (e * esize) DIV 64, 64];
    integer shift = Min(UInt(element2), esize);
    Elem[result, e, esize] = LSL(element1, shift);

Z[d] = result;
```

Operational information

If PSTATE.DIT is 1:

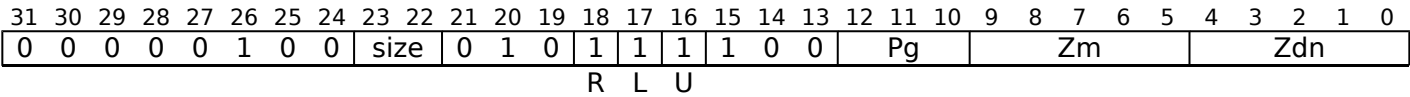
- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.



LSLR

Reversed logical shift left by vector (predicated).

Reversed shift left active elements of the second source vector by corresponding elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. The shift amount operand is a vector of unsigned elements in which all bits are significant, and not used modulo the element size. Inactive elements in the destination vector register remain unmodified.



SVE

```
LSLR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    integer shift = Min(UInt(element1), esize);
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = LSL(element2, shift);
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.

- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

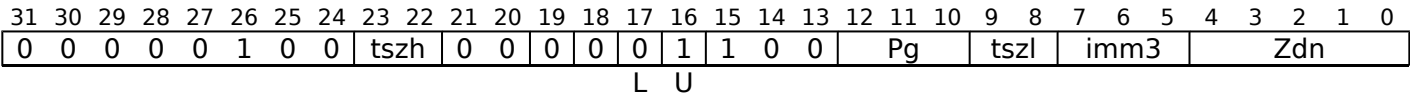
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## LSR (immediate, predicated)

Logical shift right by immediate (predicated).

Shift right by immediate, inserting zeroes, each active element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate shift amount is an unsigned value in the range 1 to number of bits per element. Inactive elements in the destination vector register remain unmodified.



### SVE

LSR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, #<const>

```
if !HaveSVE() then UNDEFINED;
bits(4) tsize = tszh:tszl;
case tsize of
  when '0000' UNDEFINED;
  when '0001' esize = 8;
  when '001x' esize = 16;
  when '01xx' esize = 32;
  when '1xxx' esize = 64;
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer shift = (2 * esize) - UInt(tsize:imm3);
```

### Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
00	00	RESERVED
00	01	B
00	1x	H
01	xx	S
1x	xx	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <const> Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(PL) mask = P[g];
bits(VL) result;

for e = 0 to elements-1
  bits(esize) element1 = Elem[operand1, e, esize];
  if ElemP[mask, e, esize] == '1' then
    Elem[result, e, esize] = LSR(element1, shift);
  else
    Elem[result, e, esize] = Elem[operand1, e, esize];
Z[dn] = result;
```

### Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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## LSR (wide elements, predicated)

Logical shift right by 64-bit wide elements (predicated).

Shift right, inserting zeroes, active elements of the first source vector by corresponding overlapping 64-bit elements of the second source vector and destructively place the results in the corresponding elements of the first source vector. The shift amount is a vector of unsigned 64-bit doubleword elements in which all bits are significant, and not used modulo the destination element size. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	0	0	1	1	0	0	Pg				Zm				Zdn					
												R		L	U																

### SVE

LSR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.D

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

### Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	RESERVED

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(64) element2 = Elem[operand2, (e * esize) DIV 64, 64];
    integer shift = Min(UInt(element2), esize);
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = LSR(element1, shift);
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

### Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:

- The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and destination element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# LSR (vectors)

Logical shift right by vector (predicated).

Shift right, inserting zeroes, active elements of the first source vector by corresponding elements of the second source vector and destructively place the results in the corresponding elements of the first source vector. The shift amount operand is a vector of unsigned elements in which all bits are significant, and not used modulo the element size. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	0	0	0	1	1	0	0	Pg				Zm					Zdn				
												R		L	U																

## SVE

LSR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    integer shift = Min(UInt(element2), esize);
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = LSR(element1, shift);
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.

- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

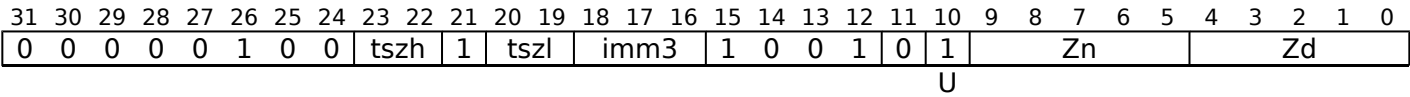
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LSR (immediate, unpredicated)

Logical shift right by immediate (unpredicated).

Shift right by immediate, inserting zeroes, each element of the source vector, and place the results in the corresponding elements of the destination vector. The immediate shift amount is an unsigned value in the range 1 to number of bits per element. This instruction is unpredicated.



SVE

LSR <Zd>.<T>, <Zn>.<T>, #<const>

```
if !HaveSVE() then UNDEFINED;
bits(4) tsize = tszh:tszl;
case tsize of
  when '0000' UNDEFINED;
  when '0001' esize = 8;
  when '001x' esize = 16;
  when '01xx' esize = 32;
  when '1xxx' esize = 64;
integer n = UInt(Zn);
integer d = UInt(Zd);
integer shift = (2 * esize) - UInt(tsize:imm3);
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
00	00	RESERVED
00	01	B
00	1x	H
01	xx	S
1x	xx	D
- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.
- <const> Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) result;

for e = 0 to elements-1
  bits(esize) element1 = Elem[operand1, e, esize];
  Elem[result, e, esize] = LSR(element1, shift);

Z[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:

- The values of the data supplied in any of its registers.
- The values of the NZCV flags.

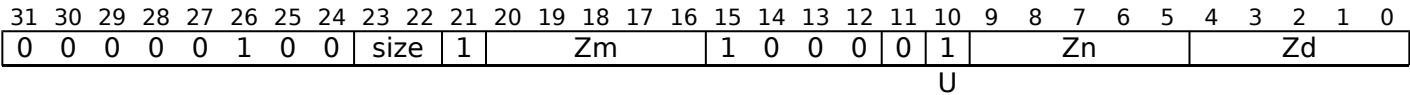
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# LSR (wide elements, unpredicated)

Logical shift right by 64-bit wide elements (unpredicated).

Shift right, inserting zeroes, all elements of the first source vector by corresponding overlapping 64-bit elements of the second source vector and place the first in the corresponding elements of the destination vector. The shift amount is a vector of unsigned 64-bit doubleword elements in which all bits are significant, and not used modulo the destination element size. This instruction is unpredicated.



## SVE

LSR <Zd>.<T>, <Zn>.<T>, <Zm>.D

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	RESERVED

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(64) element2 = Elem[operand2, (e * esize) DIV 64, 64];
    integer shift = Min(UInt(element2), esize);
    Elem[result, e, esize] = LSR(element1, shift);

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

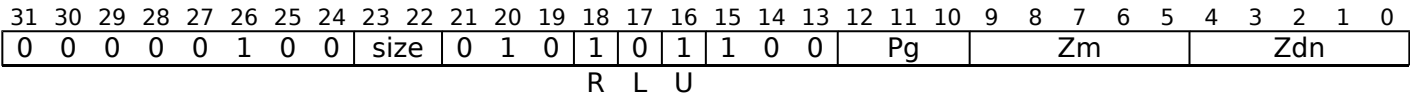
- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.



LSRR

Reversed logical shift right by vector (predicated).

Reversed shift right, inserting zeroes, active elements of the second source vector by corresponding elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. The shift amount operand is a vector of unsigned elements in which all bits are significant, and not used modulo the element size. Inactive elements in the destination vector register remain unmodified.



SVE

LSRR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    integer shift = Min(UInt(element1), esize);
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = LSR(element2, shift);
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.

- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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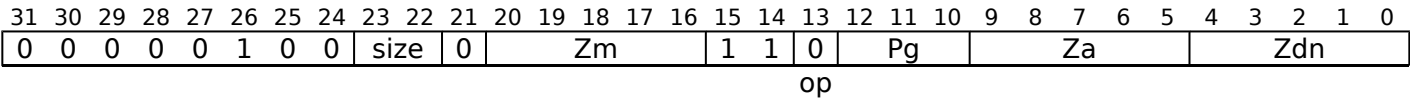
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MAD

Multiply-add vectors (predicated), writing multiplicand [Zdn = Za + Zdn \* Zm].

Multiply the corresponding active elements of the first and second source vectors and add to elements of the third (addend) vector. Destructively place the results in the destination and first source (multiplicand) vector. Inactive elements in the destination vector register remain unmodified.



SVE

```
MAD <Zdn>.<T>, <Pg>/M, <Zm>.<T>, <Za>.<T>
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
integer a = UInt(Za);
boolean sub_op = FALSE;
```

Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <Za> Is the name of the third source scalable vector register, encoded in the "Za" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[a];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, e, esize]);
    if ElemP[mask, e, esize] == '1' then
        integer product = element1 * element2;
        if sub_op then
            Elem[result, e, esize] = Elem[operand3, e, esize] - product;
        else
            Elem[result, e, esize] = Elem[operand3, e, esize] + product;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];
Z[dn] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is

UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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MATCH

Detect any matching elements, setting the condition flags.

This instruction compares each active 8-bit or 16-bit character in the first source vector with all of the characters in the corresponding 128-bit segment of the second source vector. Where the first source element detects any matching characters in the second segment it places true in the corresponding element of the destination predicate, otherwise false. Inactive elements in the destination predicate register are set to zero. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	size	1	Zm			1	0	0	Pg		Zn			0	Pd									

SVE2

```
MATCH <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '1x' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer d = UInt(Pd);
integer n = UInt(Zn);
integer m = UInt(Zm);
```

Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <T> Is the size specifier, encoded in "size<0>":

size<0>	<T>
0	B
1	H
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer eltspersegment = 128 DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(PL) result;

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer segmentbase = e - (e MOD eltspersegment);
        ElemP[result, e, esize] = '0';
        bits(esize) element1 = Elem[operand1, e, esize];
        for i = segmentbase to segmentbase + eltspersegment - 1
            bits(esize) element2 = Elem[operand2, i, esize];
            if element1 == element2 then
                ElemP[result, e, esize] = '1';
    else
        ElemP[result, e, esize] = '0';

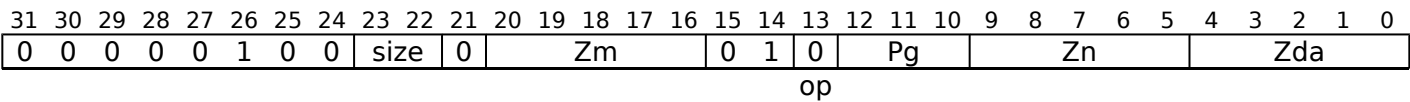
PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```



MLA (vectors)

Multiply-add vectors (predicated), writing addend [Zda = Zda + Zn \* Zm].

Multiply the corresponding active elements of the first and second source vectors and add to elements of the third source (addend) vector. Destructively place the results in the destination and third source (addend) vector. Inactive elements in the destination vector register remain unmodified.



SVE

```
MLA <Zda>.<T>, <Pg>/M, <Zn>.<T>, <Zm>.<T>
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean sub_op = FALSE;
```

Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, e, esize]);
    if ElemP[mask, e, esize] == '1' then
        integer product = element1 * element2;
        if sub_op then
            Elem[result, e, esize] = Elem[operand3, e, esize] - product;
        else
            Elem[result, e, esize] = Elem[operand3, e, esize] + product;
    else
        Elem[result, e, esize] = Elem[operand3, e, esize];
Z[da] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# MLA (indexed)

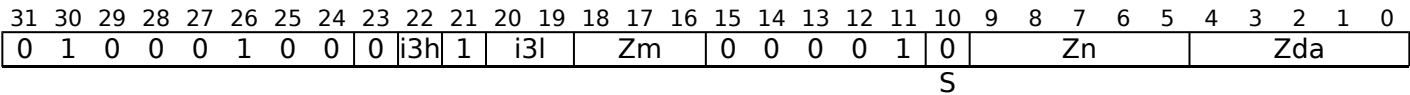
Multiply-add to accumulator (indexed).

Multiply all integer elements within each 128-bit segment of the first source vector by the specified element in the corresponding second source vector segment. The products are then destructively added to the corresponding elements of the addend and destination vector.

The elements within the second source vector are specified using an immediate index which selects the same element position within each 128-bit vector segment. The index range is from 0 to one less than the number of elements per 128-bit segment, encoded in 1 to 3 bits depending on the size of the element. This instruction is unpredicated.

It has encodings from 3 classes: [16-bit](#) , [32-bit](#) and [64-bit](#)

## 16-bit

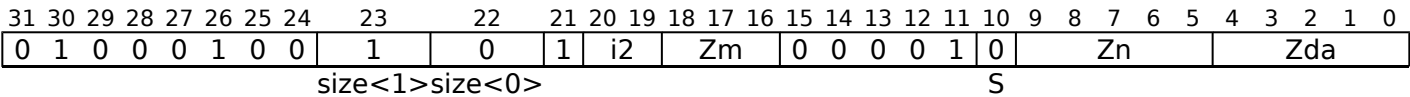


## 16-bit

MLA <Zda>.H, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 16;
integer index = UInt(i3h:i3l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## 32-bit

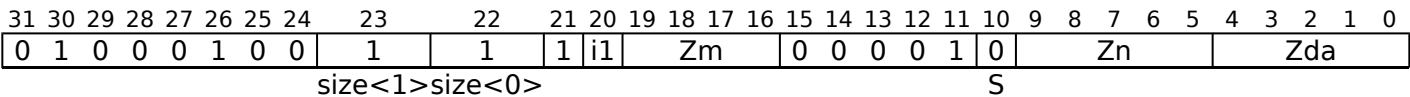


## 32-bit

MLA <Zda>.S, <Zn>.S, <Zm>.S[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## 64-bit



## 64-bit

```
MLA <Zda>.D, <Zn>.D, <Zm>.D[<imm>]
```

```
if !HaveSVE2() then UNDEFINED;
integer esize = 64;
integer index = UInt(i1);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

<Zda>	Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
<Zn>	Is the name of the first source scalable vector register, encoded in the "Zn" field.
<Zm>	For the 16-bit and 32-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  For the 64-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
<imm>	For the 16-bit variant: is the element index, in the range 0 to 7, encoded in the "i3h:i3l" fields. For the 32-bit variant: is the element index, in the range 0 to 3, encoded in the "i2" field. For the 64-bit variant: is the element index, in the range 0 to 1, encoded in the "i1" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer eltspersegment = 128 DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer segmentbase = e - (e MOD eltspersegment);
    integer s = segmentbase + index;
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, s, esize]);
    bits(esize) product = (element1 * element2)<esize-1:0>;
    Elem[result, e, esize] = Elem[result, e, esize] + product;

Z[da] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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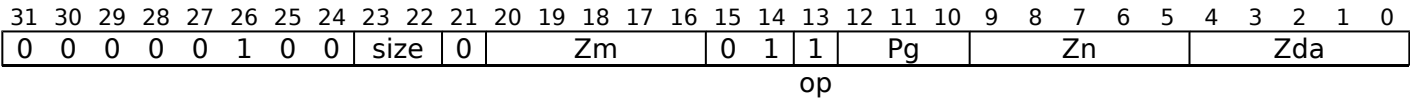
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## MLS (vectors)

Multiply-subtract vectors (predicated), writing addend [ $Zda = Zda - Zn * Zm$ ].

Multiply the corresponding active elements of the first and second source vectors and subtract from elements of the third source (addend) vector. Destructively place the results in the destination and third source (addend) vector. Inactive elements in the destination vector register remain unmodified.



## SVE

MLS <Zda>.<T>, <Pg>/M, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean sub_op = TRUE;
```

## Assembler Symbols

<Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, e, esize]);
    if ElemP[mask, e, esize] == '1' then
        integer product = element1 * element2;
        if sub_op then
            Elem[result, e, esize] = Elem[operand3, e, esize] - product;
        else
            Elem[result, e, esize] = Elem[operand3, e, esize] + product;
    else
        Elem[result, e, esize] = Elem[operand3, e, esize];
Z[da] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# MLS (indexed)

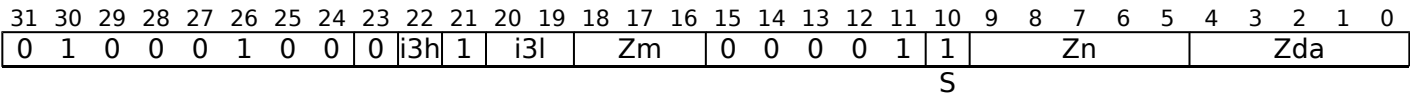
Multiply-subtract from accumulator (indexed).

Multiply all integer elements within each 128-bit segment of the first source vector by the specified element in the corresponding second source vector segment. The products are then destructively subtracted from the corresponding elements of the addend and destination vector.

The elements within the second source vector are specified using an immediate index which selects the same element position within each 128-bit vector segment. The index range is from 0 to one less than the number of elements per 128-bit segment, encoded in 1 to 3 bits depending on the size of the element. This instruction is unpredicated.

It has encodings from 3 classes: [16-bit](#) , [32-bit](#) and [64-bit](#)

## 16-bit

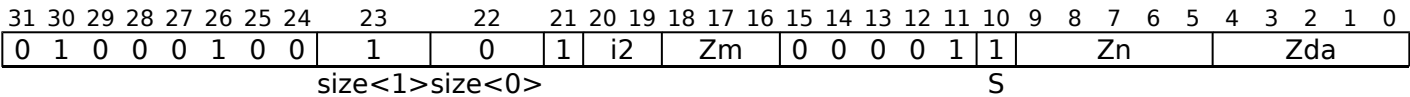


## 16-bit

MLS <Zda>.H, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 16;
integer index = UInt(i3h:i3l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## 32-bit

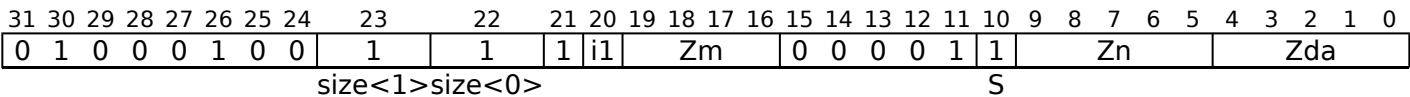


## 32-bit

MLS <Zda>.S, <Zn>.S, <Zm>.S[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## 64-bit



## 64-bit

MLS <Zda>.D, <Zn>.D, <Zm>.D[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 64;
integer index = UInt(i1);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

<Zda>	Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
<Zn>	Is the name of the first source scalable vector register, encoded in the "Zn" field.
<Zm>	For the 16-bit and 32-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  For the 64-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
<imm>	For the 16-bit variant: is the element index, in the range 0 to 7, encoded in the "i3h:i3l" fields. For the 32-bit variant: is the element index, in the range 0 to 3, encoded in the "i2" field. For the 64-bit variant: is the element index, in the range 0 to 1, encoded in the "i1" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer eltspersegment = 128 DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer segmentbase = e - (e MOD eltspersegment);
    integer s = segmentbase + index;
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, s, esize]);
    bits(esize) product = (element1 * element2)<esize-1:0>;
    Elem[result, e, esize] = Elem[result, e, esize] - product;

Z[da] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# MOV (predicate, predicated, zeroing)

Move predicates (zeroing).

Read active elements from the source predicate and place in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Does not set the condition flags.

This is an alias of [AND, ANDS \(predicates\)](#). This means:

- The encodings in this description are named to match the encodings of [AND, ANDS \(predicates\)](#).
- The description of [AND, ANDS \(predicates\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	0	0	0	Pm			0	1	Pg			0	Pn			0	Pd						
S																															

## Not setting the condition flags

MOV <Pd>.B, <Pg>/Z, <Pn>.B

is equivalent to

AND <Pd>.B, <Pg>/Z, <Pn>.B, <Pn>.B

and is the preferred disassembly when `S == '0' && Pn == Pm`.

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.

## Operation

The description of [AND, ANDS \(predicates\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

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# MOV (immediate, predicated, zeroing)

Move signed integer immediate to vector elements (zeroing).

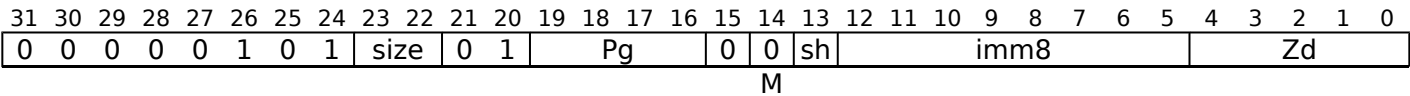
Move a signed integer immediate to each active element in the destination vector. Inactive elements in the destination vector register are set to zero.

The immediate operand is a signed value in the range -128 to +127, and for element widths of 16 bits or higher it may also be a signed multiple of 256 in the range -32768 to +32512 (excluding 0).

The immediate is encoded in 8 bits with an optional left shift by 8. The preferred disassembly when the shift option is specified is "#<simm8>, LSL #8". However an assembler and disassembler may also allow use of the shifted 16-bit value unless the immediate is 0 and the shift amount is 8, which must be unambiguously described as "#0, LSL #8".

This is an alias of [CPY \(immediate, zeroing\)](#). This means:

- The encodings in this description are named to match the encodings of [CPY \(immediate, zeroing\)](#).
- The description of [CPY \(immediate, zeroing\)](#) gives the operational pseudocode for this instruction.



## SVE

MOV <Zd>.<T>, <Pg>/Z, #<imm>{, <shift>}

is equivalent to

[CPY](#) <Zd>.<T>, <Pg>/Z, #<imm>{, <shift>}

and is always the preferred disassembly.

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.

<imm> Is a signed immediate in the range -128 to 127, encoded in the "imm8" field.

<shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #8

## Operation

The description of [CPY \(immediate, zeroing\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:

- The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
- The values of the NZCV flags.

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# MOV (immediate, predicated, merging)

Move signed integer immediate to vector elements (merging).

Move a signed integer immediate to each active element in the destination vector. Inactive elements in the destination vector register remain unmodified.

The immediate operand is a signed value in the range -128 to +127, and for element widths of 16 bits or higher it may also be a signed multiple of 256 in the range -32768 to +32512 (excluding 0).

The immediate is encoded in 8 bits with an optional left shift by 8. The preferred disassembly when the shift option is specified is "#<imm8>, LSL #8". However an assembler and disassembler may also allow use of the shifted 16-bit value unless the immediate is 0 and the shift amount is 8, which must be unambiguously described as "#0, LSL #8".

This is an alias of [CPY \(immediate, merging\)](#). This means:

- The encodings in this description are named to match the encodings of [CPY \(immediate, merging\)](#).
- The description of [CPY \(immediate, merging\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size		0	1	Pg				0	1	sh	imm8								Zd				
M																															

## SVE

MOV <Zd>.<T>, <Pg>/M, #<imm>{, <shift>}

is equivalent to

CPY <Zd>.<T>, <Pg>/M, #<imm>{, <shift>}

and is always the preferred disassembly.

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.

<imm> Is a signed immediate in the range -128 to 127, encoded in the "imm8" field.

<shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #8

## Operation

The description of [CPY \(immediate, merging\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:



- The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
- The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# MOV (scalar, predicated)

Move general-purpose register to vector elements (predicated).

Move the general-purpose scalar source register to each active element in the destination vector. Inactive elements in the destination vector register remain unmodified.

This is an alias of [CPY \(scalar\)](#). This means:

- The encodings in this description are named to match the encodings of [CPY \(scalar\)](#).
- The description of [CPY \(scalar\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	1	0	0	0	1	0	1	Pg	Rn				Zd								

## SVE

MOV [<Zd>.<T>](#), [<Pg>/M](#), [<R><n|SP>](#)

is equivalent to

[CPY <Zd>.<T>](#), [<Pg>/M](#), [<R><n|SP>](#)

and is always the preferred disassembly.

## Assembler Symbols

[<Zd>](#) Is the name of the destination scalable vector register, encoded in the "Zd" field.

[<T>](#) Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

[<Pg>](#) Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

[<R>](#) Is a width specifier, encoded in "size":

size	<R>
01	W
x0	W
11	X

[<n|SP>](#) Is the number [0-30] of the general-purpose source register or the name SP (31), encoded in the "Rn" field.

## Operation

The description of [CPY \(scalar\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# MOV (SIMD&FP scalar, predicated)

Move SIMD&FP scalar register to vector elements (predicated).

Move the SIMD & floating-point scalar source register to each active element in the destination vector. Inactive elements in the destination vector register remain unmodified.

This is an alias of [CPY \(SIMD&FP scalar\)](#). This means:

- The encodings in this description are named to match the encodings of [CPY \(SIMD&FP scalar\)](#).
- The description of [CPY \(SIMD&FP scalar\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	0	0	0	0	1	0	0	Pg	Vn				Zd								

## SVE

MOV <Zd>.<T>, <Pg>/M, <V><n>

is equivalent to

[CPY](#) <Zd>.<T>, <Pg>/M, <V><n>

and is always the preferred disassembly.

## Assembler Symbols

<Zd>	Is the name of the destination scalable vector register, encoded in the "Zd" field.										
<T>	Is the size specifier, encoded in "size": <table><tr><th>size</th><th>&lt;T&gt;</th></tr><tr><td>00</td><td>B</td></tr><tr><td>01</td><td>H</td></tr><tr><td>10</td><td>S</td></tr><tr><td>11</td><td>D</td></tr></table>	size	<T>	00	B	01	H	10	S	11	D
size	<T>										
00	B										
01	H										
10	S										
11	D										
<Pg>	Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.										
<V>	Is a width specifier, encoded in "size": <table><tr><th>size</th><th>&lt;V&gt;</th></tr><tr><td>00</td><td>B</td></tr><tr><td>01</td><td>H</td></tr><tr><td>10</td><td>S</td></tr><tr><td>11</td><td>D</td></tr></table>	size	<V>	00	B	01	H	10	S	11	D
size	<V>										
00	B										
01	H										
10	S										
11	D										
<n>	Is the number [0-31] of the source SIMD&FP register, encoded in the "Vn" field.										

## Operation

The description of [CPY \(SIMD&FP scalar\)](#) gives the operational pseudocode for this instruction.

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# MOV (immediate, unpredicated)

Move signed immediate to vector elements (unpredicated).

Unconditionally broadcast the signed integer immediate into each element of the destination vector. This instruction is unpredicated.

The immediate operand is a signed value in the range -128 to +127, and for element widths of 16 bits or higher it may also be a signed multiple of 256 in the range -32768 to +32512 (excluding 0).

The immediate is encoded in 8 bits with an optional left shift by 8. The preferred disassembly when the shift option is specified is "#<imm8>, LSL #8". However an assembler and disassembler may also allow use of the shifted 16-bit value unless the immediate is 0 and the shift amount is 8, which must be unambiguously described as "#0, LSL #8".

This is an alias of [DUP \(immediate\)](#). This means:

- The encodings in this description are named to match the encodings of [DUP \(immediate\)](#).
- The description of [DUP \(immediate\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	1	1	0	0	0	1	1	sh	imm8								Zd					

## SVE

MOV <Zd>.<T>, #<imm>{, <shift>}

is equivalent to

[DUP](#) <Zd>.<T>, #<imm>{, <shift>}

and is always the preferred disassembly.

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<imm> Is a signed immediate in the range -128 to 127, encoded in the "imm8" field.

<shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #8

## Operation

The description of [DUP \(immediate\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.



# MOV (scalar, unpredicated)

Move general-purpose register to vector elements (unpredicated).

Unconditionally broadcast the general-purpose scalar source register into each element of the destination vector. This instruction is unpredicated.

This is an alias of [DUP \(scalar\)](#). This means:

- The encodings in this description are named to match the encodings of [DUP \(scalar\)](#).
- The description of [DUP \(scalar\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size		1	0	0	0	0	0	0	0	1	1	1	0	Rn				Zd					

## SVE

MOV <Zd>.<T>, <R><n | SP>

is equivalent to

[DUP](#) <Zd>.<T>, <R><n | SP>

and is always the preferred disassembly.

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<R> Is a width specifier, encoded in "size":

size	<R>
01	W
x0	W
11	X

<n|SP> Is the number [0-30] of the general-purpose source register or the name SP (31), encoded in the "Rn" field.

## Operation

The description of [DUP \(scalar\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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MOV (SIMD&FP scalar, unpredicated)

Move indexed element or SIMD&FP scalar to vector (unpredicated).

Unconditionally broadcast the SIMD&FP scalar into each element of the destination vector. This instruction is unpredicated.

This is an alias of [DUP \(indexed\)](#). This means:

- The encodings in this description are named to match the encodings of [DUP \(indexed\)](#).
- The description of [DUP \(indexed\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	imm2		1	tsz				0	0	1	0	0	0	Zn				Zd						

MOV <Zd>.<T>, <Zn>.<T>[<imm>]

is equivalent to

[DUP](#) <Zd>.<T>, <Zn>.<T>[<imm>]

and is the preferred disassembly when BitCount(imm2:tsz) > 1.

MOV <Zd>.<T>, <V><n>

is equivalent to

[DUP](#) <Zd>.<T>, <Zn>.<T>[0]

and is the preferred disassembly when BitCount(imm2:tsz) == 1.

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "tsz":

tsz	<T>
00000	RESERVED
xxxx1	B
xxx10	H
xx100	S
x1000	D
10000	Q

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<imm> Is the immediate index, in the range 0 to one less than the number of elements in 512 bits, encoded in "imm2:tsz".

<V> Is a width specifier, encoded in "tsz":

tsz	<V>
00000	RESERVED
xxxx1	B
xxx10	H
xx100	S
x1000	D
10000	Q

<n> Is the number [0-31] of the source SIMD&FP register, encoded in the "Zn" field.

Operation

The description of [DUP \(indexed\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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MOV (bitmask immediate)

Move logical bitmask immediate to vector (unpredicated).

Unconditionally broadcast the logical bitmask immediate into each element of the destination vector. This instruction is unpredicated. The immediate is a 64-bit value consisting of a single run of ones or zeros repeating every 2, 4, 8, 16, 32 or 64 bits.

This is an alias of DUPM. This means:

- The encodings in this description are named to match the encodings of DUPM.
- The description of DUPM gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	1	1	0	0	0	0	imm13												Zd					

SVE

MOV <Zd>.<T>, #<const>

is equivalent to

DUPM <Zd>.<T>, #<const>

and is the preferred disassembly when SVEMoveMaskPreferred(imm13).

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "imm13<12>:imm13<5:0>":

imm13<12>	imm13<5:0>	<T>
0	0xxxxx	S
0	10xxxx	H
0	110xxx	B
0	1110xx	B
0	11110x	B
0	111110	RESERVED
0	111111	RESERVED
1	xxxxxx	D

<const> Is a 64, 32, 16 or 8-bit bitmask consisting of replicated 2, 4, 8, 16, 32 or 64 bit fields, each field containing a rotated run of non-zero bits, encoded in the "imm13" field.

Operation

The description of DUPM gives the operational pseudocode for this instruction.

Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

## MOV (predicate, unpredicated)

Move predicate (unpredicated).

Read all elements from the source predicate and place in the destination predicate. This instruction is unpredicated. Does not set the condition flags.

This is an alias of [ORR, ORRS \(predicates\)](#). This means:

- The encodings in this description are named to match the encodings of [ORR, ORRS \(predicates\)](#).
- The description of [ORR, ORRS \(predicates\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	1	0	0	0		Pm			0	1		Pg		0			Pn		0			Pd		
S																															

### Not setting the condition flags

MOV <Pd>.B, <Pn>.B

is equivalent to

ORR <Pd>.B, <Pn>/Z, <Pn>.B, <Pn>.B

and is the preferred disassembly when `S == '0' && Pn == Pm && Pm == Pg`.

### Assembler Symbols

<Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.

<Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.

### Operation

The description of [ORR, ORRS \(predicates\)](#) gives the operational pseudocode for this instruction.

### Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# MOV (vector, unpredicated)

Move vector register (unpredicated).  
Move vector register. This instruction is unpredicated.

This is an alias of [ORR \(vectors, unpredicated\)](#). This means:

- The encodings in this description are named to match the encodings of [ORR \(vectors, unpredicated\)](#).
  - The description of [ORR \(vectors, unpredicated\)](#) gives the operational pseudocode for this instruction.
- |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |   |    |   |   |   |    |   |   |   |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|---|---|----|---|---|---|----|---|---|---|
| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7  | 6 | 5 | 4 | 3  | 2 | 1 | 0 |
| 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  | 0  | 1  | 1  |    |    | Zm |    |    | 0  | 0  | 1  | 1  | 0  | 0  |   |   | Zn |   |   |   | Zd |   |   |   |

## SVE

MOV <Zd>.D, <Zn>.D  
is equivalent to  
[ORR](#) <Zd>.D, <Zn>.D, <Zn>.D  
and is the preferred disassembly when Zn == Zm.

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

## Operation

The description of [ORR \(vectors, unpredicated\)](#) gives the operational pseudocode for this instruction.

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# MOV (predicate, predicated, merging)

Move predicates (merging).

Read active elements from the source predicate and place in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register remain unmodified. Does not set the condition flags.

This is an alias of [SEL \(predicates\)](#). This means:

- The encodings in this description are named to match the encodings of [SEL \(predicates\)](#).
- The description of [SEL \(predicates\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	0	0	0	Pm			0	1	Pg			1	Pn			1	Pd						
S																															

## SVE

MOV <Pd>.B, <Pg>/M, <Pn>.B

is equivalent to

SEL <Pd>.B, <Pg>, <Pn>.B, <Pd>.B

and is the preferred disassembly when Pd == Pm.

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.

## Operation

The description of [SEL \(predicates\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

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# MOV (vector, predicated)

Move vector elements (predicated).

Move elements from the source vector to the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

This is an alias of [SEL \(vectors\)](#). This means:

- The encodings in this description are named to match the encodings of [SEL \(vectors\)](#).
- The description of [SEL \(vectors\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1				Zm			1	1		Pg					Zn					Zd		

## SVE

MOV <Zd>.<T>, <Pg>/M, <Zn>.<T>

is equivalent to

SEL <Zd>.<T>, <Pg>, <Zn>.<T>, <Zd>.<T>

and is the preferred disassembly when `Zd == Zm`.

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

## Operation

The description of [SEL \(vectors\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

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# MOVPRFX (predicated)

Move prefix (predicated).

The predicated MOVPRFX instruction is a hint to hardware that the instruction may be combined with the destructive instruction which follows it in program order to create a single constructive operation. Since it is a hint it is also permitted to be implemented as a discrete vector copy, and the result of executing the pair of instructions with or without combining is identical. The choice of combined versus discrete operation may vary dynamically. Unless the combination of a constructive operation with merging predication is specifically required, it is strongly recommended that for performance reasons software should prefer to use the zeroing form of predicated MOVPRFX or the unpredicated MOVPRFX instruction.

Although the operation of the instruction is defined as a simple predicated vector copy, it is required that the prefixed instruction at PC+4 must be an SVE destructive binary or ternary instruction encoding, or a unary operation with merging predication, but excluding other MOVPRFX instructions. The prefixed instruction must specify the same predicate register, and have the same maximum element size (ignoring a fixed 64-bit "wide vector" operand), and the same destination vector as the MOVPRFX instruction. The prefixed instruction must not use the destination register in any other operand position, even if they have different names but refer to the same architectural register state. Any other use is UNPREDICTABLE.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	0	0	0	M	0	0	1	Pg						Zn					Zd		

## SVE

MOVPRFX <Zd>.<T>, <Pg>/<ZM>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean merging = (M == '1');
```

## Assembler Symbols

- <Zd>

Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <ZM>

Is the predication qualifier, encoded in "M":

M	<ZM>
0	Z
1	M
- <Zn>

Is the name of the source scalable vector register, encoded in the "Zn" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[n];
bits(VL) dest = Z[d];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element = Elem[operand1, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = element;
    elseif merging then
        Elem[result, e, esize] = Elem[dest, e, esize];
    else
        Elem[result, e, esize] = Zeros();

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

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# MOVPRFX (unpredicated)

Move prefix (unpredicated).

The unpredicated MOVPRFX instruction is a hint to hardware that the instruction may be combined with the destructive instruction which follows it in program order to create a single constructive operation. Since it is a hint it is also permitted to be implemented as a discrete vector copy, and the result of executing the pair of instructions with or without combining is identical. The choice of combined versus discrete operation may vary dynamically. Although the operation of the instruction is defined as a simple unpredicated vector copy, it is required that the prefixed instruction at PC+4 must be an SVE destructive binary or ternary instruction encoding, or a unary operation with merging predication, but excluding other MOVPRFX instructions. The prefixed instruction must specify the same destination vector as the MOVPRFX instruction. The prefixed instruction must not use the destination register in any other operand position, even if they have different names but refer to the same architectural register state. Any other use is UNPREDICTABLE.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	1	1	1	1	Zn				Zd					

## SVE

MOVPRFX <Zd>, <Zn>

```
if !HaveSVE() then UNDEFINED;
integer n = UInt(Zn);
integer d = UInt(Zd);
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
bits(VL) result = Z[n];
Z[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# MOVS (predicated)

Move predicates (zeroing), setting the condition flags.

Read active elements from the source predicate and place in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

This is an alias of [AND, ANDS \(predicates\)](#). This means:

- The encodings in this description are named to match the encodings of [AND, ANDS \(predicates\)](#).
- The description of [AND, ANDS \(predicates\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	1	0	0	Pm			0	1	Pg			0	Pn			0	Pd						
S																															

## Setting the condition flags

MOVS <Pd>.B, <Pg>/Z, <Pn>.B

is equivalent to

ANDS <Pd>.B, <Pg>/Z, <Pn>.B, <Pn>.B

and is the preferred disassembly when S == '1' && Pn == Pm.

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.

## Operation

The description of [AND, ANDS \(predicates\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

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# MOVS (unpredicated)

Move predicate (unpredicated), setting the condition flags.

Read all elements from the source predicate and place in the destination predicate. This instruction is unpredicated. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

This is an alias of [ORR, ORRS \(predicates\)](#). This means:

- The encodings in this description are named to match the encodings of [ORR, ORRS \(predicates\)](#).
- The description of [ORR, ORRS \(predicates\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	1	1	0	0	Pm			0	1	Pg			0	Pn			0	Pd						
S																															

## Setting the condition flags

MOVS <Pd>.B, <Pn>.B

is equivalent to

ORRS <Pd>.B, <Pn>/Z, <Pn>.B, <Pn>.B

and is the preferred disassembly when `S == '1' && Pn == Pm && Pm == Pg`.

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.

## Operation

The description of [ORR, ORRS \(predicates\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

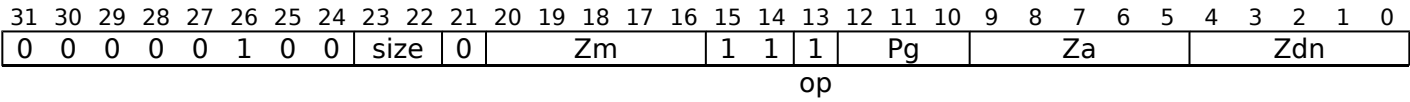
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MSB

Multiply-subtract vectors (predicated), writing multiplicand [ $Zdn = Za - Zdn * Zm$ ].

Multiply the corresponding active elements of the first and second source vectors and subtract from elements of the third (addend) vector. Destructively place the results in the destination and first source (multiplicand) vector. Inactive elements in the destination vector register remain unmodified.



SVE

```
MSB <Zdn>.<T>, <Pg>/M, <Zm>.<T>, <Za>.<T>
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
integer a = UInt(Za);
boolean sub_op = TRUE;
```

Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <Za> Is the name of the third source scalable vector register, encoded in the "Za" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[a];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, e, esize]);
    if ElemP[mask, e, esize] == '1' then
        integer product = element1 * element2;
        if sub_op then
            Elem[result, e, esize] = Elem[operand3, e, esize] - product;
        else
            Elem[result, e, esize] = Elem[operand3, e, esize] + product;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];
Z[dn] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is

UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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## MUL (vectors, predicated)

Multiply vectors (predicated).

Multiply active elements of the first source vector by corresponding elements of the second source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	0	0	0	0	0	0	0	0	Pg	Zm			Zdn								
														H		U															

### SVE

MUL <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

### Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, e, esize]);
    if ElemP[mask, e, esize] == '1' then
        integer product = element1 * element2;
        Elem[result, e, esize] = product<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

### Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.

- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# MUL (immediate)

Multiply by immediate (unpredicated).

Multiply by an immediate each element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate is a signed 8-bit value in the range -128 to +127, inclusive. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size		1	1	0	0	0	0	1	1	0	imm8								Zdn				

## SVE

MUL <Zdn>.<T>, <Zdn>.<T>, #<imm>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer dn = UInt(Zdn);
integer imm = SInt(imm8);
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <imm> Is the signed immediate operand, in the range -128 to 127, encoded in the "imm8" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, e, esize]);
    Elem[result, e, esize] = (element1 * imm)<esize-1:0>;

Z[dn] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



MUL (vectors, unpredicated)

Multiply vectors (unpredicated).

Multiply all elements of the first source vector by corresponding elements of the second source vector and place the results in the corresponding elements of the destination vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	1				Zm			0	1	1	0	0	0			Zn					Zd		

SVE2

MUL <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, e, esize]);
    integer product = element1 * element2;
    Elem[result, e, esize] = product<esize-1:0>;

Z[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
  - The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# MUL (indexed)

Multiply (indexed).

Multiply all integer elements within each 128-bit segment of the first source vector by the specified element in the corresponding second source vector segment. The results are placed in the corresponding elements of the destination vector.

The elements within the second source vector are specified using an immediate index which selects the same element position within each 128-bit vector segment. The index range is from 0 to one less than the number of elements per 128-bit segment, encoded in 1 to 3 bits depending on the size of the element. This instruction is unpredicated.

It has encodings from 3 classes: [16-bit](#) , [32-bit](#) and [64-bit](#)

## 16-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	0	i3h	1	i3l	Zm				1	1	1	1	1	0	Zn				Zd					

## 16-bit

MUL <Zd>.H, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 16;
integer index = UInt(i3h:i3l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## 32-bit

31	30	29	28	27	26	25	24	23		22		21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	1	0	1	i2	Zm		1	1	1	1	1	0	Zn				Zd									
size<1>size<0>																																	

## 32-bit

MUL <Zd>.S, <Zn>.S, <Zm>.S[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## 64-bit

31	30	29	28	27	26	25	24	23				22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	1				1	i1	Zm				1	1	1	1	1	0	Zn				Zd						
size<1>size<0>																																		

## 64-bit

MUL <Zd>.D, <Zn>.D, <Zm>.D[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 64;
integer index = UInt(i1);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd>	Is the name of the destination scalable vector register, encoded in the "Zd" field.
<Zn>	Is the name of the first source scalable vector register, encoded in the "Zn" field.
<Zm>	For the 16-bit and 32-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  For the 64-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
<imm>	For the 16-bit variant: is the element index, in the range 0 to 7, encoded in the "i3h:i3l" fields.  For the 32-bit variant: is the element index, in the range 0 to 3, encoded in the "i2" field.  For the 64-bit variant: is the element index, in the range 0 to 1, encoded in the "i1" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer eltspersegment = 128 DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer segmentbase = e - (e MOD eltspersegment);
    integer s = segmentbase + index;
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, s, esize]);
    integer res = element1 * element2;
    Elem[result, e, esize] = res<esize-1:0>;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# NAND, NANDS

Bitwise NAND predicates.

Bitwise NAND active elements of the second source predicate with corresponding elements of the first source predicate and place the results in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Optionally sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

It has encodings from 2 classes: [Not setting the condition flags](#) and [Setting the condition flags](#)

## Not setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	1	0	0	0	Pm			0	1	Pg			1	Pn			1	Pd						
S																															

## Not setting the condition flags

NAND <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = FALSE;
```

## Setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	1	1	0	0	Pm			0	1	Pg			1	Pn			1	Pd						
S																															

## Setting the condition flags

NANDS <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = TRUE;
```

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.
- <Pm> Is the name of the second source scalable predicate register, encoded in the "Pm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(PL) operand1 = P[n];
bits(PL) operand2 = P[m];
bits(PL) result;

for e = 0 to elements-1
    bit element1 = ElemP[operand1, e, esize];
    bit element2 = ElemP[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        ElemP[result, e, esize] = NOT(element1 AND element2);
    else
        ElemP[result, e, esize] = '0';

if setflags then
    PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

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NBSL

Bitwise inverted select.

Selects bits from the first source vector where the corresponding bit in the third source vector is '1', and from the second source vector where the corresponding bit in the third source vector is '0'. The inverted result is placed destructively in the destination and first source vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	1	1	Zm				0	0	1	1	1	1	1	Zk				Zdn					

SVE2

NBSL <Zdn>.D, <Zdn>.D, <Zm>.D, <Zk>.D

```
if !HaveSVE2() then UNDEFINED;
integer m = UInt(Zm);
integer k = UInt(Zk);
integer dn = UInt(Zdn);
```

Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <Zk> Is the name of the third source scalable vector register, encoded in the "Zk" field.

Operation

```
CheckSVEEnabled();
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[k];

Z[dn] = NOT((operand1 AND operand3) OR (operand2 AND NOT(operand3)));
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



# NEG

Negate (predicated).

Negate the signed integer value in each active element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	0	1	1	1	1	0	1	Pg													

## SVE

NEG <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    integer element = SInt(Elem[operand, e, esize]);
    if ElemP[mask, e, esize] == '1' then
        element = -element;
        Elem[result, e, esize] = element<esize-1:0>;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# NMATCH

Detect no matching elements, setting the condition flags.

This instruction compares each active 8-bit or 16-bit character in the first source vector with all of the characters in the corresponding 128-bit segment of the second source vector. Where the first source element detects no matching characters in the second segment it places true in the corresponding element of the destination predicate, otherwise false. Inactive elements in the destination predicate register are set to zero. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	size	1	Zm			1	0	0	Pg		Zn			1	Pd									

## SVE2

NMATCH <Pd>.<T>, <Pg>/Z, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
if size == '1x' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer d = UInt(Pd);
integer n = UInt(Zn);
integer m = UInt(Zm);
```

## Assembler Symbols

- <Pd>

Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <T>

Is the size specifier, encoded in "size<0>":

size<0>	<T>
0	B
1	H
- <Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn>

Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm>

Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer eltspersegment = 128 DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(PL) result;

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer segmentbase = e - (e MOD eltspersegment);
        ElemP[result, e, esize] = '1';
        bits(esize) element1 = Elem[operand1, e, esize];
        for i = segmentbase to segmentbase + eltspersegment - 1
            bits(esize) element2 = Elem[operand2, i, esize];
            if element1 == element2 then
                ElemP[result, e, esize] = '0';
    else
        ElemP[result, e, esize] = '0';

PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```



# NOR, NORS

Bitwise NOR predicates.

Bitwise NOR active elements of the second source predicate with corresponding elements of the first source predicate and place the results in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Optionally sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

It has encodings from 2 classes: [Not setting the condition flags](#) and [Setting the condition flags](#)

## Not setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	1	0	0	0	Pm			0	1	Pg			1	Pn			0	Pd						
S																															

## Not setting the condition flags

NOR <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = FALSE;
```

## Setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	1	1	0	0	Pm			0	1	Pg			1	Pn			0	Pd						
S																															

## Setting the condition flags

NORS <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = TRUE;
```

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.
- <Pm> Is the name of the second source scalable predicate register, encoded in the "Pm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(PL) operand1 = P[n];
bits(PL) operand2 = P[m];
bits(PL) result;

for e = 0 to elements-1
    bit element1 = ElemP[operand1, e, esize];
    bit element2 = ElemP[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        ElemP[result, e, esize] = NOT(element1 OR element2);
    else
        ElemP[result, e, esize] = '0';

if setflags then
    PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

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# NOT (predicate)

Bitwise invert predicate.

Bitwise invert each active element of the source predicate, and place the results in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Does not set the condition flags.

This is an alias of [EOR, EORS \(predicates\)](#). This means:

- The encodings in this description are named to match the encodings of [EOR, EORS \(predicates\)](#).
- The description of [EOR, EORS \(predicates\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	0	0	0	Pm				0	1	Pg				1	Pn				0	Pd			
S																															

## Not setting the condition flags

NOT <Pd>.B, <Pg>/Z, <Pn>.B

is equivalent to

EOR <Pd>.B, <Pg>/Z, <Pn>.B, <Pg>.B

and is the preferred disassembly when Pm == Pg.

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.

## Operation

The description of [EOR, EORS \(predicates\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

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# NOT (vector)

Bitwise invert vector (predicated).

Bitwise invert each active element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	1	1	0	1	0	1	Pg				Zn				Zd					

## SVE

NOT <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    bits(esize) element = Elem[operand, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = NOT element;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:



- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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NOTS

Bitwise invert predicate, setting the condition flags.

Bitwise invert each active element of the source predicate, and place the results in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

This is an alias of [EOR, EORS \(predicates\)](#). This means:

- The encodings in this description are named to match the encodings of [EOR, EORS \(predicates\)](#).
- The description of [EOR, EORS \(predicates\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	1	0	0	Pm			0	1	Pg			1	Pn			0	Pd						
S																															

Setting the condition flags

NOTS <Pd>.B, <Pg>/Z, <Pn>.B

is equivalent to

[EORS](#) <Pd>.B, <Pg>/Z, <Pn>.B, <Pg>.B

and is the preferred disassembly when Pm == Pg.

Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.

Operation

The description of [EOR, EORS \(predicates\)](#) gives the operational pseudocode for this instruction.

Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

# ORN (immediate)

Bitwise inclusive OR with inverted immediate (unpredicated).

Bitwise inclusive OR an inverted immediate with each 64-bit element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate is a 64-bit value consisting of a single run of ones or zeros repeating every 2, 4, 8, 16, 32 or 64 bits. This instruction is unpredicated.

This is a pseudo-instruction of [ORR \(immediate\)](#). This means:

- The encodings in this description are named to match the encodings of [ORR \(immediate\)](#).
- The assembler syntax is used only for assembly, and is not used on disassembly.
- The description of [ORR \(immediate\)](#) gives the operational pseudocode for this instruction.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	0	0	0	0	0	0	imm13														Zdn			

## SVE

ORN <Zdn>.<T>, <Zdn>.<T>, #<const>

is equivalent to

[ORR <Zdn>.<T>, <Zdn>.<T>, #\(-<const> - 1\)](#)

## Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "imm13<12>:imm13<5:0>":

imm13<12>	imm13<5:0>	<T>
0	0xxxxx	S
0	10xxxx	H
0	110xxx	B
0	1110xx	B
0	11110x	B
0	111110	RESERVED
0	111111	RESERVED
1	xxxxxx	D

<const> Is a 64, 32, 16 or 8-bit bitmask consisting of replicated 2, 4, 8, 16, 32 or 64 bit fields, each field containing a rotated run of non-zero bits, encoded in the "imm13" field.

## Operation

The description of [ORR \(immediate\)](#) gives the operational pseudocode for this instruction.

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



# ORN, ORNS (predicates)

Bitwise inclusive OR inverted predicate.

Bitwise inclusive OR inverted active elements of the second source predicate with corresponding elements of the first source predicate and place the results in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Optionally sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

It has encodings from 2 classes: [Not setting the condition flags](#) and [Setting the condition flags](#)

## Not setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	1	0	0	0	Pm			0	1	Pg			0	Pn			1	Pd						
S																															

## Not setting the condition flags

ORN <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = FALSE;
```

## Setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	1	1	0	0	Pm			0	1	Pg			0	Pn			1	Pd						
S																															

## Setting the condition flags

ORNS <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = TRUE;
```

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.
- <Pm> Is the name of the second source scalable predicate register, encoded in the "Pm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(PL) operand1 = P[n];
bits(PL) operand2 = P[m];
bits(PL) result;

for e = 0 to elements-1
    bit element1 = ElemP[operand1, e, esize];
    bit element2 = ElemP[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        ElemP[result, e, esize] = element1 OR (NOT element2);
    else
        ElemP[result, e, esize] = '0';

if setflags then
    PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

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# ORR, ORRS (predicates)

Bitwise inclusive OR predicate.

Bitwise inclusive OR active elements of the second source predicate with corresponding elements of the first source predicate and place the results in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Optionally sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

This instruction is used by the aliases [MOVS \(unpredicated\)](#), and [MOV \(predicate, unpredicated\)](#).

It has encodings from 2 classes: [Not setting the condition flags](#) and [Setting the condition flags](#)

## Not setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	1	0	0	0	Pm				0	1	Pg				0	Pn				0	Pd			
S																															

## Not setting the condition flags

ORR <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```

if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = FALSE;
    
```

## Setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	1	1	0	0	Pm				0	1	Pg				0	Pn				0	Pd			
S																															

## Setting the condition flags

ORRS <Pd>.B, <Pg>/Z, <Pn>.B, <Pm>.B

```

if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
boolean setflags = TRUE;
    
```

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.
- <Pm> Is the name of the second source scalable predicate register, encoded in the "Pm" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">MOVS (unpredicated)</a>	S == '1' && Pn == Pm && Pm == Pg

**Alias**[MOV \(predicate, unpredicated\)](#)**Is preferred when** $S == '0' \ \&\& \ P_n == P_m \ \&\& \ P_m == P_g$ **Operation**

```

CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(PL) operand1 = P[n];
bits(PL) operand2 = P[m];
bits(PL) result;

for e = 0 to elements-1
    bit element1 = ElemP[operand1, e, esize];
    bit element2 = ElemP[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        ElemP[result, e, esize] = element1 OR element2;
    else
        ElemP[result, e, esize] = '0';

if setflags then
    PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;

```

**Operational information**

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

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# ORR (vectors, predicated)

Bitwise inclusive OR vectors (predicated).

Bitwise inclusive OR active elements of the second source vector with corresponding elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	0	0	0	0	0	0	0	Pg	Zm				Zdn							

## SVE

ORR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = element1 OR element2;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:

- The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
- The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# ORR (immediate)

Bitwise inclusive OR with immediate (unpredicated).

Bitwise inclusive OR an immediate with each 64-bit element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate is a 64-bit value consisting of a single run of ones or zeros repeating every 2, 4, 8, 16, 32 or 64 bits. This instruction is unpredicated.

This instruction is used by the pseudo-instruction [ORN \(immediate\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	0	0	0	0	0	0	imm13														Zdn			

## SVE

ORR <Zdn>.<T>, <Zdn>.<T>, #<const>

```
if !HaveSVE() then UNDEFINED;
integer dn = UInt(Zdn);
bits(64) imm;
(imm, -) = DecodeBitMasks(imm13<12>, imm13<5:0>, imm13<11:6>, TRUE);
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "imm13<12>:imm13<5:0>":

imm13<12>	imm13<5:0>	<T>
0	0xxxxx	S
0	10xxxx	H
0	110xxx	B
0	1110xx	B
0	11110x	B
0	111110	RESERVED
0	111111	RESERVED
1	xxxxxx	D

- <const> Is a 64, 32, 16 or 8-bit bitmask consisting of replicated 2, 4, 8, 16, 32 or 64 bit fields, each field containing a rotated run of non-zero bits, encoded in the "imm13" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV 64;
bits(VL) operand = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    bits(64) element1 = Elem[operand, e, 64];
    Elem[result, e, 64] = element1 OR imm;

Z[dn] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# ORR (vectors, unpredicated)

Bitwise inclusive OR vectors (unpredicated).

Bitwise inclusive OR all elements of the second source vector with corresponding elements of the first source vector and place the first in the corresponding elements of the destination vector. This instruction is unpredicated.

This instruction is used by the alias [MOV \(vector, unpredicated\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	1	1	Zm					0	0	1	1	0	0	Zn					Zd				

## SVE

ORR <Zd>.D, <Zn>.D, <Zm>.D

```
if !HaveSVE() then UNDEFINED;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">MOV (vector, unpredicated)</a>	Zn == Zm

## Operation

```
CheckSVEEnabled();
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];

Z[d] = operand1 OR operand2;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

ORV

Bitwise inclusive OR reduction to scalar.

Bitwise inclusive OR horizontally across all lanes of a vector, and place the result in the SIMD&FP scalar destination register. Inactive elements in the source vector are treated as zero.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	0	0	0	0	0	1	Pg													

SVE

ORV <V><d>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);
```

Assembler Symbols

<V> Is a width specifier, encoded in "size":

size	<V>
00	B
01	H
10	S
11	D

<d> Is the number [0-31] of the destination SIMD&FP register, encoded in the "Vd" field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(esize) result = Zeros(esize);

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        result = result OR Elem[operand, e, esize];

V[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:

- The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
- The values of the NZCV flags.

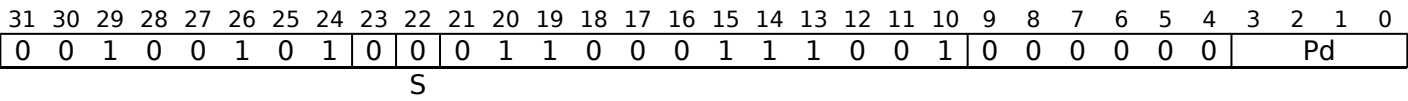
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PFALSE

Set all predicate elements to false.

Set all elements in the destination predicate to false.



SVE

```
PFALSE <Pd>.B

if !HaveSVE() then UNDEFINED;
integer d = UInt(Pd);
```

Assembler Symbols

<Pd>            Is the name of the destination scalable predicate register, encoded in the "Pd" field.

Operation

```
CheckSVEEnabled();
P[d] = Zeros(PL);
```

Operational information

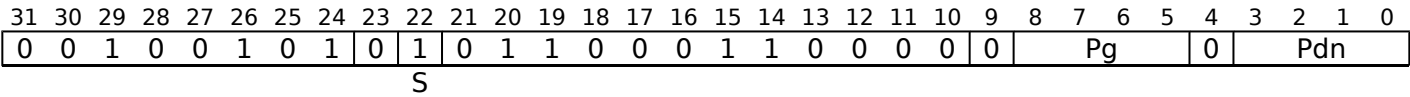
- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.



PFIRST

Set the first active predicate element to true.

Sets the first active element in the destination predicate to true, otherwise elements from the source predicate are passed through unchanged. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.



SVE

```
PFIRST <Pdn>.B, <Pg>, <Pdn>.B
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer dn = UInt(Pdn);
```

Assembler Symbols

- <Pdn> Is the name of the source and destination scalable predicate register, encoded in the "Pdn" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(PL) result = P[dn];
integer first = -1;

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' && first == -1 then
        first = e;

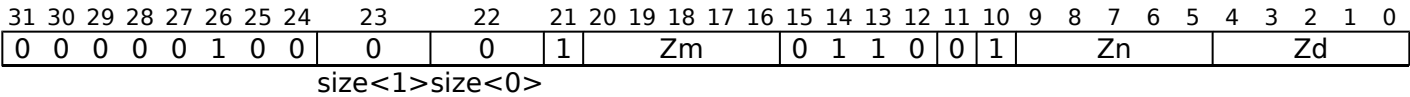
if first >= 0 then
    ElemP[result, first, esize] = '1';

PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[dn] = result;
```

# PMUL

Polynomial multiply vectors (unpredicated).

Polynomial multiply over [0, 1] all elements of the second source vector to corresponding elements of the first source vector and place the results in the corresponding elements of the destination vector. This instruction is unpredicated.



## SVE2

PMUL <Zd>.B, <Zn>.B, <Zm>.B

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = PolynomialMult(element1, element2)<esize-1:0>;

Z[d] = result;
```

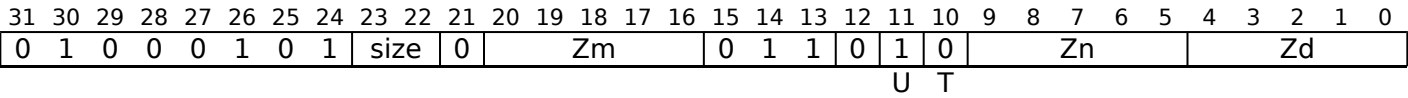
## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

PMULLB

Polynomial multiply long (bottom).

Polynomial multiply over [0, 1] the corresponding even-numbered elements of the first and second source vectors, and place the results in the overlapping double-width elements of the destination vector. This instruction is unpredicated. ID\_AA64ZFR0\_EL1.AES indicates whether the instruction variant with 64-bit source and 128-bit destination elements is implemented.



SVE2

```
PMULLB <Zd>.<T>, <Zn>.<Tb>, <Zm>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' && !HaveSVE2PMULL128() then UNDEFINED;
case size of
  when '00' esize = 128;
  when '01' esize = 16;
  when '10' UNDEFINED;
  when '11' esize = 64;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	Q
01	H
10	RESERVED
11	D

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	D
01	B
10	RESERVED
11	S

- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
  bits(esize DIV 2) element1 = Elem[operand1, 2*e + 0, esize DIV 2];
  bits(esize DIV 2) element2 = Elem[operand2, 2*e + 0, esize DIV 2];
  Elem[result, e, esize] = PolynomialMult(element1, element2);

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

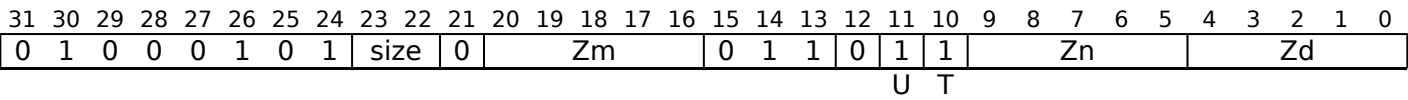
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PMULLT

Polynomial multiply long (top).

Polynomial multiply over [0, 1] the corresponding odd-numbered elements of the first and second source vectors, and place the results in the overlapping double-width elements of the destination vector. This instruction is unpredicated. ID\_AA64ZFR0\_EL1.AES indicates whether the instruction variant with 64-bit source and 128-bit destination elements is implemented.



SVE2

```
PMULLT <Zd>.<T>, <Zn>.<Tb>, <Zm>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' && !HaveSVE2PMULL128() then UNDEFINED;
case size of
    when '00' esize = 128;
    when '01' esize = 16;
    when '10' UNDEFINED;
    when '11' esize = 64;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	Q
01	H
10	RESERVED
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	D
01	B
10	RESERVED
11	S

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize DIV 2) element1 = Elem[operand1, 2*e + 1, esize DIV 2];
    bits(esize DIV 2) element2 = Elem[operand2, 2*e + 1, esize DIV 2];
    Elem[result, e, esize] = PolynomialMult(element1, element2);

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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PNEXT

Find next active predicate.

An instruction used to construct a loop which iterates over all active elements in a predicate. If all source predicate elements are false it sets the first active predicate element in the destination predicate to true. Otherwise it determines the next active predicate element following the last true source predicate element, and if one is found sets the corresponding destination predicate element to true. All other destination predicate elements are set to false. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	0	1	1	0	0	1	1	1	0	0	0	1	0			Pg		0			Pdn		

SVE

```
PNEXT <Pdn>.<T>, <Pg>, <Pdn>.<T>
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Pdn);
```

Assembler Symbols

- <Pdn> Is the name of the source and destination scalable predicate register, encoded in the "Pdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(PL) operand = P[dn];
bits(PL) result;

integer next = LastActiveElement(operand, esize) + 1;

while next < elements && (ElemP[mask, next, esize] == '0') do
    next = next + 1;

result = Zeros();
if next < elements then
    ElemP[result, next, esize] = '1';

PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[dn] = result;
```

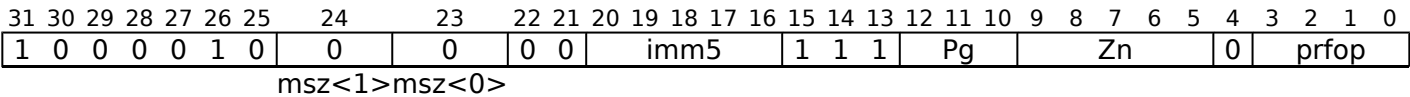
# PRFB (vector plus immediate)

Gather prefetch bytes (vector plus immediate).

Gather prefetch of bytes from the active memory addresses generated by a vector base plus immediate index. The index is in the range 0 to 31. Inactive addresses are not prefetched from memory.  
The <prfop> symbol specifies the prefetch hint as a combination of three options: access type PLD for load or PST for store; target cache level L1, L2 or L3; temporality (KEEP for temporal or STRM for non-temporal).

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

## 32-bit element

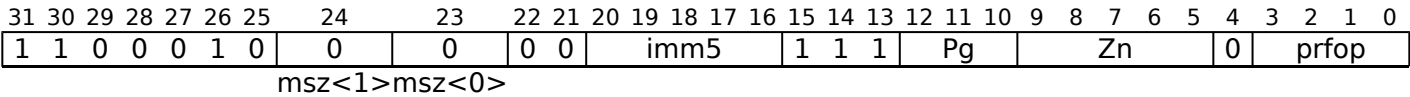


## 32-bit element

PRFB <prfop>, <Pg>, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 0;
integer offset = UInt(imm5);
```

## 64-bit element



## 64-bit element

PRFB <prfop>, <Pg>, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 0;
integer offset = UInt(imm5);
```

## Assembler Symbols

<prfop> Is the prefetch operation specifier, encoded in “prfop”:



prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, in the range 0 to 31, defaulting to 0, encoded in the "imm5" field.

## Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) base;
bits(64) addr;
base = Z[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = ZeroExtend(Elem[base, e, esize], 64) + (offset << scale);
        Hint_Prefetch(addr, pref_hint, level, stream);

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

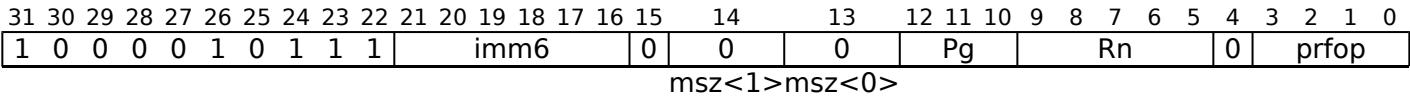
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PRFB (scalar plus immediate)

Contiguous prefetch bytes (immediate index).

Contiguous prefetch of byte elements from the memory address generated by a 64-bit scalar base and immediate index in the range -32 to 31 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address.

The predicate may be used to suppress prefetches from unwanted addresses.



SVE

PRFB <prfop>, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 0;
integer offset = SInt(imm6);
```

Assembler Symbols

<prfop> Is the prefetch operation specifier, encoded in “prfop”:

prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -32 to 31, defaulting to 0, encoded in the "imm6" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) base;
bits(64) addr;

if n == 31 then
    base = SP[];
else
    base = X[n];

addr = base + ((offset * elements) << scale);
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Hint_Prefetch(addr, pref_hint, level, stream);
    addr = addr + (1 << scale);
```

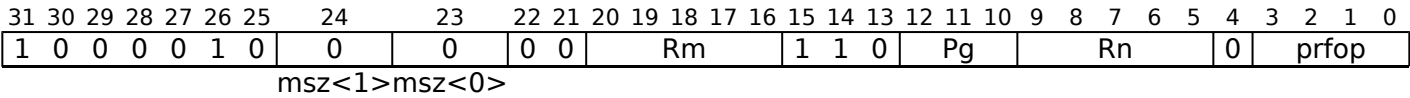
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PRFB (scalar plus scalar)

Contiguous prefetch bytes (scalar index).

Contiguous prefetch of byte elements from the memory address generated by a 64-bit scalar base and scalar index which is added to the base address. After each element prefetch the index value is incremented, but the index register is not updated.  
The predicate may be used to suppress prefetches from unwanted addresses.



SVE

PRFB <prfop>, <Pg>, [<Xn|SP>, <Xm>]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 0;
```

Assembler Symbols

<prfop> Is the prefetch operation specifier, encoded in “prfop”:

prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) base;
bits(64) offset = X[m];
bits(64) addr;

if n == 31 then
    base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = base + (UInt(offset) << scale);
        Hint_Prefetch(addr, pref_hint, level, stream);
    offset = offset + 1;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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## PRFB (scalar plus vector)

Gather prefetch bytes (scalar plus vector).

Gather prefetch of bytes from the active memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally sign or zero-extended from 32 to 64 bits. Inactive addresses are not prefetched from memory.

The <prfop> symbol specifies the prefetch hint as a combination of three options: access type PLD for load or PST for store; target cache level L1, L2 or L3; temporality (KEEP for temporal or STRM for non-temporal).

It has encodings from 3 classes: [32-bit scaled offset](#) , [32-bit unpacked scaled offset](#) and [64-bit scaled offset](#)

### 32-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	0	xs	1	Zm				0	0	0	Pg	Rn				0	prfop							
msz<1>msz<0>																															

### 32-bit scaled offset

PRFB <prfop>, <Pg>, [<Xn|SP>, <Zm>.S, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer offs_size = 32;
boolean offs_unsigned = (xs == '0');
integer scale = 0;
```

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	xs	1	Zm				0	0	0	Pg	Rn				0	prfop							
msz<1>msz<0>																															

### 32-bit unpacked scaled offset

PRFB <prfop>, <Pg>, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer offs_size = 32;
boolean offs_unsigned = (xs == '0');
integer scale = 0;
```

### 64-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	1	1	Zm				1	0	0	Pg	Rn				0	prfop							
msz<1>msz<0>																															

64-bit scaled offset

```
PRFB <prfop>, <Pg>, [<Xn|SP>, <Zm>.D]

if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer offs_size = 64;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

Assembler Symbols

<prfop> Is the prefetch operation specifier, encoded in “prfop”:

prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in “xs”:

xs	<mod>
0	UXTW
1	SXTW

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) base;
bits(64) addr;
bits(VL) offset;

if n == 31 then
    base = SP[];
else
    base = X[n];
offset = Z[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        addr = base + (off << scale);
        Hint_Prefetch(addr, pref_hint, level, stream);
```





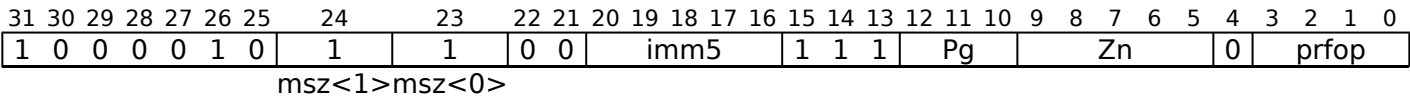
# PRFD (vector plus immediate)

Gather prefetch doublewords (vector plus immediate).

Gather prefetch of doublewords from the active memory addresses generated by a vector base plus immediate index. The index is a multiple of 8 in the range 0 to 248. Inactive addresses are not prefetched from memory. The <prfop> symbol specifies the prefetch hint as a combination of three options: access type PLD for load or PST for store; target cache level L1, L2 or L3; temporality (KEEP for temporal or STRM for non-temporal).

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

## 32-bit element

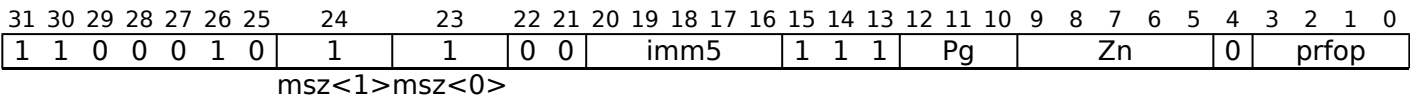


## 32-bit element

PRFD <prfop>, <Pg>, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 3;
integer offset = UInt(imm5);
```

## 64-bit element



## 64-bit element

PRFD <prfop>, <Pg>, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 3;
integer offset = UInt(imm5);
```

## Assembler Symbols

<prfop> Is the prefetch operation specifier, encoded in “prfop”:

prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 8 in the range 0 to 248, defaulting to 0, encoded in the "imm5" field.

## Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) base;
bits(64) addr;
base = Z[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = ZeroExtend(Elem[base, e, esize], 64) + (offset << scale);
        Hint_Prefetch(addr, pref_hint, level, stream);

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

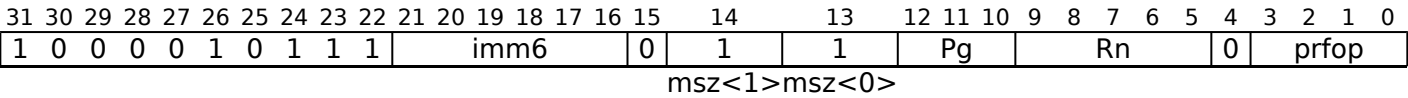
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PRFD (scalar plus immediate)

Contiguous prefetch doublewords (immediate index).

Contiguous prefetch of doubleword elements from the memory address generated by a 64-bit scalar base and immediate index in the range -32 to 31 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address.

The predicate may be used to suppress prefetches from unwanted addresses.



SVE

PRFD <prfop>, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 3;
integer offset = SInt(imm6);
```

Assembler Symbols

<prfop> Is the prefetch operation specifier, encoded in “prfop”:

prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -32 to 31, defaulting to 0, encoded in the "imm6" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) base;
bits(64) addr;

if n == 31 then
    base = SP[];
else
    base = X[n];

addr = base + ((offset * elements) << scale);
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Hint_Prefetch(addr, pref_hint, level, stream);
    addr = addr + (1 << scale);
```

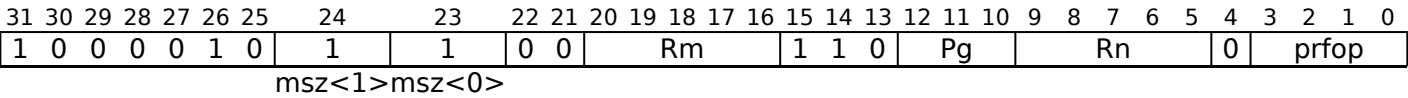
Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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PRFD (scalar plus scalar)

Contiguous prefetch doublewords (scalar index).

Contiguous prefetch of doubleword elements from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 8 and added to the base address. After each element prefetch the index value is incremented, but the index register is not updated.  
The predicate may be used to suppress prefetches from unwanted addresses.



SVE

PRFD <prfop>, <Pg>, [<Xn|SP>, <Xm>, LSL #3]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 3;
```

Assembler Symbols

<prfop> Is the prefetch operation specifier, encoded in “prfop”:

prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) base;
bits(64) offset = X[m];
bits(64) addr;

if n == 31 then
    base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = base + (UInt(offset) << scale);
        Hint_Prefetch(addr, pref_hint, level, stream);
        offset = offset + 1;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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## PRFD (scalar plus vector)

Gather prefetch doublewords (scalar plus vector).

Gather prefetch of doublewords from the active memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then multiplied by 8. Inactive addresses are not prefetched from memory.

The <prfop> symbol specifies the prefetch hint as a combination of three options: access type PLD for load or PST for store; target cache level L1, L2 or L3; temporality (KEEP for temporal or STRM for non-temporal).

It has encodings from 3 classes: [32-bit scaled offset](#) , [32-bit unpacked scaled offset](#) and [64-bit scaled offset](#)

### 32-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	0	xs	1	Zm			0	1	1	Pg	Rn			0	prfop									
																	msz<1>		msz<0>												

### 32-bit scaled offset

PRFD <prfop>, <Pg>, [<Xn|SP>, <Zm>.S, <mod> #3]

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer offs_size = 32;
boolean offs_unsigned = (xs == '0');
integer scale = 3;
```

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	xs	1	Zm			0	1	1	Pg	Rn			0	prfop									
																	msz<1>		msz<0>												

### 32-bit unpacked scaled offset

PRFD <prfop>, <Pg>, [<Xn|SP>, <Zm>.D, <mod> #3]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer offs_size = 32;
boolean offs_unsigned = (xs == '0');
integer scale = 3;
```

### 64-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	1	1	Zm			1	1	1	Pg			Rn			0	prfop							
																	msz<1>		msz<0>												

64-bit scaled offset

```
PRFD <prfop>, <Pg>, [<Xn|SP>, <Zm>.D, LSL #3]

if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer offs_size = 64;
boolean offs_unsigned = TRUE;
integer scale = 3;
```

Assembler Symbols

<prfop> Is the prefetch operation specifier, encoded in “prfop”:

prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in “xs”:

xs	<mod>
0	UXTW
1	SXTW

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) base;
bits(64) addr;
bits(VL) offset;

if n == 31 then
    base = SP[];
else
    base = X[n];
offset = Z[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        addr = base + (off << scale);
        Hint_Prefetch(addr, pref_hint, level, stream);
```





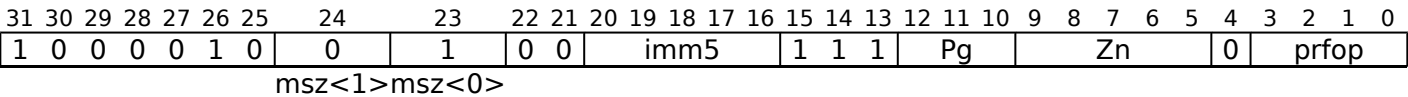
# PRFH (vector plus immediate)

Gather prefetch halfwords (vector plus immediate).

Gather prefetch of halfwords from the active memory addresses generated by a vector base plus immediate index. The index is a multiple of 2 in the range 0 to 62. Inactive addresses are not prefetched from memory. The <prfop> symbol specifies the prefetch hint as a combination of three options: access type PLD for load or PST for store; target cache level L1, L2 or L3; temporality (KEEP for temporal or STRM for non-temporal).

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

## 32-bit element

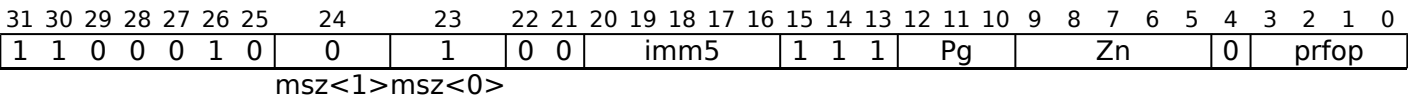


## 32-bit element

PRFH <prfop>, <Pg>, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 1;
integer offset = UInt(imm5);
```

## 64-bit element



## 64-bit element

PRFH <prfop>, <Pg>, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 1;
integer offset = UInt(imm5);
```

## Assembler Symbols

<prfop> Is the prefetch operation specifier, encoded in “prfop”:

prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 2 in the range 0 to 62, defaulting to 0, encoded in the "imm5" field.

## Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) base;
bits(64) addr;
base = Z[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = ZeroExtend(Elem[base, e, esize], 64) + (offset << scale);
        Hint_Prefetch(addr, pref_hint, level, stream);

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

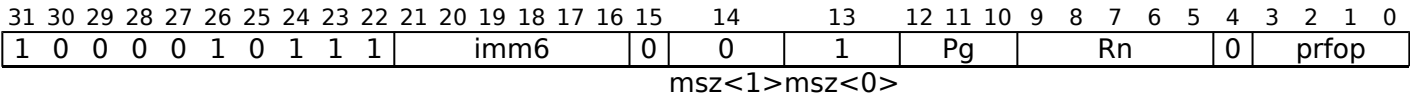
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PRFH (scalar plus immediate)

Contiguous prefetch halfwords (immediate index).

Contiguous prefetch of halfword elements from the memory address generated by a 64-bit scalar base and immediate index in the range -32 to 31 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address.

The predicate may be used to suppress prefetches from unwanted addresses.



SVE

PRFH <prfop>, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 1;
integer offset = SInt(imm6);
```

Assembler Symbols

<prfop> Is the prefetch operation specifier, encoded in “prfop”:

prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -32 to 31, defaulting to 0, encoded in the "imm6" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) base;
bits(64) addr;

if n == 31 then
    base = SP[];
else
    base = X[n];

addr = base + ((offset * elements) << scale);
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Hint_Prefetch(addr, pref_hint, level, stream);
    addr = addr + (1 << scale);
```

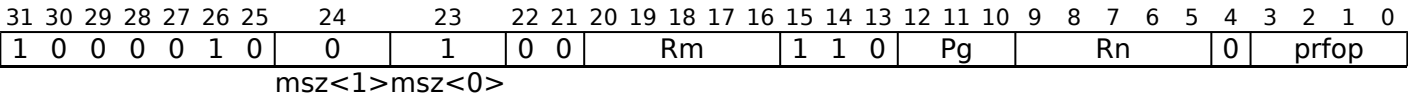
Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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PRFH (scalar plus scalar)

Contiguous prefetch halfwords (scalar index).

Contiguous prefetch of halfword elements from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 2 and added to the base address. After each element prefetch the index value is incremented, but the index register is not updated.  
The predicate may be used to suppress prefetches from unwanted addresses.



SVE

PRFH <prfop>, <Pg>, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer esize = 16;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 1;
```

Assembler Symbols

<prfop> Is the prefetch operation specifier, encoded in “prfop”:

prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) base;
bits(64) offset = X[m];
bits(64) addr;

if n == 31 then
    base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = base + (UInt(offset) << scale);
        Hint_Prefetch(addr, pref_hint, level, stream);
        offset = offset + 1;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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## PRFH (scalar plus vector)

Gather prefetch halfwords (scalar plus vector).

Gather prefetch of halfwords from the active memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then multiplied by 2. Inactive addresses are not prefetched from memory.

The <prfop> symbol specifies the prefetch hint as a combination of three options: access type PLD for load or PST for store; target cache level L1, L2 or L3; temporality (KEEP for temporal or STRM for non-temporal).

It has encodings from 3 classes: [32-bit scaled offset](#) , [32-bit unpacked scaled offset](#) and [64-bit scaled offset](#)

### 32-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	0	xs	1	Zm			0	0	1	Pg			Rn			0	prfop							
																	msz<1>		msz<0>												

### 32-bit scaled offset

PRFH <prfop>, <Pg>, [<Xn|SP>, <Zm>.S, <mod> #1]

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer offs_size = 32;
boolean offs_unsigned = (xs == '0');
integer scale = 1;
```

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	xs	1	Zm			0	0	1	Pg	Rn			0	prfop									
																	msz<1>		msz<0>												

### 32-bit unpacked scaled offset

PRFH <prfop>, <Pg>, [<Xn|SP>, <Zm>.D, <mod> #1]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer offs_size = 32;
boolean offs_unsigned = (xs == '0');
integer scale = 1;
```

### 64-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	1	1	Zm			1	0	1	Pg			Rn			0	prfop							
																	msz<1>		msz<0>												



64-bit scaled offset

```
PRFH <prfop>, <Pg>, [<Xn|SP>, <Zm>.D, LSL #1]

if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer offs_size = 64;
boolean offs_unsigned = TRUE;
integer scale = 1;
```

Assembler Symbols

<prfop>

Is the prefetch operation specifier, encoded in “prfop”:

prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

<Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Xn|SP>

Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

<Zm>

Is the name of the offset scalable vector register, encoded in the "Zm" field.

<mod>

Is the index extend and shift specifier, encoded in “xs”:

xs	<mod>
0	UXTW
1	SXTW

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) base;
bits(64) addr;
bits(VL) offset;

if n == 31 then
    base = SP[];
else
    base = X[n];
offset = Z[m];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        addr = base + (off << scale);
        Hint_Prefetch(addr, pref_hint, level, stream);
```



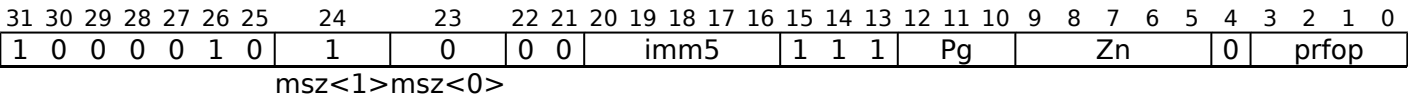
PRFW (vector plus immediate)

Gather prefetch words (vector plus immediate).

Gather prefetch of words from the active memory addresses generated by a vector base plus immediate index. The index is a multiple of 4 in the range 0 to 124. Inactive addresses are not prefetched from memory. The <prfop> symbol specifies the prefetch hint as a combination of three options: access type PLD for load or PST for store; target cache level L1, L2 or L3; temporality (KEEP for temporal or STRM for non-temporal).

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

32-bit element

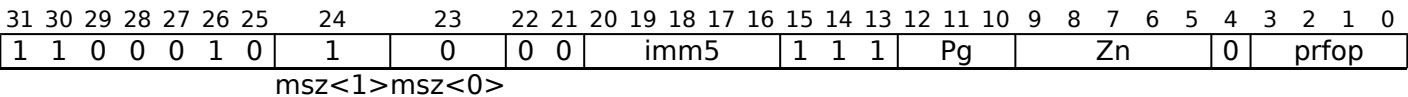


32-bit element

PRFW <prfop>, <Pg>, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 2;
integer offset = UInt(imm5);
```

64-bit element



64-bit element

PRFW <prfop>, <Pg>, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 2;
integer offset = UInt(imm5);
```

Assembler Symbols

<prfop> Is the prefetch operation specifier, encoded in “prfop”:

prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 4 in the range 0 to 124, defaulting to 0, encoded in the "imm5" field.

## Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) base;
bits(64) addr;
base = Z[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = ZeroExtend(Elem[base, e, esize], 64) + (offset << scale);
        Hint_Prefetch(addr, pref_hint, level, stream);

```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

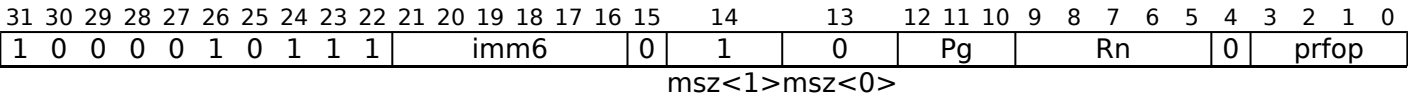
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PRFW (scalar plus immediate)

Contiguous prefetch words (immediate index).

Contiguous prefetch of word elements from the memory address generated by a 64-bit scalar base and immediate index in the range -32 to 31 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address.

The predicate may be used to suppress prefetches from unwanted addresses.



SVE

PRFW <prfop>, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 2;
integer offset = SInt(imm6);
```

Assembler Symbols

<prfop> Is the prefetch operation specifier, encoded in “prfop”:

prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

<imm> Is the optional signed immediate vector offset, in the range -32 to 31, defaulting to 0, encoded in the "imm6" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) base;
bits(64) addr;

if n == 31 then
    base = SP[];
else
    base = X[n];

addr = base + ((offset * elements) << scale);
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Hint_Prefetch(addr, pref_hint, level, stream);
    addr = addr + (1 << scale);
```

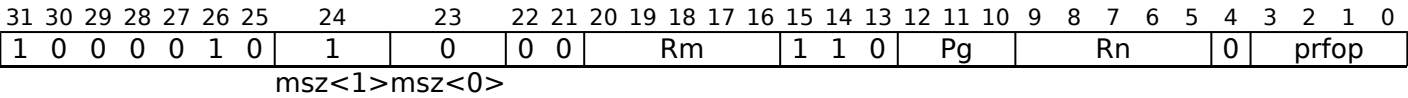
Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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PRFW (scalar plus scalar)

Contiguous prefetch words (scalar index).

Contiguous prefetch of word elements from the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 4 and added to the base address. After each element prefetch the index value is incremented, but the index register is not updated.  
The predicate may be used to suppress prefetches from unwanted addresses.



SVE

PRFW <prfop>, <Pg>, [<Xn|SP>, <Xm>, LSL #2]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer scale = 2;
```

Assembler Symbols

<prfop> Is the prefetch operation specifier, encoded in “prfop”:

prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) base;
bits(64) offset = X[m];
bits(64) addr;

if n == 31 then
    base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = base + (UInt(offset) << scale);
        Hint_Prefetch(addr, pref_hint, level, stream);
        offset = offset + 1;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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## PRFW (scalar plus vector)

Gather prefetch words (scalar plus vector).

Gather prefetch of words from the active memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then multiplied by 4. Inactive addresses are not prefetched from memory.

The <prfop> symbol specifies the prefetch hint as a combination of three options: access type PLD for load or PST for store; target cache level L1, L2 or L3; temporality (KEEP for temporal or STRM for non-temporal).

It has encodings from 3 classes: [32-bit scaled offset](#) , [32-bit unpacked scaled offset](#) and [64-bit scaled offset](#)

### 32-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	0	xs	1			Zm		0		1		0		Pg			Rn		0			prfop		
										msz<1>msz<0>																					

### 32-bit scaled offset

PRFW <prfop>, <Pg>, [<Xn|SP>, <Zm>.S, <mod> #2]

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer offs_size = 32;
boolean offs_unsigned = (xs == '0');
integer scale = 2;
```

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	xs	1			Zm		0		1		0		Pg				Rn		0			prfop	
										msz<1>msz<0>																					

### 32-bit unpacked scaled offset

PRFW <prfop>, <Pg>, [<Xn|SP>, <Zm>.D, <mod> #2]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer offs_size = 32;
boolean offs_unsigned = (xs == '0');
integer scale = 2;
```

### 64-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	1	1	Zm			1	1	0	Pg			Rn			0	prfop							
										msz<1>msz<0>																					

64-bit scaled offset

```
PRFW <prfop>, <Pg>, [<Xn|SP>, <Zm>.D, LSL #2]

if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer level = UInt(prfop<2:1>);
boolean stream = (prfop<0> == '1');
pref_hint = if prfop<3> == '0' then Prefetch_READ else Prefetch_WRITE;
integer offs_size = 64;
boolean offs_unsigned = TRUE;
integer scale = 2;
```

Assembler Symbols

<prfop>

Is the prefetch operation specifier, encoded in “prfop”:

prfop	<prfop>
0000	PLDL1KEEP
0001	PLDL1STRM
0010	PLDL2KEEP
0011	PLDL2STRM
0100	PLDL3KEEP
0101	PLDL3STRM
x11x	#uimm4
1000	PSTL1KEEP
1001	PSTL1STRM
1010	PSTL2KEEP
1011	PSTL2STRM
1100	PSTL3KEEP
1101	PSTL3STRM

<Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Xn|SP>

Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.

<Zm>

Is the name of the offset scalable vector register, encoded in the "Zm" field.

<mod>

Is the index extend and shift specifier, encoded in “xs”:

xs	<mod>
0	UXTW
1	SXTW

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(64) base;
bits(64) addr;
bits(VL) offset;

if n == 31 then
    base = SP[];
else
    base = X[n];
offset = Z[m];

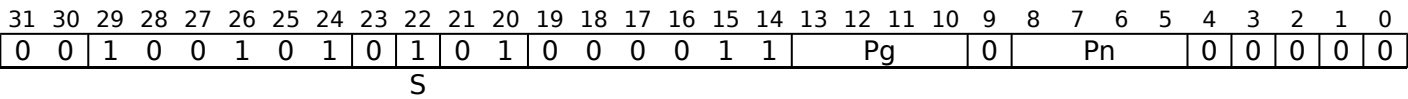
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        addr = base + (off << scale);
        Hint_Prefetch(addr, pref_hint, level, stream);
```



PTEST

Set condition flags for predicate.

Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate source register, and the V flag to zero.



SVE

```
PTEST <Pg>, <Pn>.B

if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
```

Assembler Symbols

- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the source scalable predicate register, encoded in the "Pn" field.

Operation

```
CheckSVEEnabled();
bits(PL) mask = P[g];
bits(PL) result = P[n];

PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.

PTRUE, PTRUES

Initialise predicate from named constraint.

Set elements of the destination predicate to true if the element number satisfies the named predicate constraint, or to false otherwise. If the constraint specifies more elements than are available at the current vector length then all elements of the destination predicate are set to false.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception. Optionally sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

It has encodings from 2 classes: [Not setting the condition flags](#) and [Setting the condition flags](#)

Not setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	0	1	1	0	0	0	0	1	1	1	0	0	0	pattern			0	Pd					
S																															

Not setting the condition flags

```
PTRUE <Pd>.<T>{, <pattern>}

if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer d = UInt(Pd);
boolean setflags = FALSE;
bits(5) pat = pattern;
```

Setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	0	1	1	0	0	1	1	1	1	0	0	0	pattern			0	Pd						
S																															

Setting the condition flags

```
PTRUES <Pd>.<T>{, <pattern>}

if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer d = UInt(Pd);
boolean setflags = TRUE;
bits(5) pat = pattern;
```

Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

## Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
integer count = DecodePredCount(pat, esize);
bits(PL) result;

for e = 0 to elements-1
    ElemP[result, e, esize] = if e < count then '1' else '0';

if setflags then
    PSTATE.<N,Z,C,V> = PredTest(result, result, esize);
P[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# PUNPKHI, PUNPKLO

Unpack and widen half of predicate.

Unpack elements from the lowest or highest half of the source predicate and place in elements of twice their size within the destination predicate. This instruction is unpredicated.

It has encodings from 2 classes: [High half](#) and [Low half](#)

## High half

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	0	0	1	1	0	0	0	1	0	1	0	0	0	0	0	0	Pn			0	Pd			
H																															

## High half

PUNPKHI [<Pd>](#).H, [<Pn>](#).B

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer n = UInt(Pn);
integer d = UInt(Pd);
boolean hi = TRUE;
```

## Low half

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	Pn			0	Pd				
H																															

## Low half

PUNPKLO [<Pd>](#).H, [<Pn>](#).B

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer n = UInt(Pn);
integer d = UInt(Pd);
boolean hi = FALSE;
```

## Assembler Symbols

- [<Pd>](#) Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- [<Pn>](#) Is the name of the source scalable predicate register, encoded in the "Pn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) operand = P[n];
bits(PL) result;

for e = 0 to elements-1
    ElemP[result, e, esize] = ElemP[operand, if hi then e + elements else e, esize DIV 2];
P[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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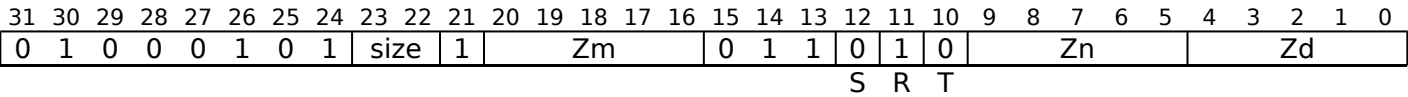
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RADDHNB

Rounding add narrow high part (bottom).

Add each vector element of the first source vector to the corresponding vector element of the second source vector, and place the most significant rounded half of the result in the even-numbered half-width destination elements, while setting the odd-numbered elements to zero. This instruction is unpredicated.



SVE2

```
RADDHNB <Zd>.<T>, <Zn>.<Tb>, <Zm>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	B
10	H
11	S

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	H
10	S
11	D

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;
integer halfesize = esize DIV 2;
integer round_const = 1 << (halfesize - 1);

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, e, esize]);
    integer res = ((element1 + element2) + round_const) >> halfesize;
    Elem[result, 2*e + 0, halfesize] = res<halfesize-1:0>;
    Elem[result, 2*e + 1, halfesize] = Zeros();

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

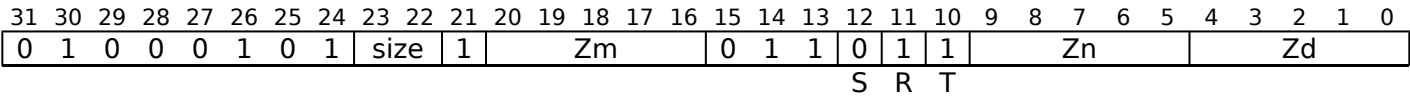
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RADDHNT

Rounding add narrow high part (top).

Add each vector element of the first source vector to the corresponding vector element of the second source vector, and place the most significant rounded half of the result in the odd-numbered half-width destination elements, leaving the even-numbered elements unchanged. This instruction is unpredicated.



SVE2

RADDHNT <Zd>.<T>, <Zn>.<Tb>, <Zm>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	B
10	H
11	S

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	H
10	S
11	D

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[d];
integer halfesize = esize DIV 2;
integer round_const = 1 << (halfesize - 1);

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, e, esize]);
    integer res = ((element1 + element2) + round_const) >> halfesize;
    Elem[result, 2*e + 1, halfesize] = res<halfesize-1:0>;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

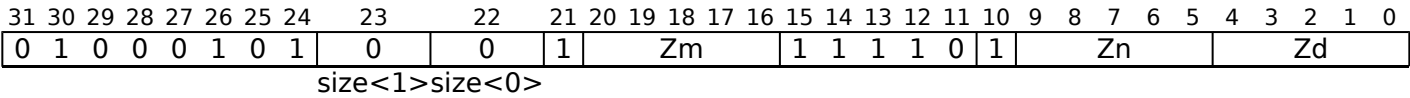
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RAX1

Bitwise rotate left by 1 and exclusive OR.

Rotate each 64-bit element of the second source vector left by 1 and exclusive OR with the corresponding elements of the first source vector. The results are placed in the corresponding elements of the destination vector. This instruction is unpredicated.  
ID\_AA64ZFR0\_EL1.SHA3 indicates whether this instruction is implemented.



SVE2

RAX1 <Zd>.D, <Zn>.D, <Zm>.D

```
if !HaveSVE2SHA3() then UNDEFINED;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV 64;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(64) element1 = Elem[operand1, e, 64];
    bits(64) element2 = Elem[operand2, e, 64];
    Elem[result, e, 64] = element1 EOR ROL(element2, 1);
Z[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# RBIT

Reverse bits (predicated).

Reverse bits in each active element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	0	1	1	1	1	0	0	Pg													

## SVE

RBIT <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    bits(esize) element = Elem[operand, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = BitReverse(element);

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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## RDFFR (unpredicated)

Read the first-fault register.

Read the first-fault register (FFR) and place in the destination predicate without predication.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	0	0	1	1	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0				Pd
																S															

## SVE

RDFFR <Pd>.B

```
if !HaveSVE() then UNDEFINED;
integer d = UInt(Pd);
```

## Assembler Symbols

<Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.

## Operation

```
CheckSVEEnabled();
bits(PL) ffr = FFR[];
P[d] = ffr;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.



## RDFFR, RDFFRS (predicated)

Return predicate of succesfully loaded elements.

Read the first-fault register (FFR) and place active elements in the corresponding elements of the destination predicate. Inactive elements in the destination predicate register are set to zero. Optionally sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.

It has encodings from 2 classes: [Not setting the condition flags](#) and [Setting the condition flags](#)

### Not setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	0	0	1	1	0	0	0	1	1	1	1	0	0	0	Pg			0	Pd				
S																															

### Not setting the condition flags

RDFFR <Pd>.B, <Pg>/Z

```
if !HaveSVE() then UNDEFINED;
integer g = UInt(Pg);
integer d = UInt(Pd);
boolean setflags = FALSE;
```

### Setting the condition flags

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	1	0	1	1	0	0	0	1	1	1	1	0	0	0	Pg			0	Pd				
S																															

### Setting the condition flags

RDFFRS <Pd>.B, <Pg>/Z

```
if !HaveSVE() then UNDEFINED;
integer g = UInt(Pg);
integer d = UInt(Pd);
boolean setflags = TRUE;
```

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.

## Operation

```
CheckSVEEnabled();
bits(PL) mask = P[g];
bits(PL) ffr = FFR[];
bits(PL) result = ffr AND mask;

if setflags then
    PSTATE.<N,Z,C,V> = PredTest(mask, result, 8);
P[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:

- The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

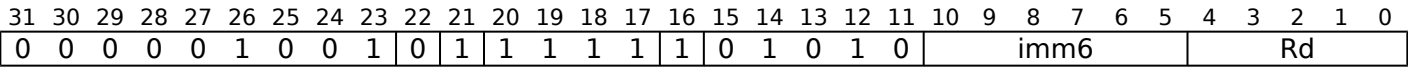
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RDVL

Read multiple of vector register size to scalar register.

Multiply the current vector register size in bytes by an immediate in the range -32 to 31 and place the result in the 64-bit destination general-purpose register.



SVE

```
RDVL <Xd>, #<imm>

if !HaveSVE() then UNDEFINED;
integer d = UInt(Rd);
integer imm = SInt(imm6);
```

Assembler Symbols

- <Xd> Is the 64-bit name of the destination general-purpose register, encoded in the "Rd" field.
- <imm> Is the signed immediate operand, in the range -32 to 31, encoded in the "imm6" field.

Operation

```
CheckSVEEnabled();
integer len = imm * (VL DIV 8);
X[d] = len<63:0>;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# REV (predicate)

Reverse all elements in a predicate.

Reverse the order of all elements in the source predicate and place in the destination predicate. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	1	0	1	0	0	0	1	0	0	0	0	0	0	0	Pn			0	Pd			

## SVE

REV <Pd>.<T>, <Pn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Pn);
integer d = UInt(Pd);
```

## Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pn> Is the name of the source scalable predicate register, encoded in the "Pn" field.

## Operation

```
CheckSVEEnabled();
bits(PL) operand = P[n];
bits(PL) result = Reverse(operand, esize DIV 8);
P[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# REV (vector)

Reverse all elements in a vector (unpredicated).

Reverse the order of all elements in the source vector and place in the destination vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	1	1	0	0	0	0	0	1	1	1	0	Zn					Zd					

## SVE

REV <Zd>.<T>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
bits(VL) operand = Z[n];
bits(VL) result = Reverse(operand, esize);
Z[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# REVB, REVH, REVW

Reverse bytes / halfwords / words within elements (predicated).

Reverse the order of 8-bit bytes, 16-bit halfwords or 32-bit words within each active element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

It has encodings from 3 classes: [Byte](#) , [Halfword](#) and [Word](#)

## Byte

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size		1	0	0	1	0	0	1	0	0	Pg			Zn				Zd					

## Byte

REVB [<Zd>.<T>](#), [<Pg>/M](#), [<Zn>.<T>](#)

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer swsize = 8;
```

## Halfword

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	0	1	0	1	1	0	0	Pg				Zn				Zd					

## Halfword

REVH [<Zd>.<T>](#), [<Pg>/M](#), [<Zn>.<T>](#)

```
if !HaveSVE() then UNDEFINED;
if size != '1x' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer swsize = 16;
```

## Word

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	0	1	1	0	1	0	0	Pg				Zn				Zd					

## Word

REWV [<Zd>.D](#), [<Pg>/M](#), [<Zn>.D](#)

```
if !HaveSVE() then UNDEFINED;
if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer swsize = 32;
```

Assembler Symbols

- <Zd>Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T>For the byte variant: is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

For the halfword variant: is the size specifier, encoded in "size<0>":

size<0>	<T>
0	S
1	D

- <Pg>Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn>Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '1' then
    bits(esize) element = Elem[operand, e, esize];
    Elem[result, e, esize] = Reverse(element, swsize);

Z[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.

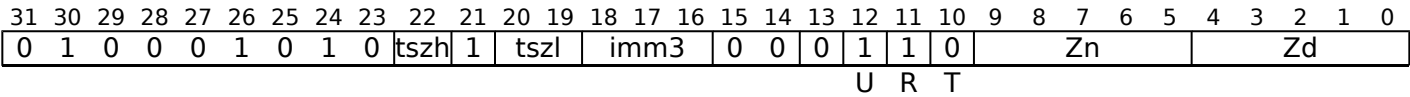
This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

RSHRNB

Rounding shift right narrow by immediate (bottom).

Shift each unsigned integer value in the source vector elements right by an immediate value, and place the rounded results in the even-numbered half-width destination elements, while setting the odd-numbered elements to zero. The immediate shift amount is an unsigned value in the range 1 to number of bits per element. This instruction is unpredicated.



SVE2

```
RSHRNB <Zd>.<T>, <Zn>.<Tb>, #<const>
```

```
if !HaveSVE2() then UNDEFINED;
bits(3) tsize = tszh:tszl;
case tsize of
  when '000' UNDEFINED;
  when '001' esize = 8;
  when '01x' esize = 16;
  when '1xx' esize = 32;
integer n = UInt(Zn);
integer d = UInt(Zd);
integer shift = (2 * esize) - UInt(tsize:imm3);
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
0	00	RESERVED
0	01	B
0	1x	H
1	xx	S

- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<Tb>
0	00	RESERVED
0	01	H
0	1x	S
1	xx	D

- <const> Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
bits(VL) operand = Z[n];
bits(VL) result;
integer round_const = 1 << (shift-1);

for e = 0 to elements-1
  bits(2*esize) element = Elem[operand, e, 2*esize];
  integer res = (UInt(element) + round_const) >> shift;
  Elem[result, 2*e + 0, esize] = res<esize-1:0>;
  Elem[result, 2*e + 1, esize] = Zeros();

Z[d] = result;
```



## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

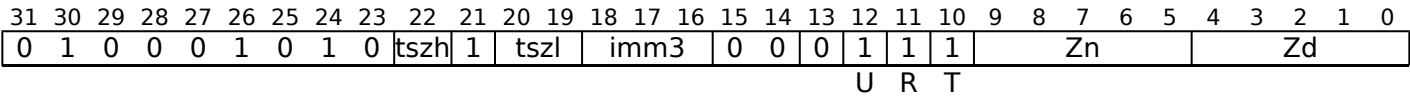
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RSHRNT

Rounding shift right narrow by immediate (top).

Shift each unsigned integer value in the source vector elements right by an immediate value, and place the rounded results in the odd-numbered half-width destination elements, leaving the even-numbered elements unchanged. The immediate shift amount is an unsigned value in the range 1 to number of bits per element. This instruction is unpredicated.



SVE2

```
RSHRNT <Zd>.<T>, <Zn>.<Tb>, #<const>
```

```
if !HaveSVE2() then UNDEFINED;
bits(3) tsize = tszh:tszl;
case tsize of
  when '000' UNDEFINED;
  when '001' esize = 8;
  when '01x' esize = 16;
  when '1xx' esize = 32;
integer n = UInt(Zn);
integer d = UInt(Zd);
integer shift = (2 * esize) - UInt(tsize:imm3);
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
0	00	RESERVED
0	01	B
0	1x	H
1	xx	S

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<Tb>
0	00	RESERVED
0	01	H
0	1x	S
1	xx	D

- <const> Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
bits(VL) operand = Z[n];
bits(VL) result = Z[d];
integer round_const = 1 << (shift-1);

for e = 0 to elements-1
  bits(2*esize) element = Elem[operand, e, 2*esize];
  integer res = (UInt(element) + round_const) >> shift;
  Elem[result, 2*e + 1, esize] = res<esize-1:0>;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

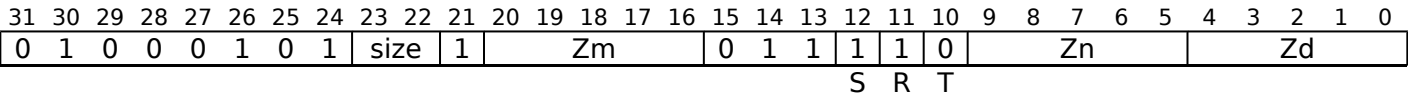
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RSUBHNB

Rounding subtract narrow high part (bottom).

Subtract each vector element of the second source vector from the corresponding vector element in the first source vector, and place the most significant rounded half of the result in the even-numbered half-width destination elements, while setting the odd-numbered half-width destination elements to zero. This instruction is unpredicated.



SVE2

```
RSUBHNB <Zd>.<T>, <Zn>.<Tb>, <Zm>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	B
10	H
11	S

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	H
10	S
11	D

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;
integer halfesize = esize DIV 2;
integer round_const = 1 << (halfesize - 1);

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, e, esize]);
    integer res = ((element1 - element2) + round_const) >> halfesize;
    Elem[result, 2*e + 0, halfesize] = res<halfesize-1:0>;
    Elem[result, 2*e + 1, halfesize] = Zeros();

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

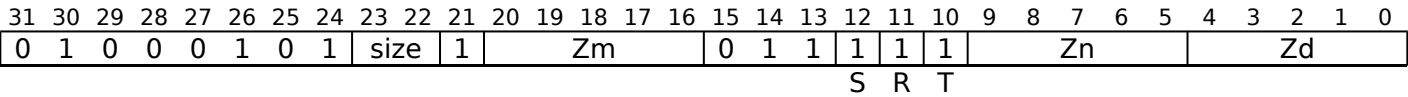
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RSUBHNT

Rounding subtract narrow high part (top).

Subtract each vector element of the second source vector from the corresponding vector element in the first source vector, and place the most significant rounded half of the result in the odd-numbered half-width destination elements, leaving the even-numbered elements unchanged. This instruction is unpredicated.



SVE2

```
RSUBHNT <Zd>.<T>, <Zn>.<Tb>, <Zm>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	B
10	H
11	S

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	H
10	S
11	D

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[d];
integer halfesize = esize DIV 2;
integer round_const = 1 << (halfesize - 1);

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, e, esize]);
    integer res = ((element1 - element2) + round_const) >> halfesize;
    Elem[result, 2*e + 1, halfesize] = res<halfesize-1:0>;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

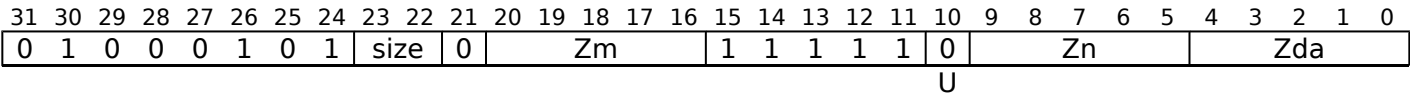
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SABA

Signed absolute difference and accumulate.

Compute the absolute difference between signed integer values in elements of the second source vector and corresponding elements of the first source vector, and add the difference to the corresponding elements of the destination vector. This instruction is unpredicated.



SVE2

SABA <Zda>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean unsigned = FALSE;
```

Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    bits(esize) absdiff = Abs(element1 - element2)<esize-1:0>;
    Elem[result, e, esize] = Elem[result, e, esize] + absdiff;

Z[da] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.



This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

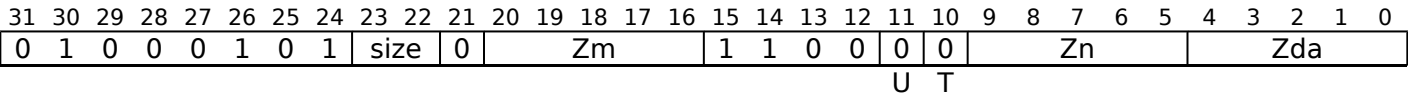
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# SABALB

Signed absolute difference and accumulate long (bottom).

Compute the absolute difference between even-numbered signed integer values in elements of the second source vector and corresponding elements of the first source vector, and destructively add to the overlapping double-width elements of the addend vector. This instruction is unpredicated.



## SVE2

SABALB <Zda>.<T>, <Zn>.<Tb>, <Zm>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

<Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, 2*e + 0, esize DIV 2]);
    integer element2 = SInt(Elem[operand2, 2*e + 0, esize DIV 2]);
    bits(esize) absdiff = Abs(element1 - element2)<esize-1:0>;
    Elem[result, e, esize] = Elem[result, e, esize] + absdiff;

Z[da] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

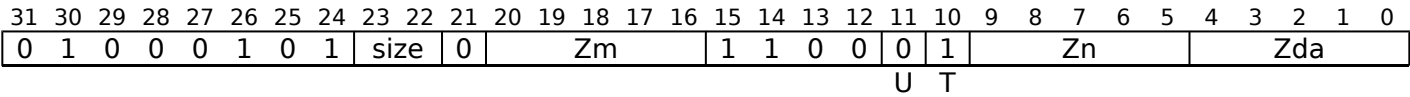
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SABALT

Signed absolute difference and accumulate long (top).

Compute the absolute difference between odd-numbered signed elements of the second source vector and corresponding elements of the first source vector, and destructively add to the overlapping double-width elements of the addend vector. This instruction is unpredicated.



SVE2

```
SABALT <Zda>.<T>, <Zn>.<Tb>, <Zm>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

Assembler Symbols

<Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, 2*e + 1, esize DIV 2]);
    integer element2 = SInt(Elem[operand2, 2*e + 1, esize DIV 2]);
    bits(esize) absdiff = Abs(element1 - element2)<esize-1:0>;
    Elem[result, e, esize] = Elem[result, e, esize] + absdiff;

Z[da] = result;
```

Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is

UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

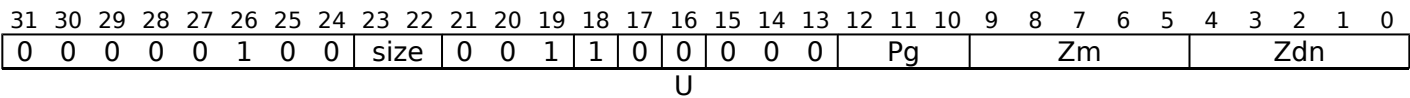
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SABD

Signed absolute difference (predicated).

Compute the absolute difference between signed integer values in active elements of the second source vector and corresponding elements of the first source vector and destructively place the difference in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



SVE

SABD <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean unsigned = FALSE;
```

Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    if ElemP[mask, e, esize] == '1' then
        integer absdiff = Abs(element1 - element2);
        Elem[result, e, esize] = absdiff<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.

- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

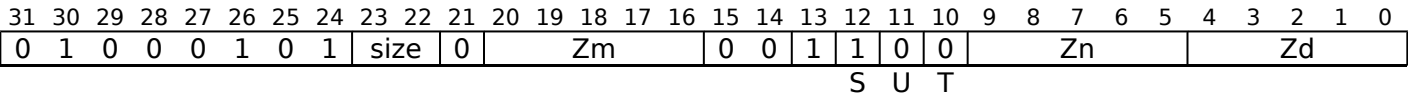
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SABDLB

Signed absolute difference long (bottom).

Compute the absolute difference between even-numbered signed integer values in elements of the second source vector and corresponding elements of the first source vector, and place the results in the overlapping double-width elements of the destination vector. This instruction is unpredicated.



SVE2

```
SABDLB <Zd>.<T>, <Zn>.<Tb>, <Zm>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, 2*e + 0, esize DIV 2]);
    integer element2 = SInt(Elem[operand2, 2*e + 0, esize DIV 2]);
    integer res = Abs(element1 - element2);
    Elem[result, e, esize] = res<esize-1:0>;

Z[d] = result;
```

Operational information

If PSTATE.DIT is 1:



- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

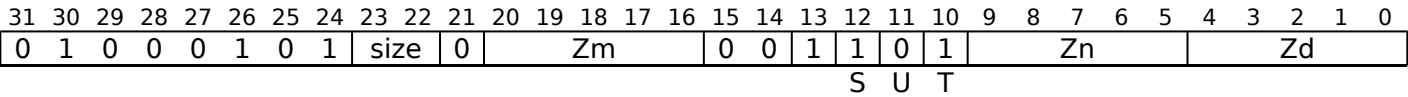
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SABDLT

Signed absolute difference long (top).

Compute the absolute difference between odd-numbered signed integer values in elements of the second source vector and corresponding elements of the first source vector, and place the results in overlapping double-width elements of the destination vector. This instruction is unpredicated.



SVE2

```
SABDLT <Zd>.<T>, <Zn>.<Tb>, <Zm>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, 2*e + 1, esize DIV 2]);
    integer element2 = SInt(Elem[operand2, 2*e + 1, esize DIV 2]);
    integer res = Abs(element1 - element2);
    Elem[result, e, esize] = res<esize-1:0>;

Z[d] = result;
```

Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

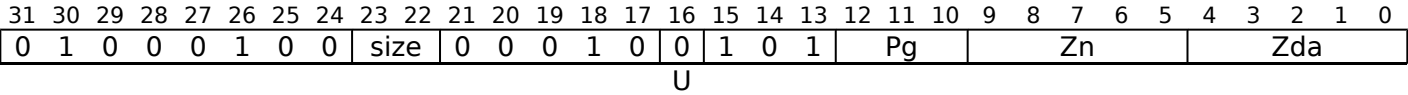
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# SADALP

Signed add and accumulate long pairwise.

Add pairs of adjacent signed integer values and accumulate the results into the overlapping double-width elements of the destination vector.



## SVE2

SADALP <Zda>.<T>, <Pg>/M, <Zn>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer da = UInt(Zda);
```

## Assembler Symbols

- <Zda>Is the name of the second source and destination scalable vector register, encoded in the "Zda" field.
- <T>Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg>Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn>Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Tb>Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand_acc = Z[da];
bits(VL) operand_src = Z[n];
bits(VL) result;

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '0' then
    Elem[result, e, esize] = Elem[operand_acc, e, esize];
  else
    integer element1 = SInt(Elem[operand_src, 2*e + 0, esize DIV 2]);
    integer element2 = SInt(Elem[operand_src, 2*e + 1, esize DIV 2]);
    bits(esize) sum = (element1 + element2)<esize-1:0>;
    Elem[result, e, esize] = Elem[operand_acc, e, esize] + sum;

Z[da] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

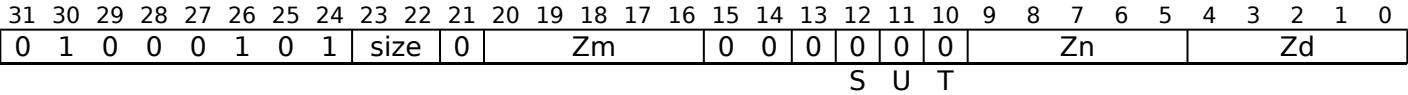
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SADDLB

Signed add long (bottom).

Add the corresponding even-numbered signed elements of the first and second source vectors, and place the results in the overlapping double-width elements of the destination vector. This instruction is unpredicated.



SVE2

```
SADDLB <Zd>.<T>, <Zn>.<Tb>, <Zm>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer sel1 = 0;
integer sel2 = 0;
boolean unsigned = FALSE;
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, 2*e + sel1, esize DIV 2], unsigned);
    integer element2 = Int(Elem[operand2, 2*e + sel2, esize DIV 2], unsigned);
    integer res = element1 + element2;
    Elem[result, e, esize] = res<esize-1:0>;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

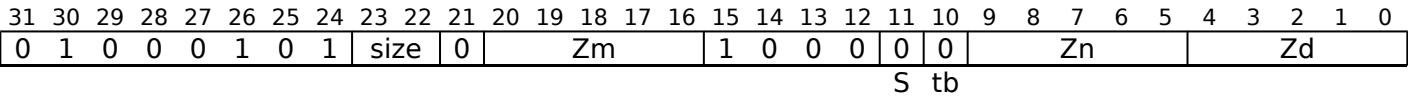
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SADDLBT

Signed add long (bottom + top).

Add the even-numbered signed elements of the first source vector to the odd-numbered signed elements of the second source vector, and place the results in the overlapping double-width elements of the destination vector. This instruction is unpredicated.



SVE2

SADDLBT <Zd>.<T>, <Zn>.<Tb>, <Zm>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer sel1 = 0;
integer sel2 = 1;
boolean unsigned = FALSE;
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, 2*e + sel1, esize DIV 2], unsigned);
    integer element2 = Int(Elem[operand2, 2*e + sel2, esize DIV 2], unsigned);
    integer res = element1 + element2;
    Elem[result, e, esize] = res<esize-1:0>;

Z[d] = result;
```



## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

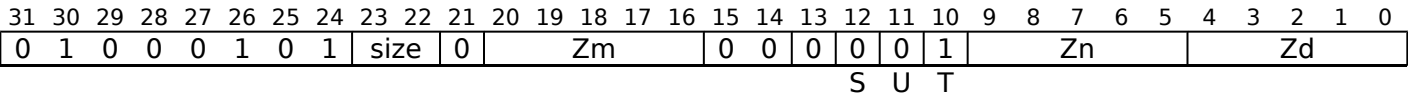
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SADDLT

Signed add long (top).

Add the corresponding odd-numbered signed elements of the first and second source vectors, and place the results in the overlapping double-width elements of the destination vector. This instruction is unpredicated.



SVE2

SADDLT <Zd>.<T>, <Zn>.<Tb>, <Zm>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer sel1 = 1;
integer sel2 = 1;
boolean unsigned = FALSE;
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, 2*e + sel1, esize DIV 2], unsigned);
    integer element2 = Int(Elem[operand2, 2*e + sel2, esize DIV 2], unsigned);
    integer res = element1 + element2;
    Elem[result, e, esize] = res<esize-1:0>;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

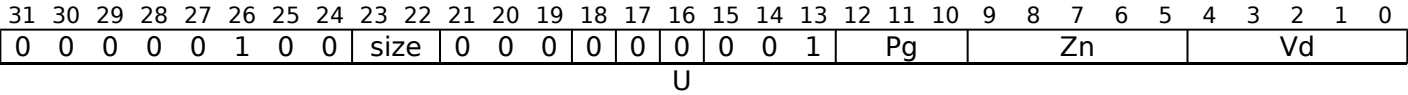
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# SADDV

Signed add reduction to scalar.

Signed add horizontally across all lanes of a vector, and place the result in the SIMD&FP scalar destination register. Narrow elements are first sign-extended to 64 bits. Inactive elements in the source vector are treated as zero.



## SVE

SADDV <Dd>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);
```

## Assembler Symbols

- <Dd>

Is the 64-bit name of the destination SIMD&FP register, encoded in the "Vd" field.
- <Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn>

Is the name of the source scalable vector register, encoded in the "Zn" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	RESERVED

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
integer sum = 0;

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer element = SInt(Elem[operand, e, esize]);
        sum = sum + element;

V[d] = sum<63:0>;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:

The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.

The values of the NZCV flags.

The response of this instruction to asynchronous exceptions does not vary based on:

The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.

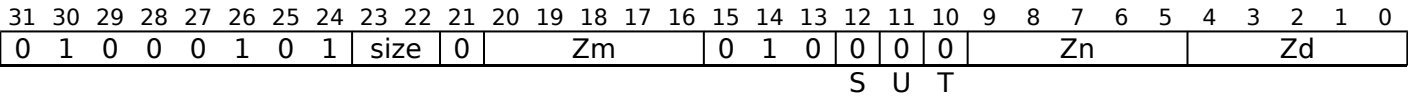
The values of the NZCV flags.



SADDWB

Signed add wide (bottom).

Add the even-numbered signed elements of the second source vector to the overlapping double-width elements of the first source vector and place the results in the corresponding double-width elements of the destination vector. This instruction is unpredicated.



SVE2

```
SADDWB <Zd>.<T>, <Zn>.<T>, <Zm>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, e, esize]);
    integer element2 = SInt(Elem[operand2, 2*e + 0, esize DIV 2]);
    Elem[result, e, esize] = (element1 + element2)<esize-1:0>;

Z[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:

- The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

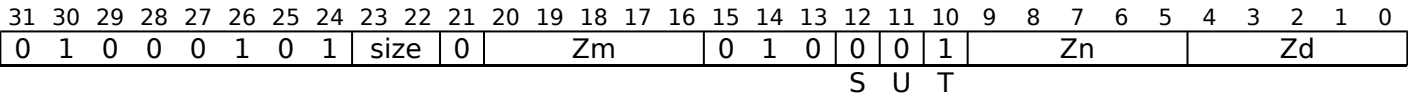
Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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SADDWT

Signed add wide (top).

Add the odd-numbered signed elements of the second source vector to the overlapping double-width elements of the first source vector and place the results in the corresponding double-width elements of the destination vector. This instruction is unpredicated.



SVE2

```
SADDWT <Zd>.<T>, <Zn>.<T>, <Zm>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, e, esize]);
    integer element2 = SInt(Elem[operand2, 2*e + 1, esize DIV 2]);
    Elem[result, e, esize] = (element1 + element2)<esize-1:0>;

Z[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:



- The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

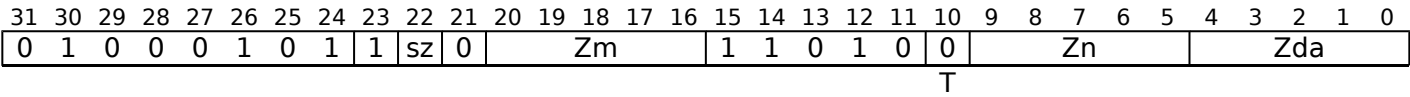
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SBCLB

Subtract with carry long (bottom).

Subtract the even-numbered elements of the first source vector and the inverted 1-bit carry from the least-significant bit of the odd-numbered elements of the second source vector from the even-numbered elements of the destination and accumulator vector. The 1-bit carry output is placed in the corresponding odd-numbered element of the destination vector.



SVE2

```
SBCLB <Zda>.<T>, <Zn>.<T>, <Zm>.<T>
```

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32 << UInt(sz);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

Assembler Symbols

<Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.

<T> Is the size specifier, encoded in "sz":

sz	<T>
0	S
1	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer pairs = VL DIV (esize * 2);
bits(VL) operand = Z[n];
bits(VL) carries = Z[m];
bits(VL) result = Z[da];

for p = 0 to pairs-1
    bits(esize) element1 = Elem[result, 2*p + 0, esize];
    bits(esize) element2 = Elem[operand, 2*p + 0, esize];
    bit carry_in = Elem[carries, 2*p + 1, esize]<0>;

    (res, nzcvc) = AddWithCarry(element1, NOT(element2), carry_in);
    carry_out = nzcvc<1>;

    Elem[result, 2*p + 0, esize] = res;
    Elem[result, 2*p + 1, esize] = ZeroExtend(carry_out);

Z[da] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:

- The values of the data supplied in any of its registers.
- The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

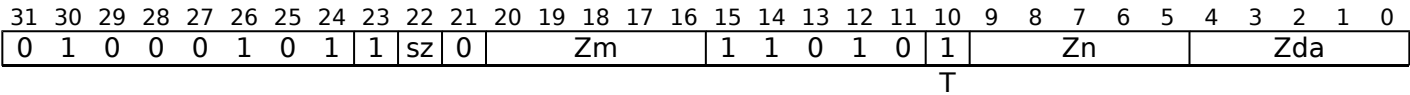
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SBCLT

Subtract with carry long (top).

Subtract the odd-numbered elements of the first source vector and the inverted 1-bit carry from the least-significant bit of the odd-numbered elements of the second source vector from the even-numbered elements of the destination and accumulator vector. The 1-bit carry output is placed in the corresponding odd-numbered element of the destination vector.



SVE2

```
SBCLT <Zda>.<T>, <Zn>.<T>, <Zm>.<T>
```

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32 << UInt(sz);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

Assembler Symbols

<Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.

<T> Is the size specifier, encoded in "sz":

sz	<T>
0	S
1	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer pairs = VL DIV (esize * 2);
bits(VL) operand = Z[n];
bits(VL) carries = Z[m];
bits(VL) result = Z[da];

for p = 0 to pairs-1
    bits(esize) element1 = Elem[result, 2*p + 0, esize];
    bits(esize) element2 = Elem[operand, 2*p + 1, esize];
    bit carry_in = Elem[carries, 2*p + 1, esize]<0>;

    (res, nzcvc) = AddWithCarry(element1, NOT(element2), carry_in);
    carry_out = nzcvc<1>;

    Elem[result, 2*p + 0, esize] = res;
    Elem[result, 2*p + 1, esize] = ZeroExtend(carry_out);

Z[da] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:

- The values of the data supplied in any of its registers.
- The values of the NZCV flags.

This instruction might be immediately preceded in program order by a **MOVPRFX** instruction. The **MOVPRFX** instruction must conform to all of the following requirements, otherwise the behavior of the **MOVPRFX** and this instruction is UNPREDICTABLE:

- The **MOVPRFX** instruction must be unpredicated.
- The **MOVPRFX** instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# SCVTF

Signed integer convert to floating-point (predicated).

Convert to floating-point from the signed integer in each active element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

If the input and result types have a different size the smaller type is held unpacked in the least significant bits of elements of the larger size. When the input is the smaller type the upper bits of each source element are ignored. When the result is the smaller type the results are zero-extended to fill each destination element.

It has encodings from 7 classes: [16-bit to half-precision](#) , [32-bit to half-precision](#) , [32-bit to single-precision](#) , [32-bit to double-precision](#) , [64-bit to half-precision](#) , [64-bit to single-precision](#) and [64-bit to double-precision](#)

## 16-bit to half-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	0	1	0	0	0	1	0	1	0	1		Pg			Zn				Zd					
int_U																															

## 16-bit to half-precision

SCVTF <Zd>.H, <Pg>/M, <Zn>.H

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 16;
integer d_esize = 16;
boolean unsigned = FALSE;
FPRounding rounding = FPRoundingMode(FPCR<31:0>);
```

## 32-bit to half-precision

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	0	1	0	1	0	1	0	0	1	0	1	Pg			Zn				Zd					
int_U																															

## 32-bit to half-precision

SCVTF <Zd>.H, <Pg>/M, <Zn>.S

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 32;
integer d_esize = 16;
boolean unsigned = FALSE;
FPRounding rounding = FPRoundingMode(FPCR<31:0>);
```

## 32-bit to single-precision

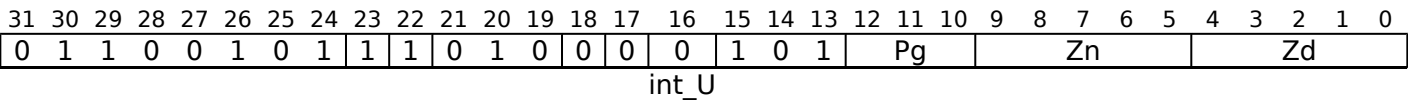
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	1	0	0	1	0	1	0	0	1	0	1	Pg			Zn				Zd					
int_U																															

32-bit to single-precision

```
SCVTF <Zd>.S, <Pg>/M, <Zn>.S

if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 32;
integer d_esize = 32;
boolean unsigned = FALSE;
FPRounding rounding = FPRoundingMode(FPCR<31:0>);
```

32-bit to double-precision

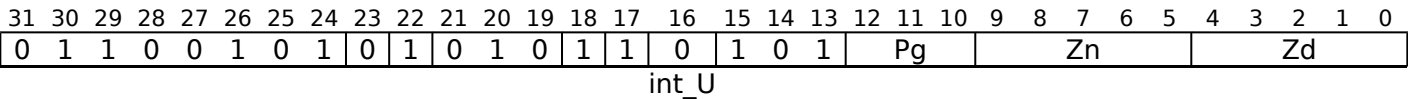


32-bit to double-precision

```
SCVTF <Zd>.D, <Pg>/M, <Zn>.S

if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 32;
integer d_esize = 64;
boolean unsigned = FALSE;
FPRounding rounding = FPRoundingMode(FPCR<31:0>);
```

64-bit to half-precision

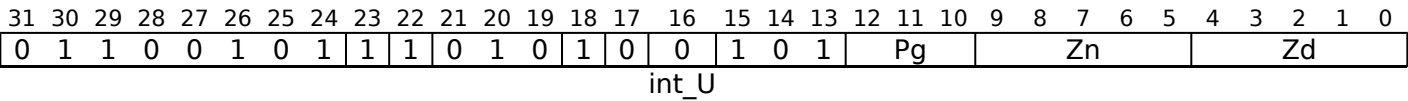


64-bit to half-precision

```
SCVTF <Zd>.H, <Pg>/M, <Zn>.D

if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 64;
integer d_esize = 16;
boolean unsigned = FALSE;
FPRounding rounding = FPRoundingMode(FPCR<31:0>);
```

64-bit to single-precision

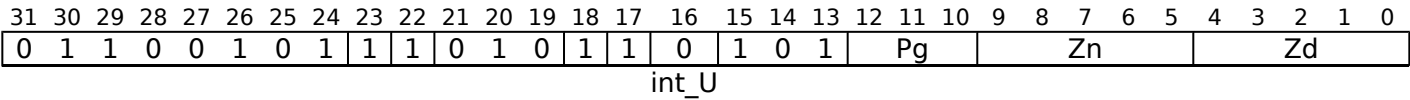


64-bit to single-precision

```
SCVTF <Zd>.S, <Pg>/M, <Zn>.D

if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 64;
integer d_esize = 32;
boolean unsigned = FALSE;
FPRounding rounding = FPRoundingMode(FPCR<31:0>);
```

64-bit to double-precision



64-bit to double-precision

```
SCVTF <Zd>.D, <Pg>/M, <Zn>.D

if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 64;
integer d_esize = 64;
boolean unsigned = FALSE;
FPRounding rounding = FPRoundingMode(FPCR<31:0>);
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    bits(esize) element = Elem[operand, e, esize];
    if ElemP[mask, e, esize] == '1' then
        bits(d_esize) fpval = FixedToFP(element<s_esize-1:0>, 0, unsigned, FPCR<31:0>, rounding);
        Elem[result, e, esize] = ZeroExtend(fpval);

Z[d] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.



- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

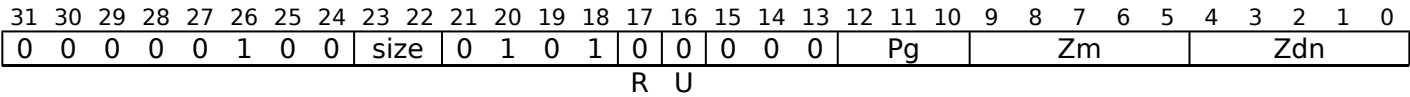
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# SDIV

Signed divide (predicated).

Signed divide active elements of the first source vector by corresponding elements of the second source vector and destructively place the quotient in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



## SVE

SDIV <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '0x' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean unsigned = FALSE;
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size<0>":

size<0>	<T>
0	S
1	D
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    if ElemP[mask, e, esize] == '1' then
        integer quotient;
        if element2 == 0 then
            quotient = 0;
        else
            quotient = RoundTowardsZero(Real(element1) / Real(element2));
        Elem[result, e, esize] = quotient<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

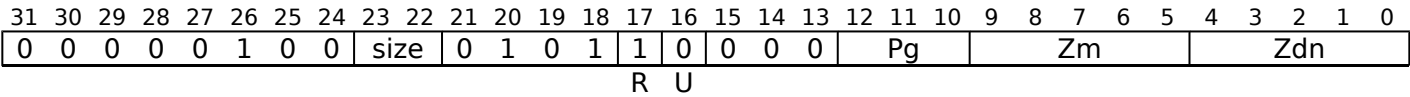
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SDIVR

Signed reversed divide (predicated).

Signed reversed divide active elements of the second source vector by corresponding elements of the first source vector and destructively place the quotient in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



SVE

SDIVR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '0x' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean unsigned = FALSE;
```

Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size<0>":

size<0>	<T>
0	S
1	D
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    if ElemP[mask, e, esize] == '1' then
        integer quotient;
        if element1 == 0 then
            quotient = 0;
        else
            quotient = RoundTowardsZero(Real(element2) / Real(element1));
        Elem[result, e, esize] = quotient<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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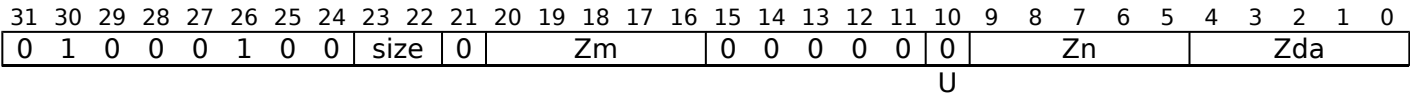
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# SDOT (vectors)

Signed integer dot product.

The signed integer dot product instruction computes the dot product of a group of four signed 8-bit or 16-bit integer values held in each 32-bit or 64-bit element of the first source vector multiplied by a group of four signed 8-bit or 16-bit integer values in the corresponding 32-bit or 64-bit element of the second source vector, and then destructively adds the widened dot product to the corresponding 32-bit or 64-bit element of the destination vector.

This instruction is unpredicated.



## SVE

SDOT <Zda>.<T>, <Zn>.<Tb>, <Zm>.<Tb>

```
if !HaveSVE() then UNDEFINED;
if size == '0x' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

<Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.

<T> Is the size specifier, encoded in "size<0>":

size<0>	<T>
0	S
1	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size<0>":

size<0>	<Tb>
0	B
1	H

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) res = Elem[operand3, e, esize];
    for i = 0 to 3
        integer element1 = SInt(Elem[operand1, 4 * e + i, esize DIV 4]);
        integer element2 = SInt(Elem[operand2, 4 * e + i, esize DIV 4]);
        res = res + element1 * element2;
    Elem[result, e, esize] = res;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# SDOT (indexed)

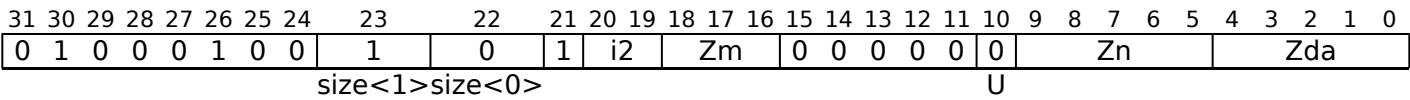
Signed integer indexed dot product.

The signed integer indexed dot product instruction computes the dot product of a group of four signed 8-bit or 16-bit integer values held in each 32-bit or 64-bit element of the first source vector multiplied by a group of four signed 8-bit or 16-bit integer values in an indexed 32-bit or 64-bit element of the second source vector, and then destructively adds the widened dot product to the corresponding 32-bit or 64-bit element of the destination vector.

The groups within the second source vector are specified using an immediate index which selects the same group position within each 128-bit vector segment. The index range is from 0 to one less than the number of groups per 128-bit segment, encoded in 1 to 2 bits depending on the size of the group. This instruction is unpredicated.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

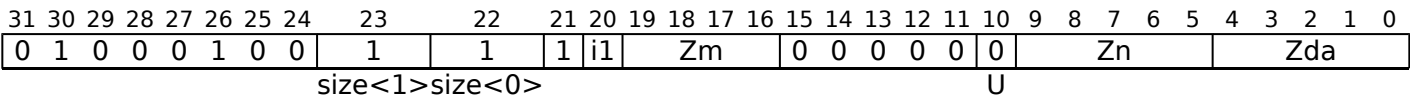


## 32-bit

SDOT <Zda>.S, <Zn>.B, <Zm>.B[<imm>]

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## 64-bit



## 64-bit

SDOT <Zda>.D, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer index = UInt(i1);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> For the 32-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  
For the 64-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
- <imm> For the 32-bit variant: is the immediate index of a quadruplet of four 8-bit elements within each 128-bit vector segment, in the range 0 to 3, encoded in the "i2" field.  
For the 64-bit variant: is the immediate index of a quadruplet of four 16-bit elements within each 128-bit vector segment, in the range 0 to 1, encoded in the "i1" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer eltspersegment = 128 DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    integer segmentbase = e - (e MOD eltspersegment);
    integer s = segmentbase + index;
    bits(esize) res = Elem[operand3, e, esize];
    for i = 0 to 3
        integer element1 = SInt(Elem[operand1, 4 * e + i, esize DIV 4]);
        integer element2 = SInt(Elem[operand2, 4 * s + i, esize DIV 4]);
        res = res + element1 * element2;
    Elem[result, e, esize] = res;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is

UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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## SEL (predicates)

Conditionally select elements from two predicates.

Read active elements from the first source predicate and inactive elements from the second source predicate and place in the corresponding elements of the destination predicate. Does not set the condition flags.

This instruction is used by the alias [MOV \(predicate, predicated, merging\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	0	0	0	Pm				0	1	Pg				1	Pn				1	Pd			
S																															

### SVE

SEL <Pd>.B, <Pg>, <Pn>.B, <Pm>.B

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer g = UInt(Pg);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
```

### Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.
- <Pn> Is the name of the first source scalable predicate register, encoded in the "Pn" field.
- <Pm> Is the name of the second source scalable predicate register, encoded in the "Pm" field.

### Alias Conditions

Alias	Is preferred when
<a href="#">MOV (predicate, predicated, merging)</a>	Pd == Pm

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(PL) operand1 = P[n];
bits(PL) operand2 = P[m];
bits(PL) result;

for e = 0 to elements-1
    bit element1 = ElemP[operand1, e, esize];
    bit element2 = ElemP[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        ElemP[result, e, esize] = element1;
    else
        ElemP[result, e, esize] = element2;

P[d] = result;
```

### Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.

- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

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# SEL (vectors)

Conditionally select elements from two vectors.

Read active elements from the first source vector and inactive elements from the second source vector and place in the corresponding elements of the destination vector.

This instruction is used by the alias [MOV \(vector, predicated\)](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	Zm			1	1	Pg			Zn			Zd										

## SVE

SEL <Zd>.<T>, <Pg>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register, encoded in the "Pg" field.

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Alias Conditions

Alias	Is preferred when
<a href="#">MOV (vector, predicated)</a>	Zd == Zm

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = element1;
    else
        Elem[result, e, esize] = element2;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

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# SETFFR

Initialise the first-fault register to all true.

Initialise the first-fault register (FFR) to all true prior to a sequence of first-fault or non-fault loads. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	0	1	0	1	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

## SVE

SETFFR

```
if !HaveSVE() then UNDEFINED;
```

### Operation

```
CheckSVEEnabled();  
FFR[] = Ones(PL);
```

### Operational information

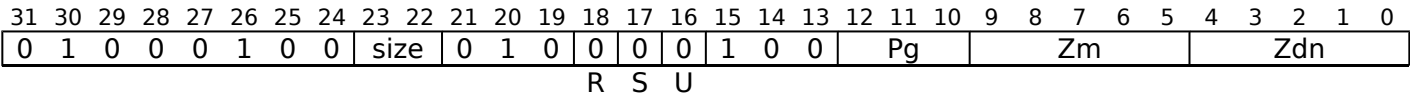
- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

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# SHADD

Signed halving addition.

Add active signed elements of the first source vector to corresponding signed elements of the second source vector, shift right one bit, and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



## SVE2

SHADD <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, e, esize]);
    integer element2 = SInt(Elem[operand2, e, esize]);
    if ElemP[mask, e, esize] == '1' then
        integer res = element1 + element2;
        Elem[result, e, esize] = res<esize:1>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.

- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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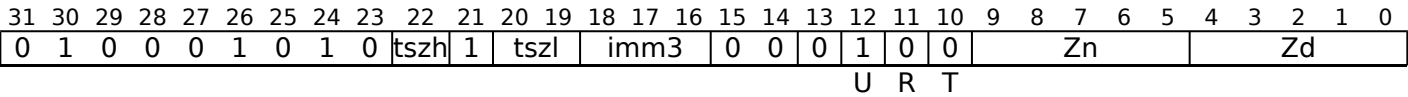
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SHRNB

Shift right narrow by immediate (bottom).

Shift each unsigned integer value in the source vector elements right by an immediate value, and place the truncated results in the even-numbered half-width destination elements, while setting the odd-numbered elements to zero. The immediate shift amount is an unsigned value in the range 1 to number of bits per element. This instruction is unpredicated.



SVE2

SHRNB <Zd>.<T>, <Zn>.<Tb>, #<const>

```
if !HaveSVE2() then UNDEFINED;
bits(3) tsize = tszh:tszl;
case tsize of
    when '000' UNDEFINED;
    when '001' esize = 8;
    when '01x' esize = 16;
    when '1xx' esize = 32;
integer n = UInt(Zn);
integer d = UInt(Zd);
integer shift = (2 * esize) - UInt(tsize:imm3);
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
0	00	RESERVED
0	01	B
0	1x	H
1	xx	S

- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<Tb>
0	00	RESERVED
0	01	H
0	1x	S
1	xx	D

- <const> Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
bits(VL) operand = Z[n];
bits(VL) result;

for e = 0 to elements-1
    bits(2*esize) element = Elem[operand, e, 2*esize];
    integer res = UInt(element) >> shift;
    Elem[result, 2*e + 0, esize] = res<esize-1:0>;
    Elem[result, 2*e + 1, esize] = Zeros();

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

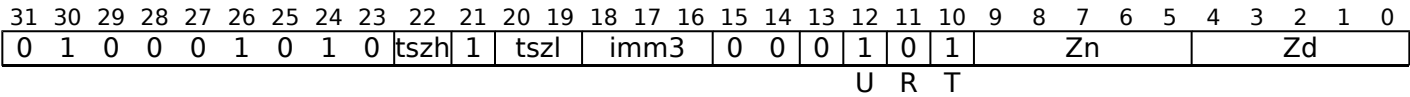
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SHRNT

Shift right narrow by immediate (top).

Shift each unsigned integer value in the source vector elements right by an immediate value, and place the truncated results in the odd-numbered half-width destination elements, leaving the even-numbered elements unchanged. The immediate shift amount is an unsigned value in the range 1 to number of bits per element. This instruction is unpredicated.



SVE2

SHRNT <Zd>.<T>, <Zn>.<Tb>, #<const>

```
if !HaveSVE2() then UNDEFINED;
bits(3) tsize = tszh:tszl;
case tsize of
  when '000' UNDEFINED;
  when '001' esize = 8;
  when '01x' esize = 16;
  when '1xx' esize = 32;
integer n = UInt(Zn);
integer d = UInt(Zd);
integer shift = (2 * esize) - UInt(tsize:imm3);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
0	00	RESERVED
0	01	B
0	1x	H
1	xx	S

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<Tb>
0	00	RESERVED
0	01	H
0	1x	S
1	xx	D

<const> Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
  bits(2*esize) element = Elem[operand, e, 2*esize];
  integer res = UInt(element) >> shift;
  Elem[result, 2*e + 1, esize] = res<esize-1:0>;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

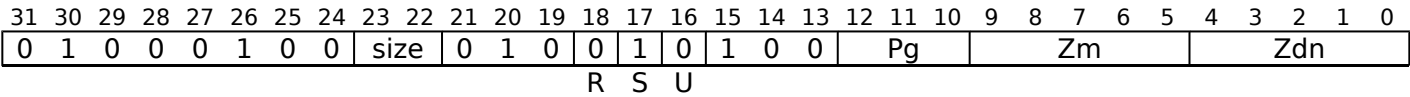
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# SHSUB

Signed halving subtract.

Subtract active signed elements of the second source vector from corresponding signed elements of the first source vector, shift right one bit, and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



## SVE2

SHSUB <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, e, esize]);
    integer element2 = SInt(Elem[operand2, e, esize]);
    if ElemP[mask, e, esize] == '1' then
        integer res = element1 - element2;
        Elem[result, e, esize] = res<esize:1>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.

- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

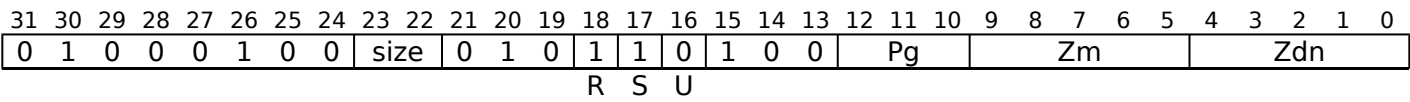
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# SHSUBR

Signed halving subtract reversed vectors.

Subtract active signed elements of the first source vector from corresponding signed elements of the second source vector, shift right one bit, and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



## SVE2

SHSUBR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, e, esize]);
    integer element2 = SInt(Elem[operand2, e, esize]);
    if ElemP[mask, e, esize] == '1' then
        integer res = element2 - element1;
        Elem[result, e, esize] = res<esize:1>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.

- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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SLI

Shift left and insert (immediate).

Shift each source vector element left by an immediate value, and insert the result into the corresponding vector element in the destination vector register, merging the shifted bits from each source element with existing bits in each destination vector element. The immediate shift amount is an unsigned value in the range 0 to number of bits per element minus 1. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	tszh	0	tszl	imm3			1	1	1	1	0	1	Zn						Zd					

SVE2

SLI <Zd>.<T>, <Zn>.<T>, #<const>

```
if !HaveSVE2() then UNDEFINED;
bits(4) tsize = tszh:tszl;
case tsize of
  when '0000' UNDEFINED;
  when '0001' esize = 8;
  when '001x' esize = 16;
  when '01xx' esize = 32;
  when '1xxx' esize = 64;
integer n = UInt(Zn);
integer d = UInt(Zd);
integer shift = UInt(tsize:imm3) - esize;
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
00	00	RESERVED
00	01	B
00	1x	H
01	xx	S
1x	xx	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<const> Is the immediate shift amount, in the range 0 to number of bits per element minus 1, encoded in "tsz:imm3".

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
  bits(esize) element1 = Elem[result, e, esize];
  bits(esize) element2 = Elem[operand, e, esize];
  bits(esize) mask = LSL(Ones(esize), shift);
  bits(esize) shiftedval = LSL(element2, shift);
  Elem[result, e, esize] = (element1 AND (NOT mask)) OR shiftedval;

Z[d] = result;
```

Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# SM4E

SM4 encryption and decryption.

The SM4E instruction reads 16 bytes of input data from each 128-bit segment of the first source vector, together with four iterations of 32-bit round keys from the corresponding 128-bit segments of the second source vector. Each block of data is encrypted by four rounds in accordance with the SM4 standard, and destructively placed in the corresponding segments of the first source vector. This instruction is unpredicated.

ID\_AA64ZFR0\_EL1.SM4 indicates whether this instruction is implemented.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	0	0	1	0	0	0	1	1	1	1	1	0	0	0	Zm					Zdn				
size<1>								size<0>																							

## SVE2

SM4E <Zdn>.S, <Zdn>.S, <Zm>.S

```
if !HaveSVE2SM4() then UNDEFINED;
integer m = UInt(Zm);
integer dn = UInt(Zdn);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer segments = VL DIV 128;
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for s = 0 to segments-1
    bits(128) key = Elem[operand2, s, 128];
    bits(32) intval;
    bits(8) sboxout;
    bits(128) roundresult = Elem[operand1, s, 128];
    bits(32) roundkey;

    for index = 0 to 3
        roundkey = Elem[key, index, 32];
        intval = roundresult<127:96> EOR roundresult<95:64> EOR roundresult<63:32> EOR roundkey;

        for i = 0 to 3
            Elem[intval, i, 8] = Sbox(Elem[intval, i, 8]);

        intval = intval EOR ROL(intval, 2) EOR ROL(intval, 10) EOR ROL(intval, 18) EOR ROL(intval, 24);
        intval = intval EOR roundresult<31:0>;

        roundresult<31:0> = roundresult<63:32>;
        roundresult<63:32> = roundresult<95:64>;
        roundresult<95:64> = roundresult<127:96>;
        roundresult<127:96> = intval;

    Elem[result, s, 128] = roundresult;

Z[dn] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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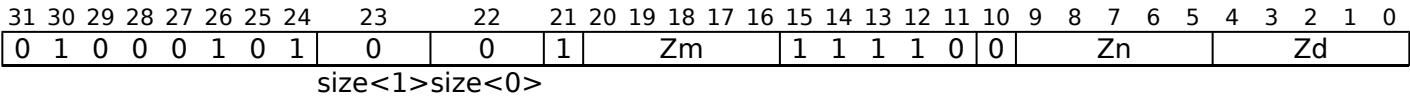
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# SM4EKEY

SM4 key updates.

The SM4EKEY instruction reads four rounds of 32-bit input key values from each 128-bit segment of the first source vector, along with four rounds of 32-bit constants from the corresponding 128-bit segment of the second source vector. The four rounds of output key values are derived in accordance with the SM4 standard, and placed in the corresponding segments of the destination vector. This instruction is unpredicated.

ID\_AA64ZFR0\_EL1.SM4 indicates whether this instruction is implemented.



## SVE2

SM4EKEY <Zd>.S, <Zn>.S, <Zm>.S

```
if !HaveSVE2SM4() then UNDEFINED;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer segments = VL DIV 128;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for s = 0 to segments-1
    bits(128) source = Elem[operand2, s, 128];
    bits(32) intval;
    bits(8) sbboxout;
    bits(32) const;
    bits(128) roundresult = Elem[operand1, s, 128];

    for index = 0 to 3
        const = Elem[source, index, 32];
        intval = roundresult<127:96> EOR roundresult<95:64> EOR roundresult<63:32> EOR const;
        for i = 0 to 3
            Elem[intval, i, 8] = Sbox(Elem[intval, i, 8]);

        intval = intval EOR ROL(intval, 13) EOR ROL(intval, 23);
        intval = intval EOR roundresult<31:0>;

        roundresult<31:0> = roundresult<63:32>;
        roundresult<63:32> = roundresult<95:64>;
        roundresult<95:64> = roundresult<127:96>;
        roundresult<127:96> = intval;

    Elem[result, s, 128] = roundresult;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

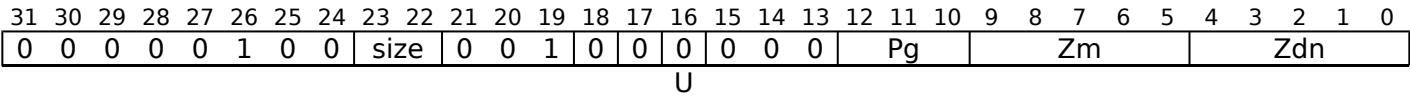
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# SMAX (vectors)

Signed maximum vectors (predicated).

Determine the signed maximum of active elements of the second source vector and corresponding elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



## SVE

SMAX <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean unsigned = FALSE;
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    if ElemP[mask, e, esize] == '1' then
        integer maximum = Max(element1, element2);
        Elem[result, e, esize] = maximum<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.

- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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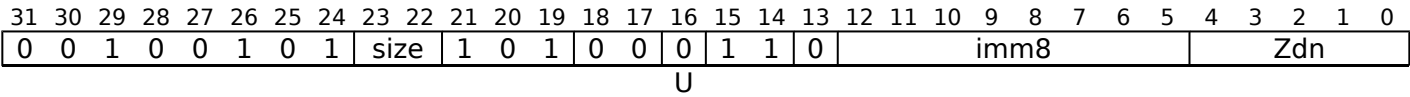
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# SMAX (immediate)

Signed maximum with immediate (unpredicated).

Determine the signed maximum of an immediate and each element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate is a signed 8-bit value in the range -128 to +127, inclusive. This instruction is unpredicated.



## SVE

SMAX <Zdn>.<T>, <Zdn>.<T>, #<imm>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer dn = UInt(Zdn);
boolean unsigned = FALSE;
integer imm = Int(imm8, unsigned);
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <imm> Is the signed immediate operand, in the range -128 to 127, encoded in the "imm8" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    Elem[result, e, esize] = Max(element1, imm)<esize-1:0>;

Z[dn] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

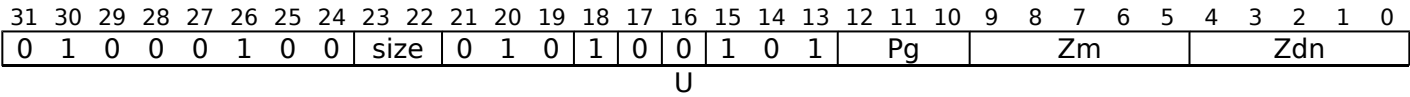
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# SMAXP

Signed maximum pairwise.

Compute the maximum value of each pair of adjacent signed integer elements within each source vector, and interleave the results from corresponding lanes. The interleaved result values are destructively placed in the first source vector.



## SVE2

SMAXP <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer m = UInt(Zm);
integer dn = UInt(Zdn);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;
integer element1;
integer element2;

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '0' then
    Elem[result, e, esize] = Elem[operand1, e, esize];
  else
    if IsEven(e) then
      element1 = SInt(Elem[operand1, e + 0, esize]);
      element2 = SInt(Elem[operand1, e + 1, esize]);
    else
      element1 = SInt(Elem[operand2, e - 1, esize]);
      element2 = SInt(Elem[operand2, e + 0, esize]);
    integer res = Max(element1, element2);
    Elem[result, e, esize] = res<esize-1:0>;

Z[dn] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is

UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

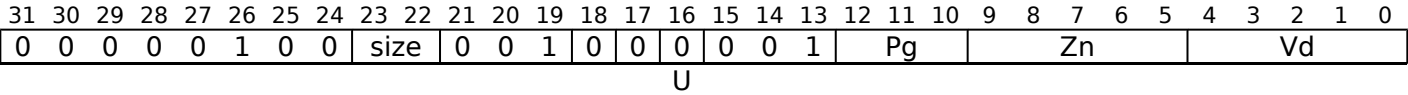
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# SMAXV

Signed maximum reduction to scalar.

Signed maximum horizontally across all lanes of a vector, and place the result in the SIMD&FP scalar destination register. Inactive elements in the source vector are treated as the minimum signed integer for the element size.



## SVE

SMAXV <V><d>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);
boolean unsigned = FALSE;
```

## Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D

<d> Is the number [0-31] of the destination SIMD&FP register, encoded in the "Vd" field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<T> Is the size specifier, encoded in “size”:

size	<T>
00	B
01	H
10	S
11	D

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
integer maximum = if unsigned then 0 else -(2^(esize-1));

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer element = Int(Elem[operand, e, esize], unsigned);
        maximum = Max(maximum, element);

V[d] = maximum<esize-1:0>;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:

- The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

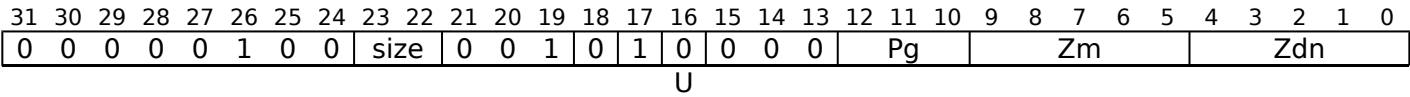
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# SMIN (vectors)

Signed minimum vectors (predicated).

Determine the signed minimum of active elements of the second source vector and corresponding elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



## SVE

SMIN <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean unsigned = FALSE;
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    if ElemP[mask, e, esize] == '1' then
        integer minimum = Min(element1, element2);
        Elem[result, e, esize] = minimum<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.

- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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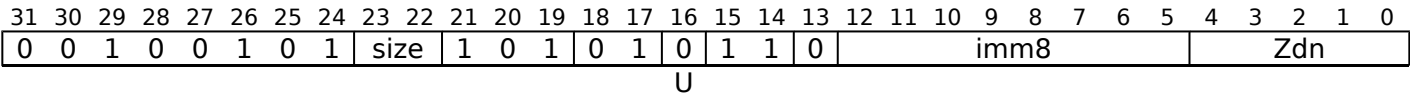
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SMIN (immediate)

Signed minimum with immediate (unpredicated).

Determine the signed minimum of an immediate and each element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate is a signed 8-bit value in the range -128 to +127, inclusive. This instruction is unpredicated.



SVE

```
SMIN <Zdn>.<T>, <Zdn>.<T>, #<imm>
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer dn = UInt(Zdn);
boolean unsigned = FALSE;
integer imm = Int(imm8, unsigned);
```

Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <imm> Is the signed immediate operand, in the range -128 to 127, encoded in the "imm8" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    Elem[result, e, esize] = Min(element1, imm)<esize-1:0>;

Z[dn] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

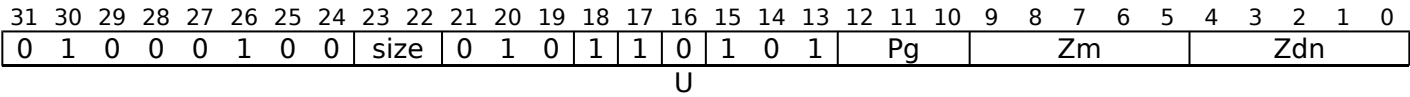
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# SMINP

Signed minimum pairwise.

Compute the minimum value of each pair of adjacent signed integer elements within each source vector, and interleave the results from corresponding lanes. The interleaved result values are destructively placed in the first source vector.



## SVE2

SMINP <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer m = UInt(Zm);
integer dn = UInt(Zdn);
```

## Assembler Symbols

- <Zdn>Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T>Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg>Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm>Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;
integer element1;
integer element2;

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '0' then
    Elem[result, e, esize] = Elem[operand1, e, esize];
  else
    if IsEven(e) then
      element1 = SInt(Elem[operand1, e + 0, esize]);
      element2 = SInt(Elem[operand1, e + 1, esize]);
    else
      element1 = SInt(Elem[operand2, e - 1, esize]);
      element2 = SInt(Elem[operand2, e + 0, esize]);
    integer res = Min(element1, element2);
    Elem[result, e, esize] = res<esize-1:0>;

Z[dn] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

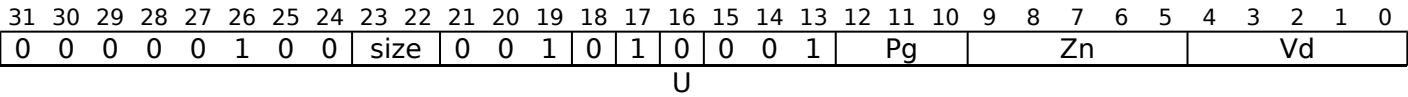
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SMINV

Signed minimum reduction to scalar.

Signed minimum horizontally across all lanes of a vector, and place the result in the SIMD&FP scalar destination register. Inactive elements in the source vector are treated as the maximum signed integer for the element size.



SVE

SMINV <V><d>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);
boolean unsigned = FALSE;
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D

<d> Is the number [0-31] of the destination SIMD&FP register, encoded in the "Vd" field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<T> Is the size specifier, encoded in “size”:

size	<T>
00	B
01	H
10	S
11	D

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
integer minimum = if unsigned then (2^esize - 1) else (2^(esize-1) - 1);

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer element = Int(Elem[operand, e, esize], unsigned);
        minimum = Min(minimum, element);

V[d] = minimum<esize-1:0>;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:

- The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

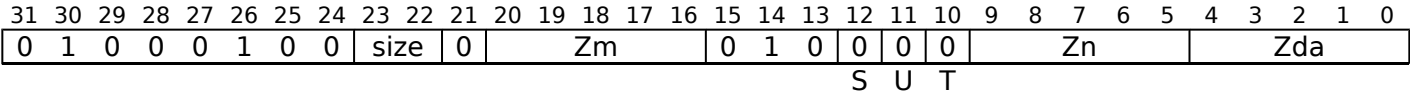
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# SMLALB (vectors)

Signed multiply-add long to accumulator (bottom).

Multiply the corresponding even-numbered signed elements of the first and second source vectors and destructively add to the overlapping double-width elements of the addend vector. This instruction is unpredicated.



## SVE2

SMLALB <Zda>.<T>, <Zn>.<Tb>, <Zm>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, 2*e + 0, esize DIV 2]);
    integer element2 = SInt(Elem[operand2, 2*e + 0, esize DIV 2]);
    bits(esize) product = (element1 * element2)<esize-1:0>;
    Elem[result, e, esize] = Elem[result, e, esize] + product;

Z[da] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:

- The values of the data supplied in any of its registers.
- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a **MOVPRFX** instruction. The **MOVPRFX** instruction must conform to all of the following requirements, otherwise the behavior of the **MOVPRFX** and this instruction is UNPREDICTABLE:

- The **MOVPRFX** instruction must be unpredicated.
- The **MOVPRFX** instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# SMLALB (indexed)

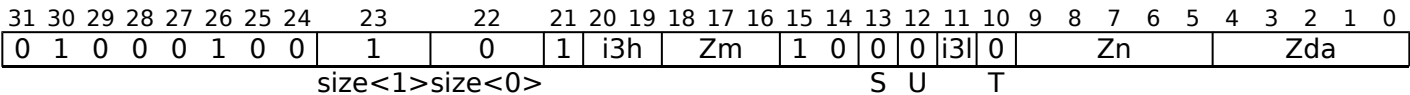
Signed multiply-add long to accumulator (bottom, indexed).

Multiply the even-numbered signed elements within each 128-bit segment of the first source vector by the specified signed element in the corresponding second source vector segment and destructively add to the overlapping double-width elements of the addend vector.

The elements within the second source vector are specified using an immediate index which selects the same element position within each 128-bit vector segment. The index range is from 0 to one less than the number of elements per 128-bit segment, encoded in 2 or 3 bits depending on the size of the element.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

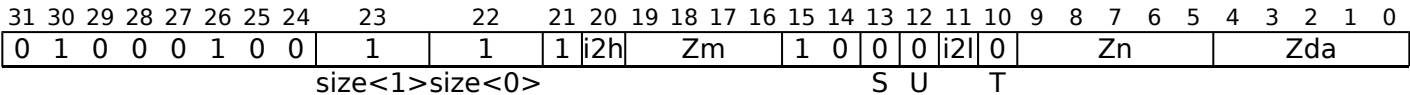


## 32-bit

SMLALB <Zda>.S, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 16;
integer index = UInt(i3h:i3l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel = 0;
```

## 64-bit



## 64-bit

SMLALB <Zda>.D, <Zn>.S, <Zm>.S[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2h:i2l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel = 0;
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> For the 32-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  
For the 64-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
- <imm> For the 32-bit variant: is the element index, in the range 0 to 7, encoded in the "i3h:i3l" fields.  
For the 64-bit variant: is the element index, in the range 0 to 3, encoded in the "i2h:i2l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
integer eltspersegment = 128 DIV (2 * esize);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer s = e - (e MOD eltspersegment);
    integer element1 = SInt(Elem[operand1, 2 * e + sel, esize]);
    integer element2 = SInt(Elem[operand2, 2 * s + index, esize]);
    bits(2*esize) product = (element1 * element2)<2*esize-1:0>;
    Elem[result, e, 2*esize] = Elem[result, e, 2*esize] + product;

Z[da] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is

UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

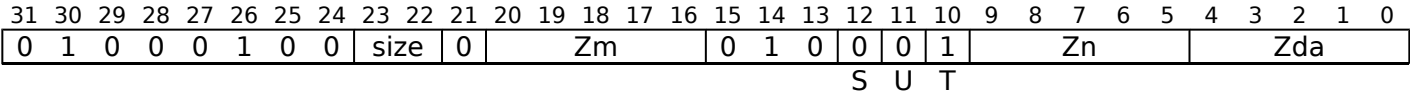
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# SMLALT (vectors)

Signed multiply-add long to accumulator (top).

Multiply the corresponding odd-numbered signed elements of the first and second source vectors and destructively add to the overlapping double-width elements of the addend vector. This instruction is unpredicated.



## SVE2

SMLALT <Zda>.<T>, <Zn>.<Tb>, <Zm>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, 2*e + 1, esize DIV 2]);
    integer element2 = SInt(Elem[operand2, 2*e + 1, esize DIV 2]);
    bits(esize) product = (element1 * element2)<esize-1:0>;
    Elem[result, e, esize] = Elem[result, e, esize] + product;

Z[da] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:

- The values of the data supplied in any of its registers.
- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# SMLALT (indexed)

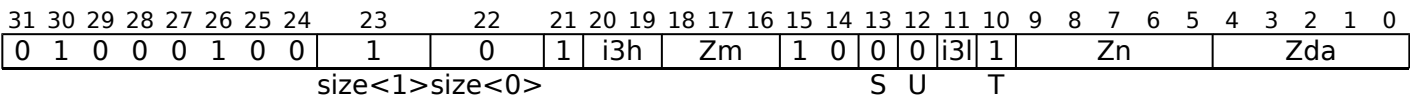
Signed multiply-add long to accumulator (top, indexed).

Multiply the odd-numbered signed elements within each 128-bit segment of the first source vector by the specified signed element in the corresponding second source vector segment and destructively add to the overlapping double-width elements of the addend vector.

The elements within the second source vector are specified using an immediate index which selects the same element position within each 128-bit vector segment. The index range is from 0 to one less than the number of elements per 128-bit segment, encoded in 2 or 3 bits depending on the size of the element.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

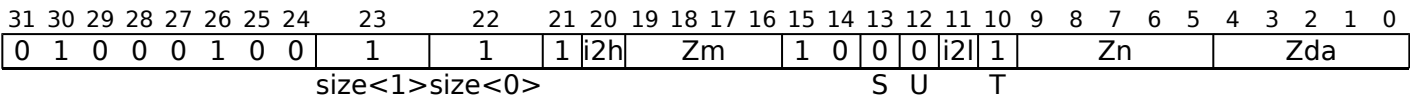


## 32-bit

SMLALT <Zda>.S, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 16;
integer index = UInt(i3h:i3l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel = 1;
```

## 64-bit



## 64-bit

SMLALT <Zda>.D, <Zn>.S, <Zm>.S[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2h:i2l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel = 1;
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> For the 32-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  
For the 64-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
- <imm> For the 32-bit variant: is the element index, in the range 0 to 7, encoded in the "i3h:i3l" fields.  
For the 64-bit variant: is the element index, in the range 0 to 3, encoded in the "i2h:i2l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
integer eltspersegment = 128 DIV (2 * esize);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer s = e - (e MOD eltspersegment);
    integer element1 = SInt(Elem[operand1, 2 * e + sel, esize]);
    integer element2 = SInt(Elem[operand2, 2 * s + index, esize]);
    bits(2*esize) product = (element1 * element2)<2*esize-1:0>;
    Elem[result, e, 2*esize] = Elem[result, e, 2*esize] + product;

Z[da] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

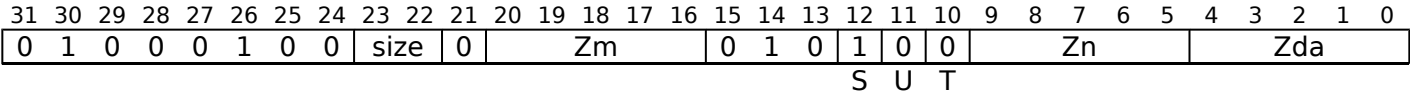
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# SMLS LB (vectors)

Signed multiply-subtract long from accumulator (bottom).

Multiply the corresponding even-numbered signed elements of the first and second source vectors and destructively subtract from the overlapping double-width elements of the addend vector. This instruction is unpredicated.



## SVE2

SMLS LB <Zda>.<T>, <Zn>.<Tb>, <Zm>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, 2*e + 0, esize DIV 2]);
    integer element2 = SInt(Elem[operand2, 2*e + 0, esize DIV 2]);
    bits(esize) product = (element1 * element2)<esize-1:0>;
    Elem[result, e, esize] = Elem[result, e, esize] - product;

Z[da] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:

- The values of the data supplied in any of its registers.
- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# SMLSBLB (indexed)

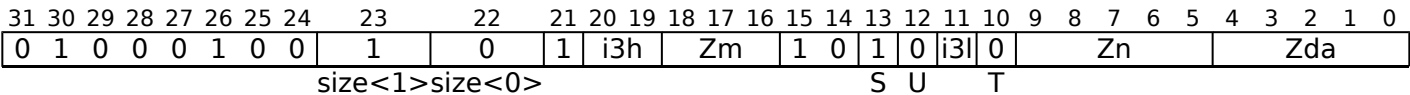
Signed multiply-subtract long from accumulator (bottom, indexed).

Multiply the even-numbered signed elements within each 128-bit segment of the first source vector by the specified signed element in the corresponding second source vector segment and destructively subtract from the overlapping double-width elements of the addend vector.

The elements within the second source vector are specified using an immediate index which selects the same element position within each 128-bit vector segment. The index range is from 0 to one less than the number of elements per 128-bit segment, encoded in 2 or 3 bits depending on the size of the element.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

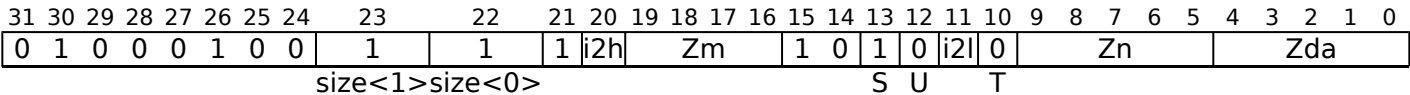


## 32-bit

SMLSBLB <Zda>.S, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 16;
integer index = UInt(i3h:i3l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel = 0;
```

## 64-bit



## 64-bit

SMLSBLB <Zda>.D, <Zn>.S, <Zm>.S[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2h:i2l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel = 0;
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> For the 32-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  
For the 64-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
- <imm> For the 32-bit variant: is the element index, in the range 0 to 7, encoded in the "i3h:i3l" fields.  
For the 64-bit variant: is the element index, in the range 0 to 3, encoded in the "i2h:i2l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
integer eltspersegment = 128 DIV (2 * esize);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer s = e - (e MOD eltspersegment);
    integer element1 = SInt(Elem[operand1, 2 * e + sel, esize]);
    integer element2 = SInt(Elem[operand2, 2 * s + index, esize]);
    bits(2*esize) product = (element1 * element2)<2*esize-1:0>;
    Elem[result, e, 2*esize] = Elem[result, e, 2*esize] - product;

Z[da] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is

UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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## SMLSLT (vectors)

Signed multiply-subtract long from accumulator (top).

Multiply the corresponding odd-numbered signed elements of the first and second source vectors and destructively subtract from the overlapping double-width elements of the addend vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size	0	Zm				0	1	0	1	0	1	Zn				Zda							
S U T																															

## SVE2

SMLS LT <Zda>.<T>, <Zn>.<Tb>, <Zm>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

<b>&lt;Zda&gt;</b>	Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
--------------------	---

**<T>** Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<b>&lt;Zn&gt;</b>	Is the name of the first source scalable vector register, encoded in the "Zn" field.
-------------------	--

**<Tb>** Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

**<Zm>** Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, 2*e + 1, esize DIV 2]);
    integer element2 = SInt(Elem[operand2, 2*e + 1, esize DIV 2]);
    bits(esize) product = (element1 * element2)<esize-1:0>;
    Elem[result, e, esize] = Elem[result, e, esize] - product;

Z[da] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:

- The values of the data supplied in any of its registers.
- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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## SMLSLT (indexed)

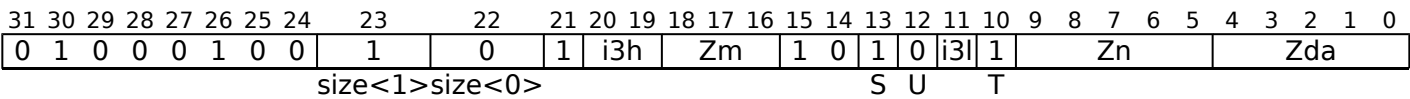
Signed multiply-subtract long from accumulator (top, indexed).

Multiply the odd-numbered signed elements within each 128-bit segment of the first source vector by the specified signed element in the corresponding second source vector segment and destructively subtract from the overlapping double-width elements of the addend vector.

The elements within the second source vector are specified using an immediate index which selects the same element position within each 128-bit vector segment. The index range is from 0 to one less than the number of elements per 128-bit segment, encoded in 2 or 3 bits depending on the size of the element.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

### 32-bit

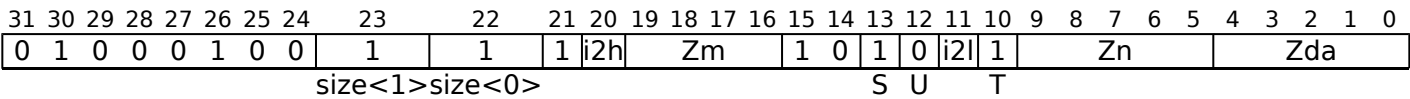


### 32-bit

SMLSLT <Zda>.S, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 16;
integer index = UInt(i3h:i3l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel = 1;
```

### 64-bit



### 64-bit

SMLSLT <Zda>.D, <Zn>.S, <Zm>.S[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2h:i2l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel = 1;
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> For the 32-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  
For the 64-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
- <imm> For the 32-bit variant: is the element index, in the range 0 to 7, encoded in the "i3h:i3l" fields.  
For the 64-bit variant: is the element index, in the range 0 to 3, encoded in the "i2h:i2l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
integer eltspersegment = 128 DIV (2 * esize);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer s = e - (e MOD eltspersegment);
    integer element1 = SInt(Elem[operand1, 2 * e + sel, esize]);
    integer element2 = SInt(Elem[operand2, 2 * s + index, esize]);
    bits(2*esize) product = (element1 * element2)<2*esize-1:0>;
    Elem[result, e, 2*esize] = Elem[result, e, 2*esize] - product;

Z[da] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is

UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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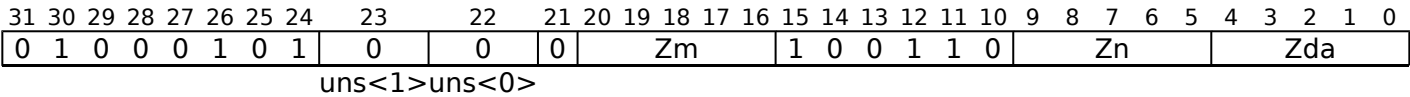
# SMMLA

Signed integer matrix multiply-accumulate.

The signed integer matrix multiply-accumulate instruction multiplies the 2×8 matrix of signed 8-bit integer values held in each 128-bit segment of the first source vector by the 8×2 matrix of signed 8-bit integer values in the corresponding segment of the second source vector. The resulting 2×2 widened 32-bit integer matrix product is then destructively added to the 32-bit integer matrix accumulator held in the corresponding segment of the addend and destination vector. This is equivalent to performing an 8-way dot product per destination element.

This instruction is unpredicated.

ID\_AA64ZFR0\_EL1.I8MM indicates whether this instruction is implemented.



## SVE

SMMLA <Zda>.S, <Zn>.B, <Zm>.B

```
if !HaveSVE() || !HaveInt8MatMulExt() then UNDEFINED;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean op1_unsigned = FALSE;
boolean op2_unsigned = FALSE;
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer segments = VL DIV 128;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result = Zeros();
bits(128) op1, op2;
bits(128) res, addend;

for s = 0 to segments-1
    op1 = Elem[operand1, s, 128];
    op2 = Elem[operand2, s, 128];
    addend = Elem[operand3, s, 128];
    res = MatMulAdd(addend, op1, op2, op1_unsigned, op2_unsigned);
    Elem[result, s, 128] = res;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

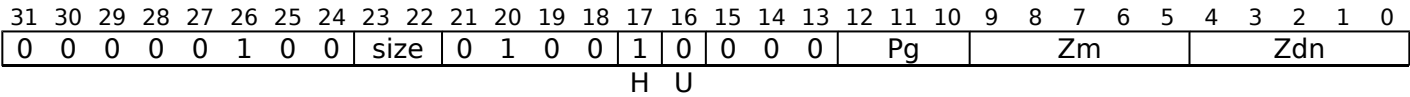




# SMULH (predicated)

Signed multiply returning high half (predicated).

Widening multiply signed integer values in active elements of the first source vector by corresponding elements of the second source vector and destructively place the high half of the result in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



## SVE

SMULH <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean unsigned = FALSE;
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    if ElemP[mask, e, esize] == '1' then
        integer product = (element1 * element2) >> esize;
        Elem[result, e, esize] = product<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.

- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

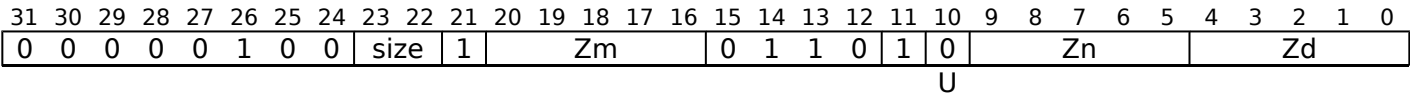
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# SMULH (unpredicated)

Signed multiply returning high half (unpredicated).

Widening multiply signed integer values of all elements of the first source vector by corresponding elements of the second source vector and place the high half of the result in the corresponding elements of the destination vector. This instruction is unpredicated.



## SVE2

SMULH <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
boolean unsigned = FALSE;
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    integer product = (element1 * element2) >> esize;
    Elem[result, e, esize] = product<esize-1:0>;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

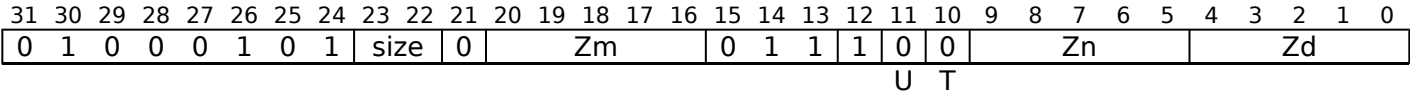
- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.



# SMULLB (vectors)

Signed multiply long (bottom).

Multiply the corresponding even-numbered signed elements of the first and second source vectors, and place the results in the overlapping double-width elements of the destination vector. This instruction is unpredicated.



## SVE2

SMULLB <Zd>.<T>, <Zn>.<Tb>, <Zm>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, 2*e + 0, esize DIV 2]);
    integer element2 = SInt(Elem[operand2, 2*e + 0, esize DIV 2]);
    integer res = element1 * element2;
    Elem[result, e, esize] = res<esize-1:0>;

Z[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:

- The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# SMULLB (indexed)

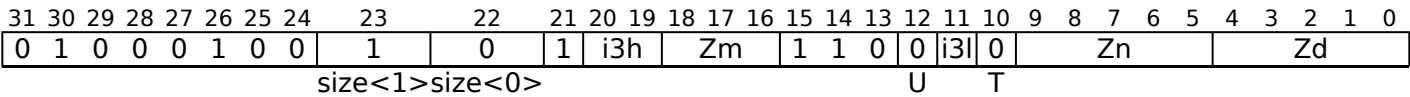
Signed multiply long (bottom, indexed).

Multiply the even-numbered signed elements within each 128-bit segment of the first source vector by the specified signed element in the corresponding second source vector segment, and place the results in the overlapping double-width elements of the destination vector register.

The elements within the second source vector are specified using an immediate index which selects the same element position within each 128-bit vector segment. The index range is from 0 to one less than the number of elements per 128-bit segment, encoded in 2 or 3 bits depending on the size of the element.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

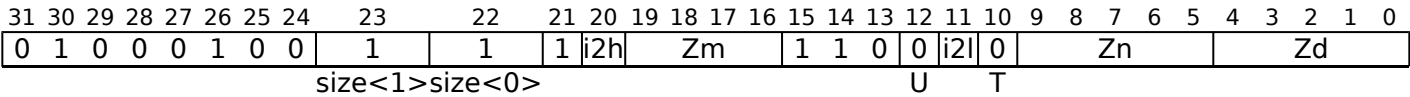


## 32-bit

SMULLB <Zd>.S, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 16;
integer index = UInt(i3h:i3l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer sel = 0;
```

## 64-bit



## 64-bit

SMULLB <Zd>.D, <Zn>.S, <Zm>.S[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2h:i2l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer sel = 0;
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> For the 32-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  
For the 64-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
- <imm> For the 32-bit variant: is the element index, in the range 0 to 7, encoded in the "i3h:i3l" fields.  
For the 64-bit variant: is the element index, in the range 0 to 3, encoded in the "i2h:i2l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
integer eltspersegment = 128 DIV (2 * esize);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer s = e - (e MOD eltspersegment);
    integer element1 = SInt(Elem[operand1, 2 * e + sel, esize]);
    integer element2 = SInt(Elem[operand2, 2 * s + index, esize]);
    integer res = element1 * element2;
    Elem[result, e, 2*esize] = res<2*esize-1:0>;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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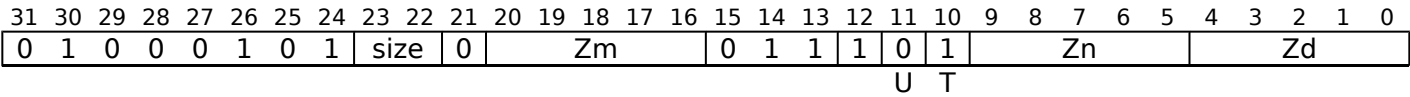
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# SMULLT (vectors)

Signed multiply long (top).

Multiply the corresponding odd-numbered signed elements of the first and second source vectors, and place the results in the overlapping double-width elements of the destination vector. This instruction is unpredicated.



## SVE2

SMULLT <Zd>.<T>, <Zn>.<Tb>, <Zm>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, 2*e + 1, esize DIV 2]);
    integer element2 = SInt(Elem[operand2, 2*e + 1, esize DIV 2]);
    integer res = element1 * element2;
    Elem[result, e, esize] = res<esize-1:0>;

Z[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:

- The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# SMULLT (indexed)

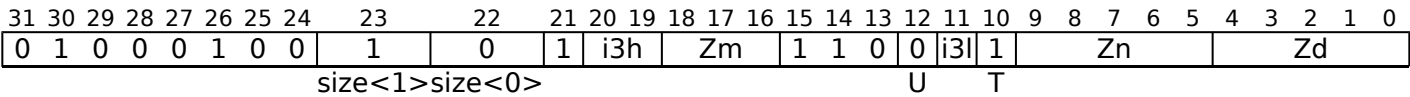
Signed multiply long (top, indexed).

Multiply the odd-numbered signed elements within each 128-bit segment of the first source vector by the specified element in the corresponding second source vector segment, and place the results in the overlapping double-width elements of the destination vector register.

The elements within the second source vector are specified using an immediate index which selects the same element position within each 128-bit vector segment. The index range is from 0 to one less than the number of elements per 128-bit segment, encoded in 2 or 3 bits depending on the size of the element.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

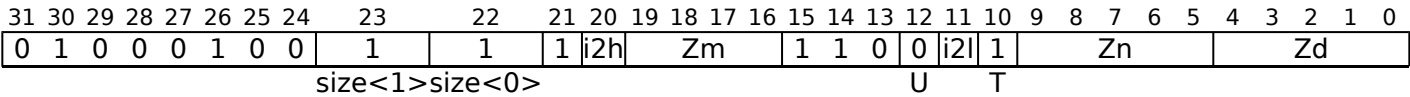


## 32-bit

SMULLT <Zd>.S, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 16;
integer index = UInt(i3h:i3l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer sel = 1;
```

## 64-bit



## 64-bit

SMULLT <Zd>.D, <Zn>.S, <Zm>.S[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2h:i2l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer sel = 1;
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> For the 32-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  
For the 64-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
- <imm> For the 32-bit variant: is the element index, in the range 0 to 7, encoded in the "i3h:i3l" fields.  
For the 64-bit variant: is the element index, in the range 0 to 3, encoded in the "i2h:i2l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
integer eltspersegment = 128 DIV (2 * esize);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer s = e - (e MOD eltspersegment);
    integer element1 = SInt(Elem[operand1, 2 * e + sel, esize]);
    integer element2 = SInt(Elem[operand2, 2 * s + index, esize]);
    integer res = element1 * element2;
    Elem[result, e, 2*esize] = res<2*esize-1:0>;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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SPLICE

Splice two vectors under predicate control.

Copy the first active to last active elements (inclusive) from the first source vector to the lowest-numbered elements of the result. Then set any remaining elements of the result to a copy of the lowest-numbered elements from the second source vector. The result is placed destructively in the destination and first source vector, or constructively in the destination vector.

It has encodings from 2 classes: [Constructive](#) and [Destructive](#)

Constructive

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size			1	0	1	1	0	1	1	0	0	Pg			Zn			Zd					

Constructive

SPLICE <Zd>.<T>, <Pg>, { <Zn1>.<T>, <Zn2>.<T> }

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dst = UInt(Zd);
integer s1 = UInt(Zn);
integer s2 = (s1 + 1) MOD 32;
```

Destructive

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size			1	0	1	1	0	0	1	0	0	Pg			Zm			Zdn					

Destructive

SPLICE <Zdn>.<T>, <Pg>, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dst = UInt(Zdn);
integer s1 = dst;
integer s2 = UInt(Zm);
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn1> Is the name of the first scalable vector register of a multi-vector sequence, encoded in the "Zn" field.
- <Zn2> Is the name of the second scalable vector register of a multi-vector sequence, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[s1];
bits(VL) operand2 = Z[s2];
bits(VL) result;
integer x = 0;
boolean active = FALSE;
integer lastnum = LastActiveElement(mask, esize);

if lastnum >= 0 then
    for e = 0 to lastnum
        active = active || ElemP[mask, e, esize] == '1';
        if active then
            Elem[result, x, esize] = Elem[operand1, e, esize];
            x = x + 1;

elements = elements - x - 1;
for e = 0 to elements
    Elem[result, x, esize] = Elem[operand2, e, esize];
    x = x + 1;

Z[dst] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

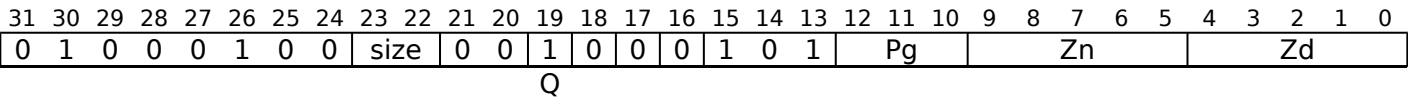
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SQABS

Signed saturating absolute value.

Compute the absolute value of the signed integer in each active element of the source vector, and place the results in the corresponding elements of the destination vector. Each result element is saturated to the N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . Inactive elements in the destination vector register remain unmodified.



SVE2

SQABS <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    integer element = SInt(Elem[operand, e, esize]);
    if ElemP[mask, e, esize] == '1' then
        element = Abs(element);
        Elem[result, e, esize] = SignedSat(element, esize);

Z[d] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

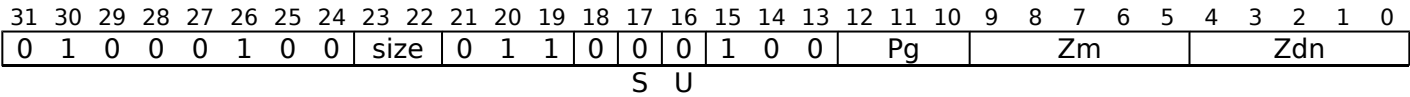




# SQADD (vectors, predicated)

Signed saturating addition (predicated).

Add active signed elements of the first source vector to corresponding signed elements of the second source vector and destructively place the results in the corresponding elements of the first source vector. Each result element is saturated to the N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . Inactive elements in the destination vector register remain unmodified.



## SVE2

SQADD <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean unsigned = FALSE;
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, e, esize]);
    integer element2 = SInt(Elem[operand2, e, esize]);
    if ElemP[mask, e, esize] == '1' then
        integer res = SInt(Sat(element1 + element2, esize, unsigned));
        Elem[result, e, esize] = res<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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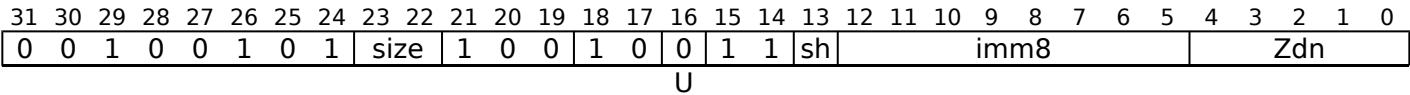
# SQADD (immediate)

Signed saturating add immediate (unpredicated).

Signed saturating add of an unsigned immediate to each element of the source vector, and destructively place the results in the corresponding elements of the source vector. Each result element is saturated to the N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . This instruction is unpredicated.

The immediate is an unsigned value in the range 0 to 255, and for element widths of 16 bits or higher it may also be a positive multiple of 256 in the range 256 to 65280.

The immediate is encoded in 8 bits with an optional left shift by 8. The preferred disassembly when the shift option is specified is "#<uimm8>, LSL #8". However an assembler and disassembler may also allow use of the shifted 16-bit value unless the immediate is 0 and the shift amount is 8, which must be unambiguously described as "#0, LSL #8".



## SVE

SQADD <Zdn>.<T>, <Zdn>.<T>, #<imm>{, <shift>}

```
if !HaveSVE() then UNDEFINED;
if size:sh == '001' then UNDEFINED;
integer esize = 8 << UInt(size);
integer dn = UInt(Zdn);
integer imm = UInt(imm8);
if sh == '1' then imm = imm << 8;
boolean unsigned = FALSE;
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <imm> Is an unsigned immediate in the range 0 to 255, encoded in the "imm8" field.
- <shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #8

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 + imm, esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

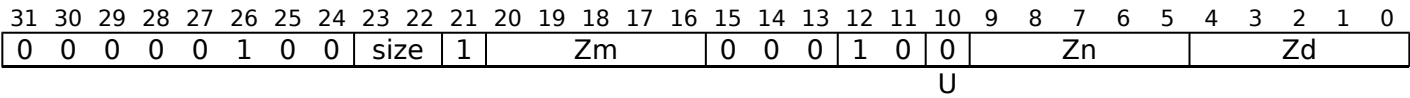
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SQADD (vectors, unpredicated)

Signed saturating add vectors (unpredicated).

Signed saturating add all elements of the second source vector to corresponding elements of the first source vector and place the results in the corresponding elements of the destination vector. Each result element is saturated to the N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . This instruction is unpredicated.



SVE

SQADD <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
boolean unsigned = FALSE;
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 + element2, esize, unsigned);

Z[d] = result;
```

SQCADD

Saturating complex integer add with rotate.

Add the real and imaginary components of the integral complex numbers from the first source vector to the complex numbers from the second source vector which have first been rotated by 90 or 270 degrees in the direction from the positive real axis towards the positive imaginary axis, when considered in polar representation, equivalent to multiplying the complex numbers in the second source vector by  $\pm j$  beforehand. Destructively place the results in the corresponding elements of the first source vector. Each result element is saturated to the N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . This instruction is unpredicated.

Each complex number is represented in a vector register as an even/odd pair of elements with the real part in the even-numbered element and the imaginary part in the odd-numbered element.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	size		0	0	0	0	0	1	1	1	0	1	1	rot	Zm				Zdn					

SVE2

SQCADD <Zdn>.<T>, <Zdn>.<T>, <Zm>.<T>, <const>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Zm);
integer dn = UInt(Zdn);
boolean sub_i = (rot == '0');
boolean sub_r = (rot == '1');
```

Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <const> Is the const specifier, encoded in "rot":

rot	<const>
0	#90
1	#270

## Operation

```
CheckSVEEnabled();
integer pairs = VL DIV (2 * esize);
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for p = 0 to pairs-1
    integer acc_r = SInt(Elem[operand1, 2 * p + 0, esize]);
    integer acc_i = SInt(Elem[operand1, 2 * p + 1, esize]);
    integer elt2_r = SInt(Elem[operand2, 2 * p + 0, esize]);
    integer elt2_i = SInt(Elem[operand2, 2 * p + 1, esize]);
    if sub_i then
        acc_r = acc_r - elt2_i;
        acc_i = acc_i + elt2_r;
    if sub_r then
        acc_r = acc_r + elt2_i;
        acc_i = acc_i - elt2_r;

    Elem[result, 2 * p + 0, esize] = SignedSat(acc_r, esize);
    Elem[result, 2 * p + 1, esize] = SignedSat(acc_i, esize);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# SQDECB

Signed saturating decrement scalar by multiple of 8-bit predicate constraint element count.

Determines the number of active 8-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement the scalar destination. The result is saturated to the source general-purpose register's signed integer range. A 32-bit saturated result is then sign-extended to 64 bits.

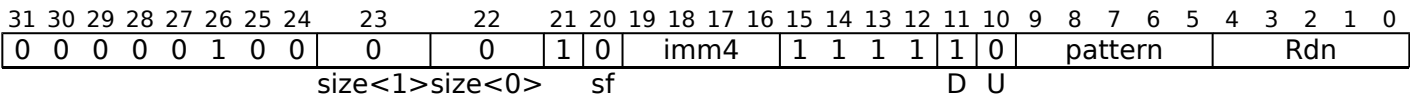
The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

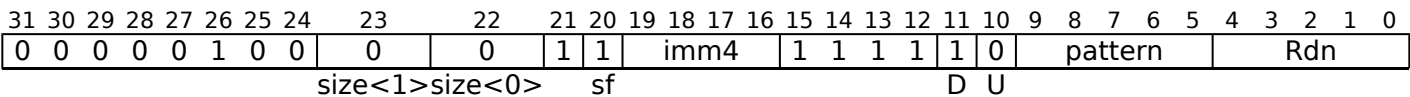


## 32-bit

SQDECB <Xdn>, <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 32;
```

## 64-bit



## 64-bit

SQDECB <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 64;
```

## Assembler Symbols

- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":



pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 - (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

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# SQDECD (scalar)

Signed saturating decrement scalar by multiple of 64-bit predicate constraint element count.

Determines the number of active 64-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement the scalar destination. The result is saturated to the source general-purpose register's signed integer range. A 32-bit saturated result is then sign-extended to 64 bits.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	1	1	0	imm4				1	1	1	1	1	0	pattern					Rdn				
size<1>size<0>								sf									D		U												

## 32-bit

SQDECD <Xdn>, <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	1	1	1	imm4				1	1	1	1	1	0	pattern					Rdn				
size<1>size<0>								sf									D		U												

## 64-bit

SQDECD <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 64;
```

## Assembler Symbols

- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 - (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

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SQDECD (vector)

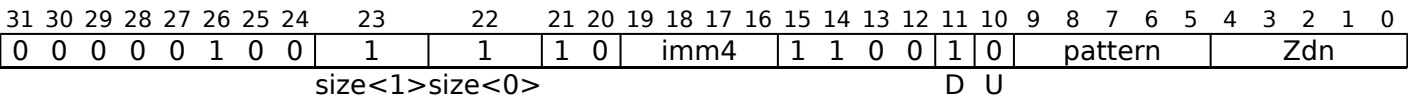
Signed saturating decrement vector by multiple of 64-bit predicate constraint element count.

Determines the number of active 64-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement all destination vector elements. The results are saturated to the 64-bit signed integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.



SVE

SQDECD <Zdn>.D{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
```

Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer count = DecodePredCount(pat, esize);
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 - (count * imm), esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# SQDECH (scalar)

Signed saturating decrement scalar by multiple of 16-bit predicate constraint element count.

Determines the number of active 16-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement the scalar destination. The result is saturated to the source general-purpose register's signed integer range. A 32-bit saturated result is then sign-extended to 64 bits.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	1	1	0	imm4				1	1	1	1	1	0	pattern					Rdn				
size<1>size<0>								sf									D		U												

## 32-bit

SQDECH <Xdn>, <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	1	1	1	imm4				1	1	1	1	1	0	pattern					Rdn				
size<1>size<0>								sf									D		U												

## 64-bit

SQDECH <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 64;
```

## Assembler Symbols

- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 - (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

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SQDECH (vector)

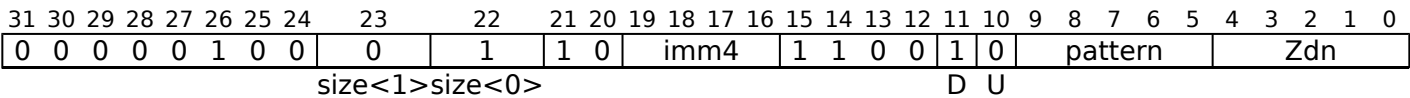
Signed saturating decrement vector by multiple of 16-bit predicate constraint element count.

Determines the number of active 16-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement all destination vector elements. The results are saturated to the 16-bit signed integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.



SVE

SQDECH <Zdn>.H{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
```

Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer count = DecodePredCount(pat, esize);
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 - (count * imm), esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# SQDECP (scalar)

Signed saturating decrement scalar by count of true predicate elements.

Counts the number of true elements in the source predicate and then uses the result to decrement the scalar destination. The result is saturated to the source general-purpose register's signed integer range. A 32-bit saturated result is then sign-extended to 64 bits.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size		1	0	1	0	1	0	1	0	0	0	1	0	0	Pm			Rdn					
D														U		sf															

## 32-bit

SQDECP <Xdn>, <Pm>.<T>, <Wdn>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Rdn);
boolean unsigned = FALSE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size		1	0	1	0	1	0	1	0	0	0	1	1	0	Pm			Rdn					
D														U		sf															

## 64-bit

SQDECP <Xdn>, <Pm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Rdn);
boolean unsigned = FALSE;
integer ssize = 64;
```

## Assembler Symbols

- <Xdn>

Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Pm>

Is the name of the source scalable predicate register, encoded in the "Pm" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <Wdn>

Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(ssize) operand1 = X[dn];
bits(PL) operand2 = P[m];
bits(ssize) result;
integer count = 0;

for e = 0 to elements-1
    if ElemP[operand2, e, esize] == '1' then
        count = count + 1;

integer element = Int(operand1, unsigned);
(result, -) = Sat0(element - count, ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);
```

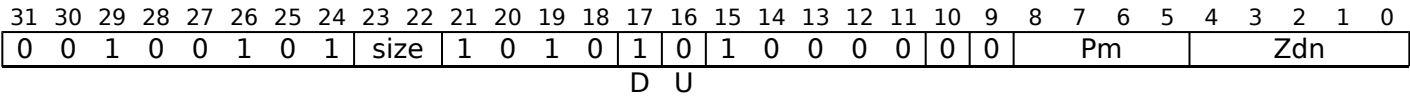
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## SQDECP (vector)

Signed saturating decrement vector by count of true predicate elements.

Counts the number of true elements in the source predicate and then uses the result to decrement all destination vector elements. The results are saturated to the element signed integer range.  
The predicate size specifier may be omitted in assembler source code, but this is deprecated and will be prohibited in a future release of the architecture.



## SVE

SQDECP <Zdn>.<T>, <Pm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Zdn);
boolean unsigned = FALSE;
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pm> Is the name of the source scalable predicate register, encoded in the "Pm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(PL) operand2 = P[m];
bits(VL) result;
integer count = 0;

for e = 0 to elements-1
    if ElemP[operand2, e, esize] == '1' then
        count = count + 1;

for e = 0 to elements-1
    integer element = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = Sat0(element - count, esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# SQDECW (scalar)

Signed saturating decrement scalar by multiple of 32-bit predicate constraint element count.

Determines the number of active 32-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement the scalar destination. The result is saturated to the source general-purpose register's signed integer range. A 32-bit saturated result is then sign-extended to 64 bits.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	0	1	0	imm4				1	1	1	1	1	0	pattern					Rdn				
size<1>size<0>								sf									D		U												

## 32-bit

SQDECW <Xdn>, <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	0	1	1	imm4				1	1	1	1	1	0	pattern					Rdn				
size<1>size<0>								sf									D		U												

## 64-bit

SQDECW <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 64;
```

## Assembler Symbols

- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 - (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

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# SQDECW (vector)

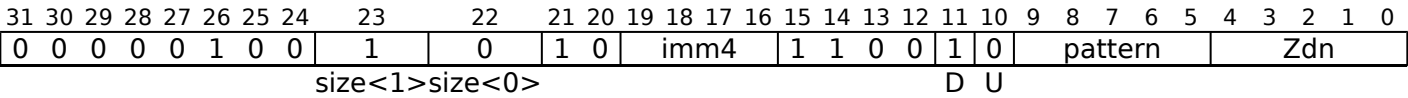
Signed saturating decrement vector by multiple of 32-bit predicate constraint element count.

Determines the number of active 32-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement all destination vector elements. The results are saturated to the 32-bit signed integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.



## SVE

SQDECW <Zdn>.S{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer count = DecodePredCount(pat, esize);
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 - (count * imm), esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

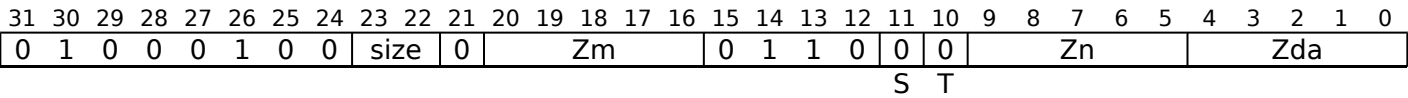
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SQDMLALB (vectors)

Signed saturating doubling multiply-add long to accumulator (bottom).

Multiply then double the corresponding even-numbered signed elements of the first and second source vectors. Each intermediate value is saturated to the double-width N-bit value's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . Then destructively add to the overlapping double-width elements of the addend and destination vector. Each destination element is saturated to the double-width N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . This instruction is unpredicated.



SVE2

```
SQDMLALB <Zda>.<T>, <Zn>.<Tb>, <Zm>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel1 = 0;
integer sel2 = 0;
```

Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, 2 * e + sel1, esize DIV 2]);
    integer element2 = SInt(Elem[operand2, 2 * e + sel2, esize DIV 2]);
    integer element3 = SInt(Elem[result, e, esize]);
    integer product = SInt(SignedSat(2 * element1 * element2, esize));
    Elem[result, e, esize] = SignedSat(element3 + product, esize);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# SQDMLALB (indexed)

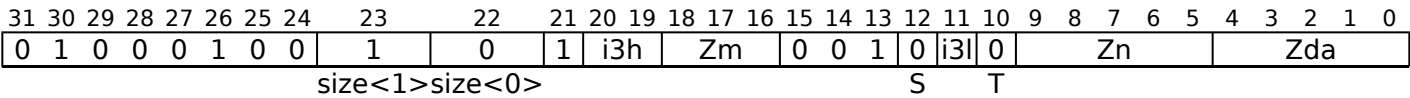
Signed saturating doubling multiply-add long to accumulator (bottom, indexed).

Multiply then double the even-numbered signed elements within each 128-bit segment of the first source vector and specified signed element in the corresponding second source vector segment. Each intermediate value is saturated to the double-width N-bit value's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . Then destructively add to the overlapping double-width elements of the addend and destination vector. Each destination element is saturated to the double-width N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ .

The elements within the second source vector are specified using an immediate index which selects the same element position within each 128-bit vector segment. The index range is from 0 to one less than the number of elements per 128-bit segment, encoded in 2 or 3 bits depending on the size of the element.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

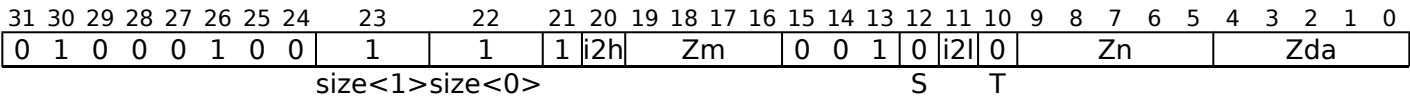


## 32-bit

SQDMLALB <Zda>.S, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 16;
integer index = UInt(i3h:i3l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel = 0;
```

## 64-bit



## 64-bit

SQDMLALB <Zda>.D, <Zn>.S, <Zm>.S[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2h:i2l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel = 0;
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> For the 32-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  
For the 64-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
- <imm> For the 32-bit variant: is the element index, in the range 0 to 7, encoded in the "i3h:i3l" fields.

For the 64-bit variant: is the element index, in the range 0 to 3, encoded in the "i2h:i2l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
integer eltspersegment = 128 DIV (2 * esize);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer s = e - (e MOD eltspersegment);
    integer element1 = SInt(Elem[operand1, 2 * e + sel, esize]);
    integer element2 = SInt(Elem[operand2, 2 * s + index, esize]);
    integer element3 = SInt(Elem[result, e, 2*esize]);
    integer product = SInt(SignedSat(2 * element1 * element2, 2*esize));
    integer res = element3 + product;
    Elem[result, e, 2*esize] = SignedSat(res, 2*esize);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

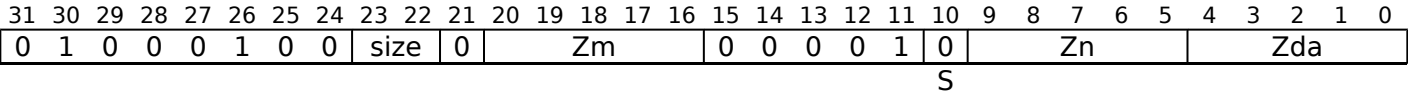
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SQDMLALBT

Signed saturating doubling multiply-add long to accumulator (bottom × top).

Multiply then double the corresponding even-numbered signed elements of the first and odd-numbered signed elements of the second source vector. Each intermediate value is saturated to the double-width N-bit value's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . Then destructively add to the overlapping double-width elements of the addend and destination vector. Each destination element is saturated to the double-width N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . This instruction is unpredicated.



SVE2

SQDMLALBT <Zda>.<T>, <Zn>.<Tb>, <Zm>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel1 = 0;
integer sel2 = 1;
```

Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, 2 * e + sel1, esize DIV 2]);
    integer element2 = SInt(Elem[operand2, 2 * e + sel2, esize DIV 2]);
    integer element3 = SInt(Elem[result, e, esize]);
    integer product = SInt(SignedSat(2 * element1 * element2, esize));
    Elem[result, e, esize] = SignedSat(element3 + product, esize);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

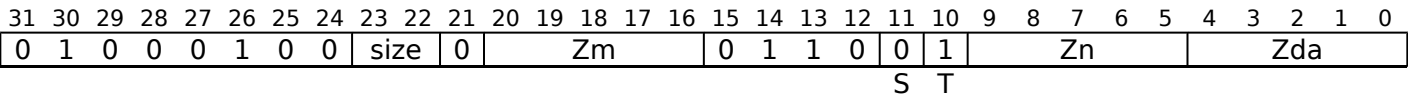
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# SQDMLALT (vectors)

Signed saturating doubling multiply-add long to accumulator (top).

Multiply then double the corresponding odd-numbered signed elements of the first and second source vectors. Each intermediate value is saturated to the double-width N-bit value's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . Then destructively add to the overlapping double-width elements of the addend and destination vector. Each destination element is saturated to the double-width N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . This instruction is unpredicated.



## SVE2

SQDMLALT <Zda>.<T>, <Zn>.<Tb>, <Zm>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel1 = 1;
integer sel2 = 1;
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, 2 * e + sel1, esize DIV 2]);
    integer element2 = SInt(Elem[operand2, 2 * e + sel2, esize DIV 2]);
    integer element3 = SInt(Elem[result, e, esize]);
    integer product = SInt(SignedSat(2 * element1 * element2, esize));
    Elem[result, e, esize] = SignedSat(element3 + product, esize);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# SQDMLALT (indexed)

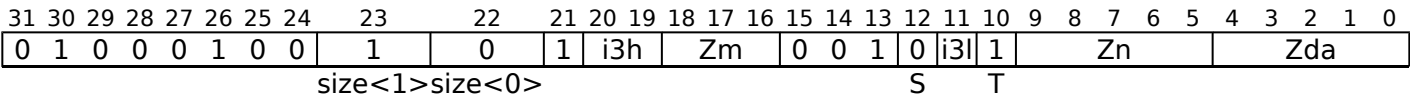
Signed saturating doubling multiply-add long to accumulator (top, indexed).

Multiply then double the odd-numbered signed elements within each 128-bit segment of the first source vector and the specified signed element in the corresponding second source vector segment. Each intermediate value is saturated to the double-width N-bit value's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . Then destructively add to the overlapping double-width elements of the addend and destination vector. Each destination element is saturated to the double-width N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ .

The elements within the second source vector are specified using an immediate index which selects the same element position within each 128-bit vector segment. The index range is from 0 to one less than the number of elements per 128-bit segment, encoded in 2 or 3 bits depending on the size of the element.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

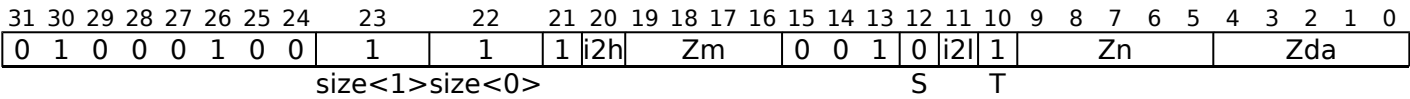


## 32-bit

SQDMLALT <Zda>.S, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 16;
integer index = UInt(i3h:i3l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel = 1;
```

## 64-bit



## 64-bit

SQDMLALT <Zda>.D, <Zn>.S, <Zm>.S[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2h:i2l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel = 1;
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> For the 32-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  
For the 64-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
- <imm> For the 32-bit variant: is the element index, in the range 0 to 7, encoded in the "i3h:i3l" fields.

For the 64-bit variant: is the element index, in the range 0 to 3, encoded in the "i2h:i2l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
integer eltspersegment = 128 DIV (2 * esize);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer s = e - (e MOD eltspersegment);
    integer element1 = SInt(Elem[operand1, 2 * e + sel, esize]);
    integer element2 = SInt(Elem[operand2, 2 * s + index, esize]);
    integer element3 = SInt(Elem[result, e, 2*esize]);
    integer product = SInt(SignedSat(2 * element1 * element2, 2*esize));
    integer res = element3 + product;
    Elem[result, e, 2*esize] = SignedSat(res, 2*esize);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

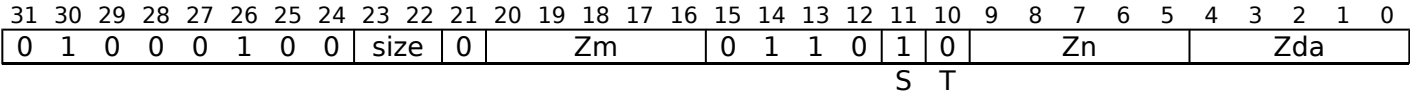
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SQDMLSLB (vectors)

Signed saturating doubling multiply-subtract long from accumulator (bottom).

Multiply then double the corresponding even-numbered signed elements of the first and second source vectors. Each intermediate value is saturated to the double-width N-bit value's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . Then destructively subtract from the overlapping double-width elements of the addend and destination vector. Each destination element is saturated to the double-width N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . This instruction is unpredicated.



SVE2

SQDMLSLB <Zda>.<T>, <Zn>.<Tb>, <Zm>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel1 = 0;
integer sel2 = 0;
```

Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, 2 * e + sel1, esize DIV 2]);
    integer element2 = SInt(Elem[operand2, 2 * e + sel2, esize DIV 2]);
    integer element3 = SInt(Elem[result, e, esize]);
    integer product = SInt(SignedSat(2 * element1 * element2, esize));
    Elem[result, e, esize] = SignedSat(element3 - product, esize);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# SQDMLSLB (indexed)

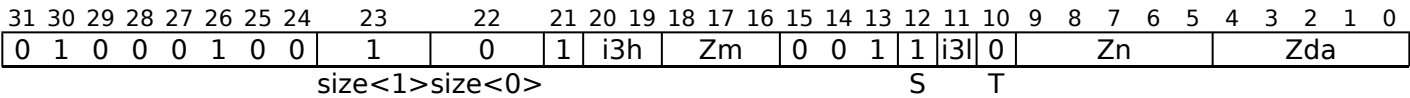
Signed saturating doubling multiply-subtract long from accumulator (bottom, indexed).

Multiply then double the even-numbered signed elements within each 128-bit segment of the first source vector and the specified signed element in the corresponding second source vector segment. Each intermediate value is saturated to the double-width N-bit value's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . Then destructively subtract from the overlapping double-width elements of the addend and destination vector. Each destination element is saturated to the double-width N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ .

The elements within the second source vector are specified using an immediate index which selects the same element position within each 128-bit vector segment. The index range is from 0 to one less than the number of elements per 128-bit segment, encoded in 2 or 3 bits depending on the size of the element.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

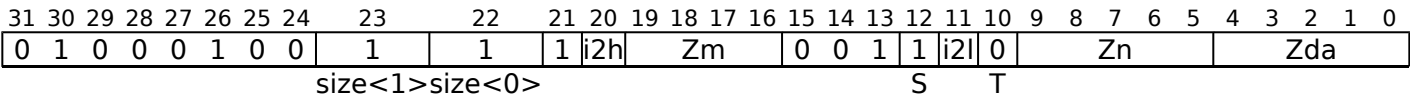


## 32-bit

SQDMLSLB <Zda>.S, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 16;
integer index = UInt(i3h:i3l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel = 0;
```

## 64-bit



## 64-bit

SQDMLSLB <Zda>.D, <Zn>.S, <Zm>.S[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2h:i2l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel = 0;
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> For the 32-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  
For the 64-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
- <imm> For the 32-bit variant: is the element index, in the range 0 to 7, encoded in the "i3h:i3l" fields.

For the 64-bit variant: is the element index, in the range 0 to 3, encoded in the "i2h:i2l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
integer eltspersegment = 128 DIV (2 * esize);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer s = e - (e MOD eltspersegment);
    integer element1 = SInt(Elem[operand1, 2 * e + sel, esize]);
    integer element2 = SInt(Elem[operand2, 2 * s + index, esize]);
    integer element3 = SInt(Elem[result, e, 2*esize]);
    integer product = SInt(SignedSat(2 * element1 * element2, 2*esize));
    integer res = element3 - product;
    Elem[result, e, 2*esize] = SignedSat(res, 2*esize);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

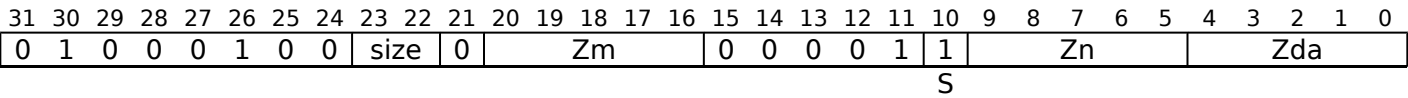
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SQDMLSLBT

Signed saturating doubling multiply-subtract long from accumulator (bottom × top).

Multiply then double the corresponding even-numbered signed elements of the first and odd-numbered signed elements of the second source vector. Each intermediate value is saturated to the double-width N-bit value's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . Then destructively subtract from the overlapping double-width elements of the addend and destination vector. Each destination element is saturated to the double-width N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . This instruction is unpredicated.



SVE2

SQDMLSLBT <Zda>.<T>, <Zn>.<Tb>, <Zm>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel1 = 0;
integer sel2 = 1;
```

Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, 2 * e + sel1, esize DIV 2]);
    integer element2 = SInt(Elem[operand2, 2 * e + sel2, esize DIV 2]);
    integer element3 = SInt(Elem[result, e, esize]);
    integer product = SInt(SignedSat(2 * element1 * element2, esize));
    Elem[result, e, esize] = SignedSat(element3 - product, esize);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

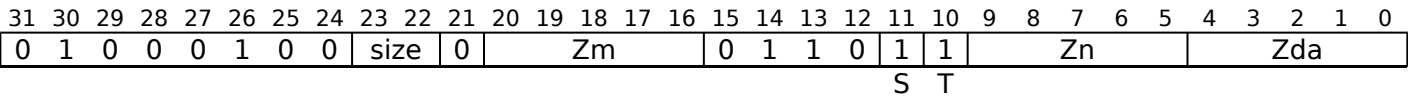
Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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SQDMLSLT (vectors)

Signed saturating doubling multiply-subtract long from accumulator (top).

Multiply then double the corresponding odd-numbered signed elements of the first and second source vectors. Each intermediate value is saturated to the double-width N-bit value's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . Then destructively subtract from the overlapping double-width elements of the addend and destination vector. Each destination element is saturated to the double-width N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . This instruction is unpredicated.



SVE2

SQDMLSLT <Zda>.<T>, <Zn>.<Tb>, <Zm>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel1 = 1;
integer sel2 = 1;
```

Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, 2 * e + sel1, esize DIV 2]);
    integer element2 = SInt(Elem[operand2, 2 * e + sel2, esize DIV 2]);
    integer element3 = SInt(Elem[result, e, esize]);
    integer product = SInt(SignedSat(2 * element1 * element2, esize));
    Elem[result, e, esize] = SignedSat(element3 - product, esize);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# SQDMLSLT (indexed)

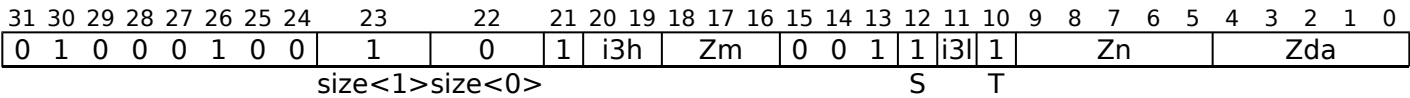
Signed saturating doubling multiply-subtract long from accumulator (top, indexed).

Multiply then double the odd-numbered signed elements within each 128-bit segment of the first source vector and the specified signed element in the corresponding second source vector segment. Each intermediate value is saturated to the double-width N-bit value's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . Then destructively subtract from the overlapping double-width elements of the addend and destination vector. Each destination element is saturated to the double-width N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ .

The elements within the second source vector are specified using an immediate index which selects the same element position within each 128-bit vector segment. The index range is from 0 to one less than the number of elements per 128-bit segment, encoded in 2 or 3 bits depending on the size of the element.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

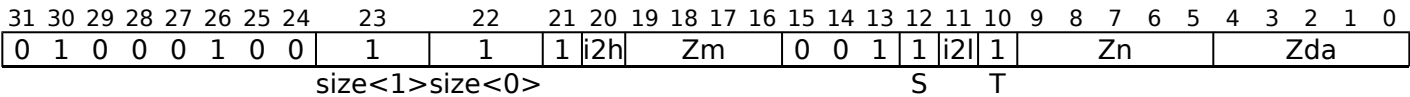


## 32-bit

SQDMLSLT <Zda>.S, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 16;
integer index = UInt(i3h:i3l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel = 1;
```

## 64-bit



## 64-bit

SQDMLSLT <Zda>.D, <Zn>.S, <Zm>.S[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2h:i2l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel = 1;
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> For the 32-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  
For the 64-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
- <imm> For the 32-bit variant: is the element index, in the range 0 to 7, encoded in the "i3h:i3l" fields.

For the 64-bit variant: is the element index, in the range 0 to 3, encoded in the "i2h:i2l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
integer eltspersegment = 128 DIV (2 * esize);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer s = e - (e MOD eltspersegment);
    integer element1 = SInt(Elem[operand1, 2 * e + sel, esize]);
    integer element2 = SInt(Elem[operand2, 2 * s + index, esize]);
    integer element3 = SInt(Elem[result, e, 2*esize]);
    integer product = SInt(SignedSat(2 * element1 * element2, 2*esize));
    integer res = element3 - product;
    Elem[result, e, 2*esize] = SignedSat(res, 2*esize);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

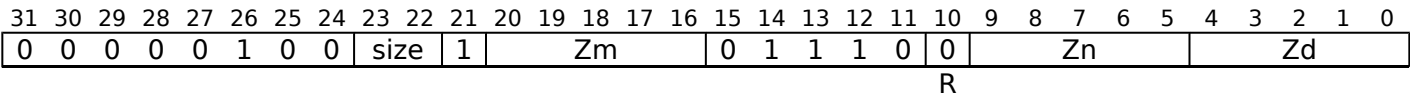
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# SQDMULH (vectors)

Signed saturating doubling multiply high (unpredicated).

Multiply then double the corresponding signed elements of the first and second source vectors, and place the most significant half of the results in the corresponding elements of the destination vector register. Each result element is saturated to the N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . This instruction is unpredicated.



## SVE2

SQDMULH <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, e, esize]);
    integer element2 = SInt(Elem[operand2, e, esize]);
    integer res = 2 * element1 * element2;
    Elem[result, e, esize] = SignedSat(res >> esize, esize);

Z[d] = result;
```

# SQDMULH (indexed)

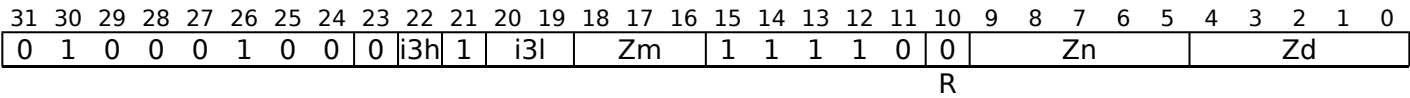
Signed saturating doubling multiply high (indexed).

Multiply all signed elements within each 128-bit segment of the first source vector by the specified signed element in the corresponding second source vector segment, double and place the most significant half of the result in the corresponding elements of the destination vector register. Each result element is saturated to the N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ .

The elements within the second source vector are specified using an immediate index which selects the same element position within each 128-bit vector segment. The index range is from 0 to one less than the number of elements per 128-bit segment, encoded in 1 to 3 bits depending on the size of the element.

It has encodings from 3 classes: [16-bit](#) , [32-bit](#) and [64-bit](#)

## 16-bit

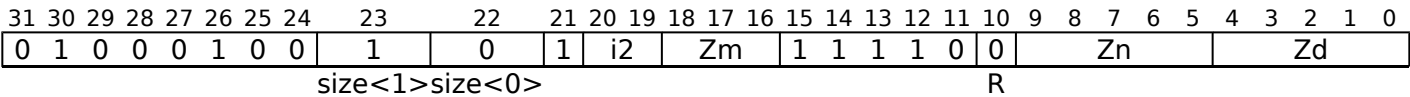


## 16-bit

SQDMULH <Zd>.H, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 16;
integer index = UInt(i3h:i3l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## 32-bit

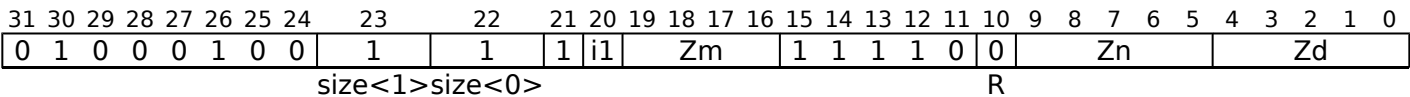


## 32-bit

SQDMULH <Zd>.S, <Zn>.S, <Zm>.S[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## 64-bit



## 64-bit

SQDMULH <Zd>.D, <Zn>.D, <Zm>.D[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 64;
integer index = UInt(i1);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd>	Is the name of the destination scalable vector register, encoded in the "Zd" field.
<Zn>	Is the name of the first source scalable vector register, encoded in the "Zn" field.
<Zm>	For the 16-bit and 32-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  For the 64-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
<imm>	For the 16-bit variant: is the element index, in the range 0 to 7, encoded in the "i3h:i3l" fields. For the 32-bit variant: is the element index, in the range 0 to 3, encoded in the "i2" field. For the 64-bit variant: is the element index, in the range 0 to 1, encoded in the "i1" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer eltsegment = 128 DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer segmentbase = e - (e MOD eltsegment);
    integer s = segmentbase + index;
    integer element1 = SInt(Elem[operand1, e, esize]);
    integer element2 = SInt(Elem[operand2, s, esize]);
    integer res = 2 * element1 * element2;
    Elem[result, e, esize] = SignedSat(res >> esize, esize);

Z[d] = result;
```

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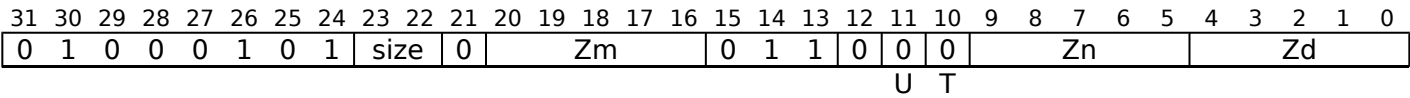
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SQDMULLB (vectors)

Signed saturating doubling multiply long (bottom).

Multiply the corresponding even-numbered signed elements of the first and second source vectors, double and place the results in the overlapping double-width elements of the destination vector. Each result element is saturated to the double-width N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . This instruction is unpredicated.



SVE2

SQDMULLB <Zd>.<T>, <Zn>.<Tb>, <Zm>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, 2*e + 0, esize DIV 2]);
    integer element2 = SInt(Elem[operand2, 2*e + 0, esize DIV 2]);
    integer res = 2 * element1 * element2;
    Elem[result, e, esize] = SignedSat(res, esize);

Z[d] = result;
```

# SQDMULLB (indexed)

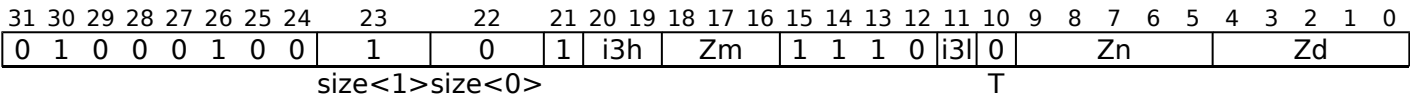
Signed saturating doubling multiply long (bottom, indexed).

Multiply then double the even-numbered signed elements within each 128-bit segment of the first source vector and the specified element in the corresponding second source vector segment, and place the results in overlapping double-width elements of the destination vector register. Each result element is saturated to the double-width N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ .

The elements within the second source vector are specified using an immediate index which selects the same element position within each 128-bit vector segment. The index range is from 0 to one less than the number of elements per 128-bit segment, encoded in 2 or 3 bits depending on the size of the element.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

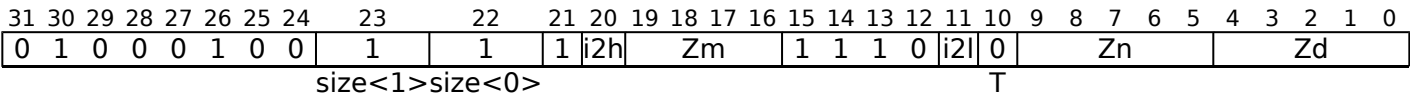


## 32-bit

SQDMULLB <Zd>.S, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 16;
integer index = UInt(i3h:i3l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer sel = 0;
```

## 64-bit



## 64-bit

SQDMULLB <Zd>.D, <Zn>.S, <Zm>.S[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2h:i2l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer sel = 0;
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> For the 32-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  
For the 64-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
- <imm> For the 32-bit variant: is the element index, in the range 0 to 7, encoded in the "i3h:i3l" fields.

For the 64-bit variant: is the element index, in the range 0 to 3, encoded in the "i2h:i2l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
integer eltspersegment = 128 DIV (2 * esize);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer s = e - (e MOD eltspersegment);
    integer element1 = SInt(Elem[operand1, 2 * e + sel, esize]);
    integer element2 = SInt(Elem[operand2, 2 * s + index, esize]);
    integer res = 2 * element1 * element2;
    Elem[result, e, 2*esize] = SignedSat(res, 2*esize);

Z[d] = result;
```

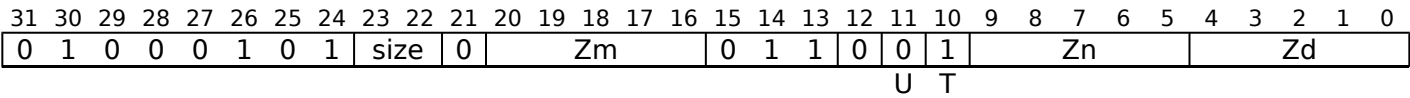
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SQDMULLT (vectors)

Signed saturating doubling multiply long (top).

Multiply the corresponding odd-numbered signed elements of the first and second source vectors, double and place the results in the overlapping double-width elements of the destination vector. Each result element is saturated to the double-width N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . This instruction is unpredicated.



SVE2

```
SQDMULLT <Zd>.<T>, <Zn>.<Tb>, <Zm>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, 2*e + 1, esize DIV 2]);
    integer element2 = SInt(Elem[operand2, 2*e + 1, esize DIV 2]);
    integer res = 2 * element1 * element2;
    Elem[result, e, esize] = SignedSat(res, esize);

Z[d] = result;
```

# SQDMULLT (indexed)

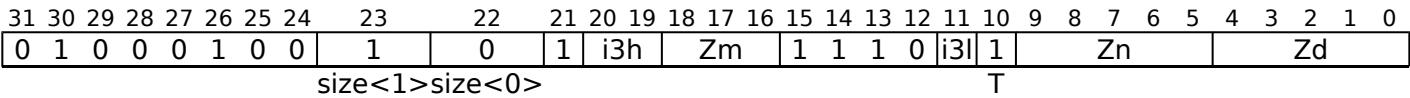
Signed saturating doubling multiply long (top, indexed).

Multiply then double the odd-numbered signed elements within each 128-bit segment of the first source vector and the specified element in the corresponding second source vector segment, and place the results in overlapping double-width elements of the destination vector register. Each result element is saturated to the double-width N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ .

The elements within the second source vector are specified using an immediate index which selects the same element position within each 128-bit vector segment. The index range is from 0 to one less than the number of elements per 128-bit segment, encoded in 2 or 3 bits depending on the size of the element.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

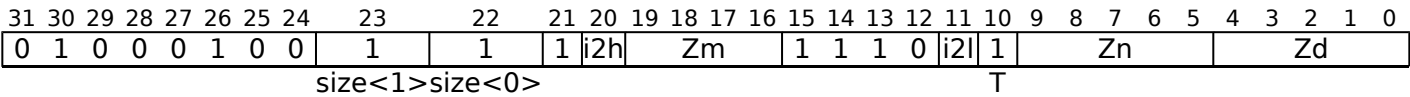


## 32-bit

SQDMULLT <Zd>.S, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 16;
integer index = UInt(i3h:i3l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer sel = 1;
```

## 64-bit



## 64-bit

SQDMULLT <Zd>.D, <Zn>.S, <Zm>.S[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2h:i2l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer sel = 1;
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> For the 32-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  
For the 64-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
- <imm> For the 32-bit variant: is the element index, in the range 0 to 7, encoded in the "i3h:i3l" fields.

For the 64-bit variant: is the element index, in the range 0 to 3, encoded in the "i2h:i2l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
integer eltspersegment = 128 DIV (2 * esize);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer s = e - (e MOD eltspersegment);
    integer element1 = SInt(Elem[operand1, 2 * e + sel, esize]);
    integer element2 = SInt(Elem[operand2, 2 * s + index, esize]);
    integer res = 2 * element1 * element2;
    Elem[result, e, 2*esize] = SignedSat(res, 2*esize);

Z[d] = result;
```

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# SQINCB

Signed saturating increment scalar by multiple of 8-bit predicate constraint element count.

Determines the number of active 8-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment the scalar destination. The result is saturated to the source general-purpose register's signed integer range. A 32-bit saturated result is then sign-extended to 64 bits.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	1	0	imm4				1	1	1	1	0	0	pattern					Rdn				
size<1>size<0>								sf			D U																				

## 32-bit

SQINCB <Xdn>, <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	1	1	imm4				1	1	1	1	0	0	pattern					Rdn				
size<1>size<0>								sf			D U																				

## 64-bit

SQINCB <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 64;
```

## Assembler Symbols

- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 + (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

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# SQINCD (scalar)

Signed saturating increment scalar by multiple of 64-bit predicate constraint element count.

Determines the number of active 64-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment the scalar destination. The result is saturated to the source general-purpose register's signed integer range. A 32-bit saturated result is then sign-extended to 64 bits.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	1	1	0	imm4				1	1	1	1	0	0	pattern					Rdn				
size<1>size<0>								sf													D	U									

## 32-bit

SQINCD <Xdn>, <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	1	1	1	imm4				1	1	1	1	0	0	pattern					Rdn				
size<1>size<0>								sf													D	U									

## 64-bit

SQINCD <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 64;
```

## Assembler Symbols

- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 + (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

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SQINCD (vector)

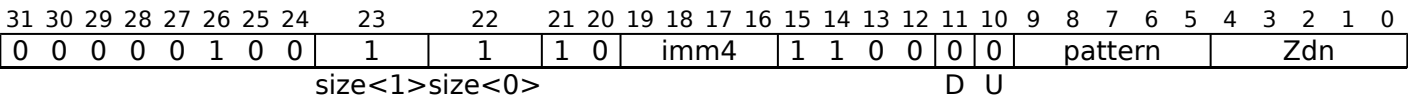
Signed saturating increment vector by multiple of 64-bit predicate constraint element count.

Determines the number of active 64-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment all destination vector elements. The results are saturated to the 64-bit signed integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.



SVE

```
SQINCD <Zdn>.D{, <pattern>{, MUL #<imm>}}
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
```

Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer count = DecodePredCount(pat, esize);
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 + (count * imm), esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# SQINCH (scalar)

Signed saturating increment scalar by multiple of 16-bit predicate constraint element count.

Determines the number of active 16-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment the scalar destination. The result is saturated to the source general-purpose register's signed integer range. A 32-bit saturated result is then sign-extended to 64 bits.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	1	1	0	imm4				1	1	1	1	0	0	pattern					Rdn				
size<1>size<0>								sf			D U																				

## 32-bit

SQINCH <Xdn>, <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	1	1	1	imm4				1	1	1	1	0	0	pattern					Rdn				
size<1>size<0>								sf			D U																				

## 64-bit

SQINCH <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 64;
```

## Assembler Symbols

- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 + (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

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# SQINCH (vector)

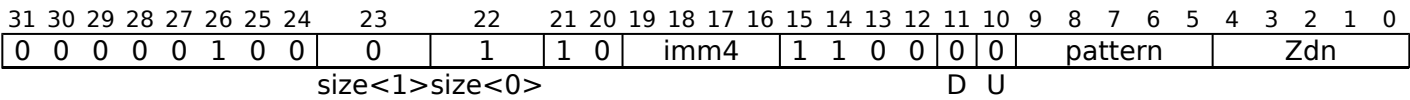
Signed saturating increment vector by multiple of 16-bit predicate constraint element count.

Determines the number of active 16-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment all destination vector elements. The results are saturated to the 16-bit signed integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.



## SVE

SQINCH <Zdn>.H{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer count = DecodePredCount(pat, esize);
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 + (count * imm), esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# SQINCP (scalar)

Signed saturating increment scalar by count of true predicate elements.

Counts the number of true elements in the source predicate and then uses the result to increment the scalar destination. The result is saturated to the source general-purpose register's signed integer range. A 32-bit saturated result is then sign-extended to 64 bits.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	0	1	0	0	0	1	0	0	0	1	0	0	Pm	Rdn								
D U														sf																	

## 32-bit

SQINCP <Xdn>, <Pm>.<T>, <Wdn>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Rdn);
boolean unsigned = FALSE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	0	1	0	0	0	1	0	0	0	1	1	0	Pm			Rdn						
D U														sf																	

## 64-bit

SQINCP <Xdn>, <Pm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Rdn);
boolean unsigned = FALSE;
integer ssize = 64;
```

## Assembler Symbols

- <Xdn>

Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Pm>

Is the name of the source scalable predicate register, encoded in the "Pm" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <Wdn>

Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(ssize) operand1 = X[dn];
bits(PL) operand2 = P[m];
bits(ssize) result;
integer count = 0;

for e = 0 to elements-1
    if ElemP[operand2, e, esize] == '1' then
        count = count + 1;

integer element = Int(operand1, unsigned);
(result, -) = Sat0(element + count, ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);
```

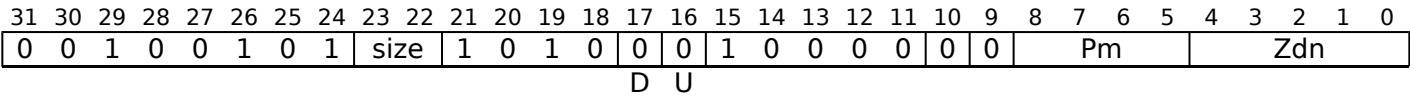
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# SQINCP (vector)

Signed saturating increment vector by count of true predicate elements.

Counts the number of true elements in the source predicate and then uses the result to increment all destination vector elements. The results are saturated to the element signed integer range. The predicate size specifier may be omitted in assembler source code, but this is deprecated and will be prohibited in a future release of the architecture.



## SVE

SQINCP <Zdn>.<T>, <Pm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Zdn);
boolean unsigned = FALSE;
```

## Assembler Symbols

- <Zdn>Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T>Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pm>Is the name of the source scalable predicate register, encoded in the "Pm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(PL) operand2 = P[m];
bits(VL) result;
integer count = 0;

for e = 0 to elements-1
    if ElemP[operand2, e, esize] == '1' then
        count = count + 1;

for e = 0 to elements-1
    integer element = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element + count, esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# SQINCW (scalar)

Signed saturating increment scalar by multiple of 32-bit predicate constraint element count.

Determines the number of active 32-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment the scalar destination. The result is saturated to the source general-purpose register's signed integer range. A 32-bit saturated result is then sign-extended to 64 bits.

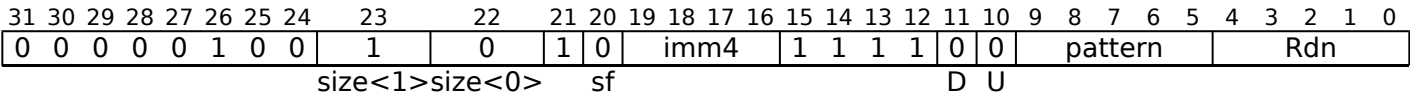
The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

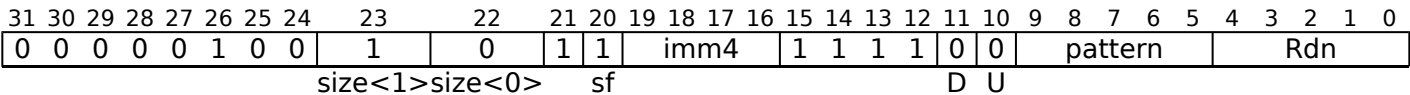


## 32-bit

SQINCW <Xdn>, <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 32;
```

## 64-bit



## 64-bit

SQINCW <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
integer ssize = 64;
```

## Assembler Symbols

- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 + (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

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# SQINCW (vector)

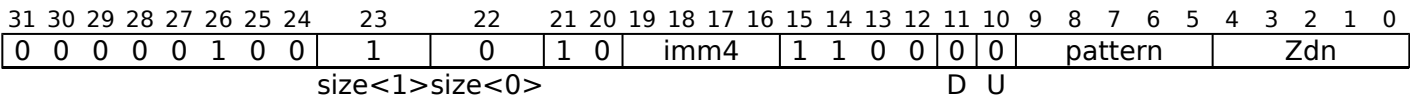
Signed saturating increment vector by multiple of 32-bit predicate constraint element count.

Determines the number of active 32-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment all destination vector elements. The results are saturated to the 32-bit signed integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.



## SVE

SQINCW <Zdn>.S{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = FALSE;
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer count = DecodePredCount(pat, esize);
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 + (count * imm), esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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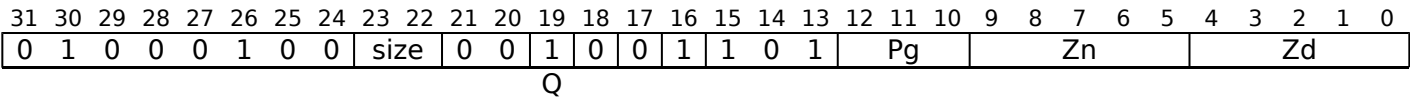
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# SQNEG

Signed saturating negate.

Negate the signed integer value in each active element of the source vector, and place the results in the corresponding elements of the destination vector. Each result element is saturated to the N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . Inactive elements in the destination vector register remain unmodified.



## SVE2

SQNEG <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    integer element = SInt(Elem[operand, e, esize]);
    if ElemP[mask, e, esize] == '1' then
        element = -element;
        Elem[result, e, esize] = SignedSat(element, esize);

Z[d] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



SQRDCMLAH (vectors)

Saturating rounding doubling complex integer multiply-add high with rotate.

Multiply without saturation the duplicated real components for rotations 0 and 180, or imaginary components for rotations 90 and 270, of the integral numbers in the first source vector by the corresponding complex number in the second source vector rotated by 0, 90, 180 or 270 degrees in the direction from the positive real axis towards the positive imaginary axis, when considered in polar representation.

Then double and add the products to the corresponding components of the complex numbers in the addend vector. Destructively place the most significant rounded half of the results in the corresponding elements of the addend vector. Each result element is saturated to the N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . This instruction is unpredicated.

These transformations permit the creation of a variety of multiply-add and multiply-subtract operations on complex numbers by combining two of these instructions with the same vector operands but with rotations that are 90 degrees apart.

Each complex number is represented in a vector register as an even/odd pair of elements with the real part in the even-numbered element and the imaginary part in the odd-numbered element.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size	0			Zm		0	0	1	1	rot				Zn						Zda			

SVE2

SQRDCMLAH <Zda>.<T>, <Zn>.<T>, <Zm>.<T>, <const>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel_a = UInt(rot<0>);
integer sel_b = UInt(NOT(rot<0>));
boolean sub_r = (rot<0> != rot<1>);
boolean sub_i = (rot<1> == '1');
```

Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.
- <const> Is the const specifier, encoded in "rot":

rot	<const>
00	#0
01	#90
10	#180
11	#270

## Operation

```
CheckSVEEnabled();
integer pairs = VL DIV (2 * esize);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

integer round_const = 1 << (esize-1);
integer res_r, res_i;

for p = 0 to pairs-1
    integer elt1_a = SInt(Elem[operand1, 2 * p + sel_a, esize]);
    integer elt2_a = SInt(Elem[operand2, 2 * p + sel_a, esize]);
    integer elt2_b = SInt(Elem[operand2, 2 * p + sel_b, esize]);
    bits(esize) elt3_r = Elem[operand3, 2 * p + 0, esize];
    bits(esize) elt3_i = Elem[operand3, 2 * p + 1, esize];
    integer product_r = elt1_a * elt2_a;
    integer product_i = elt1_a * elt2_b;
    if sub_r then
        res_r = (SInt(elt3_r) << esize) - 2 * product_r + round_const;
    else
        res_r = (SInt(elt3_r) << esize) + 2 * product_r + round_const;
    if sub_i then
        res_i = (SInt(elt3_i) << esize) - 2 * product_i + round_const;
    else
        res_i = (SInt(elt3_i) << esize) + 2 * product_i + round_const;
    Elem[result, 2 * p + 0, esize] = SignedSat(res_r >> esize, esize);
    Elem[result, 2 * p + 1, esize] = SignedSat(res_i >> esize, esize);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# SQRDCMLAH (indexed)

Saturating rounding doubling complex integer multiply-add high with rotate (indexed).

Multiply without saturation the duplicated real components for rotations 0 and 180, or imaginary components for rotations 90 and 270, of the integral numbers in each 128-bit segment of the first source vector by the specified complex number in the corresponding the second source vector segment rotated by 0, 90, 180 or 270 degrees in the direction from the positive real axis towards the positive imaginary axis, when considered in polar representation. Then double and add the products to the corresponding components of the complex numbers in the addend vector. Destructively place the most significant rounded half of the results in the corresponding elements of the addend vector. Each result element is saturated to the N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . This instruction is unpredicated.

These transformations permit the creation of a variety of multiply-add and multiply-subtract operations on complex numbers by combining two of these instructions with the same vector operands but with rotations that are 90 degrees apart.

Each complex number is represented in a vector register as an even/odd pair of elements with the real part in the even-numbered element and the imaginary part in the odd-numbered element.

It has encodings from 2 classes: [16-bit](#) and [32-bit](#)

## 16-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	1	0	1	i2	Zm	0	1	1	1	rot	Zn				Zda									
size<1>size<0>																															

## 16-bit

SQRDCMLAH <Zda>.H, <Zn>.H, <Zm>.H[<imm>], <const>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 16;
integer index = UInt(i2);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel_a = UInt(rot<0>);
integer sel_b = UInt(NOT(rot<0>));
boolean sub_r = (rot<0> != rot<1>);
boolean sub_i = (rot<1> == '1');
```

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	1	1	1	i1	Zm			0			1	1	1	rot			Zn				Zda			
size<1>size<0>																															

## 32-bit

SQRDCMLAH <Zda>.S, <Zn>.S, <Zm>.S[<imm>], <const>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer index = UInt(i1);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel_a = UInt(rot<0>);
integer sel_b = UInt(NOT(rot<0>));
boolean sub_r = (rot<0> != rot<1>);
boolean sub_i = (rot<1> == '1');
```

## Assembler Symbols

<Zda>	Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
<Zn>	Is the name of the first source scalable vector register, encoded in the "Zn" field.
<Zm>	For the 16-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  For the 32-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
<imm>	For the 16-bit variant: is the element index, in the range 0 to 3, encoded in the "i2" field.  For the 32-bit variant: is the element index, in the range 0 to 1, encoded in the "i1" field.
<const>	Is the const specifier, encoded in "rot":

rot	<const>
00	#0
01	#90
10	#180
11	#270

## Operation

```
CheckSVEEnabled();
integer pairs = VL DIV (2 * esize);
integer pairspersegment = 128 DIV (2 * esize);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

integer round_const = 1 << (esize-1);
integer res_r, res_i;

for p = 0 to pairs-1
    integer segmentbase = p - (p MOD pairspersegment);
    integer s = segmentbase + index;
    integer elt1_a = SInt(Elem[operand1, 2 * p + sel_a, esize]);
    integer elt2_a = SInt(Elem[operand2, 2 * s + sel_a, esize]);
    integer elt2_b = SInt(Elem[operand2, 2 * s + sel_b, esize]);
    bits(esize) elt3_r = Elem[operand3, 2 * p + 0, esize];
    bits(esize) elt3_i = Elem[operand3, 2 * p + 1, esize];
    integer product_r = elt1_a * elt2_a;
    integer product_i = elt1_a * elt2_b;
    if sub_r then
        res_r = (SInt(elt3_r) << esize) - 2 * product_r + round_const;
    else
        res_r = (SInt(elt3_r) << esize) + 2 * product_r + round_const;
    if sub_i then
        res_i = (SInt(elt3_i) << esize) - 2 * product_i + round_const;
    else
        res_i = (SInt(elt3_i) << esize) + 2 * product_i + round_const;
    Elem[result, 2 * p + 0, esize] = SignedSat(res_r >> esize, esize);
    Elem[result, 2 * p + 1, esize] = SignedSat(res_i >> esize, esize);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

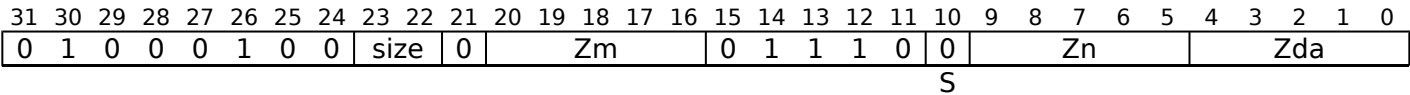
- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



# SQRDMLAH (vectors)

Signed saturating rounding doubling multiply-add high to accumulator (unpredicated).

Multiply then double the corresponding signed elements of the first and second source vectors, and destructively add the rounded high half of each result to the corresponding elements of the addend and destination vector. Each destination element is saturated to the N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . This instruction is unpredicated.



## SVE2

SQRDMLAH <Zda>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;
integer round_const = 1 << (esize - 1);

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, e, esize]);
    integer element2 = SInt(Elem[operand2, e, esize]);
    integer element3 = SInt(Elem[operand3, e, esize]);
    integer res = (element3 << esize) + (2 * element1 * element2);
    Elem[result, e, esize] = SignedSat((res + round_const) >> esize, esize);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.



- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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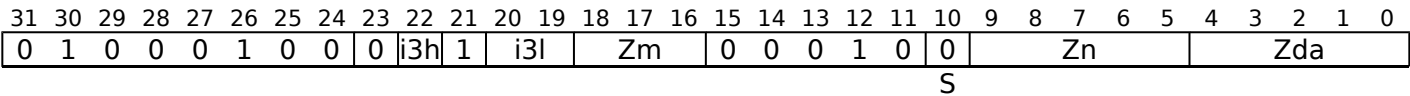
# SQRDMLAH (indexed)

Signed saturating rounding doubling multiply-add high to accumulator (indexed).

Multiply then double all signed elements within each 128-bit segment of the first source vector and the specified signed element of the corresponding second source vector segment, and destructively add the rounded high half of each result to the corresponding elements of the addend and destination vector. Each destination element is saturated to the N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ .  
The elements within the second source vector are specified using an immediate index which selects the same element position within each 128-bit vector segment. The index range is from 0 to one less than the number of elements per 128-bit segment, encoded in 1 to 3 bits depending on the size of the element.

It has encodings from 3 classes: [16-bit](#) , [32-bit](#) and [64-bit](#)

## 16-bit

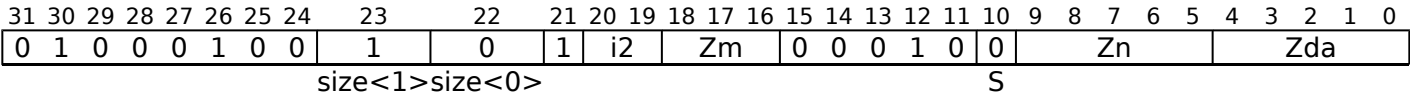


## 16-bit

SQRDMLAH <Zda>.H, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 16;
integer index = UInt(i3h:i3l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## 32-bit

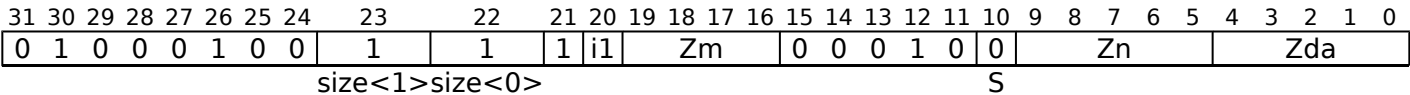


## 32-bit

SQRDMLAH <Zda>.S, <Zn>.S, <Zm>.S[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## 64-bit



## 64-bit

SQRDMLAH <Zda>.D, <Zn>.D, <Zm>.D[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 64;
integer index = UInt(i1);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

<Zda>	Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
<Zn>	Is the name of the first source scalable vector register, encoded in the "Zn" field.
<Zm>	For the 16-bit and 32-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  For the 64-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
<imm>	For the 16-bit variant: is the element index, in the range 0 to 7, encoded in the "i3h:i3l" fields. For the 32-bit variant: is the element index, in the range 0 to 3, encoded in the "i2" field. For the 64-bit variant: is the element index, in the range 0 to 1, encoded in the "i1" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer eltsperssegment = 128 DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;
integer round_const = 1 << (esize - 1);

for e = 0 to elements-1
    integer segmentbase = e - (e MOD eltsperssegment);
    integer s = segmentbase + index;
    integer element1 = SInt(Elem[operand1, e, esize]);
    integer element2 = SInt(Elem[operand2, s, esize]);
    integer element3 = SInt(Elem[operand3, e, esize]);
    integer res = (element3 << esize) + (2 * element1 * element2);
    Elem[result, e, esize] = SignedSat((res + round_const) >> esize, esize);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

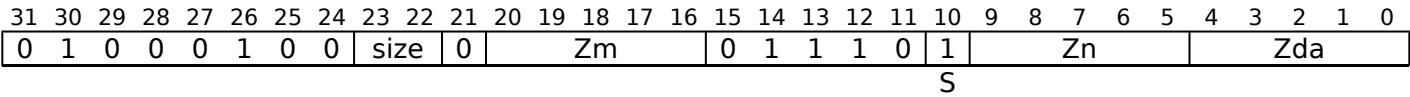
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# SQRDMLSH (vectors)

Signed saturating rounding doubling multiply-subtract high from accumulator (unpredicated).

Multiply then double the corresponding signed elements of the first and second source vectors, and destructively subtract the rounded high half of each result from the corresponding elements of the addend and destination vector. Each destination element is saturated to the N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . This instruction is unpredicated.



## SVE2

SQRDMLSH <Zda>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

<Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;
integer round_const = 1 << (esize - 1);

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, e, esize]);
    integer element2 = SInt(Elem[operand2, e, esize]);
    integer element3 = SInt(Elem[operand3, e, esize]);
    integer res = (element3 << esize) - (2 * element1 * element2);
    Elem[result, e, esize] = SignedSat((res + round_const) >> esize, esize);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# SQRDMLSH (indexed)

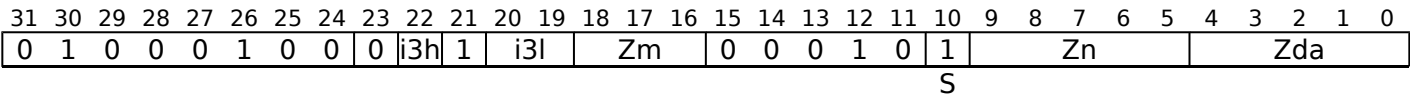
Signed saturating rounding doubling multiply-subtract high from accumulator (indexed).

Multiply then double all signed elements within each 128-bit segment of the first source vector and the specified signed element of the corresponding second source vector segment, and destructively subtract the rounded high half of each result to the corresponding elements of the addend and destination vector. Each destination element is saturated to the N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ .

The elements within the second source vector are specified using an immediate index which selects the same element position within each 128-bit vector segment. The index range is from 0 to one less than the number of elements per 128-bit segment, encoded in 1 to 3 bits depending on the size of the element.

It has encodings from 3 classes: [16-bit](#) , [32-bit](#) and [64-bit](#)

## 16-bit

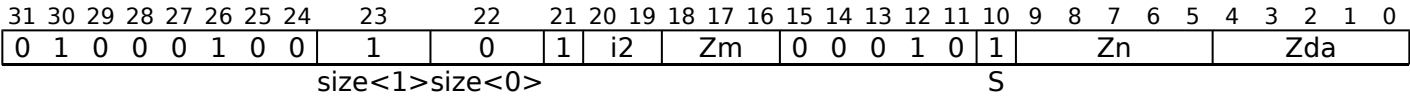


## 16-bit

SQRDMLSH <Zda>.H, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 16;
integer index = UInt(i3h:i3l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## 32-bit

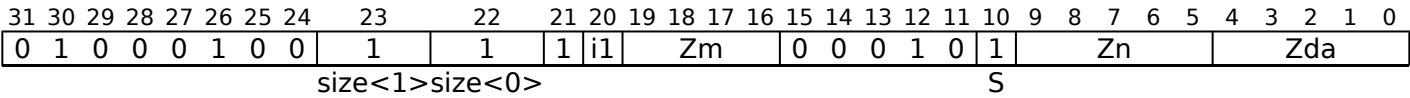


## 32-bit

SQRDMLSH <Zda>.S, <Zn>.S, <Zm>.S[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## 64-bit



## 64-bit

SQRDMLSH <Zda>.D, <Zn>.D, <Zm>.D[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 64;
integer index = UInt(i1);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

<Zda>	Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
<Zn>	Is the name of the first source scalable vector register, encoded in the "Zn" field.
<Zm>	For the 16-bit and 32-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  For the 64-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
<imm>	For the 16-bit variant: is the element index, in the range 0 to 7, encoded in the "i3h:i3l" fields. For the 32-bit variant: is the element index, in the range 0 to 3, encoded in the "i2" field. For the 64-bit variant: is the element index, in the range 0 to 1, encoded in the "i1" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer eltsperssegment = 128 DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;
integer round_const = 1 << (esize - 1);

for e = 0 to elements-1
    integer segmentbase = e - (e MOD eltsperssegment);
    integer s = segmentbase + index;
    integer element1 = SInt(Elem[operand1, e, esize]);
    integer element2 = SInt(Elem[operand2, s, esize]);
    integer element3 = SInt(Elem[operand3, e, esize]);
    integer res = (element3 << esize) - (2 * element1 * element2);
    Elem[result, e, esize] = SignedSat((res + round_const) >> esize, esize);

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

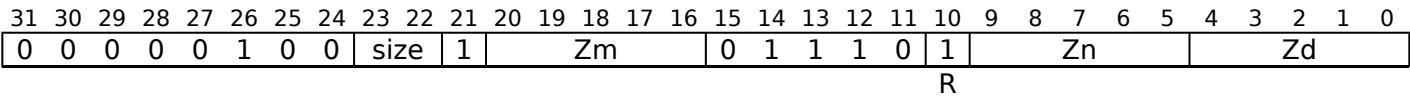
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SQRDMULH (vectors)

Signed saturating rounding doubling multiply high (unpredicated).

Multiply then double the corresponding signed elements of the first and second source vectors, and place the most significant rounded half of the result in the corresponding elements of the destination vector. Each result element is saturated to the N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . This instruction is unpredicated.



SVE2

SQRDMULH <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;
integer round_const = 1 << (esize - 1);

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, e, esize]);
    integer element2 = SInt(Elem[operand2, e, esize]);
    integer res = 2 * element1 * element2;
    Elem[result, e, esize] = SignedSat((res + round_const) >> esize, esize);

Z[d] = result;
```



# SQRDMULH (indexed)

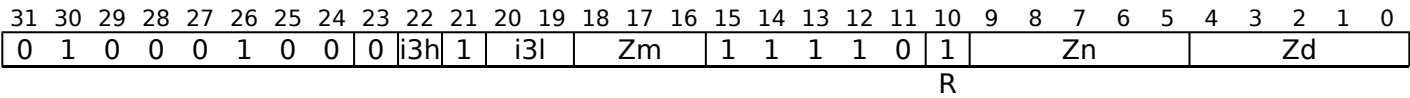
Signed saturating rounding doubling multiply high (indexed).

Multiply all signed elements within each 128-bit segment of the first source vector by the specified signed element in the corresponding second source vector segment, double and place the most significant rounded half of the result in the corresponding elements of the destination vector register. Each result element is saturated to the N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ .

The elements within the second source vector are specified using an immediate index which selects the same element position within each 128-bit vector segment. The index range is from 0 to one less than the number of elements per 128-bit segment, encoded in 1 to 3 bits depending on the size of the element.

It has encodings from 3 classes: [16-bit](#) , [32-bit](#) and [64-bit](#)

## 16-bit

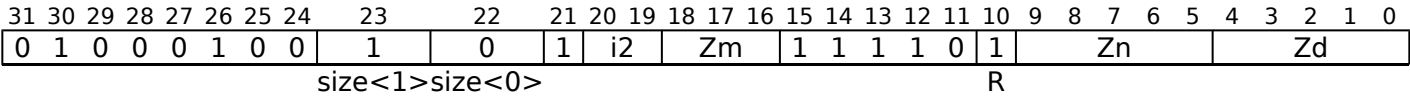


## 16-bit

SQRDMULH <Zd>.H, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 16;
integer index = UInt(i3h:i3l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## 32-bit

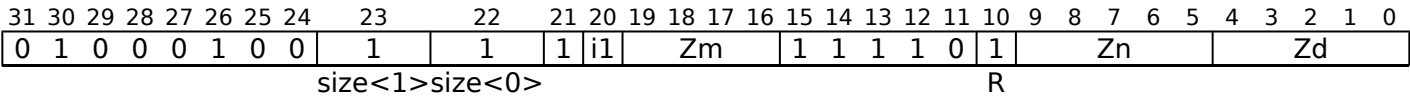


## 32-bit

SQRDMULH <Zd>.S, <Zn>.S, <Zm>.S[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## 64-bit



## 64-bit

SQRDMULH <Zd>.D, <Zn>.D, <Zm>.D[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 64;
integer index = UInt(i1);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd>	Is the name of the destination scalable vector register, encoded in the "Zd" field.
<Zn>	Is the name of the first source scalable vector register, encoded in the "Zn" field.
<Zm>	For the 16-bit and 32-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  For the 64-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
<imm>	For the 16-bit variant: is the element index, in the range 0 to 7, encoded in the "i3h:i3l" fields. For the 32-bit variant: is the element index, in the range 0 to 3, encoded in the "i2" field. For the 64-bit variant: is the element index, in the range 0 to 1, encoded in the "i1" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer eltspersegment = 128 DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;
integer round_const = 1 << (esize - 1);

for e = 0 to elements-1
    integer segmentbase = e - (e MOD eltspersegment);
    integer s = segmentbase + index;
    integer element1 = SInt(Elem[operand1, e, esize]);
    integer element2 = SInt(Elem[operand2, s, esize]);
    integer res = 2 * element1 * element2;
    Elem[result, e, esize] = SignedSat((res + round_const) >> esize, esize);

Z[d] = result;
```

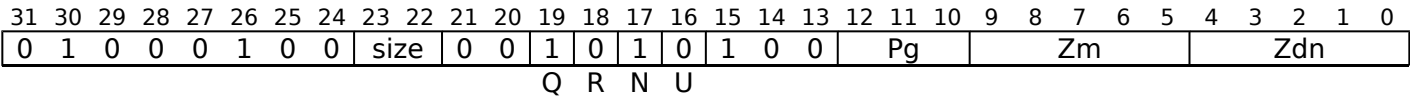
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SQRSHL

Signed saturating rounding shift left by vector (predicated).

Shift active signed elements of the first source vector by corresponding elements of the second source vector and destructively place the rounded results in the corresponding elements of the first source vector. A positive shift amount performs a left shift, otherwise a right shift by the negated shift amount is performed. Each result element is saturated to the N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . Inactive elements in the destination vector register remain unmodified.



SVE2

SQRSHL <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer m = UInt(Zm);
integer dn = UInt(Zdn);
```

Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element = SInt(Elem[operand1, e, esize]);
    integer shift = ShiftSat(SInt(Elem[operand2, e, esize]), esize);
    integer round_const = 1 << (-shift - 1); // 0 for left shift, 2^(n-1) for right shift
    if ElemP[mask, e, esize] == '1' then
        integer res = (element + round_const) << shift;
        Elem[result, e, esize] = SignedSat(res, esize);
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];
Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

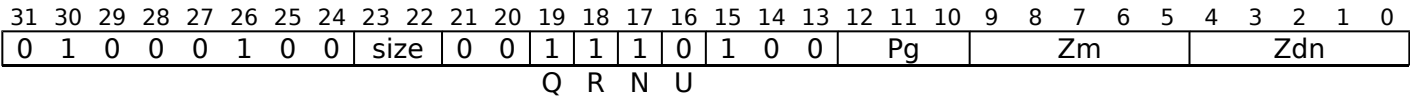
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SQRSHLR

Signed saturating rounding shift left reversed vectors (predicated).

Shift active signed elements of the second source vector by corresponding elements of the first source vector and destructively place the rounded results in the corresponding elements of the first source vector. A positive shift amount performs a left shift, otherwise a right shift by the negated shift amount is performed. Each result element is saturated to the N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . Inactive elements in the destination vector register remain unmodified.



SVE2

SQRSHLR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer m = UInt(Zm);
integer dn = UInt(Zdn);
```

Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[m];
bits(VL) operand2 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element = SInt(Elem[operand1, e, esize]);
    integer shift = ShiftSat(SInt(Elem[operand2, e, esize]), esize);
    integer round_const = 1 << (-shift - 1); // 0 for left shift, 2^(n-1) for right shift
    if ElemP[mask, e, esize] == '1' then
        integer res = (element + round_const) << shift;
        Elem[result, e, esize] = SignedSat(res, esize);
    else
        Elem[result, e, esize] = Elem[operand2, e, esize];
Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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**SQSRHRNB**

Signed saturating rounding shift right narrow by immediate (bottom).

Shift each signed integer value in the source vector elements right by an immediate value, and place the rounded results in the even-numbered half-width destination elements, while setting the odd-numbered elements to zero. Each result element is saturated to the half-width N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . The immediate shift amount is an unsigned value in the range 1 to number of bits per element. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0												
0	1	0	0	0	1	0	1	0	tszh	1	tszl		imm3	0	0	1	0	1	0																								
																				U			R			T								Zn					Zd				

## SVE2

SQRSHRNB <Zd>.<T>, <Zn>.<Tb>, #<const>

```
if !HaveSVE2() then UNDEFINED;
bits(3) tsize = tszh:tszl;
case tsize of
  when '000' UNDEFINED;
  when '001' esize = 8;
  when '01x' esize = 16;
  when '1xx' esize = 32;
integer n = UInt(Zn);
integer d = UInt(Zd);
integer shift = (2 * esize) - UInt(tsize:imm3);
```

## Assembler Symbols

**<Zd>** Is the name of the destination scalable vector register, encoded in the "Zd" field.

**<T>** Is the size specifier, encoded in “tszh:tszl”:

tszh	tszl	<T>
0	00	RESERVED
0	01	B
0	1x	H
1	xx	S

**<Zn>** Is the name of the source scalable vector register, encoded in the "Zn" field.

<Tb>	Is the size specifier, encoded in "tszh:tszl":
------	--

tszh	tszl	<Tb>
0	00	RESERVED
0	01	H
0	1x	S
1	xx	D

**<const>** Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
bits(VL) operand = Z[n];
bits(VL) result;
integer round_const = 1 << (shift-1);

for e = 0 to elements-1
    bits(2*esize) element = Elem[operand, e, 2*esize];
    integer res = (SInt(element) + round_const) >> shift;
    Elem[result, 2*e + 0, esize] = SignedSat(res, esize);
    Elem[result, 2*e + 1, esize] = Zeros();

Z[d] = result;
```

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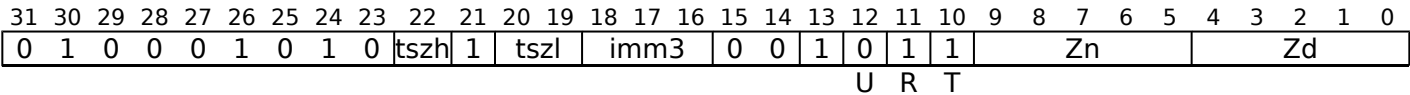
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SQRSHRNT

Signed saturating rounding shift right narrow by immediate (top).

Shift each signed integer value in the source vector elements right by an immediate value, and place the rounded results in the odd-numbered half-width destination elements, leaving the even-numbered elements unchanged. Each result element is saturated to the half-width N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . The immediate shift amount is an unsigned value in the range 1 to number of bits per element. This instruction is unpredicated.



SVE2

SQRSHRNT <Zd>.<T>, <Zn>.<Tb>, #<const>

```
if !HaveSVE2() then UNDEFINED;
bits(3) tsize = tszh:tszl;
case tsize of
    when '000' UNDEFINED;
    when '001' esize = 8;
    when '01x' esize = 16;
    when '1xx' esize = 32;
integer n = UInt(Zn);
integer d = UInt(Zd);
integer shift = (2 * esize) - UInt(tsize:imm3);
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
0	00	RESERVED
0	01	B
0	1x	H
1	xx	S

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<Tb>
0	00	RESERVED
0	01	H
0	1x	S
1	xx	D

- <const> Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
bits(VL) operand = Z[n];
bits(VL) result = Z[d];
integer round_const = 1 << (shift-1);

for e = 0 to elements-1
    bits(2*esize) element = Elem[operand, e, 2*esize];
    integer res = (SInt(element) + round_const) >> shift;
    Elem[result, 2*e + 1, esize] = SignedSat(res, esize);

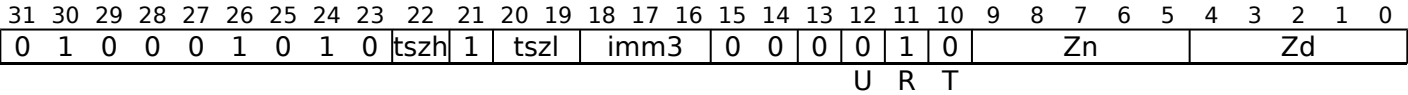
Z[d] = result;
```



SQRSHRUNB

Signed saturating rounding shift right unsigned narrow by immediate (bottom).

Shift each signed integer value in the source vector elements right by an immediate value, and place the rounded results in the even-numbered half-width destination elements, while setting the odd-numbered elements to zero. Each result element is saturated to the half-width N-bit element's unsigned integer range 0 to (2<sup>N</sup>)-1. The immediate shift amount is an unsigned value in the range 1 to number of bits per element. This instruction is unpredicated.



SVE2

SQRSHRUNB <Zd>.<T>, <Zn>.<Tb>, #<const>

```
if !HaveSVE2() then UNDEFINED;
bits(3) tsize = tszh:tszl;
case tsize of
    when '000' UNDEFINED;
    when '001' esize = 8;
    when '01x' esize = 16;
    when '1xx' esize = 32;
integer n = UInt(Zn);
integer d = UInt(Zd);
integer shift = (2 * esize) - UInt(tsize:imm3);
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
0	00	RESERVED
0	01	B
0	1x	H
1	xx	S

- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<Tb>
0	00	RESERVED
0	01	H
0	1x	S
1	xx	D

- <const> Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
bits(VL) operand = Z[n];
bits(VL) result;
integer round_const = 1 << (shift-1);

for e = 0 to elements-1
    bits(2*esize) element = Elem[operand, e, 2*esize];
    integer res = (SInt(element) + round_const) >> shift;
    Elem[result, 2*e + 0, esize] = UnsignedSat(res, esize);
    Elem[result, 2*e + 1, esize] = Zeros();

Z[d] = result;
```

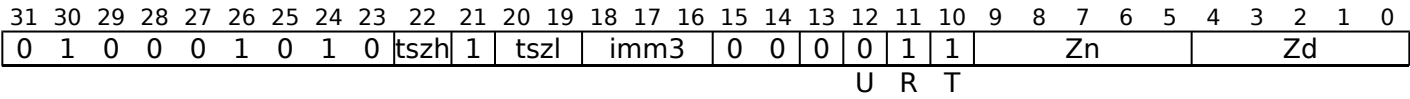
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# SQRSHRUNT

Signed saturating rounding shift right unsigned narrow by immediate (top).

Shift each signed integer value in the source vector elements right by an immediate value, and place the rounded results in the odd-numbered half-width destination elements, leaving the even-numbered elements unchanged. Each result element is saturated to the half-width N-bit element's unsigned integer range 0 to  $(2^N)-1$ . The immediate shift amount is an unsigned value in the range 1 to number of bits per element. This instruction is unpredicated.



## SVE2

SQRSHRUNT <Zd>.<T>, <Zn>.<Tb>, #<const>

```
if !HaveSVE2() then UNDEFINED;
bits(3) tsize = tszh:tszl;
case tsize of
    when '000' UNDEFINED;
    when '001' esize = 8;
    when '01x' esize = 16;
    when '1xx' esize = 32;
integer n = UInt(Zn);
integer d = UInt(Zd);
integer shift = (2 * esize) - UInt(tsize:imm3);
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
0	00	RESERVED
0	01	B
0	1x	H
1	xx	S

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<Tb>
0	00	RESERVED
0	01	H
0	1x	S
1	xx	D

- <const> Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
bits(VL) operand = Z[n];
bits(VL) result = Z[d];
integer round_const = 1 << (shift-1);

for e = 0 to elements-1
    bits(2*esize) element = Elem[operand, e, 2*esize];
    integer res = (SInt(element) + round_const) >> shift;
    Elem[result, 2*e + 1, esize] = UnsignedSat(res, esize);

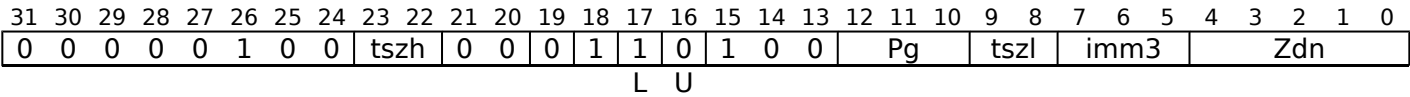
Z[d] = result;
```



# SQSHL (immediate)

Signed saturating shift left by immediate.

Shift left by immediate each active signed element of the source vector, and destructively place the results in the corresponding elements of the source vector. Each result element is saturated to the N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . The immediate shift amount is an unsigned value in the range 0 to number of bits per element minus 1. Inactive elements in the destination vector register remain unmodified.



## SVE2

SQSHL <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, #<const>

```
if !HaveSVE2() then UNDEFINED;
bits(4) tsize = tszh:tszl;
case tsize of
    when '0000' UNDEFINED;
    when '0001' esize = 8;
    when '001x' esize = 16;
    when '01xx' esize = 32;
    when '1xxx' esize = 64;
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer shift = UInt(tsize:imm3) - esize;
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
00	00	RESERVED
00	01	B
00	1x	H
01	xx	S
1x	xx	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <const> Is the immediate shift amount, in the range 0 to number of bits per element minus 1, encoded in "tsz:imm3".

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(PL) mask = P[g];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = SInt(Elm[operand1, e, esize]);
    if ElmP[mask, e, esize] == '1' then
        integer res = element1 << shift;
        Elm[result, e, esize] = SignedSat(res, esize);
    else
        Elm[result, e, esize] = Elm[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# SQSHL (vectors)

Signed saturating shift left by vector (predicated).

Shift active signed elements of the first source vector by corresponding elements of the second source vector and destructively place the results in the corresponding elements of the first source vector. A positive shift amount performs a left shift, otherwise a right shift by the negated shift amount is performed. Each result element is saturated to the N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size	0	0	1	0	0	0	1	0	0	Pg	Zm				Zdn								
Q R N U																															

## SVE2

SQSHL <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer m = UInt(Zm);
integer dn = UInt(Zdn);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element = SInt(Elem[operand1, e, esize]);
    integer shift = ShiftSat(SInt(Elem[operand2, e, esize]), esize);
    if ElemP[mask, e, esize] == '1' then
        integer res = element << shift;
        Elem[result, e, esize] = SignedSat(res, esize);
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

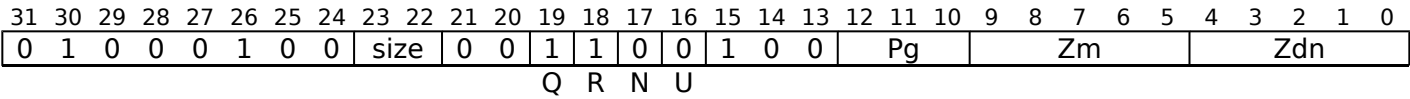
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SQSHLR

Signed saturating shift left reversed vectors (predicated).

Shift active signed elements of the second source vector by corresponding elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. A positive shift amount performs a left shift, otherwise a right shift by the negated shift amount is performed. Each result element is saturated to the N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . Inactive elements in the destination vector register remain unmodified.



SVE2

SQSHLR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer m = UInt(Zm);
integer dn = UInt(Zdn);
```

Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[m];
bits(VL) operand2 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element = SInt(Elem[operand1, e, esize]);
    integer shift = ShiftSat(SInt(Elem[operand2, e, esize]), esize);
    if ElemP[mask, e, esize] == '1' then
        integer res = element << shift;
        Elem[result, e, esize] = SignedSat(res, esize);
    else
        Elem[result, e, esize] = Elem[operand2, e, esize];

Z[dn] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

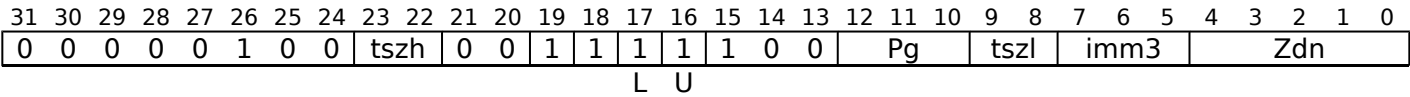
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# SQSHLU

Signed saturating shift left unsigned by immediate.

Shift left by immediate each active signed element of the source vector, and destructively place the results in the corresponding elements of the source vector. Each result element is saturated to the N-bit element's unsigned integer range 0 to (2<sup>N</sup>)-1. The immediate shift amount is an unsigned value in the range 0 to number of bits per element minus 1. Inactive elements in the destination vector register remain unmodified.



## SVE2

SQSHLU <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, #<const>

```
if !HaveSVE2() then UNDEFINED;
bits(4) tsize = tszh:tszl;
case tsize of
    when '0000' UNDEFINED;
    when '0001' esize = 8;
    when '001x' esize = 16;
    when '01xx' esize = 32;
    when '1xxx' esize = 64;
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer shift = UInt(tsize:imm3) - esize;
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
00	00	RESERVED
00	01	B
00	1x	H
01	xx	S
1x	xx	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <const> Is the immediate shift amount, in the range 0 to number of bits per element minus 1, encoded in "tsz:imm3".

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(PL) mask = P[g];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = SInt(Elm[operand1, e, esize]);
    if ElmP[mask, e, esize] == '1' then
        integer res = element1 << shift;
        Elm[result, e, esize] = UnsignedSat(res, esize);
    else
        Elm[result, e, esize] = Elm[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

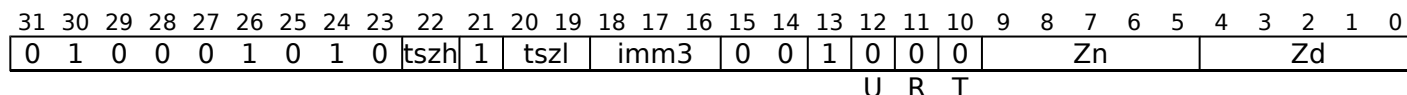
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**SQSHRNB**

Signed saturating shift right narrow by immediate (bottom).

Shift each signed integer value in the source vector elements right by an immediate value, and place the truncated results in the even-numbered half-width destination elements, while setting the odd-numbered elements to zero. Each result element is saturated to the half-width N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . The immediate shift amount is an unsigned value in the range 1 to number of bits per element. This instruction is unpredicated.



## SVE2

SQSHRNB <Zd>.<T>, <Zn>.<Tb>, #<const>

```
if !HaveSVE2() then UNDEFINED;
bits(3) tsize = tszh:tszl;
case tsize of
  when '000' UNDEFINED;
  when '001' esize = 8;
  when '01x' esize = 16;
  when '1xx' esize = 32;
integer n = UInt(Zn);
integer d = UInt(Zd);
integer shift = (2 * esize) - UInt(tsize:imm3);
```

## Assembler Symbols

**<Zd>** Is the name of the destination scalable vector register, encoded in the "Zd" field.

**<T>** Is the size specifier, encoded in “tsh:tsz”:

tszh	tszl	<T>
0	00	RESERVED
0	01	B
0	1x	H
1	xx	S

**<Zn>** Is the name of the source scalable vector register, encoded in the "Zn" field.

<b>&lt;Tb&gt;</b>	Is the size specifier, encoded in “tszh:tszl”:
-------------------	--

tszh	tszl	<Tb>
0	00	RESERVED
0	01	H
0	1x	S
1	xx	D

**<const>** Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "sz:imm3".

## Operation

```

CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
bits(VL) operand = Z[n];
bits(VL) result;

for e = 0 to elements-1
    bits(2*esize) element = Elem[operand, e, 2*esize];
    integer res = SInt(element) >> shift;
    Elem[result, 2*e + 0, esize] = SignedSat(res, esize);
    Elem[result, 2*e + 1, esize] = Zeros();

Z[d] = result;

```

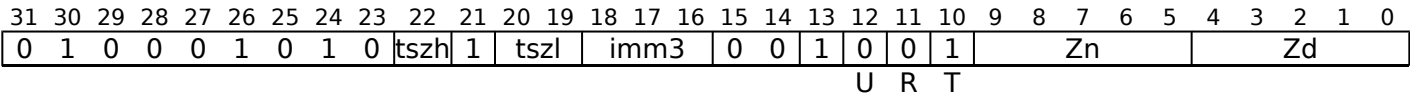




# SQSHRNT

Signed saturating shift right narrow by immediate (top).

Shift each signed integer value in the source vector elements right by an immediate value, and place the truncated results in the odd-numbered half-width destination elements, leaving the even-numbered elements unchanged. Each result element is saturated to the half-width N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . The immediate shift amount is an unsigned value in the range 1 to number of bits per element. This instruction is unpredicated.



## SVE2

SQSHRNT <Zd>.<T>, <Zn>.<Tb>, #<const>

```
if !HaveSVE2() then UNDEFINED;
bits(3) tsize = tszh:tszl;
case tsize of
    when '000' UNDEFINED;
    when '001' esize = 8;
    when '01x' esize = 16;
    when '1xx' esize = 32;
integer n = UInt(Zn);
integer d = UInt(Zd);
integer shift = (2 * esize) - UInt(tsize:imm3);
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
0	00	RESERVED
0	01	B
0	1x	H
1	xx	S

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<Tb>
0	00	RESERVED
0	01	H
0	1x	S
1	xx	D

- <const> Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    bits(2*esize) element = Elem[operand, e, 2*esize];
    integer res = SInt(element) >> shift;
    Elem[result, 2*e + 1, esize] = SignedSat(res, esize);

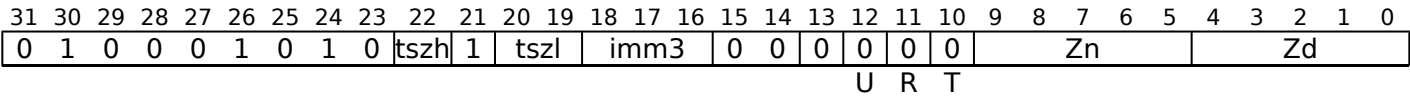
Z[d] = result;
```



# SQSHRUNB

Signed saturating shift right unsigned narrow by immediate (bottom).

Shift each signed integer value in the source vector elements right by an immediate value, and place the truncated results in the even-numbered half-width destination elements, while setting the odd-numbered elements to zero. Each result element is saturated to the half-width N-bit element's unsigned integer range 0 to  $(2^N)-1$ . The immediate shift amount is an unsigned value in the range 1 to number of bits per element. This instruction is unpredicated.



## SVE2

SQSHRUNB <Zd>.<T>, <Zn>.<Tb>, #<const>

```
if !HaveSVE2() then UNDEFINED;
bits(3) tsize = tszh:tszl;
case tsize of
    when '000' UNDEFINED;
    when '001' esize = 8;
    when '01x' esize = 16;
    when '1xx' esize = 32;
integer n = UInt(Zn);
integer d = UInt(Zd);
integer shift = (2 * esize) - UInt(tsize:imm3);
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
0	00	RESERVED
0	01	B
0	1x	H
1	xx	S

- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<Tb>
0	00	RESERVED
0	01	H
0	1x	S
1	xx	D

- <const> Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
bits(VL) operand = Z[n];
bits(VL) result;

for e = 0 to elements-1
    bits(2*esize) element = Elem[operand, e, 2*esize];
    integer res = SInt(element) >> shift;
    Elem[result, 2*e + 0, esize] = UnsignedSat(res, esize);
    Elem[result, 2*e + 1, esize] = Zeros();

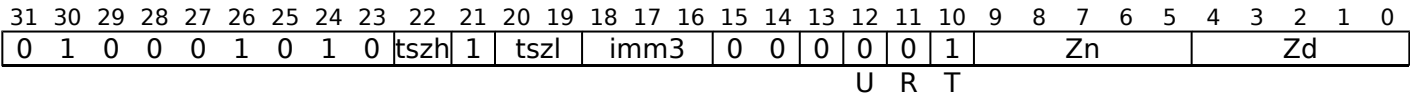
Z[d] = result;
```



# SQSHRUNT

Signed saturating shift right unsigned narrow by immediate (top).

Shift each signed integer value in the source vector elements right by an immediate value, and place the truncated results in the odd-numbered half-width destination elements, leaving the even-numbered elements unchanged. Each result element is saturated to the half-width N-bit element's unsigned integer range 0 to  $(2^N)-1$ . The immediate shift amount is an unsigned value in the range 1 to number of bits per element. This instruction is unpredicated.



## SVE2

SQSHRUNT <Zd>.<T>, <Zn>.<Tb>, #<const>

```
if !HaveSVE2() then UNDEFINED;
bits(3) tsize = tszh:tszl;
case tsize of
    when '000' UNDEFINED;
    when '001' esize = 8;
    when '01x' esize = 16;
    when '1xx' esize = 32;
integer n = UInt(Zn);
integer d = UInt(Zd);
integer shift = (2 * esize) - UInt(tsize:imm3);
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
0	00	RESERVED
0	01	B
0	1x	H
1	xx	S

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<Tb>
0	00	RESERVED
0	01	H
0	1x	S
1	xx	D

- <const> Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    bits(2*esize) element = Elem[operand, e, 2*esize];
    integer res = SInt(element) >> shift;
    Elem[result, 2*e + 1, esize] = UnsignedSat(res, esize);

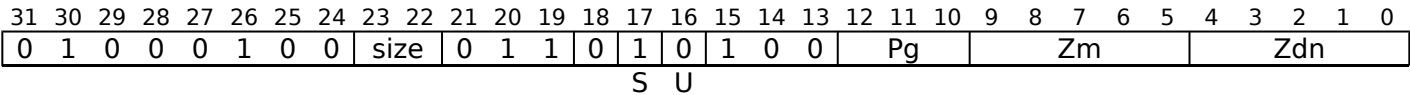
Z[d] = result;
```



# SQSUB (vectors, predicated)

Signed saturating subtraction (predicated).

Subtract active signed elements of the second source vector from corresponding signed elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. Each result element is saturated to the N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . Inactive elements in the destination vector register remain unmodified.



## SVE2

SQSUB <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean unsigned = FALSE;
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, e, esize]);
    integer element2 = SInt(Elem[operand2, e, esize]);
    if ElemP[mask, e, esize] == '1' then
        integer res = SInt(Sat(element1 - element2, esize, unsigned));
        Elem[result, e, esize] = res<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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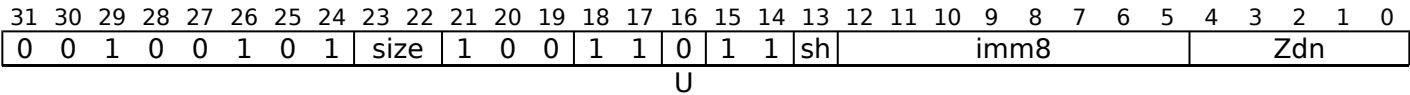
# SQSUB (immediate)

Signed saturating subtract immediate (unpredicated).

Signed saturating subtract of an unsigned immediate from each element of the source vector, and destructively place the results in the corresponding elements of the source vector. Each result element is saturated to the N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . This instruction is unpredicated.

The immediate is an unsigned value in the range 0 to 255, and for element widths of 16 bits or higher it may also be a positive multiple of 256 in the range 256 to 65280.

The immediate is encoded in 8 bits with an optional left shift by 8. The preferred disassembly when the shift option is specified is "#<uimm8>, LSL #8". However an assembler and disassembler may also allow use of the shifted 16-bit value unless the immediate is 0 and the shift amount is 8, which must be unambiguously described as "#0, LSL #8".



## SVE

SQSUB <Zdn>.<T>, <Zdn>.<T>, #<imm>{, <shift>}

```
if !HaveSVE() then UNDEFINED;
if size:sh == '001' then UNDEFINED;
integer esize = 8 << UInt(size);
integer dn = UInt(Zdn);
integer imm = UInt(imm8);
if sh == '1' then imm = imm << 8;
boolean unsigned = FALSE;
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <imm> Is an unsigned immediate in the range 0 to 255, encoded in the "imm8" field.
- <shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #8

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 - imm, esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

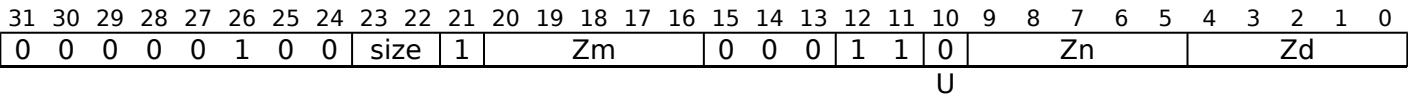
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## SQSUB (vectors, unpredicated)

Signed saturating subtract vectors (unpredicated).

Signed saturating subtract all elements of the second source vector from corresponding elements of the first source vector and place the results in the corresponding elements of the destination vector. Each result element is saturated to the N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . This instruction is unpredicated.



### SVE

SQSUB <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
boolean unsigned = FALSE;
```

### Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

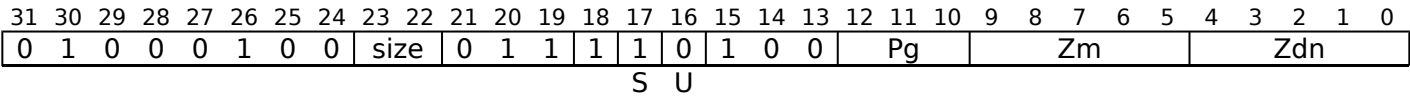
for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 - element2, esize, unsigned);

Z[d] = result;
```

# SQSUBR

Signed saturating subtraction reversed vectors (predicated).

Subtract active signed elements of the first source vector from corresponding signed elements of the second source vector and destructively place the results in the corresponding elements of the first source vector. Each result element is saturated to the N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . Inactive elements in the destination vector register remain unmodified.



## SVE2

SQSUBR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean unsigned = FALSE;
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, e, esize]);
    integer element2 = SInt(Elem[operand2, e, esize]);
    if ElemP[mask, e, esize] == '1' then
        integer res = SInt(Sat(element2 - element1, esize, unsigned));
        Elem[result, e, esize] = res<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

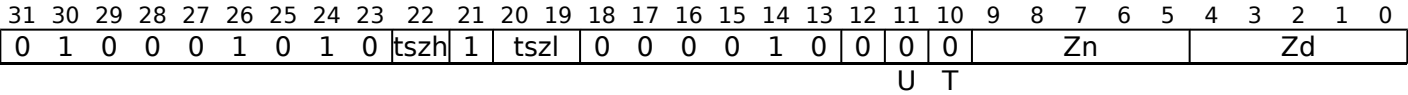
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SQXTNB

Signed saturating extract narrow (bottom).

Saturate the signed integer value in each source element to half the original source element width, and place the results in the even-numbered half-width destination elements, while setting the odd-numbered elements to zero.



SVE2

SQXTNB <Zd>.<T>, <Zn>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
bits(3) tsize = tszh:tszl;
case tsize of
    when '001' esize = 16;
    when '010' esize = 32;
    when '100' esize = 64;
    otherwise UNDEFINED;
integer n = UInt(Zn);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
0	00	RESERVED
0	01	B
0	10	H
x	11	RESERVED
1	00	S
1	01	RESERVED
1	10	RESERVED

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<Tb>
0	00	RESERVED
0	01	H
0	10	S
x	11	RESERVED
1	00	D
1	01	RESERVED
1	10	RESERVED

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) result;
integer halfesize = esize DIV 2;

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, e, esize]);
    bits(halfesize) res = SignedSat(element1, halfesize);
    Elem[result, 2*e + 0, halfesize] = res;
    Elem[result, 2*e + 1, halfesize] = Zeros();

Z[d] = result;
```

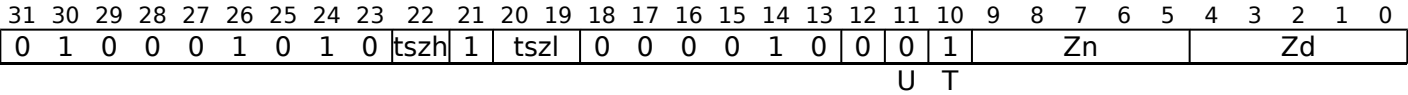
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SQXTNT

Signed saturating extract narrow (top).

Saturate the signed integer value in each source element to half the original source element width, and place the results in the odd-numbered half-width destination elements, leaving the even-numbered elements unchanged.



SVE2

SQXTNT <Zd>.<T>, <Zn>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
bits(3) tsize = tszh:tszl;
case tsize of
  when '001' esize = 16;
  when '010' esize = 32;
  when '100' esize = 64;
  otherwise UNDEFINED;
integer n = UInt(Zn);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
0	00	RESERVED
0	01	B
0	10	H
x	11	RESERVED
1	00	S
1	01	RESERVED
1	10	RESERVED

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<Tb>
0	00	RESERVED
0	01	H
0	10	S
x	11	RESERVED
1	00	D
1	01	RESERVED
1	10	RESERVED



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) result = Z[d];
integer halfesize = esize DIV 2;

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, e, esize]);
    bits(halfesize) res = SignedSat(element1, halfesize);
    Elem[result, 2*e + 1, halfesize] = res;

Z[d] = result;
```

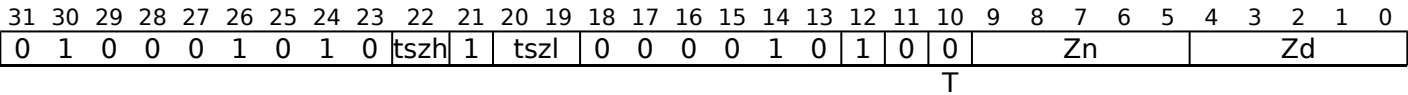
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SQXTUNB

Signed saturating unsigned extract narrow (bottom).

Saturate the signed integer value in each source element to an unsigned integer value that is half the original source element width, and place the results in the even-numbered half-width destination elements, while setting the odd-numbered elements to zero.



SVE2

SQXTUNB <Zd>.<T>, <Zn>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
bits(3) tsize = tszh:tszl;
case tsize of
  when '001' esize = 16;
  when '010' esize = 32;
  when '100' esize = 64;
  otherwise UNDEFINED;
integer n = UInt(Zn);
integer d = UInt(Zd);
```

Assembler Symbols

- <Zd>Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T>Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
0	00	RESERVED
0	01	B
0	10	H
x	11	RESERVED
1	00	S
1	01	RESERVED
1	10	RESERVED

- <Zn>Is the name of the source scalable vector register, encoded in the "Zn" field.
- <Tb>Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<Tb>
0	00	RESERVED
0	01	H
0	10	S
x	11	RESERVED
1	00	D
1	01	RESERVED
1	10	RESERVED

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) result;
integer halfesize = esize DIV 2;

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, e, esize]);
    bits(halfesize) res = UnsignedSat(element1, halfesize);
    Elem[result, 2*e + 0, halfesize] = res;
    Elem[result, 2*e + 1, halfesize] = Zeros();

Z[d] = result;
```

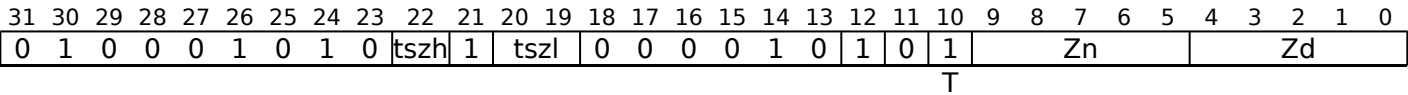
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SQXTUNT

Signed saturating unsigned extract narrow (top).

Saturate the signed integer value in each source element to an unsigned integer value that is half the original source element width, and place the results in the odd-numbered half-width destination elements, leaving the even-numbered elements unchanged.



SVE2

SQXTUNT <Zd>.<T>, <Zn>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
bits(3) tsize = tszh:tszl;
case tsize of
  when '001' esize = 16;
  when '010' esize = 32;
  when '100' esize = 64;
  otherwise UNDEFINED;
integer n = UInt(Zn);
integer d = UInt(Zd);
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
0	00	RESERVED
0	01	B
0	10	H
x	11	RESERVED
1	00	S
1	01	RESERVED
1	10	RESERVED

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<Tb>
0	00	RESERVED
0	01	H
0	10	S
x	11	RESERVED
1	00	D
1	01	RESERVED
1	10	RESERVED

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) result = Z[d];
integer halfesize = esize DIV 2;

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, e, esize]);
    bits(halfesize) res = UnsignedSat(element1, halfesize);
    Elem[result, 2*e + 1, halfesize] = res;

Z[d] = result;
```

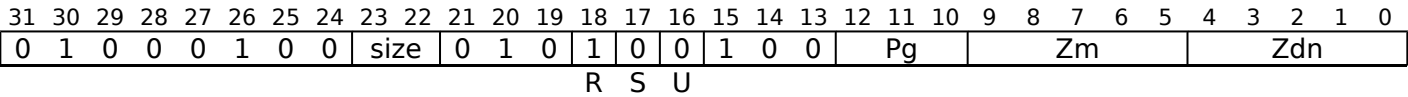
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# SRHADD

Signed rounding halving addition.

Add active signed elements of the first source vector to corresponding signed elements of the second source vector, shift right one bit, and destructively place the rounded results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



## SVE2

SRHADD <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

### Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;
integer round_const = 1;

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, e, esize]);
    integer element2 = SInt(Elem[operand2, e, esize]);
    if ElemP[mask, e, esize] == '1' then
        integer res = element1 + element2 + round_const;
        Elem[result, e, esize] = res<size:1>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

### Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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SRI

Shift right and insert (immediate).

Shift each source vector element right by an immediate value, and insert the result into the corresponding vector element in the destination vector register, merging the shifted bits from each source element with existing bits in each destination vector element. The immediate shift amount is an unsigned value in the range 1 to number of bits per element. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	tszh	0	tszl	imm3			1	1	1	1	0	0	Zn						Zd					

SVE2

SRI <Zd>.<T>, <Zn>.<T>, #<const>

```
if !HaveSVE2() then UNDEFINED;
bits(4) tsize = tszh:tszl;
case tsize of
  when '0000' UNDEFINED;
  when '0001' esize = 8;
  when '001x' esize = 16;
  when '01xx' esize = 32;
  when '1xxx' esize = 64;
integer n = UInt(Zn);
integer d = UInt(Zd);
integer shift = (2 * esize) - UInt(tsize:imm3);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
00	00	RESERVED
00	01	B
00	1x	H
01	xx	S
1x	xx	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<const> Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
  bits(esize) element1 = Elem[result, e, esize];
  bits(esize) element2 = Elem[operand, e, esize];
  bits(esize) mask = LSR(Ones(esize), shift);
  bits(esize) shiftedval = LSR(element2, shift);
  Elem[result, e, esize] = (element1 AND (NOT mask)) OR shiftedval;

Z[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:



- The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

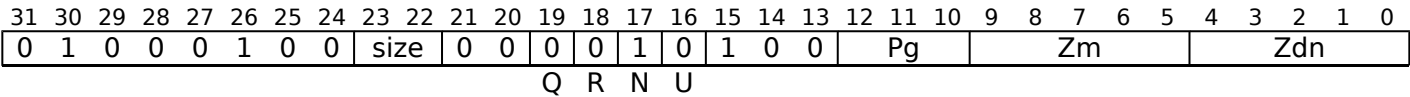
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SRSHL

Signed rounding shift left by vector (predicated).

Shift active signed elements of the first source vector by corresponding elements of the second source vector and destructively place the rounded results in the corresponding elements of the first source vector. A positive shift amount performs a left shift, otherwise a right shift by the negated shift amount is performed. Inactive elements in the destination vector register remain unmodified.



SVE2

SRSHL <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer m = UInt(Zm);
integer dn = UInt(Zdn);
```

Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element = SInt(Elem[operand1, e, esize]);
    integer shift = ShiftSat(SInt(Elem[operand2, e, esize]), esize);
    integer round_const = 1 << (-shift - 1); // 0 for left shift, 2^(n-1) for right shift
    if ElemP[mask, e, esize] == '1' then
        integer res = (element + round_const) << shift;
        Elem[result, e, esize] = res<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

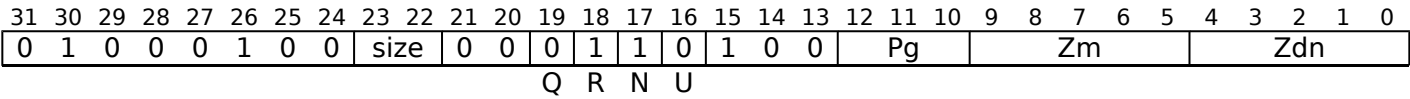
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SRSHLR

Signed rounding shift left reversed vectors (predicated).

Shift active signed elements of the second source vector by corresponding elements of the first source vector and destructively place the rounded results in the corresponding elements of the first source vector. A positive shift amount performs a left shift, otherwise a right shift by the negated shift amount is performed. Inactive elements in the destination vector register remain unmodified.



SVE2

```
SRSHLR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>
```

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer m = UInt(Zm);
integer dn = UInt(Zdn);
```

Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[m];
bits(VL) operand2 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element = SInt(Elem[operand1, e, esize]);
    integer shift = ShiftSat(SInt(Elem[operand2, e, esize]), esize);
    integer round_const = 1 << (-shift - 1); // 0 for left shift, 2^(n-1) for right shift
    if ElemP[mask, e, esize] == '1' then
        integer res = (element + round_const) << shift;
        Elem[result, e, esize] = res<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand2, e, esize];

Z[dn] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

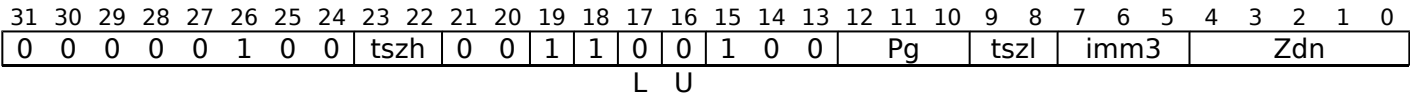
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SRSHR

Signed rounding shift right by immediate.

Shift right by immediate each active signed element of the source vector, and destructively place the rounded results in the corresponding elements of the source vector. The immediate shift amount is an unsigned value in the range 1 to number of bits per element. Inactive elements in the destination vector register remain unmodified.



SVE2

SRSHR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, #<const>

```
if !HaveSVE2() then UNDEFINED;
bits(4) tsize = tszh:tszl;
case tsize of
  when '0000' UNDEFINED;
  when '0001' esize = 8;
  when '001x' esize = 16;
  when '01xx' esize = 32;
  when '1xxx' esize = 64;
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer shift = (2 * esize) - UInt(tsize:imm3);
```

Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
00	00	RESERVED
00	01	B
00	1x	H
01	xx	S
1x	xx	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <const> Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(PL) mask = P[g];
bits(VL) result;
integer round_const = 1 << (shift-1);

for e = 0 to elements-1
  integer element1 = SInt(Elem[operand1, e, esize]);
  if ElemP[mask, e, esize] == '1' then
    integer res = (element1 + round_const) >> shift;
    Elem[result, e, esize] = res<esize-1:0>;
  else
    Elem[result, e, esize] = Elem[operand1, e, esize];
Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

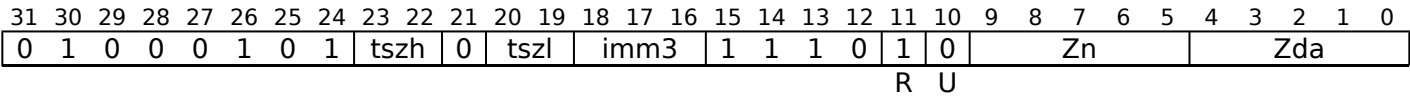
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SRSRA

Signed rounding shift right and accumulate (immediate).

Shift right by immediate each signed element of the source vector, preserving the sign bit, and add the rounded intermediate result destructively to the corresponding elements of the addend vector. The immediate shift amount is an unsigned value in the range 1 to number of bits per element. This instruction is unpredicated.



SVE2

```
SRSRA <Zda>.<T>, <Zn>.<T>, #<const>
```

```
if !HaveSVE2() then UNDEFINED;
bits(4) tsize = tszh:tszl;
case tsize of
  when '0000' UNDEFINED;
  when '0001' esize = 8;
  when '001x' esize = 16;
  when '01xx' esize = 32;
  when '1xxx' esize = 64;
integer n = UInt(Zn);
integer da = UInt(Zda);
integer shift = (2 * esize) - UInt(tsize:imm3);
```

Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
00	00	RESERVED
00	01	B
00	1x	H
01	xx	S
1x	xx	D

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <const> Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[da];
bits(VL) result;
integer round_const = 1 << (shift - 1);

for e = 0 to elements-1
  integer element = (SInt(Elem[operand1, e, esize]) + round_const) >> shift;
  Elem[result, e, esize] = Elem[operand2, e, esize] + element<esize-1:0>;

Z[da] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:



- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

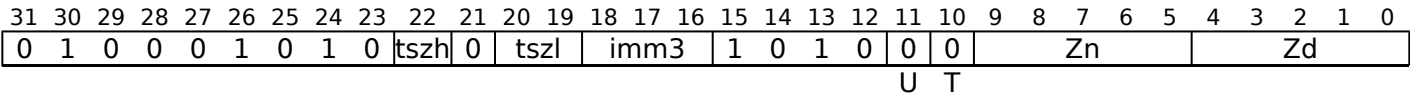
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SSHLLB

Signed shift left long by immediate (bottom).

Shift left by immediate each even-numbered signed element of the source vector, and place the results in the overlapping double-width elements of the destination vector. The immediate shift amount is an unsigned value in the range 0 to number of bits per element minus 1. This instruction is unpredicated.



SVE2

SSHLLB <Zd>.<T>, <Zn>.<Tb>, #<const>

```
if !HaveSVE2() then UNDEFINED;
bits(3) tsize = tszh:tszl;
case tsize of
  when '000' UNDEFINED;
  when '001' esize = 8;
  when '01x' esize = 16;
  when '1xx' esize = 32;
integer n = UInt(Zn);
integer d = UInt(Zd);
integer shift = UInt(tsize:imm3) - esize;
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
0	00	RESERVED
0	01	H
0	1x	S
1	xx	D

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<Tb>
0	00	RESERVED
0	01	B
0	1x	H
1	xx	S

<const> Is the immediate shift amount, in the range 0 to number of bits per element minus 1, encoded in "tsz:imm3".

Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
bits(VL) operand = Z[n];
bits(VL) result;

for e = 0 to elements-1
  bits(esize) element = Elem[operand, 2*e + 0, esize];
  integer shifted_value = SInt(element) << shift;
  Elem[result, e, 2*esize] = shifted_value<2*esize-1:0>;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

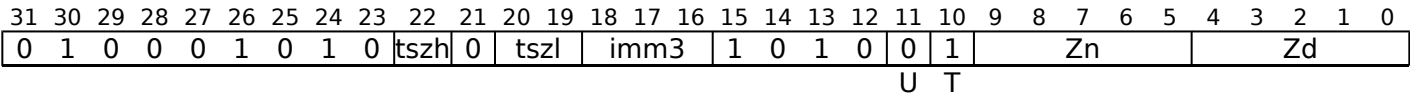
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SSHLLT

Signed shift left long by immediate (top).

Shift left by immediate each odd-numbered signed element of the source vector, and place the results in the overlapping double-width elements of the destination vector. The immediate shift amount is an unsigned value in the range 0 to number of bits per element minus 1. This instruction is unpredicated.



SVE2

```
SSHLLT <Zd>.<T>, <Zn>.<Tb>, #<const>
```

```
if !HaveSVE2() then UNDEFINED;
bits(3) tsize = tszh:tszl;
case tsize of
  when '000' UNDEFINED;
  when '001' esize = 8;
  when '01x' esize = 16;
  when '1xx' esize = 32;
integer n = UInt(Zn);
integer d = UInt(Zd);
integer shift = UInt(tsize:imm3) - esize;
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
0	00	RESERVED
0	01	H
0	1x	S
1	xx	D

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<Tb>
0	00	RESERVED
0	01	B
0	1x	H
1	xx	S

<const> Is the immediate shift amount, in the range 0 to number of bits per element minus 1, encoded in "tsz:imm3".

Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
bits(VL) operand = Z[n];
bits(VL) result;

for e = 0 to elements-1
  bits(esize) element = Elem[operand, 2*e + 1, esize];
  integer shifted_value = SInt(element) << shift;
  Elem[result, e, 2*esize] = shifted_value<2*esize-1:0>;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

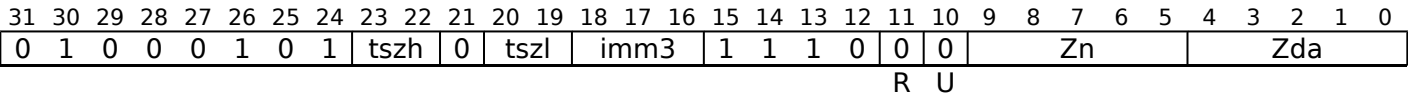
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SSRA

Signed shift right and accumulate (immediate).

Shift right by immediate each signed element of the source vector, preserving the sign bit, and add the truncated intermediate result destructively to the corresponding elements of the addend vector. The immediate shift amount is an unsigned value in the range 1 to number of bits per element. This instruction is unpredicated.



SVE2

```
SSRA <Zda>.<T>, <Zn>.<T>, #<const>
```

```
if !HaveSVE2() then UNDEFINED;
bits(4) tsize = tszh:tszl;
case tsize of
  when '0000' UNDEFINED;
  when '0001' esize = 8;
  when '001x' esize = 16;
  when '01xx' esize = 32;
  when '1xxx' esize = 64;
integer n = UInt(Zn);
integer da = UInt(Zda);
integer shift = (2 * esize) - UInt(tsize:imm3);
```

Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
00	00	RESERVED
00	01	B
00	1x	H
01	xx	S
1x	xx	D

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <const> Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[da];
bits(VL) result;

for e = 0 to elements-1
  integer element = SInt(Elem[operand1, e, esize]) >> shift;
  Elem[result, e, esize] = Elem[operand2, e, esize] + element<esize-1:0>;

Z[da] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a **MOVPRFX** instruction. The **MOVPRFX** instruction must conform to all of the following requirements, otherwise the behavior of the **MOVPRFX** and this instruction is UNPREDICTABLE:

- The **MOVPRFX** instruction must be unpredicated.
- The **MOVPRFX** instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

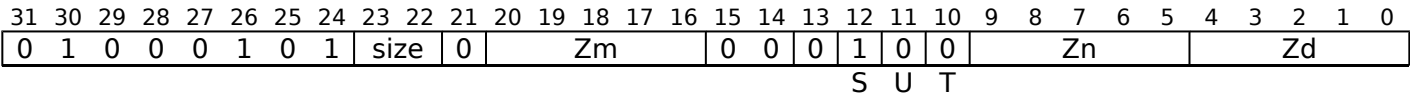
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SSUBLB

Signed subtract long (bottom).

Subtract the even-numbered signed elements of the second source vector from the corresponding signed elements of the first source vector, and place the results in the overlapping double-width elements of the destination vector. This instruction is unpredicated.



SVE2

```
SSUBLB <Zd>.<T>, <Zn>.<Tb>, <Zm>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer sel1 = 0;
integer sel2 = 0;
boolean unsigned = FALSE;
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, 2*e + sel1, esize DIV 2], unsigned);
    integer element2 = Int(Elem[operand2, 2*e + sel2, esize DIV 2], unsigned);
    integer res = element1 - element2;
    Elem[result, e, esize] = res<esize-1:0>;

Z[d] = result;
```



## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

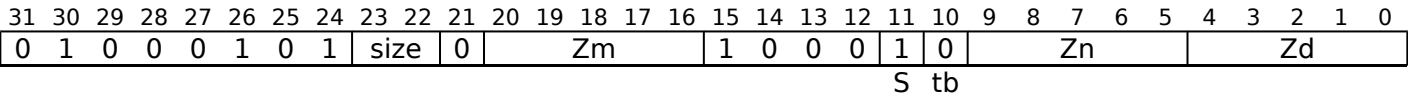
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SSUBLBT

Signed subtract long (bottom - top).

Subtract the odd-numbered signed elements of the second source vector from the even-numbered signed elements of the first source vector, and place the results in the overlapping double-width elements of the destination vector. This instruction is unpredicated.



SVE2

```
SSUBLBT <Zd>.<T>, <Zn>.<Tb>, <Zm>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer sel1 = 0;
integer sel2 = 1;
boolean unsigned = FALSE;
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, 2*e + sel1, esize DIV 2], unsigned);
    integer element2 = Int(Elem[operand2, 2*e + sel2, esize DIV 2], unsigned);
    integer res = element1 - element2;
    Elem[result, e, esize] = res<esize-1:0>;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

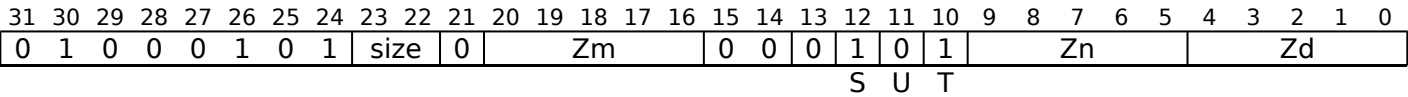
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SSUBLT

Signed subtract long (top).

Subtract the odd-numbered signed elements of the second source vector from the corresponding signed elements of the first source vector, and place the results in the overlapping double-width elements of the destination vector. This instruction is unpredicated.



SVE2

```
SSUBLT <Zd>.<T>, <Zn>.<Tb>, <Zm>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer sel1 = 1;
integer sel2 = 1;
boolean unsigned = FALSE;
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, 2*e + sel1, esize DIV 2], unsigned);
    integer element2 = Int(Elem[operand2, 2*e + sel2, esize DIV 2], unsigned);
    integer res = element1 - element2;
    Elem[result, e, esize] = res<esize-1:0>;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

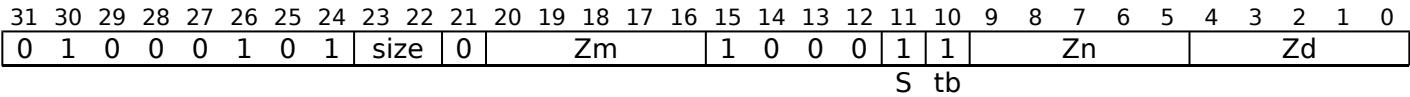
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# SSUBLTB

Signed subtract long (top - bottom).

Subtract the even-numbered signed elements of the second source vector from the odd-numbered signed elements of the first source vector, and place the results in the overlapping double-width elements of the destination vector. This instruction is unpredicated.



## SVE2

SSUBLTB <Zd>.<T>, <Zn>.<Tb>, <Zm>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer sel1 = 1;
integer sel2 = 0;
boolean unsigned = FALSE;
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, 2*e + sel1, esize DIV 2], unsigned);
    integer element2 = Int(Elem[operand2, 2*e + sel2, esize DIV 2], unsigned);
    integer res = element1 - element2;
    Elem[result, e, esize] = res<esize-1:0>;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

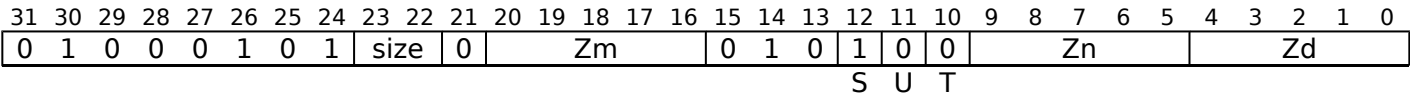
Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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SSUBWB

Signed subtract wide (bottom).

Subtract the even-numbered signed elements of the second source vector from the overlapping double-width elements of the first source vector and place the results in the corresponding double-width elements of the destination vector. This instruction is unpredicated.



SVE2

```
SSUBWB <Zd>.<T>, <Zn>.<T>, <Zm>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, e, esize]);
    integer element2 = SInt(Elem[operand2, 2*e + 0, esize DIV 2]);
    Elem[result, e, esize] = (element1 - element2)<esize-1:0>;

Z[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:



- The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

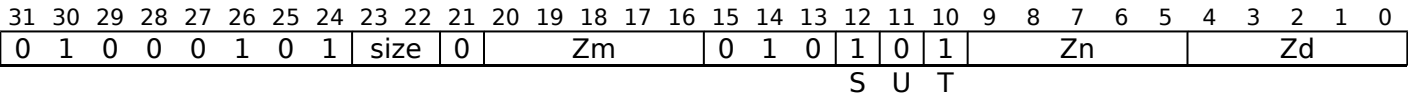
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SSUBWT

Signed subtract wide (top).

Subtract the even-numbered signed elements of the second source vector from the overlapping double-width elements of the first source vector and place the results in the corresponding double-width elements of the destination vector. This instruction is unpredicated.



SVE2

```
SSUBWT <Zd>.<T>, <Zn>.<T>, <Zm>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = SInt(Elem[operand1, e, esize]);
    integer element2 = SInt(Elem[operand2, 2*e + 1, esize DIV 2]);
    Elem[result, e, esize] = (element1 - element2)<esize-1:0>;

Z[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:

- The values of the data supplied in any of its registers.
- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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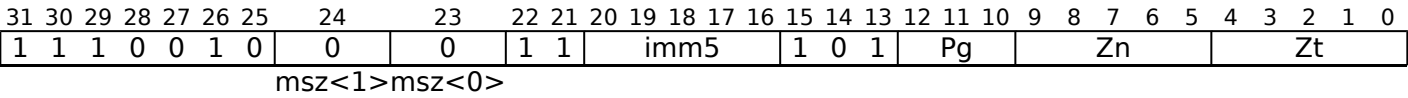
## ST1B (vector plus immediate)

Scatter store bytes from a vector (immediate index).

Scatter store of bytes from the active elements of a vector register to the memory addresses generated by a vector base plus immediate index. The index is in the range 0 to 31. Inactive elements are not written to memory.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

### 32-bit element

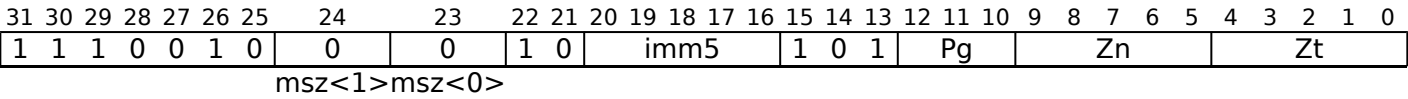


### 32-bit element

ST1B { <Zt>.S }, <Pg>, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
integer offset = UInt(imm5);
```

### 64-bit element



### 64-bit element

ST1B { <Zt>.D }, <Pg>, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
integer offset = UInt(imm5);
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, in the range 0 to 31, defaulting to 0, encoded in the "imm5" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) base = Z[n];
bits(VL) src = Z[t];
bits(PL) mask = P[g];
bits(64) addr;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
```

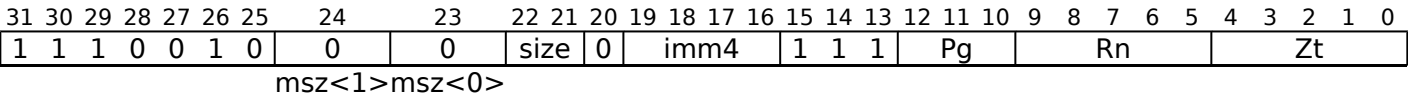
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ST1B (scalar plus immediate)

Contiguous store bytes from vector (immediate index).

Contiguous store of bytes from elements of a vector register to the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements are not written to memory.



SVE

ST1B { <Zt>.<T> }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8 << UInt(size);
integer msize = 8;
integer offset = SInt(imm4);
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) src = Z[t];
constant integer mbytes = msize DIV 8;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

addr = base + offset * elements * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
    addr = addr + mbytes;
```

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ST1B (scalar plus scalar)

Contiguous store bytes from vector (scalar index).

Contiguous store of bytes from elements of a vector register to the memory address generated by a 64-bit scalar base and scalar index which is added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements are not written to memory.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	0	0	size			Rm				0	1	0	Pg			Rn				Zt					

SVE

ST1B { <Zt>.<T> }, <Pg>, [<Xn|SP>, <Xm>]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 8 << UInt(size);
integer msize = 8;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(64) offset = X[m];
bits(VL) src = Z[t];
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    if ElemP[mask, e, esize] == '1' then
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
    offset = offset + 1;
```

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## ST1B (scalar plus vector)

Scatter store bytes from a vector (vector index).

Scatter store of bytes from the active elements of a vector register to the memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally sign or zero-extended from 32 to 64 bits. Inactive elements are not written to memory.

It has encodings from 3 classes: [32-bit unpacked unscaled offset](#) , [32-bit unscaled offset](#) and [64-bit unscaled offset](#)

### 32-bit unpacked unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	0	0	0	0	Zm	1	xs	0	Pg	Rn	Zt														
msz<1>msz<0>																															

### 32-bit unpacked unscaled offset

ST1B { <Zt>.D }, <Pg>, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
integer offs_size = 32;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

### 32-bit unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	0	0	1	0	Zm			1	xs	0	Pg			Rn			Zt								
msz<1>msz<0>																															

### 32-bit unscaled offset

ST1B { <Zt>.S }, <Pg>, [<Xn|SP>, <Zm>.S, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
integer offs_size = 32;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

### 64-bit unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	0	0	0	0	Zm			1	0	1	Pg			Rn			Zt								
msz<1>msz<0>																															

64-bit unscaled offset

```
ST1B { <Zt>.D }, <Pg>, [<Xn|SP>, <Zm>.D]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
integer offs_size = 64;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(VL) offset = Z[m];
bits(VL) src = Z[t];
bits(PL) mask = P[g];
bits(64) addr;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

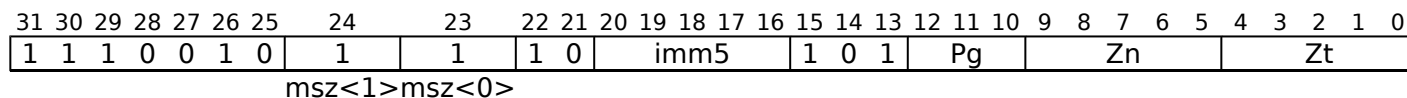
if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        addr = base + (off << scale);
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
```

## ST1D (vector plus immediate)

Scatter store doublewords from a vector (immediate index).

Scatter store of doublewords from the active elements of a vector register to the memory addresses generated by a vector base plus immediate index. The index is a multiple of 8 in the range 0 to 248. Inactive elements are not written to memory.



## SVE

ST1D { <Zt>.D }, <Pg>, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
integer offset = UInt(imm5);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 8 in the range 0 to 248, defaulting to 0, encoded in the "imm5" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) base = Z[n];
bits(VL) src = Z[t];
bits(PL) mask = P[g];
bits(64) addr;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
```

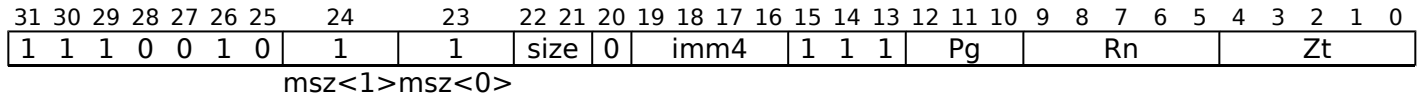
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## ST1D (scalar plus immediate)

Contiguous store doublewords from vector (immediate index).

Contiguous store of doublewords from elements of a vector register to the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements are not written to memory.



### SVE

ST1D { <Zt>.D }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
if size != '11' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8 << UInt(size);
integer msize = 64;
integer offset = SInt(imm4);
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) src = Z[t];
constant integer mbytes = msize DIV 8;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

addr = base + offset * elements * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
    addr = addr + mbytes;
```

## ST1D (scalar plus scalar)

Contiguous store doublewords from vector (scalar index).

Contiguous store of doublewords from elements of a vector register to the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 8 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements are not written to memory.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	1	1	1	1	Rm				0	1	0	Pg			Rn				Zt						

### SVE

ST1D { <Zt>.D }, <Pg>, [<Xn|SP>, <Xm>, LSL #3]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(64) offset = X[m];
bits(VL) src = Z[t];
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        base = SP[];
    else
        base = X[n];
else
    base = X[n];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    if ElemP[mask, e, esize] == '1' then
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
    offset = offset + 1;
```

## ST1D (scalar plus vector)

Scatter store doublewords from a vector (vector index).

Scatter store of doublewords from the active elements of a vector register to the memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then optionally multiplied by 8. Inactive elements are not written to memory.

It has encodings from 4 classes: [32-bit unpacked scaled offset](#) , [32-bit unpacked unscaled offset](#) , [64-bit scaled offset](#) and [64-bit unscaled offset](#)

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	1	1	0	1	Zm				1	xs	0	Pg			Rn				Zt						
							msz<1>		msz<0>																						

### 32-bit unpacked scaled offset

ST1D { <Zt>.D }, <Pg>, [<Xn|SP>, <Zm>.D, <mod> #3]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
integer offs_size = 32;
boolean offs_unsigned = xs == '0';
integer scale = 3;
```

### 32-bit unpacked unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	1	1	0	0	Zm				1	xs	0	Pg			Rn				Zt						
							msz<1>		msz<0>																						

### 32-bit unpacked unscaled offset

ST1D { <Zt>.D }, <Pg>, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
integer offs_size = 32;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

### 64-bit scaled offset

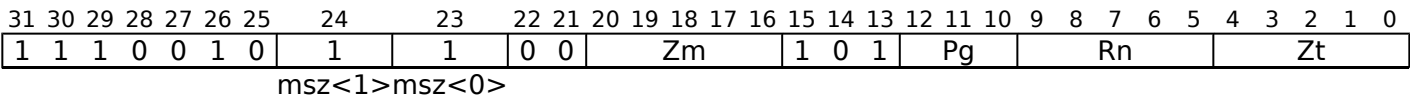
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	1	1	0	1	Zm				1	0	1	Pg			Rn				Zt						
							msz<1>		msz<0>																						

64-bit scaled offset

ST1D { <Zt>.D }, <Pg>, [<Xn|SP>, <Zm>.D, LSL #3]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
integer offs_size = 64;
boolean offs_unsigned = TRUE;
integer scale = 3;
```

64-bit unscaled offset



64-bit unscaled offset

ST1D { <Zt>.D }, <Pg>, [<Xn|SP>, <Zm>.D]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
integer offs_size = 64;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(VL) offset = Z[m];
bits(VL) src = Z[t];
bits(PL) mask = P[g];
bits(64) addr;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        addr = base + (off << scale);
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
```

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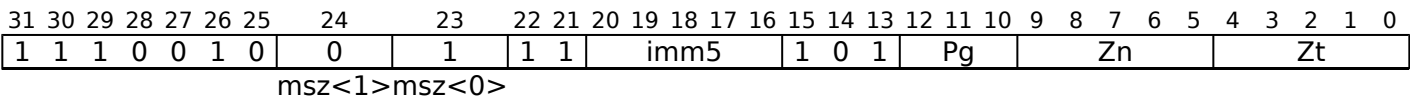
# ST1H (vector plus immediate)

Scatter store halfwords from a vector (immediate index).

Scatter store of halfwords from the active elements of a vector register to the memory addresses generated by a vector base plus immediate index. The index is a multiple of 2 in the range 0 to 62. Inactive elements are not written to memory.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

## 32-bit element

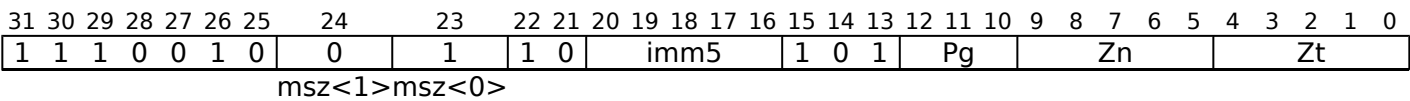


## 32-bit element

ST1H { <Zt>.S }, <Pg>, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
integer offset = UInt(imm5);
```

## 64-bit element



## 64-bit element

ST1H { <Zt>.D }, <Pg>, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offset = UInt(imm5);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 2 in the range 0 to 62, defaulting to 0, encoded in the "imm5" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) base = Z[n];
bits(VL) src = Z[t];
bits(PL) mask = P[g];
bits(64) addr;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
```

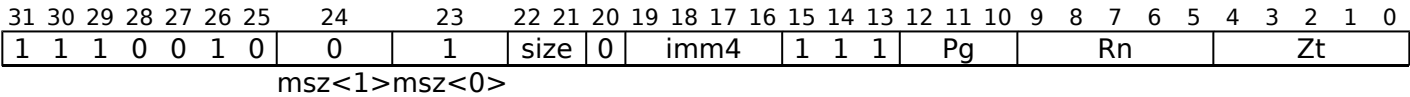
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ST1H (scalar plus immediate)

Contiguous store halfwords from vector (immediate index).

Contiguous store of halfwords from elements of a vector register to the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements are not written to memory.



SVE

ST1H { <Zt>.<T> }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8 << UInt(size);
integer msize = 16;
integer offset = SInt(imm4);
```

Assembler Symbols

- <Zt>

Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D
- <Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP>

Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm>

Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) src = Z[t];
constant integer mbytes = msize DIV 8;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

addr = base + offset * elements * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
    addr = addr + mbytes;
```

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ST1H (scalar plus scalar)

Contiguous store halfwords from vector (scalar index).

Contiguous store of halfwords from elements of a vector register to the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 2 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements are not written to memory.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	0	1	size			Rm				0	1	0	Pg			Rn				Zt					

SVE

ST1H { <Zt>.<T> }, <Pg>, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
if Rm == '1111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 8 << UInt(size);
integer msize = 16;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(64) offset = X[m];
bits(VL) src = Z[t];
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    if ElemP[mask, e, esize] == '1' then
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
    offset = offset + 1;
```

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## ST1H (scalar plus vector)

Scatter store halfwords from a vector (vector index).

Scatter store of halfwords from the active elements of a vector register to the memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then optionally multiplied by 2. Inactive elements are not written to memory.

It has encodings from 6 classes: [32-bit scaled offset](#) , [32-bit unpacked scaled offset](#) , [32-bit unpacked unscaled offset](#) , [32-bit unscaled offset](#) , [64-bit scaled offset](#) and [64-bit unscaled offset](#)

### 32-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	0	1	1	Zm			1	xs	0	Pg			Rn			Zt									
msz<1>msz<0>																															

### 32-bit scaled offset

ST1H { <Zt>.S }, <Pg>, [<Xn|SP>, <Zm>.S, <mod> #1]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
integer offs_size = 32;
boolean offs_unsigned = xs == '0';
integer scale = 1;
```

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	0	1	0	1	Zm			1	xs	0	Pg			Rn			Zt								
msz<1>msz<0>																															

### 32-bit unpacked scaled offset

ST1H { <Zt>.D }, <Pg>, [<Xn|SP>, <Zm>.D, <mod> #1]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 32;
boolean offs_unsigned = xs == '0';
integer scale = 1;
```

### 32-bit unpacked unscaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	0	1	0	0	Zm	1	xs	0	Pg	Rn	Zt														
							msz<1>		msz<0>																						

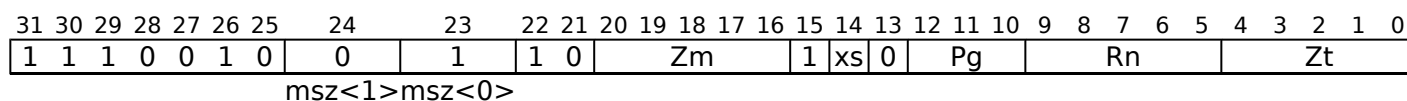


### 32-bit unpacked unscaled offset

ST1H { <Zt>.D }, <Pg>, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 32;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

### 32-bit unscaled offset

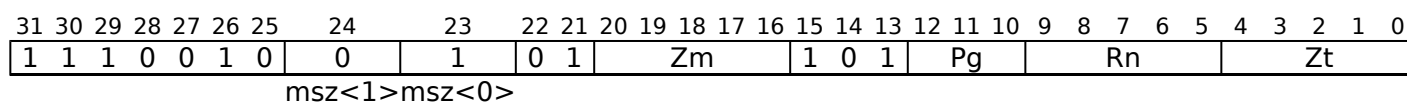


### 32-bit unscaled offset

ST1H { <Zt>.S }, <Pg>, [<Xn|SP>, <Zm>.S, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
integer offs_size = 32;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

### 64-bit scaled offset

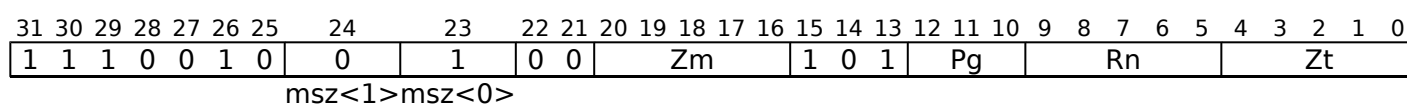


### 64-bit scaled offset

ST1H { <Zt>.D }, <Pg>, [<Xn|SP>, <Zm>.D, LSL #1]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 64;
boolean offs_unsigned = TRUE;
integer scale = 1;
```

### 64-bit unscaled offset



64-bit unscaled offset

```
ST1H { <Zt>.D }, <Pg>, [<Xn|SP>, <Zm>.D]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
integer offs_size = 64;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(VL) offset = Z[m];
bits(VL) src = Z[t];
bits(PL) mask = P[g];
bits(64) addr;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        base = SP[];
    else
        base = X[n];
else
    base = X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        addr = base + (off << scale);
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
```

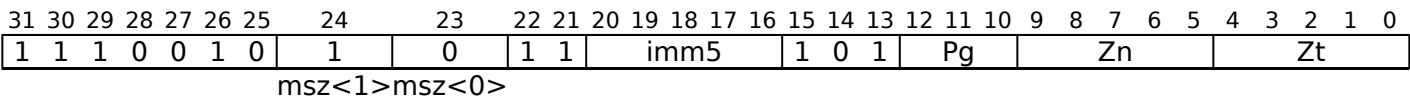
# ST1W (vector plus immediate)

Scatter store words from a vector (immediate index).

Scatter store of words from the active elements of a vector register to the memory addresses generated by a vector base plus immediate index. The index is a multiple of 4 in the range 0 to 124. Inactive elements are not written to memory.

It has encodings from 2 classes: [32-bit element](#) and [64-bit element](#)

## 32-bit element

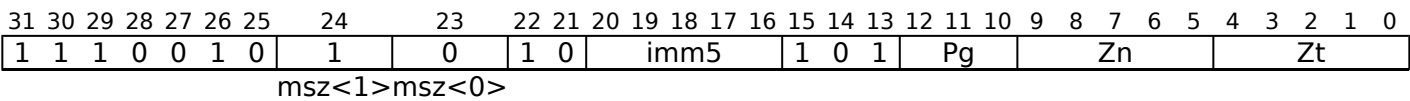


## 32-bit element

ST1W { <Zt>.S }, <Pg>, [<Zn>.S{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 32;
integer offset = UInt(imm5);
```

## 64-bit element



## 64-bit element

ST1W { <Zt>.D }, <Pg>, [<Zn>.D{, #<imm>}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offset = UInt(imm5);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <imm> Is the optional unsigned immediate byte offset, a multiple of 4 in the range 0 to 124, defaulting to 0, encoded in the "imm5" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) base = Z[n];
bits(VL) src = Z[t];
bits(PL) mask = P[g];
bits(64) addr;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = ZeroExtend(Elem[base, e, esize], 64) + offset * mbytes;
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
```

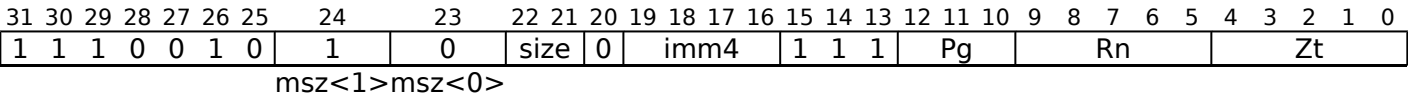
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## ST1W (scalar plus immediate)

Contiguous store words from vector (immediate index).

Contiguous store of words from elements of a vector register to the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements are not written to memory.



### SVE

ST1W { <Zt>.<T> }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
if size != 'lx' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8 << UInt(size);
integer msize = 32;
integer offset = SInt(imm4);
```

### Assembler Symbols

- <Zt>

Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <T>

Is the size specifier, encoded in "size<0>":

size<0>	<T>
0	S
1	D
- <Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP>

Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm>

Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(VL) src = Z[t];
constant integer mbytes = msize DIV 8;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

addr = base + offset * elements * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
    addr = addr + mbytes;
```

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## ST1W (scalar plus scalar)

Contiguous store words from vector (scalar index).

Contiguous store of words from elements of a vector register to the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 4 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements are not written to memory.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	1	0	size			Rm				0	1	0	Pg			Rn				Zt					

### SVE

ST1W { <Zt>.<T> }, <Pg>, [<Xn|SP>, <Xm>, LSL #2]

```
if !HaveSVE() then UNDEFINED;
if size != '1x' then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 8 << UInt(size);
integer msize = 32;
```

### Assembler Symbols

- <Zt>

Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <T>

Is the size specifier, encoded in "size<0>":

size<0>	<T>
0	S
1	D
- <Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP>

Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm>

Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(64) offset = X[m];
bits(VL) src = Z[t];
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    if ElemP[mask, e, esize] == '1' then
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
    offset = offset + 1;
```

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## ST1W (scalar plus vector)

Scatter store words from a vector (vector index).

Scatter store of words from the active elements of a vector register to the memory addresses generated by a 64-bit scalar base plus vector index. The index values are optionally first sign or zero-extended from 32 to 64 bits and then optionally multiplied by 4. Inactive elements are not written to memory.

It has encodings from 6 classes: [32-bit scaled offset](#) , [32-bit unpacked scaled offset](#) , [32-bit unpacked unscaled offset](#) , [32-bit unscaled offset](#) , [64-bit scaled offset](#) and [64-bit unscaled offset](#)

### 32-bit scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	1	0	1	1	Zm				1	xs	0	Pg			Rn				Zt						
							msz<1>		msz<0>																						

### 32-bit scaled offset

ST1W { <Zt>.S }, <Pg>, [<Xn|SP>, <Zm>.S, <mod> #2]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 32;
integer offs_size = 32;
boolean offs_unsigned = xs == '0';
integer scale = 2;
```

### 32-bit unpacked scaled offset

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	1	0	0	1	Zm				1	xs	0	Pg			Rn				Zt						
							msz<1>		msz<0>																						

### 32-bit unpacked scaled offset

ST1W { <Zt>.D }, <Pg>, [<Xn|SP>, <Zm>.D, <mod> #2]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 32;
boolean offs_unsigned = xs == '0';
integer scale = 2;
```

### 32-bit unpacked unscaled offset

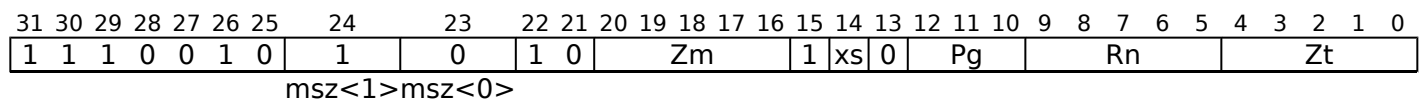
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	1	0	0	0	Zm				1	xs	0	Pg			Rn				Zt						
							msz<1>		msz<0>																						

### 32-bit unpacked unscaled offset

ST1W { <Zt>.D }, <Pg>, [<Xn|SP>, <Zm>.D, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 32;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

### 32-bit unscaled offset

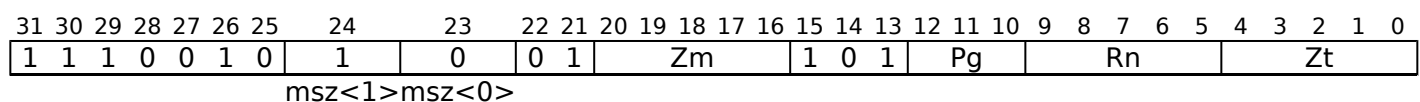


### 32-bit unscaled offset

ST1W { <Zt>.S }, <Pg>, [<Xn|SP>, <Zm>.S, <mod>]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 32;
integer offs_size = 32;
boolean offs_unsigned = xs == '0';
integer scale = 0;
```

### 64-bit scaled offset

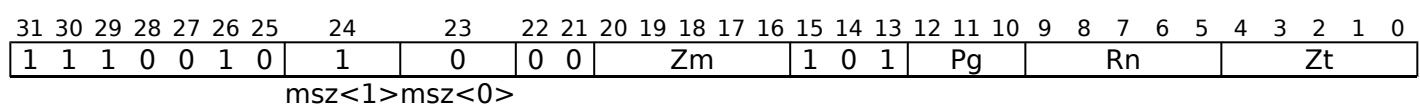


### 64-bit scaled offset

ST1W { <Zt>.D }, <Pg>, [<Xn|SP>, <Zm>.D, LSL #2]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 64;
boolean offs_unsigned = TRUE;
integer scale = 2;
```

### 64-bit unscaled offset



64-bit unscaled offset

```
ST1W { <Zt>.D }, <Pg>, [<Xn|SP>, <Zm>.D]
```

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Zm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
integer offs_size = 64;
boolean offs_unsigned = TRUE;
integer scale = 0;
```

Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Zm> Is the name of the offset scalable vector register, encoded in the "Zm" field.
- <mod> Is the index extend and shift specifier, encoded in "xs":

xs	<mod>
0	UXTW
1	SXTW

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(VL) offset = Z[m];
bits(VL) src = Z[t];
bits(PL) mask = P[g];
bits(64) addr;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

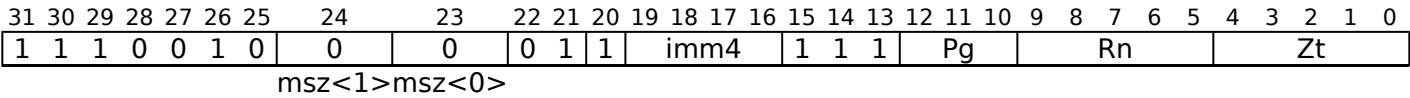
if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        base = SP[];
    else
        base = X[n];
else
    base = X[n];

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer off = Int(Elem[offset, e, esize]<offs_size-1:0>, offs_unsigned);
        addr = base + (off << scale);
        Mem[addr, mbytes, AccType_NORMAL] = Elem[src, e, esize]<msize-1:0>;
```

## ST2B (scalar plus immediate)

Contiguous store two-byte structures from two vectors (immediate index).

Contiguous store two-byte structures, each from the same element number in two vector registers to the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 2 in the range -16 to 14 that is multiplied by the vector's in-memory size, irrespective of predication,  
Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive bytes in memory which make up each structure. Inactive structures are not written to memory.



### SVE

ST2B { <Zt1>.B, <Zt2>.B }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8;
integer offset = SInt(imm4);
integer nreg = 2;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 2 in the range -16 to 14, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

addr = base + offset * elements * nreg * mbytes;
for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
            addr = addr + mbytes;
```

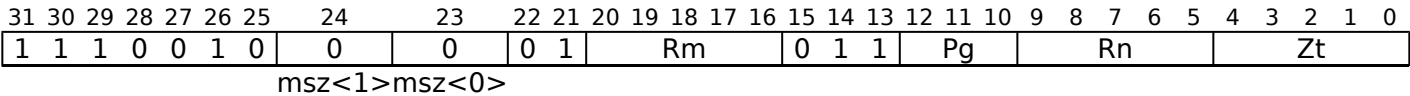
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## ST2B (scalar plus scalar)

Contiguous store two-byte structures from two vectors (scalar index).

Contiguous store two-byte structures, each from the same element number in two vector registers to the memory address generated by a 64-bit scalar base and a 64-bit scalar index register and added to the base address. After each structure access the index value is incremented by two. The index register is not updated by the instruction. Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive bytes in memory which make up each structure. Inactive structures are not written to memory.



### SVE

ST2B { <Zt1>.B, <Zt2>.B }, <Pg>, [<Xn|SP>, <Xm>]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 8;
integer nreg = 2;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(64) offset = X[m];
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
            addr = addr + mbytes;
    offset = offset + nreg;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

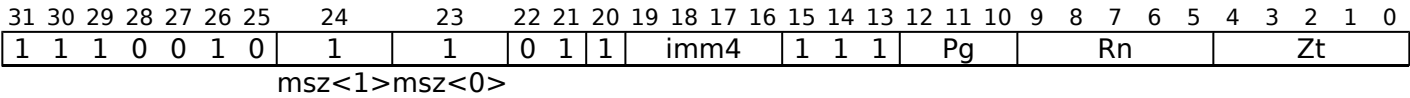
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## ST2D (scalar plus immediate)

Contiguous store two-doubleword structures from two vectors (immediate index).

Contiguous store two-doubleword structures, each from the same element number in two vector registers to the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 2 in the range -16 to 14 that is multiplied by the vector's in-memory size, irrespective of predication,

Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive doublewords in memory which make up each structure. Inactive structures are not written to memory.



### SVE

ST2D { <Zt1>.D, <Zt2>.D }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer offset = SInt(imm4);
integer nreg = 2;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 2 in the range -16 to 14, defaulting to 0, encoded in the "imm4" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

addr = base + offset * elements * nreg * mbytes;
for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
            addr = addr + mbytes;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

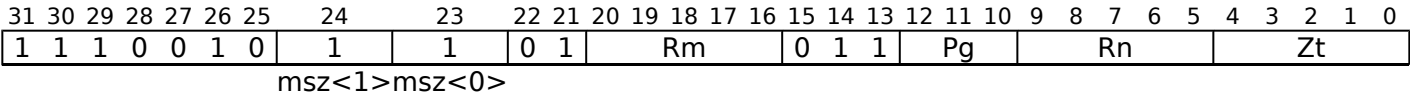
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## ST2D (scalar plus scalar)

Contiguous store two-doubleword structures from two vectors (scalar index).

Contiguous store two-doubleword structures, each from the same element number in two vector registers to the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by two. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive doublewords in memory which make up each structure. Inactive structures are not written to memory.



### SVE

ST2D { <Zt1>.D, <Zt2>.D }, <Pg>, [<Xn|SP>, <Xm>, LSL #3]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer nreg = 2;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(64) offset = X[m];
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
            addr = addr + mbytes;
    offset = offset + nreg;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

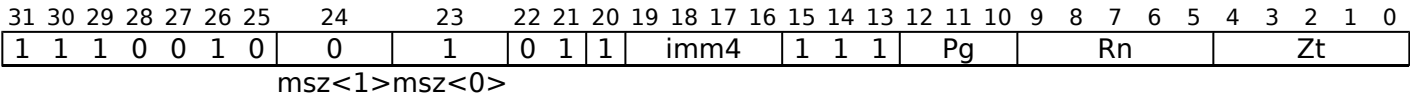
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## ST2H (scalar plus immediate)

Contiguous store two-halfword structures from two vectors (immediate index).

Contiguous store two-halfword structures, each from the same element number in two vector registers to the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 2 in the range -16 to 14 that is multiplied by the vector's in-memory size, irrespective of predication,

Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive halfwords in memory which make up each structure. Inactive structures are not written to memory.



### SVE

ST2H { <Zt1>.H, <Zt2>.H }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer offset = SInt(imm4);
integer nreg = 2;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 2 in the range -16 to 14, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

addr = base + offset * elements * nreg * mbytes;
for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
            addr = addr + mbytes;
```

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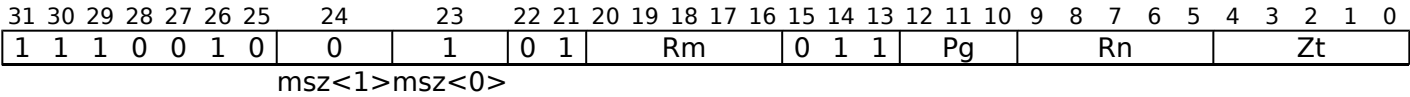
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## ST2H (scalar plus scalar)

Contiguous store two-halfword structures from two vectors (scalar index).

Contiguous store two-halfword structures, each from the same element number in two vector registers to the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by two. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive halfwords in memory which make up each structure. Inactive structures are not written to memory.



### SVE

ST2H { <Zt1>.H, <Zt2>.H }, <Pg>, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
integer nreg = 2;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(64) offset = X[m];
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
        addr = addr + mbytes;
    offset = offset + nreg;
```

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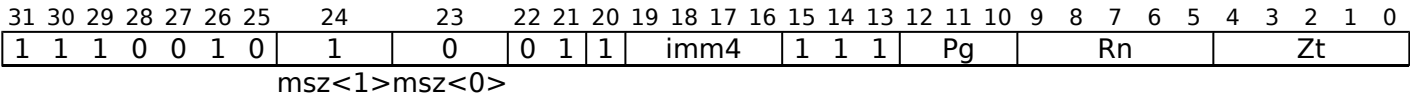
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## ST2W (scalar plus immediate)

Contiguous store two-word structures from two vectors (immediate index).

Contiguous store two-word structures, each from the same element number in two vector registers to the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 2 in the range -16 to 14 that is multiplied by the vector's in-memory size, irrespective of predication,

Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive words in memory which make up each structure. Inactive structures are not written to memory.



### SVE

ST2W { <Zt1>.S, <Zt2>.S }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer offset = SInt(imm4);
integer nreg = 2;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 2 in the range -16 to 14, defaulting to 0, encoded in the "imm4" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

addr = base + offset * elements * nreg * mbytes;
for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
            addr = addr + mbytes;
```

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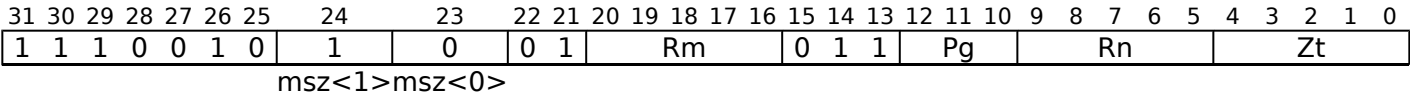
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## ST2W (scalar plus scalar)

Contiguous store two-word structures from two vectors (scalar index).

Contiguous store two-word structures, each from the same element number in two vector registers to the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by two. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the two vector registers, or equivalently to the two consecutive words in memory which make up each structure. Inactive structures are not written to memory.



### SVE

ST2W { <Zt1>.S, <Zt2>.S }, <Pg>, [<Xn|SP>, <Xm>, LSL #2]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer nreg = 2;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(64) offset = X[m];
constant integer mbytes = esize DIV 8;
array [0..1] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
            addr = addr + mbytes;
    offset = offset + nreg;
```

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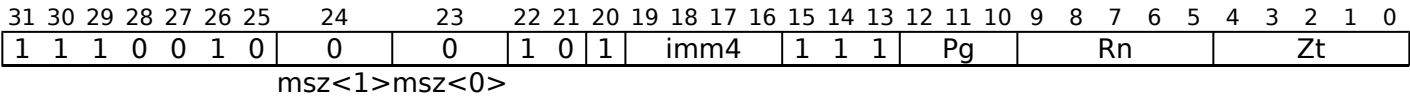
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## ST3B (scalar plus immediate)

Contiguous store three-byte structures from three vectors (immediate index).

Contiguous store three-byte structures, each from the same element number in three vector registers to the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 3 in the range -24 to 21 that is multiplied by the vector's in-memory size, irrespective of predication,

Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive bytes in memory which make up each structure. Inactive structures are not written to memory.



### SVE

ST3B { <Zt1>.B, <Zt2>.B, <Zt3>.B }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8;
integer offset = SInt(imm4);
integer nreg = 3;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 3 in the range -24 to 21, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

addr = base + offset * elements * nreg * mbytes;
for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
            addr = addr + mbytes;
```

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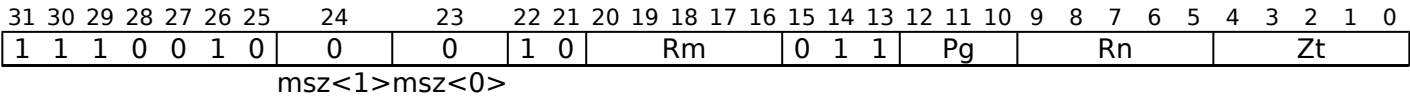
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# ST3B (scalar plus scalar)

Contiguous store three-byte structures from three vectors (scalar index).

Contiguous store three-byte structures, each from the same element number in three vector registers to the memory address generated by a 64-bit scalar base and a 64-bit scalar index register and added to the base address. After each structure access the index value is incremented by three. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive bytes in memory which make up each structure. Inactive structures are not written to memory.



## SVE

ST3B { <Zt1>.B, <Zt2>.B, <Zt3>.B }, <Pg>, [<Xn|SP>, <Xm>]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 8;
integer nreg = 3;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(64) offset = X[m];
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
            addr = addr + mbytes;
    offset = offset + nreg;
```

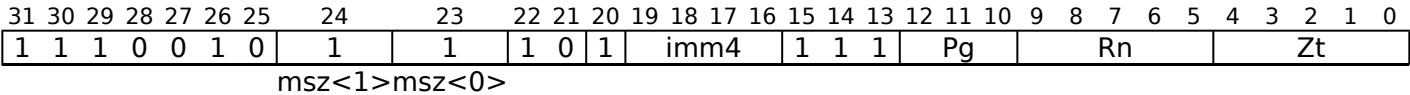
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## ST3D (scalar plus immediate)

Contiguous store three-doubleword structures from three vectors (immediate index).

Contiguous store three-doubleword structures, each from the same element number in three vector registers to the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 3 in the range -24 to 21 that is multiplied by the vector's in-memory size, irrespective of predication, Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive doublewords in memory which make up each structure. Inactive structures are not written to memory.



### SVE

ST3D { <Zt1>.D, <Zt2>.D, <Zt3>.D }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer offset = SInt(imm4);
integer nreg = 3;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 3 in the range -24 to 21, defaulting to 0, encoded in the "imm4" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

addr = base + offset * elements * nreg * mbytes;
for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
            addr = addr + mbytes;
```

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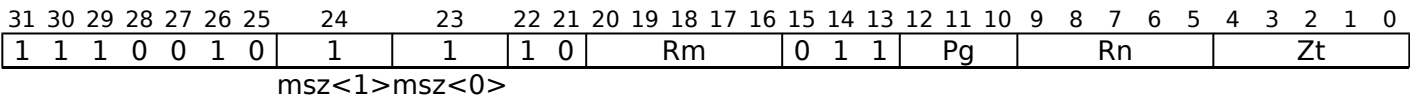
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## ST3D (scalar plus scalar)

Contiguous store three-doubleword structures from three vectors (scalar index).

Contiguous store three-doubleword structures, each from the same element number in three vector registers to the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by three. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive doublewords in memory which make up each structure. Inactive structures are not written to memory.



### SVE

ST3D { <Zt1>.D, <Zt2>.D, <Zt3>.D }, <Pg>, [<Xn|SP>, <Xm>, LSL #3]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer nreg = 3;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(64) offset = X[m];
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
        addr = addr + mbytes;
    offset = offset + nreg;
```

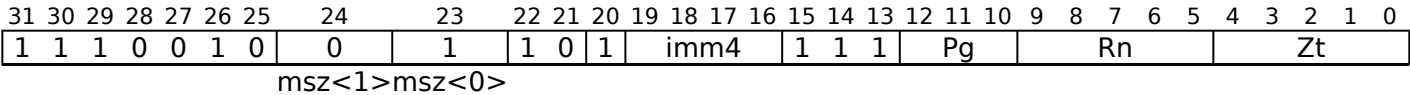
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## ST3H (scalar plus immediate)

Contiguous store three-halfword structures from three vectors (immediate index).

Contiguous store three-halfword structures, each from the same element number in three vector registers to the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 3 in the range -24 to 21 that is multiplied by the vector's in-memory size, irrespective of predication, Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive halfwords in memory which make up each structure. Inactive structures are not written to memory.



### SVE

ST3H { <Zt1>.H, <Zt2>.H, <Zt3>.H }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer offset = SInt(imm4);
integer nreg = 3;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 3 in the range -24 to 21, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

addr = base + offset * elements * nreg * mbytes;
for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
            addr = addr + mbytes;
```

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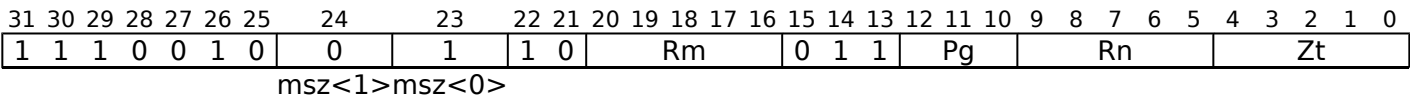
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## ST3H (scalar plus scalar)

Contiguous store three-halfword structures from three vectors (scalar index).

Contiguous store three-halfword structures, each from the same element number in three vector registers to the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by three. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive halfwords in memory which make up each structure. Inactive structures are not written to memory.



### SVE

ST3H { <Zt1>.H, <Zt2>.H, <Zt3>.H }, <Pg>, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
integer nreg = 3;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(64) offset = X[m];
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
            addr = addr + mbytes;
    offset = offset + nreg;
```

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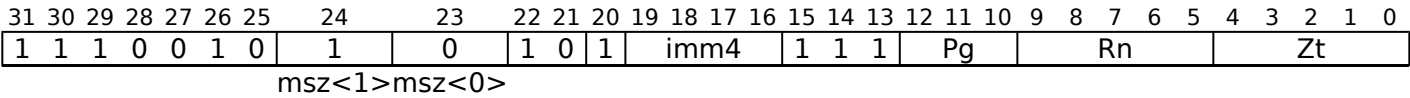
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# ST3W (scalar plus immediate)

Contiguous store three-word structures from three vectors (immediate index).

Contiguous store three-word structures, each from the same element number in three vector registers to the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 3 in the range -24 to 21 that is multiplied by the vector's in-memory size, irrespective of predication,

Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive words in memory which make up each structure. Inactive structures are not written to memory.



## SVE

ST3W { <Zt1>.S, <Zt2>.S, <Zt3>.S }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer offset = SInt(imm4);
integer nreg = 3;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 3 in the range -24 to 21, defaulting to 0, encoded in the "imm4" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

addr = base + offset * elements * nreg * mbytes;
for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
            addr = addr + mbytes;
```

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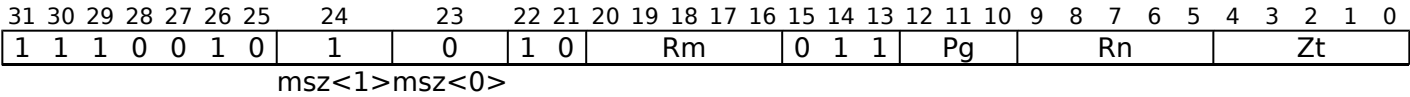
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## ST3W (scalar plus scalar)

Contiguous store three-word structures from three vectors (scalar index).

Contiguous store three-word structures, each from the same element number in three vector registers to the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by three. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the three vector registers, or equivalently to the three consecutive words in memory which make up each structure. Inactive structures are not written to memory.



### SVE

ST3W { <Zt1>.S, <Zt2>.S, <Zt3>.S }, <Pg>, [<Xn|SP>, <Xm>, LSL #2]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer nreg = 3;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(64) offset = X[m];
constant integer mbytes = esize DIV 8;
array [0..2] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
            addr = addr + mbytes;
    offset = offset + nreg;
```

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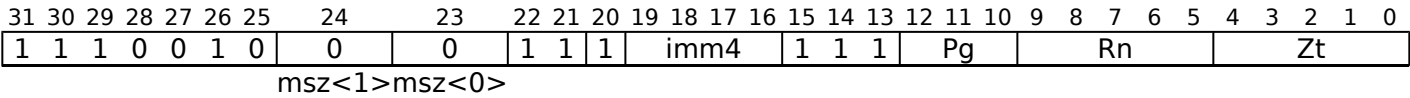
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## ST4B (scalar plus immediate)

Contiguous store four-byte structures from four vectors (immediate index).

Contiguous store four-byte structures, each from the same element number in four vector registers to the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 4 in the range -32 to 28 that is multiplied by the vector's in-memory size, irrespective of predication,

Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive bytes in memory which make up each structure. Inactive structures are not written to memory.



### SVE

ST4B { <Zt1>.B, <Zt2>.B, <Zt3>.B, <Zt4>.B }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8;
integer offset = SInt(imm4);
integer nreg = 4;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 4 in the range -32 to 28, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

addr = base + offset * elements * nreg * mbytes;
for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
            addr = addr + mbytes;
```

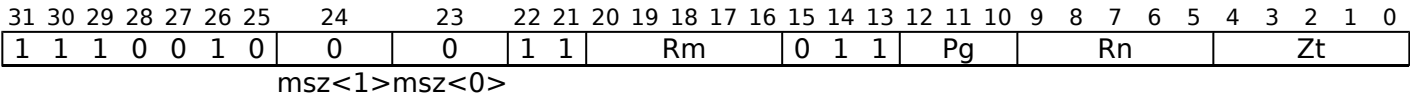
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# ST4B (scalar plus scalar)

Contiguous store four-byte structures from four vectors (scalar index).

Contiguous store four-byte structures, each from the same element number in four vector registers to the memory address generated by a 64-bit scalar base and a 64-bit scalar index register and added to the base address. After each structure access the index value is incremented by four. The index register is not updated by the instruction. Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive bytes in memory which make up each structure. Inactive structures are not written to memory.



## SVE

ST4B { <Zt1>.B, <Zt2>.B, <Zt3>.B, <Zt4>.B }, <Pg>, [<Xn|SP>, <Xm>]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 8;
integer nreg = 4;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(64) offset = X[m];
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
            addr = addr + mbytes;
    offset = offset + nreg;
```

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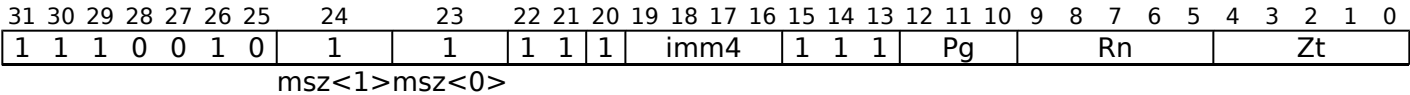
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## ST4D (scalar plus immediate)

Contiguous store four-doubleword structures from four vectors (immediate index).

Contiguous store four-doubleword structures, each from the same element number in four vector registers to the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 4 in the range -32 to 28 that is multiplied by the vector's in-memory size, irrespective of predication,

Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive doublewords in memory which make up each structure. Inactive structures are not written to memory.



### SVE

ST4D { <Zt1>.D, <Zt2>.D, <Zt3>.D, <Zt4>.D }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer offset = SInt(imm4);
integer nreg = 4;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 4 in the range -32 to 28, defaulting to 0, encoded in the "imm4" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

addr = base + offset * elements * nreg * mbytes;
for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
            addr = addr + mbytes;
```

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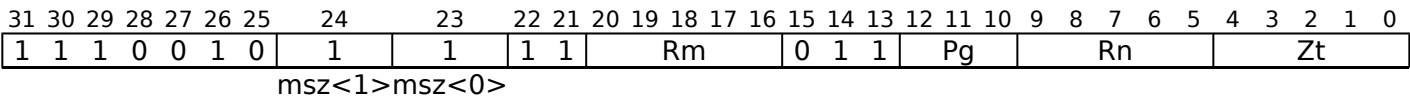
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## ST4D (scalar plus scalar)

Contiguous store four-doubleword structures from four vectors (scalar index).

Contiguous store four-doubleword structures, each from the same element number in four vector registers to the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by four. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive doublewords in memory which make up each structure. Inactive structures are not written to memory.



### SVE

ST4D { <Zt1>.D, <Zt2>.D, <Zt3>.D, <Zt4>.D }, <Pg>, [<Xn|SP>, <Xm>, LSL #3]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer nreg = 4;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(64) offset = X[m];
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
        addr = addr + mbytes;
    offset = offset + nreg;
```

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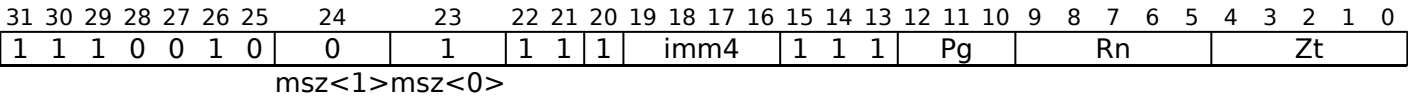
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## ST4H (scalar plus immediate)

Contiguous store four-halfword structures from four vectors (immediate index).

Contiguous store four-halfword structures, each from the same element number in four vector registers to the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 4 in the range -32 to 28 that is multiplied by the vector's in-memory size, irrespective of predication,

Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive halfwords in memory which make up each structure. Inactive structures are not written to memory.



### SVE

ST4H { <Zt1>.H, <Zt2>.H, <Zt3>.H, <Zt4>.H }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer offset = SInt(imm4);
integer nreg = 4;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 4 in the range -32 to 28, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

addr = base + offset * elements * nreg * mbytes;
for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
            addr = addr + mbytes;
```

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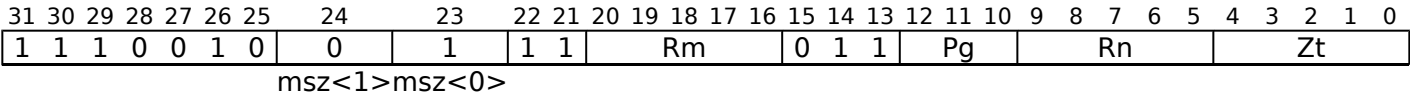
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## ST4H (scalar plus scalar)

Contiguous store four-halfword structures from four vectors (scalar index).

Contiguous store four-halfword structures, each from the same element number in four vector registers to the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by four. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive halfwords in memory which make up each structure. Inactive structures are not written to memory.



### SVE

ST4H { <Zt1>.H, <Zt2>.H, <Zt3>.H, <Zt4>.H }, <Pg>, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
integer nreg = 4;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(64) offset = X[m];
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
            addr = addr + mbytes;
    offset = offset + nreg;
```

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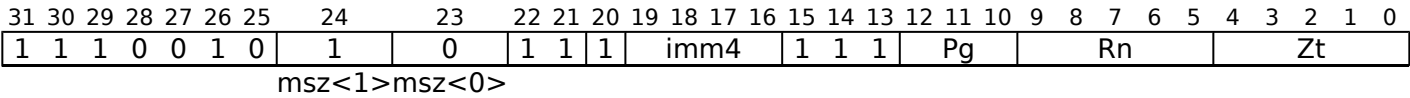
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## ST4W (scalar plus immediate)

Contiguous store four-word structures from four vectors (immediate index).

Contiguous store four-word structures, each from the same element number in four vector registers to the memory address generated by a 64-bit scalar base and an immediate index which is a multiple of 4 in the range -32 to 28 that is multiplied by the vector's in-memory size, irrespective of predication,

Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive words in memory which make up each structure. Inactive structures are not written to memory.



### SVE

ST4W { <Zt1>.S, <Zt2>.S, <Zt3>.S, <Zt4>.S }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer offset = SInt(imm4);
integer nreg = 4;
```

### Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, a multiple of 4 in the range -32 to 28, defaulting to 0, encoded in the "imm4" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

addr = base + offset * elements * nreg * mbytes;
for e = 0 to elements-1
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
            addr = addr + mbytes;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

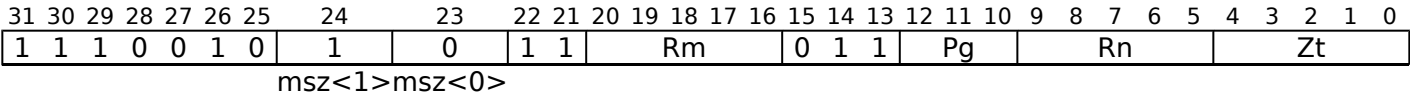
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# ST4W (scalar plus scalar)

Contiguous store four-word structures from four vectors (scalar index).

Contiguous store four-word structures, each from the same element number in four vector registers to the memory address generated by a 64-bit scalar base and a 64-bit scalar index register scaled by the element size (LSL option) and added to the base address. After each structure access the index value is incremented by four. The index register is not updated by the instruction.

Each predicate element applies to the same element number in each of the four vector registers, or equivalently to the four consecutive words in memory which make up each structure. Inactive structures are not written to memory.



## SVE

ST4W { <Zt1>.S, <Zt2>.S, <Zt3>.S, <Zt4>.S }, <Pg>, [<Xn|SP>, <Xm>, LSL #2]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer nreg = 4;
```

## Assembler Symbols

- <Zt1> Is the name of the first scalable vector register to be transferred, encoded in the "Zt" field.
- <Zt2> Is the name of the second scalable vector register to be transferred, encoded as "Zt" plus 1 modulo 32.
- <Zt3> Is the name of the third scalable vector register to be transferred, encoded as "Zt" plus 2 modulo 32.
- <Zt4> Is the name of the fourth scalable vector register to be transferred, encoded as "Zt" plus 3 modulo 32.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(PL) mask = P[g];
bits(64) offset = X[m];
constant integer mbytes = esize DIV 8;
array [0..3] of bits(VL) values;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
    base = SP[];
else
    base = X[n];

for r = 0 to nreg-1
    values[r] = Z[(t+r) MOD 32];

for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    for r = 0 to nreg-1
        if ElemP[mask, e, esize] == '1' then
            Mem[addr, mbytes, AccType_NORMAL] = Elem[values[r], e, esize];
        addr = addr + mbytes;
    offset = offset + nreg;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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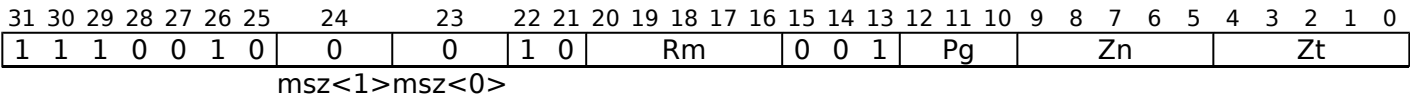
# STNT1B (vector plus scalar)

Scatter store non-temporal bytes.

Scatter store non-temporal of bytes from the active elements of a vector register to the memory addresses generated by a vector base plus a 64-bit unscaled scalar register offset. Inactive elements are not written to memory. A non-temporal store is a hint to the system that this data is unlikely to be referenced again soon.

It has encodings from 2 classes: [32-bit unscaled offset](#) and [64-bit unscaled offset](#)

## 32-bit unscaled offset

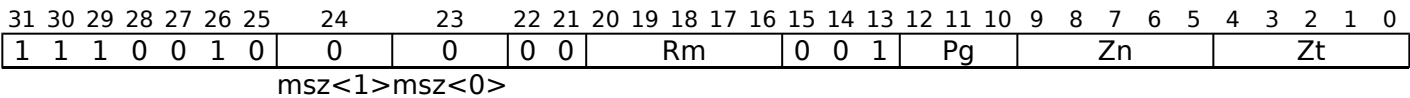


## 32-bit unscaled offset

STNT1B { <Zt>.S }, <Pg>, [<Zn>.S{, <Xm>}]

```
if !HaveSVE2() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 8;
```

## 64-bit unscaled offset



## 64-bit unscaled offset

STNT1B { <Zt>.D }, <Pg>, [<Zn>.D{, <Xm>}]

```
if !HaveSVE2() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 8;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <Xm> Is the optional 64-bit name of the general-purpose offset register, defaulting to XZR, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) base = Z[n];
bits(64) offset = X[m];
bits(VL) src = Z[t];
bits(PL) mask = P[g];
bits(64) addr;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = ZeroExtend(Elem[base, e, esize], 64) + offset;
        Mem[addr, mbytes, AccType_STREAM] = Elem[src, e, esize]<msize-1:0>;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

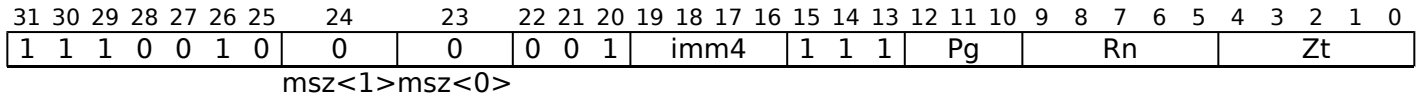
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## STNT1B (scalar plus immediate)

Contiguous store non-temporal bytes from vector (immediate index).

Contiguous store non-temporal of bytes from elements of a vector register to the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements are not written to memory.

A non-temporal store is a hint to the system that this data is unlikely to be referenced again soon.



### SVE

STNT1B { <Zt>.B }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 8;
integer offset = SInt(imm4);
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
constant integer mbytes = esize DIV 8;
bits(VL) src;
bits(PL) mask = P[g];

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
        base = SP[];
    else
        if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
        base = X[n];
src = Z[t];

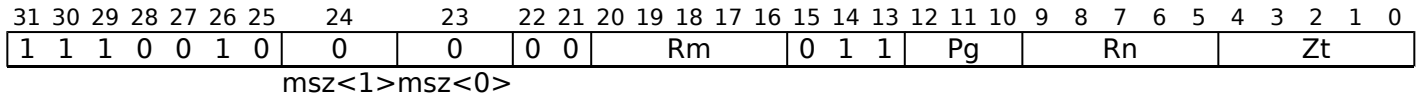
addr = base + offset * elements * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Mem[addr, mbytes, AccType_STREAM] = Elem[src, e, esize];
        addr = addr + mbytes;
```

## STNT1B (scalar plus scalar)

Contiguous store non-temporal bytes from vector (scalar index).

Contiguous store non-temporal of bytes from elements of a vector register to the memory address generated by a 64-bit scalar base and scalar index which is added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements are not written to memory.

A non-temporal store is a hint to the system that this data is unlikely to be referenced again soon.



### SVE

STNT1B { <Zt>.B }, <Pg>, [<Xn|SP>, <Xm>]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 8;
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(64) offset = X[m];
bits(VL) src;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        base = SP[];
    else
        base = X[n];

src = Z[t];
for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    if ElemP[mask, e, esize] == '1' then
        Mem[addr, mbytes, AccType_STREAM] = Elem[src, e, esize];
    offset = offset + 1;
```

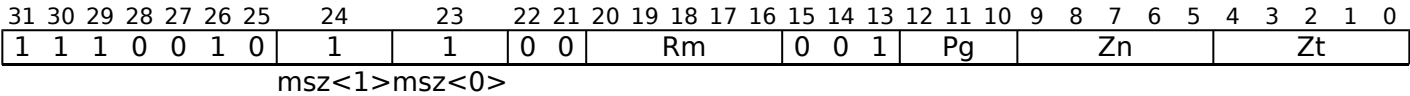




# STNT1D (vector plus scalar)

Scatter store non-temporal doublewords.

Scatter store non-temporal of doublewords from the active elements of a vector register to the memory addresses generated by a vector base plus a 64-bit unscaled scalar register offset. Inactive elements are not written to memory. A non-temporal store is a hint to the system that this data is unlikely to be referenced again soon.



## SVE2

STNT1D { <Zt>.D }, <Pg>, [<Zn>.D{, <Xm>}]

```
if !HaveSVE2() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 64;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <Xm> Is the optional 64-bit name of the general-purpose offset register, defaulting to XZR, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) base = Z[n];
bits(64) offset = X[m];
bits(VL) src = Z[t];
bits(PL) mask = P[g];
bits(64) addr;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

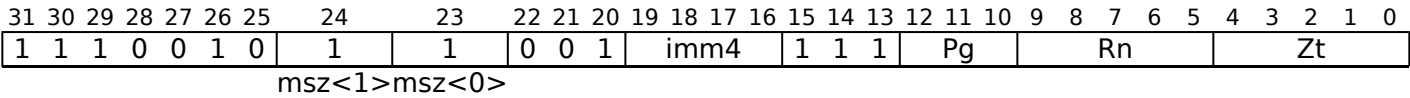
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = ZeroExtend(Elem[base, e, esize], 64) + offset;
        Mem[addr, mbytes, AccType_STREAM] = Elem[src, e, esize]<msize-1:0>;
```

# STNT1D (scalar plus immediate)

Contiguous store non-temporal doublewords from vector (immediate index).

Contiguous store non-temporal of doublewords from elements of a vector register to the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements are not written to memory.

A non-temporal store is a hint to the system that this data is unlikely to be referenced again soon.



## SVE

STNT1D { <Zt>.D }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 64;
integer offset = SInt(imm4);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
constant integer mbytes = esize DIV 8;
bits(VL) src;
bits(PL) mask = P[g];

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
        base = SP[];
    else
        if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
        base = X[n];
src = Z[t];

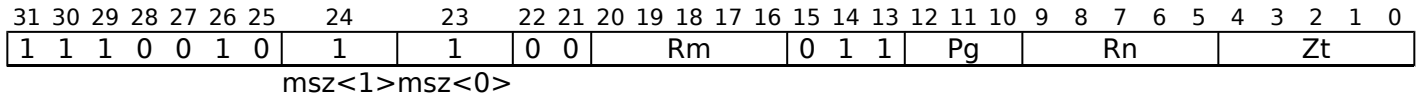
addr = base + offset * elements * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Mem[addr, mbytes, AccType_STREAM] = Elem[src, e, esize];
        addr = addr + mbytes;
```

## STNT1D (scalar plus scalar)

Contiguous store non-temporal doublewords from vector (scalar index).

Contiguous store non-temporal of doublewords from elements of a vector register to the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 8 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements are not written to memory.

A non-temporal store is a hint to the system that this data is unlikely to be referenced again soon.



### SVE

STNT1D { <Zt>.D }, <Pg>, [<Xn|SP>, <Xm>, LSL #3]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(64) offset = X[m];
bits(VL) src;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        base = SP[];
    else
        base = X[n];

src = Z[t];
for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    if ElemP[mask, e, esize] == '1' then
        Mem[addr, mbytes, AccType_STREAM] = Elem[src, e, esize];
    offset = offset + 1;
```



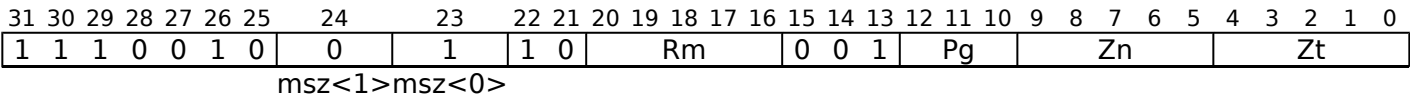
# STNT1H (vector plus scalar)

Scatter store non-temporal halfwords.

Scatter store non-temporal of halfwords from the active elements of a vector register to the memory addresses generated by a vector base plus a 64-bit unscaled scalar register offset. Inactive elements are not written to memory. A non-temporal store is a hint to the system that this data is unlikely to be referenced again soon.

It has encodings from 2 classes: [32-bit unscaled offset](#) and [64-bit unscaled offset](#)

## 32-bit unscaled offset

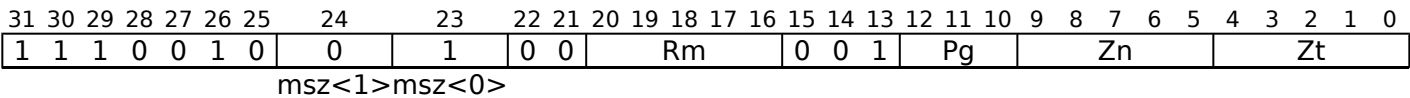


## 32-bit unscaled offset

STNT1H { <Zt>.S }, <Pg>, [<Zn>.S{, <Xm>}]

```
if !HaveSVE2() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 16;
```

## 64-bit unscaled offset



## 64-bit unscaled offset

STNT1H { <Zt>.D }, <Pg>, [<Zn>.D{, <Xm>}]

```
if !HaveSVE2() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 16;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <Xm> Is the optional 64-bit name of the general-purpose offset register, defaulting to XZR, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) base = Z[n];
bits(64) offset = X[m];
bits(VL) src = Z[t];
bits(PL) mask = P[g];
bits(64) addr;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = ZeroExtend(Elem[base, e, esize], 64) + offset;
        Mem[addr, mbytes, AccType_STREAM] = Elem[src, e, esize]<msize-1:0>;
```

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

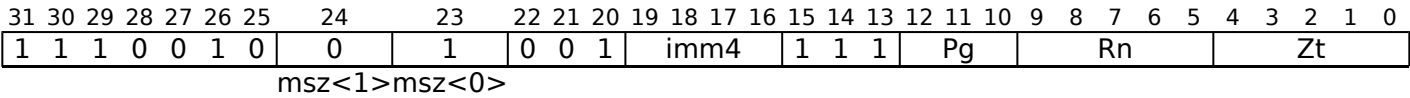
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# STNT1H (scalar plus immediate)

Contiguous store non-temporal halfwords from vector (immediate index).

Contiguous store non-temporal of halfwords from elements of a vector register to the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements are not written to memory.

A non-temporal store is a hint to the system that this data is unlikely to be referenced again soon.



## SVE

STNT1H { <Zt>.H }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 16;
integer offset = SInt(imm4);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
constant integer mbytes = esize DIV 8;
bits(VL) src;
bits(PL) mask = P[g];

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        if HaveMTEEExt() then SetTagCheckedInstruction(FALSE);
        base = SP[];
    else
        if HaveMTEEExt() then SetTagCheckedInstruction(TRUE);
        base = X[n];
src = Z[t];

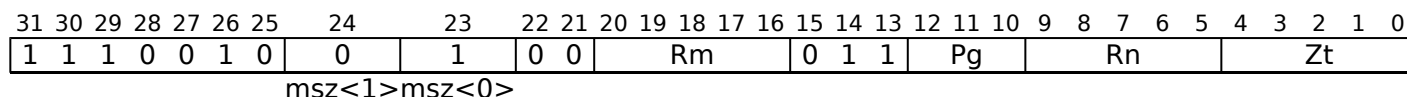
addr = base + offset * elements * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Mem[addr, mbytes, AccType_STREAM] = Elem[src, e, esize];
        addr = addr + mbytes;
```

## STNT1H (scalar plus scalar)

Contiguous store non-temporal halfwords from vector (scalar index).

Contiguous store non-temporal of halfwords from elements of a vector register to the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 2 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements are not written to memory.

A non-temporal store is a hint to the system that this data is unlikely to be referenced again soon.



### SVE

STNT1H { <Zt>.H }, <Pg>, [<Xn|SP>, <Xm>, LSL #1]

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 16;
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(64) offset = X[m];
bits(VL) src;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        base = SP[];
    else
        base = X[n];

src = Z[t];
for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    if ElemP[mask, e, esize] == '1' then
        Mem[addr, mbytes, AccType_STREAM] = Elem[src, e, esize];
    offset = offset + 1;
```





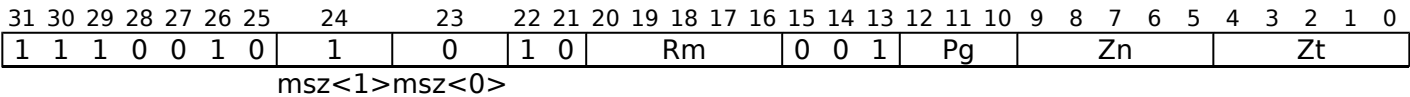
# STNT1W (vector plus scalar)

Scatter store non-temporal words.

Scatter store non-temporal of words from the active elements of a vector register to the memory addresses generated by a vector base plus a 64-bit unscaled scalar register offset. Inactive elements are not written to memory. A non-temporal store is a hint to the system that this data is unlikely to be referenced again soon.

It has encodings from 2 classes: [32-bit unscaled offset](#) and [64-bit unscaled offset](#)

## 32-bit unscaled offset

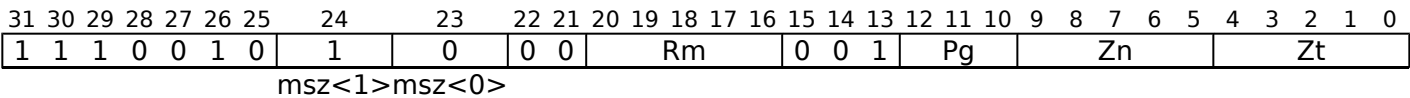


## 32-bit unscaled offset

STNT1W { <Zt>.S }, <Pg>, [<Zn>.S{, <Xm>}]

```
if !HaveSVE2() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
integer msize = 32;
```

## 64-bit unscaled offset



## 64-bit unscaled offset

STNT1W { <Zt>.D }, <Pg>, [<Zn>.D{, <Xm>}]

```
if !HaveSVE2() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Zn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 64;
integer msize = 32;
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the base scalable vector register, encoded in the "Zn" field.
- <Xm> Is the optional 64-bit name of the general-purpose offset register, defaulting to XZR, encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) base = Z[n];
bits(64) offset = X[m];
bits(VL) src = Z[t];
bits(PL) mask = P[g];
bits(64) addr;
constant integer mbytes = msize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        addr = ZeroExtend(Elem[base, e, esize], 64) + offset;
        Mem[addr, mbytes, AccType_STREAM] = Elem[src, e, esize]<msize-1:0>;
```

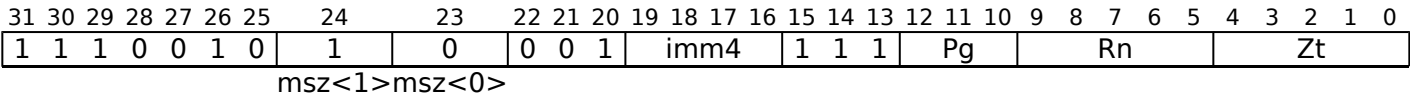
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# STNT1W (scalar plus immediate)

Contiguous store non-temporal words from vector (immediate index).

Contiguous store non-temporal of words from elements of a vector register to the memory address generated by a 64-bit scalar base and immediate index in the range -8 to 7 which is multiplied by the vector's in-memory size, irrespective of predication, and added to the base address. Inactive elements are not written to memory. A non-temporal store is a hint to the system that this data is unlikely to be referenced again soon.



## SVE

STNT1W { <Zt>.S }, <Pg>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer g = UInt(Pg);
integer esize = 32;
integer offset = SInt(imm4);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -8 to 7, defaulting to 0, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
constant integer mbytes = esize DIV 8;
bits(VL) src;
bits(PL) mask = P[g];

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
        base = SP[];
    else
        if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
        base = X[n];
src = Z[t];

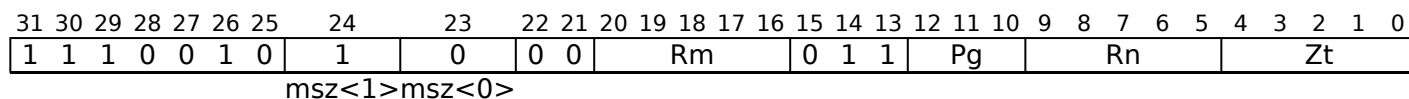
addr = base + offset * elements * mbytes;
for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        Mem[addr, mbytes, AccType_STREAM] = Elem[src, e, esize];
        addr = addr + mbytes;
```

## STNT1W (scalar plus scalar)

Contiguous store non-temporal words from vector (scalar index).

Contiguous store non-temporal of words from elements of a vector register to the memory address generated by a 64-bit scalar base and scalar index which is multiplied by 4 and added to the base address. After each element access the index value is incremented, but the index register is not updated. Inactive elements are not written to memory.

A non-temporal store is a hint to the system that this data is unlikely to be referenced again soon.



### SVE

```
STNT1W { <Zt>.S }, <Pg>, [<Xn|SP>, <Xm>, LSL #2]
```

```
if !HaveSVE() then UNDEFINED;
if Rm == '11111' then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer g = UInt(Pg);
integer esize = 32;
```

### Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the general-purpose offset register, encoded in the "Rm" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(64) base;
bits(64) addr;
bits(64) offset = X[m];
bits(VL) src;
bits(PL) mask = P[g];
constant integer mbytes = esize DIV 8;

if HaveMTEExt() then SetTagCheckedInstruction(TRUE);

if n == 31 then
    if LastActiveElement(mask, esize) >= 0 ||
        ConstrainUnpredictableBool(Unpredictable_CHECKSPNONEACTIVE) then
        CheckSPAlignment();
        base = SP[];
    else
        base = X[n];

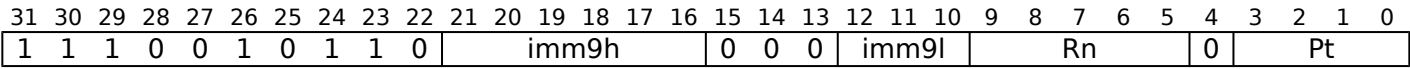
src = Z[t];
for e = 0 to elements-1
    addr = base + UInt(offset) * mbytes;
    if ElemP[mask, e, esize] == '1' then
        Mem[addr, mbytes, AccType_STREAM] = Elem[src, e, esize];
    offset = offset + 1;
```



# STR (predicate)

Store predicate register.

Store a predicate register to a memory address generated by a 64-bit scalar base, plus an immediate offset in the range -256 to 255 which is multiplied by the current predicate register size in bytes. This instruction is unpredicated. The store is performed as a stream of bytes containing 8 consecutive predicate bits in ascending element order, without any endian conversion.



## SVE

STR <Pt>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Pt);
integer n = UInt(Rn);
integer imm = SInt(imm9h:imm9l);
```

## Assembler Symbols

- <Pt> Is the name of the scalable predicate transfer register, encoded in the "Pt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -256 to 255, defaulting to 0, encoded in the "imm9h:imm9l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = PL DIV 8;
bits(PL) src;
bits(64) base;
integer offset = imm * elements;

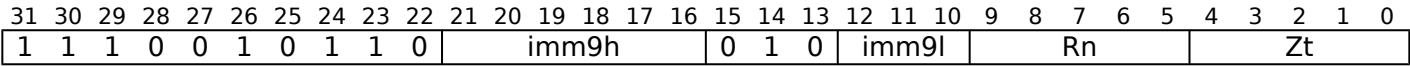
if n == 31 then
    CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

src = P[t];
boolean aligned = AArch64.CheckAlignment(base + offset, 2, AccType_NORMAL, TRUE);
for e = 0 to elements-1
    AArch64.MemSingle[base + offset, 1, AccType_NORMAL, aligned] = Elem[src, e, 8];
    offset = offset + 1;
```

# STR (vector)

Store vector register.

Store a vector register to a memory address generated by a 64-bit scalar base, plus an immediate offset in the range -256 to 255 which is multiplied by the current vector register size in bytes. This instruction is unpredicated. The store is performed as a stream of byte elements in ascending element order, without any endian conversion.



## SVE

STR <Zt>, [<Xn|SP>{, #<imm>, MUL VL}]

```
if !HaveSVE() then UNDEFINED;
integer t = UInt(Zt);
integer n = UInt(Rn);
integer imm = SInt(imm9h:imm9l);
```

## Assembler Symbols

- <Zt> Is the name of the scalable vector register to be transferred, encoded in the "Zt" field.
- <Xn|SP> Is the 64-bit name of the general-purpose base register or stack pointer, encoded in the "Rn" field.
- <imm> Is the optional signed immediate vector offset, in the range -256 to 255, defaulting to 0, encoded in the "imm9h:imm9l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV 8;
bits(VL) src;
bits(64) base;
integer offset = imm * elements;

if n == 31 then
    CheckSPAlignment();
    if HaveMTEExt() then SetTagCheckedInstruction(FALSE);
    base = SP[];
else
    if HaveMTEExt() then SetTagCheckedInstruction(TRUE);
    base = X[n];

src = Z[t];
boolean aligned = AArch64.CheckAlignment(base + offset, 16, AccType_NORMAL, TRUE);
for e = 0 to elements-1
    AArch64.MemSingle[base + offset, 1, AccType_NORMAL, aligned] = Elem[src, e, 8];
    offset = offset + 1;
```



# SUB (vectors, predicated)

Subtract vectors (predicated).

Subtract active elements of the second source vector from corresponding elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	0	0	0	0	1	0	0	0	Pg	Zm				Zdn								

## SVE

SUB <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = element1 - element2;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:

- The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
- The values of the NZCV flags.

This instruction might be immediately preceded in program order by a **MOVPRFX** instruction. The **MOVPRFX** instruction must conform to all of the following requirements, otherwise the behavior of the **MOVPRFX** and this instruction is UNPREDICTABLE:

- The **MOVPRFX** instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The **MOVPRFX** instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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SUB (immediate)

Subtract immediate (unpredicated).

Subtract an unsigned immediate from each element of the source vector, and destructively place the results in the corresponding elements of the source vector. This instruction is unpredicated.

The immediate is an unsigned value in the range 0 to 255, and for element widths of 16 bits or higher it may also be a positive multiple of 256 in the range 256 to 65280.

The immediate is encoded in 8 bits with an optional left shift by 8. The preferred disassembly when the shift option is specified is "#<uimm8>, LSL #8". However an assembler and disassembler may also allow use of the shifted 16-bit value unless the immediate is 0 and the shift amount is 8, which must be unambiguously described as "#0, LSL #8".

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size		1	0	0	0	0	1	1	1	sh	imm8								Zdn				

SVE

SUB <Zdn>.<T>, <Zdn>.<T>, #<imm>{, <shift>}

```
if !HaveSVE() then UNDEFINED;
if size:sh == '001' then UNDEFINED;
integer esize = 8 << UInt(size);
integer dn = UInt(Zdn);
integer imm = UInt(imm8);
if sh == '1' then imm = imm << 8;
```

Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<imm> Is an unsigned immediate in the range 0 to 255, encoded in the "imm8" field.

<shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #8

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    Elem[result, e, esize] = element1 - imm;

Z[dn] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# SUB (vectors, unpredicated)

Subtract vectors (unpredicated).

Subtract all elements of the second source vector from corresponding elements of the first source vector and place the results in the corresponding elements of the destination vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	1				Zm			0	0	0	0	0	1			Zn					Zd		

## SVE

SUB <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    Elem[result, e, esize] = element1 - element2;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

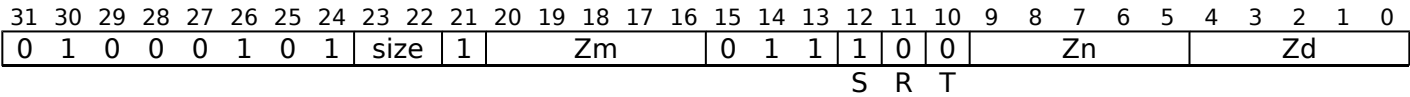
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SUBHNB

Subtract narrow high part (bottom).

Subtract each vector element of the second source vector from the corresponding vector element in the first source vector, and place the most significant half of the result in the even-numbered half-width destination elements, while setting the odd-numbered elements to zero. This instruction is unpredicated.



SVE2

SUBHNB <Zd>.<T>, <Zn>.<Tb>, <Zm>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	B
10	H
11	S

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	H
10	S
11	D

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;
integer halfesize = esize DIV 2;

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, e, esize]);
    integer res = (element1 - element2) >> halfesize;
    Elem[result, 2*e + 0, halfesize] = res<halfesize-1:0>;
    Elem[result, 2*e + 1, halfesize] = Zeros();

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

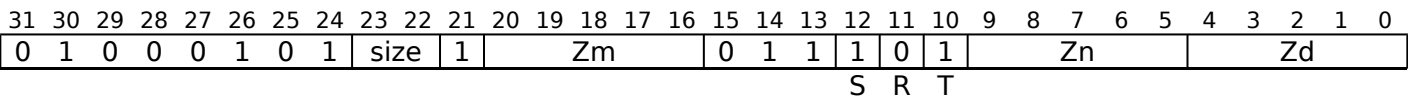
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SUBHNT

Subtract narrow high part (top).

Subtract each vector element of the second source vector from the corresponding vector element in the first source vector, and place the most significant half of the result in the odd-numbered half-width destination elements, leaving the even-numbered elements unchanged. This instruction is unpredicated.



SVE2

```
SUBHNT <Zd>.<T>, <Zn>.<Tb>, <Zm>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	B
10	H
11	S

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	H
10	S
11	D

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[d];
integer halfesize = esize DIV 2;

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, e, esize]);
    integer res = (element1 - element2) >> halfesize;
    Elem[result, 2*e + 1, halfesize] = res<halfesize-1:0>;

Z[d] = result;
```



## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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## SUBR (vectors)

Reversed subtract vectors (predicated).

Reversed subtract active elements of the first source vector from corresponding elements of the second source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	0	0	0	1	1	0	0	0		Pg					Zm					Zdn		

### SVE

SUBR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

### Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = element2 - element1;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

### Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:

- The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
- The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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SUBR (immediate)

Reversed subtract from immediate (unpredicated).

Reversed subtract from an unsigned immediate each element of the source vector, and destructively place the results in the corresponding elements of the source vector. This instruction is unpredicated.

The immediate is an unsigned value in the range 0 to 255, and for element widths of 16 bits or higher it may also be a positive multiple of 256 in the range 256 to 65280.

The immediate is encoded in 8 bits with an optional left shift by 8. The preferred disassembly when the shift option is specified is "#<uimm8>, LSL #8". However an assembler and disassembler may also allow use of the shifted 16-bit value unless the immediate is 0 and the shift amount is 8, which must be unambiguously described as "#0, LSL #8".

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	0	0	0	1	1	1	1	1	sh	imm8								Zdn				

SVE

SUBR <Zdn>.<T>, <Zdn>.<T>, #<imm>{, <shift>}

```
if !HaveSVE() then UNDEFINED;
if size:sh == '001' then UNDEFINED;
integer esize = 8 << UInt(size);
integer dn = UInt(Zdn);
integer imm = UInt(imm8);
if sh == '1' then imm = imm << 8;
```

Assembler Symbols

<Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<imm> Is an unsigned immediate in the range 0 to 255, encoded in the "imm8" field.

<shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #8

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, e, esize]);
    Elem[result, e, esize] = (imm - element1)<esize-1:0>;

Z[dn] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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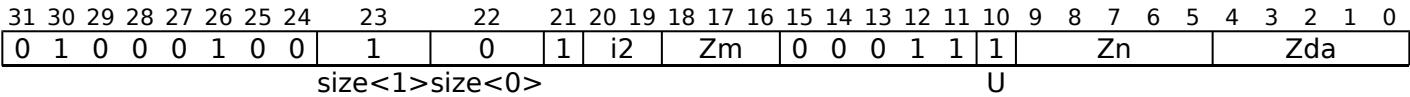
# SUDOT

Signed by unsigned integer indexed dot product.

The signed by unsigned integer indexed dot product instruction computes the dot product of a group of four signed 8-bit integer values held in each 32-bit element of the first source vector multiplied by a group of four unsigned 8-bit integer values in an indexed 32-bit element of the second source vector, and then destructively adds the widened dot product to the corresponding 32-bit element of the destination vector.

The groups within the second source vector are specified using an immediate index which selects the same group position within each 128-bit vector segment. The index range is from 0 to 3. This instruction is unpredicated.

ID\_AA64ZFR0\_EL1.I8MM indicates whether this instruction is implemented.



## SVE

SUDOT <Zda>.S, <Zn>.B, <Zm>.B[<imm>]

```
if !HaveSVE() || !HaveInt8MatMulExt() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.
- <imm> Is the immediate index of a quadruplet of four 8-bit elements within each 128-bit vector segment, in the range 0 to 3, encoded in the "i2" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer eltsegment = 128 DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    integer segmentbase = e - (e MOD eltsegment);
    integer s = segmentbase + index;
    bits(esize) res = Elem[operand3, e, esize];
    for i = 0 to 3
        integer element1 = SInt(Elem[operand1, 4 * e + i, esize DIV 4]);
        integer element2 = UInt(Elem[operand2, 4 * s + i, esize DIV 4]);
        res = res + element1 * element2;
    Elem[result, e, esize] = res;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# SUNPKHI, SUNPKLO

Signed unpack and extend half of vector.

Unpack elements from the lowest or highest half of the source vector and then sign-extend them to place in elements of twice their size within the destination vector. This instruction is unpredicated.

It has encodings from 2 classes: [High half](#) and [Low half](#)

## High half

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	1	0	0	0	1	1	0	0	1	1	1	0	Zn				Zd					
														U	H																

## High half

SUNPKHI [<Zd>.<T>](#), [<Zn>.<Tb>](#)

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean unsigned = FALSE;
boolean hi = TRUE;
```

## Low half

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	1	0	0	0	0	0	0	1	1	1	0	Zn				Zd						
														U	H																

## Low half

SUNPKLO [<Zd>.<T>](#), [<Zn>.<Tb>](#)

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean unsigned = FALSE;
boolean hi = FALSE;
```

## Assembler Symbols

[<Zd>](#) Is the name of the destination scalable vector register, encoded in the "Zd" field.

[<T>](#) Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

[<Zn>](#) Is the name of the source scalable vector register, encoded in the "Zn" field.

[<Tb>](#) Is the size specifier, encoded in "size":



size	<Tb>
00	RESERVED
01	B
10	H
11	S

## Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
integer hsize = esize DIV 2;
bits(VL) operand = Z[n];
bits(VL) result;

for e = 0 to elements-1
    bits(hsize) element = if hi then Elem[operand, e + elements, hsize] else Elem[operand, e, hsize];
    Elem[result, e, esize] = Extend(element, esize, unsigned);

Z[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

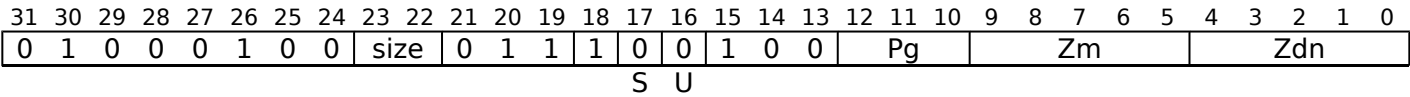
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# SUQADD

Signed saturating addition of unsigned value.

Add active unsigned elements of the source vector to the corresponding signed elements of the addend vector, and destructively place the results in the corresponding elements of the addend vector. Each result element is saturated to the N-bit element's signed integer range  $-2^{(N-1)}$  to  $(2^{(N-1)})-1$ . Inactive elements in the destination vector register remain unmodified.



## SVE2

SUQADD <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = SignedSat(SInt(element1) + UInt(element2), esize);
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.

- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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SXTB, SXTH, SXTW

Signed byte / halfword / word extend (predicated).

Sign-extend the least-significant sub-element of each active element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

It has encodings from 3 classes: [Byte](#) , [Halfword](#) and [Word](#)

Byte

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	0	0	0	0	0	1	0	1	Pg			Zn					Zd				
U																															

Byte

SXTB <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer s_esize = 8;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean unsigned = FALSE;
```

Halfword

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	0	0	1	0	0	1	0	1	Pg			Zn					Zd				
U																															

Halfword

SXTH <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size != '1x' then UNDEFINED;
integer esize = 8 << UInt(size);
integer s_esize = 16;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean unsigned = FALSE;
```

Word

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	0	1	0	0	1	0	1	Pg			Zn				Zd						
U																															

Word

```
SXTW <Zd>.D, <Pg>/M, <Zn>.D
```

```
if !HaveSVE() then UNDEFINED;
if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer s_esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean unsigned = FALSE;
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> For the byte variant: is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

For the halfword variant: is the size specifier, encoded in "size<0>":

size<0>	<T>
0	S
1	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    bits(esize) element = Elem[operand, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Extend(element<s_esize-1:0>, esize, unsigned);

Z[d] = result;
```

Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



TBX

Programmable table lookup in single vector table (merging).

Reads each element of the second source (index) vector and uses its value to select an indexed element from a table of elements in the first source vector, and places the indexed element in the destination vector element corresponding to the index vector element. If an index value is greater than or equal to the number of vector elements then the corresponding destination vector element is left unchanged.

Since the index values can select any element in a vector this operation is not naturally vector length agnostic.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	Zm						0	0	1	0	1	1	Zn						Zd			

SVE2

TBX <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[d];

for e = 0 to elements-1
    integer element2 = UInt(Elem[operand2, e, esize]);
    if element2 < elements then
        Elem[result, e, esize] = Elem[operand1, element2, esize];

Z[d] = result;
```

Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.





## TRN1, TRN2 (predicates)

Interleave even or odd elements from two predicates.

Interleave alternating even or odd-numbered elements from the first and second source predicates and place in elements of the destination predicate. This instruction is unpredicated.

It has encodings from 2 classes: [Even](#) and [Odd](#)

### Even

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	Pm				0	1	0	1	0	0	0	Pn				0	Pd				
H																															

### Even

TRN1 [<Pd>.<T>](#), [<Pn>.<T>](#), [<Pm>.<T>](#)

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
integer part = 0;
```

### Odd

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	Pm				0	1	0	1	0	1	0	Pn				0	Pd				
H																															

### Odd

TRN2 [<Pd>.<T>](#), [<Pn>.<T>](#), [<Pm>.<T>](#)

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
integer part = 1;
```

## Assembler Symbols

- <Pd>

Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <Pn>

Is the name of the first source scalable predicate register, encoded in the "Pn" field.
- <Pm>

Is the name of the second source scalable predicate register, encoded in the "Pm" field.

## Operation

```
CheckSVEEnabled();
integer pairs = VL DIV (esize * 2);
bits(PL) operand1 = P[n];
bits(PL) operand2 = P[m];
bits(PL) result;

for p = 0 to pairs-1
    Elem[result, 2*p+0, esize DIV 8] = Elem[operand1, 2*p+part, esize DIV 8];
    Elem[result, 2*p+1, esize DIV 8] = Elem[operand2, 2*p+part, esize DIV 8];

P[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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## TRN1, TRN2 (vectors)

Interleave even or odd elements from two vectors.

Interleave alternating even or odd-numbered elements from the first and second source vectors and place in elements of the destination vector. This instruction is unpredicated. The 128-bit element variant of this instruction requires that the current vector length is at least 256 bits, and if the current vector length is not an integer multiple of 256 bits then the trailing bits are set to zero.

ID\_AA64ZFR0\_EL1.F64MM indicates whether the 128-bit element variant of the instruction is implemented.

It has encodings from 4 classes: [Even](#) , [Even \(quadwords\)](#) , [Odd](#) and [Odd \(quadwords\)](#)

### Even

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	Zm			0	1	1	1	0	0	Zn			Zd									
																										H					

### Even

TRN1 <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer part = 0;
```

### Even (quadwords)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	1	0	1	Zm				0			0	0	1	1	0	Zn				Zd				
																										H					

### Even (quadwords)

TRN1 <Zd>.Q, <Zn>.Q, <Zm>.Q

```
if !HaveSVEFP64MatMulExt() then UNDEFINED;
integer esize = 128;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer part = 0;
```

### Odd

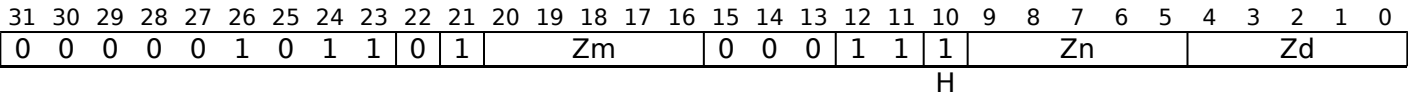
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	Zm			0		1	1	1		0	1	Zn			Zd							
																										H					

### Odd

TRN2 <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer part = 1;
```

Odd (quadwords)



Odd (quadwords)

```
TRN2 <Zd>.Q, <Zn>.Q, <Zm>.Q

if !HaveSVEFP64MatMulExt() then UNDEFINED;
integer esize = 128;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer part = 1;
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
if VL < esize * 2 then UNDEFINED;
integer pairs = VL DIV (esize * 2);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Zeros();

for p = 0 to pairs-1
    Elem[result, 2*p+0, esize] = Elem[operand1, 2*p+part, esize];
    Elem[result, 2*p+1, esize] = Elem[operand2, 2*p+part, esize];

Z[d] = result;
```

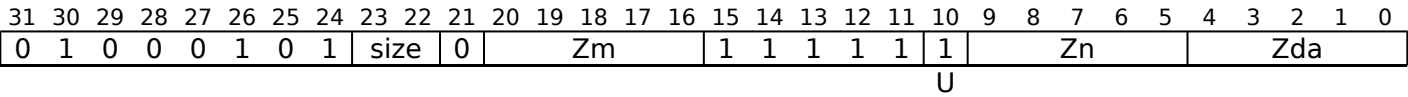
Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

UABA

Unsigned absolute difference and accumulate.

Compute the absolute difference between unsigned integer values in elements of the second source vector and corresponding elements of the first source vector, and add the difference to the corresponding elements of the destination vector. This instruction is unpredicated.



SVE2

```
UABA <Zda>.<T>, <Zn>.<T>, <Zm>.<T>
```

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean unsigned = TRUE;
```

Assembler Symbols

<Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    bits(esize) absdiff = Abs(element1 - element2)<esize-1:0>;
    Elem[result, e, esize] = Elem[result, e, esize] + absdiff;

Z[da] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

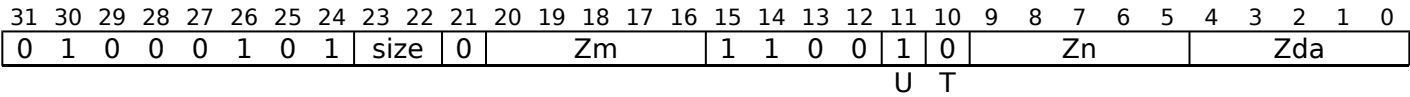
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UABALB

Unsigned absolute difference and accumulate long (bottom).

Compute the absolute difference between even-numbered unsigned elements of the second source vector and corresponding elements of the first source vector, and destructively add to the overlapping double-width elements of the addend vector. This instruction is unpredicated.



SVE2

```
UABALB <Zda>.<T>, <Zn>.<Tb>, <Zm>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

Assembler Symbols

<Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, 2*e + 0, esize DIV 2]);
    integer element2 = UInt(Elem[operand2, 2*e + 0, esize DIV 2]);
    bits(esize) absdiff = Abs(element1 - element2)<esize-1:0>;
    Elem[result, e, esize] = Elem[result, e, esize] + absdiff;

Z[da] = result;
```

Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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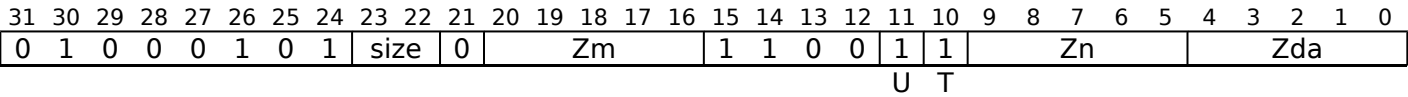
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UABALT

Unsigned absolute difference and accumulate long (top).

Compute the absolute difference between odd-numbered unsigned elements of the second source vector and corresponding elements of the first source vector, and destructively add to the overlapping double-width elements of the addend vector. This instruction is unpredicated.



SVE2

```
UABALT <Zda>.<T>, <Zn>.<Tb>, <Zm>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

Assembler Symbols

<Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, 2*e + 1, esize DIV 2]);
    integer element2 = UInt(Elem[operand2, 2*e + 1, esize DIV 2]);
    bits(esize) absdiff = Abs(element1 - element2)<esize-1:0>;
    Elem[result, e, esize] = Elem[result, e, esize] + absdiff;

Z[da] = result;
```

Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

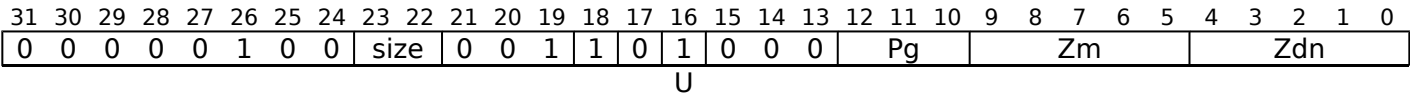
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UABD

Unsigned absolute difference (predicated).

Compute the absolute difference between unsigned integer values in active elements of the second source vector and corresponding elements of the first source vector and destructively place the difference in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



SVE

UABD <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean unsigned = TRUE;
```

Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    if ElemP[mask, e, esize] == '1' then
        integer absdiff = Abs(element1 - element2);
        Elem[result, e, esize] = absdiff<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.

- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

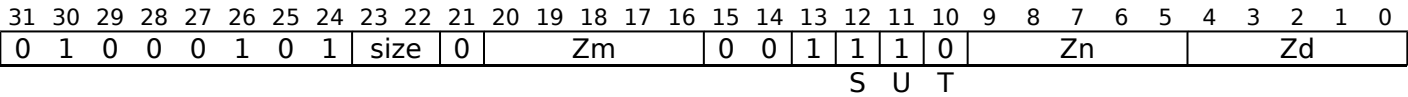
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# UABDLB

Unsigned absolute difference long (bottom).

Compute the absolute difference between the even-numbered unsigned integer values in elements of the second source vector and the corresponding elements of the first source vector, and place the results in the overlapping double-width elements of the destination vector. This instruction is unpredicated.



## SVE2

```
UABDLB <Zd>.<T>, <Zn>.<Tb>, <Zm>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, 2*e + 0, esize DIV 2]);
    integer element2 = UInt(Elem[operand2, 2*e + 0, esize DIV 2]);
    integer res = Abs(element1 - element2);
    Elem[result, e, esize] = res<esize-1:0>;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

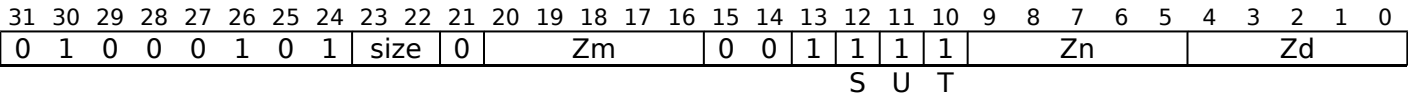
Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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UABDLT

Unsigned absolute difference long (top).

Compute the absolute difference between the odd-numbered unsigned integer values in elements of the second source vector and corresponding elements of the first source vector, and place the results in the overlapping double-width elements of the destination vector. This instruction is unpredicated.



SVE2

```
UABDLT <Zd>.<T>, <Zn>.<Tb>, <Zm>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, 2*e + 1, esize DIV 2]);
    integer element2 = UInt(Elem[operand2, 2*e + 1, esize DIV 2]);
    integer res = Abs(element1 - element2);
    Elem[result, e, esize] = res<esize-1:0>;

Z[d] = result;
```

Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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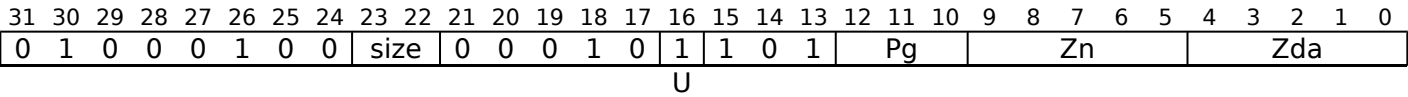
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UADALP

Unsigned add and accumulate long pairwise.

Add pairs of adjacent unsigned integer values and accumulate the results into the overlapping double-width elements of the destination vector.



SVE2

```
UADALP <Zda>.<T>, <Pg>/M, <Zn>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer da = UInt(Zda);
```

Assembler Symbols

- <Zda> Is the name of the second source and destination scalable vector register, encoded in the "Zda" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand_acc = Z[da];
bits(VL) operand_src = Z[n];
bits(VL) result;

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '0' then
    Elem[result, e, esize] = Elem[operand_acc, e, esize];
  else
    integer element1 = UInt(Elem[operand_src, 2*e + 0, esize DIV 2]);
    integer element2 = UInt(Elem[operand_src, 2*e + 1, esize DIV 2]);
    bits(esize) sum = (element1 + element2)<esize-1:0>;
    Elem[result, e, esize] = Elem[operand_acc, e, esize] + sum;

Z[da] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is

UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

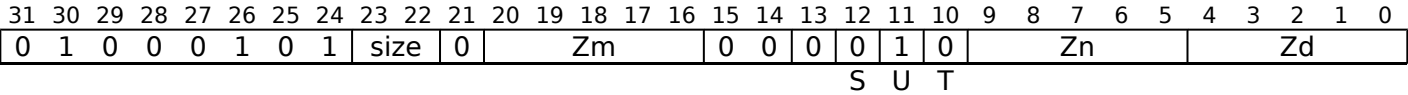
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UADDLB

Unsigned add long (bottom).

Add the corresponding even-numbered unsigned elements of the first and second source vectors, and place the results in the overlapping double-width elements of the destination vector. This instruction is unpredicated.



SVE2

UADDLB <Zd>.<T>, <Zn>.<Tb>, <Zm>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer sel1 = 0;
integer sel2 = 0;
boolean unsigned = TRUE;
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, 2*e + sel1, esize DIV 2], unsigned);
    integer element2 = Int(Elem[operand2, 2*e + sel2, esize DIV 2], unsigned);
    integer res = element1 + element2;
    Elem[result, e, esize] = res<esize-1:0>;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

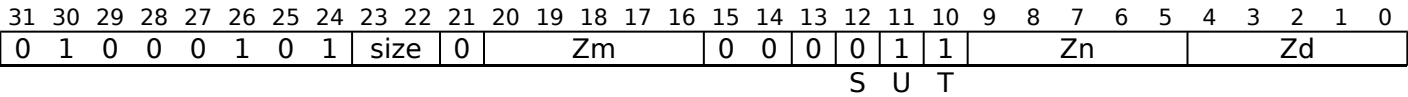
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UADDLT

Unsigned add long (top).

Add the corresponding odd-numbered unsigned elements of the first and second source vectors, and place the results in the overlapping double-width elements of the destination vector. This instruction is unpredicated.



SVE2

UADDLT <Zd>.<T>, <Zn>.<Tb>, <Zm>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer sel1 = 1;
integer sel2 = 1;
boolean unsigned = TRUE;
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, 2*e + sel1, esize DIV 2], unsigned);
    integer element2 = Int(Elem[operand2, 2*e + sel2, esize DIV 2], unsigned);
    integer res = element1 + element2;
    Elem[result, e, esize] = res<esize-1:0>;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

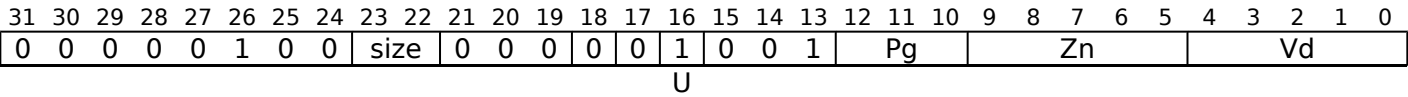
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UADDV

Unsigned add reduction to scalar.

Unsigned add horizontally across all lanes of a vector, and place the result in the SIMD&FP scalar destination register. Narrow elements are first zero-extended to 64 bits. Inactive elements in the source vector are treated as zero.



SVE

UADDV <Dd>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);
```

Assembler Symbols

- <Dd> Is the 64-bit name of the destination SIMD&FP register, encoded in the "Vd" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
integer sum = 0;

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer element = UInt(Elem[operand, e, esize]);
        sum = sum + element;

V[d] = sum<63:0>;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.

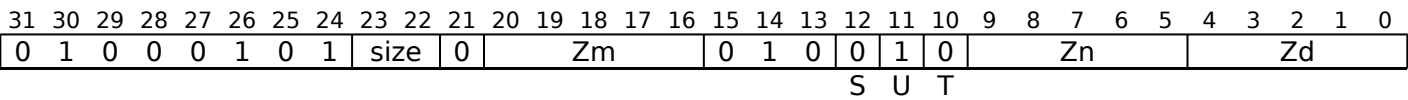




UADDWB

Unsigned add wide (bottom).

Add the even-numbered unsigned elements of the second source vector to the overlapping double-width elements of the first source vector and place the results in the corresponding double-width elements of the destination vector. This instruction is unpredicated.



SVE2

```
UADDWB <Zd>.<T>, <Zn>.<T>, <Zm>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, 2*e + 0, esize DIV 2]);
    Elem[result, e, esize] = (element1 + element2)<esize-1:0>;

Z[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:

- The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

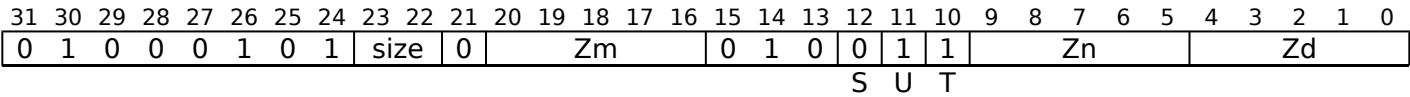
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UADDWT

Unsigned add wide (top).

Add the odd-numbered unsigned elements of the second source vector to the overlapping double-width elements of the first source vector and place the results in the corresponding double-width elements of the destination vector. This instruction is unpredicated.



SVE2

```
UADDWT <Zd>.<T>, <Zn>.<T>, <Zm>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, 2*e + 1, esize DIV 2]);
    Elem[result, e, esize] = (element1 + element2)<esize-1:0>;

Z[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:

- The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# UCVTF

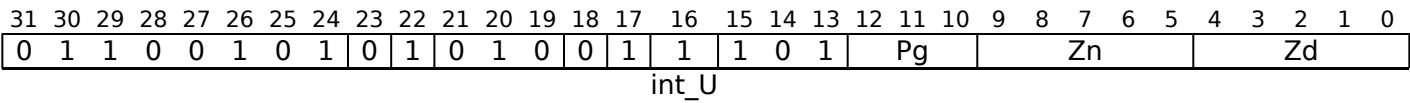
Unsigned integer convert to floating-point (predicated).

Convert to floating-point from the unsigned integer in each active element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

If the input and result types have a different size the smaller type is held unpacked in the least significant bits of elements of the larger size. When the input is the smaller type the upper bits of each source element are ignored. When the result is the smaller type the results are zero-extended to fill each destination element.

It has encodings from 7 classes: [16-bit to half-precision](#) , [32-bit to half-precision](#) , [32-bit to single-precision](#) , [32-bit to double-precision](#) , [64-bit to half-precision](#) , [64-bit to single-precision](#) and [64-bit to double-precision](#)

## 16-bit to half-precision

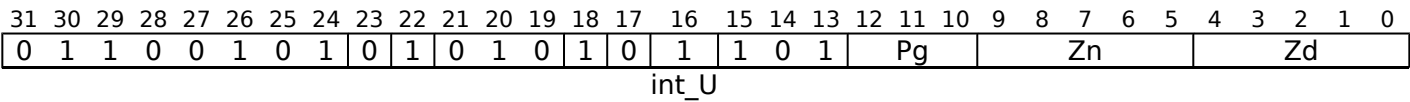


## 16-bit to half-precision

UCVTF <Zd>.H, <Pg>/M, <Zn>.H

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 16;
integer d_esize = 16;
boolean unsigned = TRUE;
FPRounding rounding = FPRoundingMode(FPCR<31:0>);
```

## 32-bit to half-precision

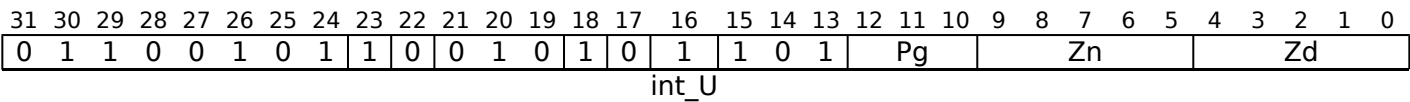


## 32-bit to half-precision

UCVTF <Zd>.H, <Pg>/M, <Zn>.S

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 32;
integer d_esize = 16;
boolean unsigned = TRUE;
FPRounding rounding = FPRoundingMode(FPCR<31:0>);
```

## 32-bit to single-precision

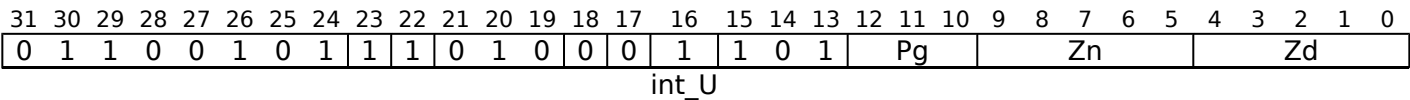


32-bit to single-precision

```
UCVTF <Zd>.S, <Pg>/M, <Zn>.S

if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 32;
integer d_esize = 32;
boolean unsigned = TRUE;
FPRounding rounding = FPRoundingMode(FPCR<31:0>);
```

32-bit to double-precision

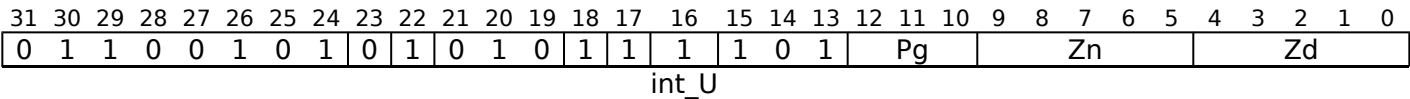


32-bit to double-precision

```
UCVTF <Zd>.D, <Pg>/M, <Zn>.S

if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 32;
integer d_esize = 64;
boolean unsigned = TRUE;
FPRounding rounding = FPRoundingMode(FPCR<31:0>);
```

64-bit to half-precision

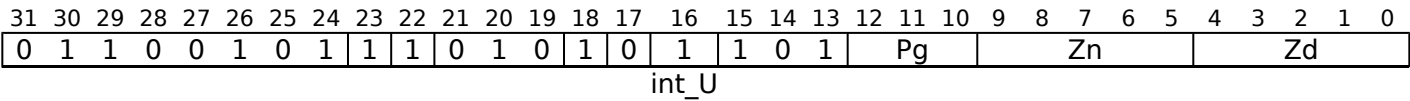


64-bit to half-precision

```
UCVTF <Zd>.H, <Pg>/M, <Zn>.D

if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 64;
integer d_esize = 16;
boolean unsigned = TRUE;
FPRounding rounding = FPRoundingMode(FPCR<31:0>);
```

64-bit to single-precision

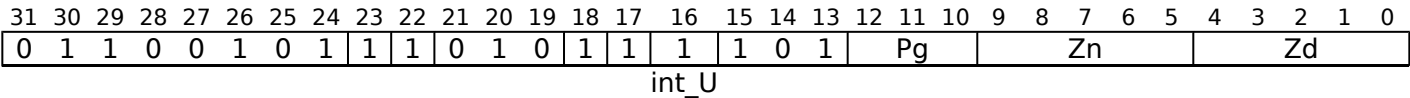


### 64-bit to single-precision

```
UCVTF <Zd>.S, <Pg>/M, <Zn>.D

if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 64;
integer d_esize = 32;
boolean unsigned = TRUE;
FPRounding rounding = FPRoundingMode(FPCR<31:0>);
```

### 64-bit to double-precision



### 64-bit to double-precision

```
UCVTF <Zd>.D, <Pg>/M, <Zn>.D

if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
integer s_esize = 64;
integer d_esize = 64;
boolean unsigned = TRUE;
FPRounding rounding = FPRoundingMode(FPCR<31:0>);
```

### Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

### Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    bits(esize) element = Elem[operand, e, esize];
    if ElemP[mask, e, esize] == '1' then
        bits(d_esize) fpval = FixedToFP(element<s_esize-1:0>, 0, unsigned, FPCR<31:0>, rounding);
        Elem[result, e, esize] = ZeroExtend(fpval);

Z[d] = result;
```

### Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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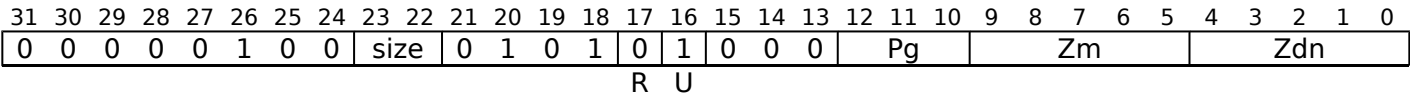
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# UDIV

Unsigned divide (predicated).

Unsigned divide active elements of the first source vector by corresponding elements of the second source vector and destructively place the quotient in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



## SVE

UDIV <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '0x' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean unsigned = TRUE;
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size<0>":

size<0>	<T>
0	S
1	D
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    if ElemP[mask, e, esize] == '1' then
        integer quotient;
        if element2 == 0 then
            quotient = 0;
        else
            quotient = RoundTowardsZero(Real(element1) / Real(element2));
        Elem[result, e, esize] = quotient<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

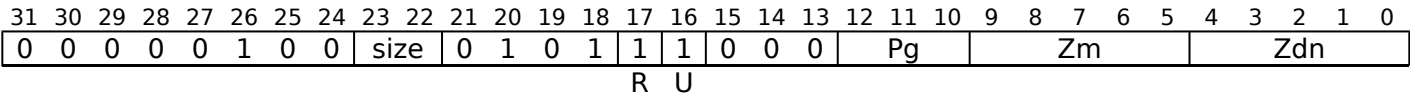
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UDIVR

Unsigned reversed divide (predicated).

Unsigned reversed divide active elements of the second source vector by corresponding elements of the first source vector and destructively place the quotient in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



SVE

UDIVR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '0x' then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean unsigned = TRUE;
```

Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size<0>":

size<0>	<T>
0	S
1	D
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    if ElemP[mask, e, esize] == '1' then
        integer quotient;
        if element1 == 0 then
            quotient = 0;
        else
            quotient = RoundTowardsZero(Real(element2) / Real(element1));
        Elem[result, e, esize] = quotient<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

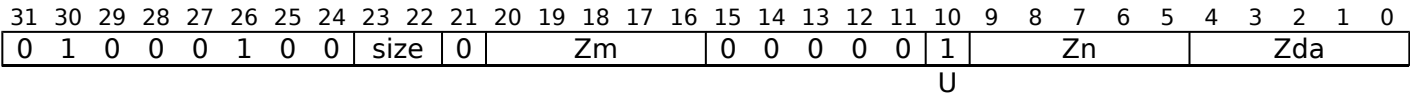
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# UDOT (vectors)

Unsigned integer dot product.

The unsigned integer dot product instruction computes the dot product of a group of four unsigned 8-bit or 16-bit integer values held in each 32-bit or 64-bit element of the first source vector multiplied by a group of four unsigned 8-bit or 16-bit integer values in the corresponding 32-bit or 64-bit element of the second source vector, and then destructively adds the widened dot product to the corresponding 32-bit or 64-bit element of the destination vector. This instruction is unpredicated.



## SVE

UDOT <Zda>.<T>, <Zn>.<Tb>, <Zm>.<Tb>

```
if !HaveSVE() then UNDEFINED;
if size == '0x' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

<Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.

<T> Is the size specifier, encoded in "size<0>":

size<0>	<T>
0	S
1	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size<0>":

size<0>	<Tb>
0	B
1	H

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) res = Elem[operand3, e, esize];
    for i = 0 to 3
        integer element1 = UInt(Elem[operand1, 4 * e + i, esize DIV 4]);
        integer element2 = UInt(Elem[operand2, 4 * e + i, esize DIV 4]);
        res = res + element1 * element2;
    Elem[result, e, esize] = res;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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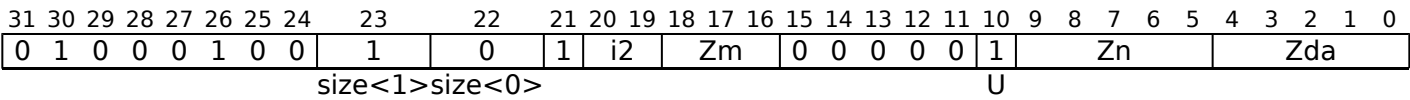
# UDOT (indexed)

Unsigned integer indexed dot product.

The unsigned integer indexed dot product instruction computes the dot product of a group of four unsigned 8-bit or 16-bit integer values held in each 32-bit or 64-bit element of the first source vector multiplied by a group of four unsigned 8-bit or 16-bit integer values in an indexed 32-bit or 64-bit element of the second source vector, and then destructively adds the widened dot product to the corresponding 32-bit or 64-bit element of the destination vector. The groups within the second source vector are specified using an immediate index which selects the same group position within each 128-bit vector segment. The index range is from 0 to one less than the number of groups per 128-bit segment, encoded in 1 to 2 bits depending on the size of the group. This instruction is unpredicated.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

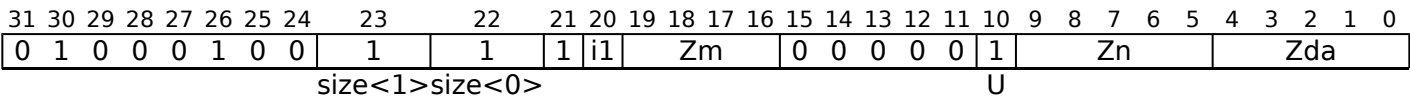


## 32-bit

UDOT <Zda>.S, <Zn>.B, <Zm>.B[<imm>]

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## 64-bit



## 64-bit

UDOT <Zda>.D, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer index = UInt(i1);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> For the 32-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  
For the 64-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
- <imm> For the 32-bit variant: is the immediate index of a quadruplet of four 8-bit elements within each 128-bit vector segment, in the range 0 to 3, encoded in the "i2" field.  
For the 64-bit variant: is the immediate index of a quadruplet of four 16-bit elements within each 128-bit vector segment, in the range 0 to 1, encoded in the "i1" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer eltspersegment = 128 DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    integer segmentbase = e - (e MOD eltspersegment);
    integer s = segmentbase + index;
    bits(esize) res = Elem[operand3, e, esize];
    for i = 0 to 3
        integer element1 = UInt(Elem[operand1, 4 * e + i, esize DIV 4]);
        integer element2 = UInt(Elem[operand2, 4 * s + i, esize DIV 4]);
        res = res + element1 * element2;
    Elem[result, e, esize] = res;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is

UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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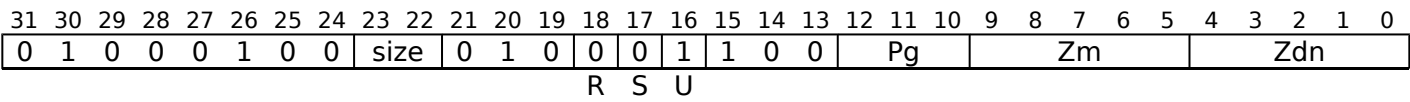
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# UHADD

Unsigned halving addition.

Add active unsigned elements of the first source vector to corresponding unsigned elements of the second source vector, shift right one bit, and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



## SVE2

UHADD <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, e, esize]);
    if ElemP[mask, e, esize] == '1' then
        integer res = element1 + element2;
        Elem[result, e, esize] = res<esize:1>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.

- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

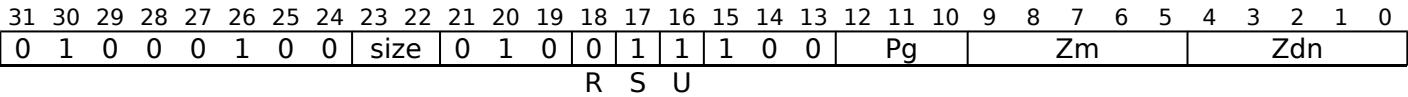
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# UHSUB

Unsigned halving subtract.

Subtract active unsigned elements of the second source vector from corresponding unsigned elements of the first source vector, shift right one bit, and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



## SVE2

UHSUB <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, e, esize]);
    if ElemP[mask, e, esize] == '1' then
        integer res = element1 - element2;
        Elem[result, e, esize] = res<esize:1>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.

- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

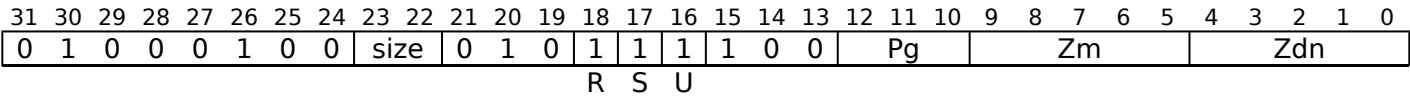
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# UHSUBR

Unsigned halving subtract reversed vectors.

Subtract active unsigned elements of the first source vector from corresponding unsigned elements of the second source vector, shift right one bit, and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



## SVE2

UHSUBR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, e, esize]);
    if ElemP[mask, e, esize] == '1' then
        integer res = element2 - element1;
        Elem[result, e, esize] = res<esize:1>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
    - The values of the NZCV flags.

- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

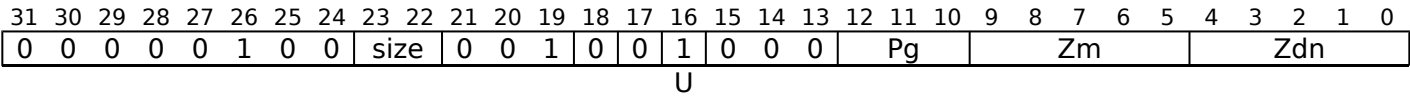
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# UMAX (vectors)

Unsigned maximum vectors (predicated).

Determine the unsigned maximum of active elements of the second source vector and corresponding elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



## SVE

UMAX <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean unsigned = TRUE;
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    if ElemP[mask, e, esize] == '1' then
        integer maximum = Max(element1, element2);
        Elem[result, e, esize] = maximum<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.

- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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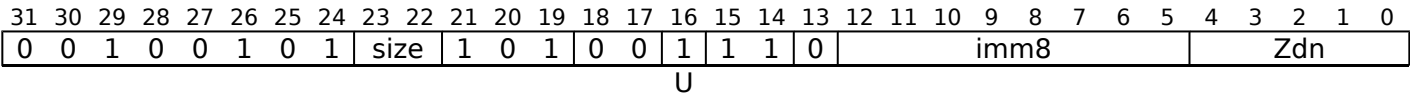
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# UMAX (immediate)

Unsigned maximum with immediate (unpredicated).

Determine the unsigned maximum of an immediate and each element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate is an unsigned 8-bit value in the range 0 to 255, inclusive. This instruction is unpredicated.



## SVE

UMAX <Zdn>.<T>, <Zdn>.<T>, #<imm>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer dn = UInt(Zdn);
boolean unsigned = TRUE;
integer imm = Int(imm8, unsigned);
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <imm> Is the unsigned immediate operand, in the range 0 to 255, encoded in the "imm8" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    Elem[result, e, esize] = Max(element1, imm)<esize-1:0>;

Z[dn] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

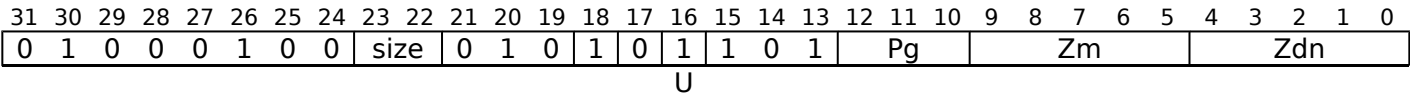
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# UMAXP

Unsigned maximum pairwise.

Compute the maximum value of each pair of adjacent unsigned integer elements within each source vector, and interleave the results from corresponding lanes. The interleaved result values are destructively placed in the first source vector.



## SVE2

UMAXP <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer m = UInt(Zm);
integer dn = UInt(Zdn);
```

## Assembler Symbols

- <Zdn>Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T>Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg>Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm>Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;
integer element1;
integer element2;

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '0' then
    Elem[result, e, esize] = Elem[operand1, e, esize];
  else
    if IsEven(e) then
      element1 = UInt(Elem[operand1, e + 0, esize]);
      element2 = UInt(Elem[operand1, e + 1, esize]);
    else
      element1 = UInt(Elem[operand2, e - 1, esize]);
      element2 = UInt(Elem[operand2, e + 0, esize]);
    integer res = Max(element1, element2);
    Elem[result, e, esize] = res<esize-1:0>;

Z[dn] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is

UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

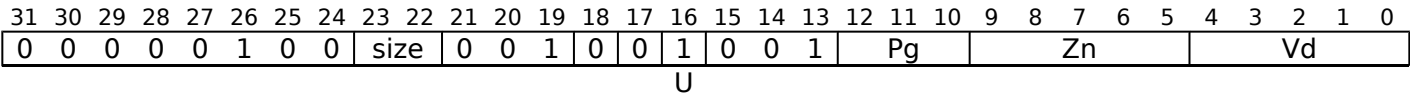
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UMAXV

Unsigned maximum reduction to scalar.

Unsigned maximum horizontally across all lanes of a vector, and place the result in the SIMD&FP scalar destination register. Inactive elements in the source vector are treated as zero.



SVE

UMAXV <V><d>, <Pg>, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);
boolean unsigned = TRUE;
```

Assembler Symbols

- <V>

Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D
- <d>

Is the number [0-31] of the destination SIMD&FP register, encoded in the "Vd" field.
- <Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn>

Is the name of the source scalable vector register, encoded in the "Zn" field.
- <T>

Is the size specifier, encoded in “size”:

size	<T>
00	B
01	H
10	S
11	D

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
integer maximum = if unsigned then 0 else -(2^(esize-1));

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer element = Int(Elem[operand, e, esize], unsigned);
        maximum = Max(maximum, element);

V[d] = maximum<esize-1:0>;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:

- The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

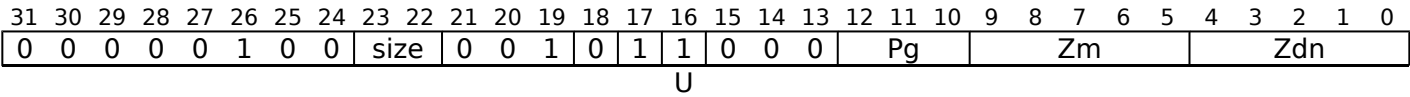
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# UMIN (vectors)

Unsigned minimum vectors (predicated).

Determine the unsigned minimum of active elements of the second source vector and corresponding elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



## SVE

UMIN <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean unsigned = TRUE;
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    if ElemP[mask, e, esize] == '1' then
        integer minimum = Min(element1, element2);
        Elem[result, e, esize] = minimum<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.

- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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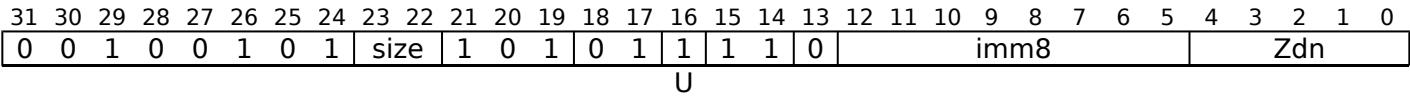
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# UMIN (immediate)

Unsigned minimum with immediate (unpredicated).

Determine the unsigned minimum of an immediate and each element of the source vector, and destructively place the results in the corresponding elements of the source vector. The immediate is an unsigned 8-bit value in the range 0 to 255, inclusive. This instruction is unpredicated.



## SVE

UMIN <Zdn>.<T>, <Zdn>.<T>, #<imm>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer dn = UInt(Zdn);
boolean unsigned = TRUE;
integer imm = Int(imm8, unsigned);
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <imm> Is the unsigned immediate operand, in the range 0 to 255, encoded in the "imm8" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    Elem[result, e, esize] = Min(element1, imm)<esize-1:0>;

Z[dn] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

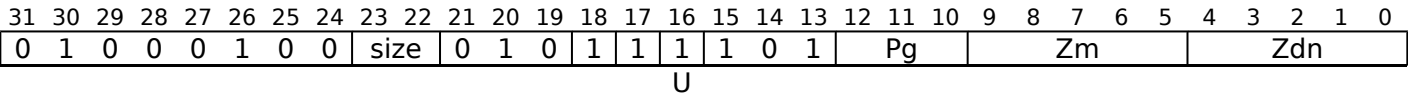
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# UMINP

Unsigned minimum pairwise.

Compute the minimum value of each pair of adjacent unsigned integer elements within each source vector, and interleave the results from corresponding lanes. The interleaved result values are destructively placed in the first source vector.



## SVE2

UMINP <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer m = UInt(Zm);
integer dn = UInt(Zdn);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;
integer element1;
integer element2;

for e = 0 to elements-1
  if ElemP[mask, e, esize] == '0' then
    Elem[result, e, esize] = Elem[operand1, e, esize];
  else
    if IsEven(e) then
      element1 = UInt(Elem[operand1, e + 0, esize]);
      element2 = UInt(Elem[operand1, e + 1, esize]);
    else
      element1 = UInt(Elem[operand2, e - 1, esize]);
      element2 = UInt(Elem[operand2, e + 0, esize]);
    integer res = Min(element1, element2);
    Elem[result, e, esize] = res<esize-1:0>;

Z[dn] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is

UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

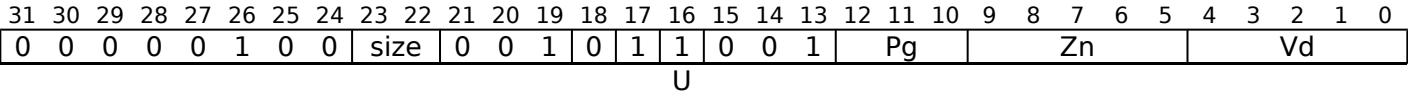
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UMINV

Unsigned minimum reduction to scalar.

Unsigned minimum horizontally across all lanes of a vector, and place the result in the SIMD&FP scalar destination register. Inactive elements in the source vector are treated as the maximum unsigned integer for the element size.



SVE

```
UMINV <V><d>, <Pg>, <Zn>.<T>
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Vd);
boolean unsigned = TRUE;
```

Assembler Symbols

<V> Is a width specifier, encoded in “size”:

size	<V>
00	B
01	H
10	S
11	D

<d> Is the number [0-31] of the destination SIMD&FP register, encoded in the "Vd" field.

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<T> Is the size specifier, encoded in “size”:

size	<T>
00	B
01	H
10	S
11	D

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
integer minimum = if unsigned then (2^esize - 1) else (2^(esize-1) - 1);

for e = 0 to elements-1
    if ElemP[mask, e, esize] == '1' then
        integer element = Int(Elem[operand, e, esize], unsigned);
        minimum = Min(minimum, element);

V[d] = minimum<esize-1:0>;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:

- The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

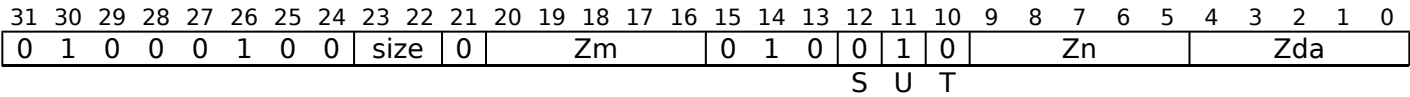
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# UMLALB (vectors)

Unsigned multiply-add long to accumulator (bottom).

Multiply the corresponding even-numbered unsigned elements of the first and second source vectors and destructively add to the overlapping double-width elements of the addend vector. This instruction is unpredicated.



## SVE2

UMLALB <Zda>.<T>, <Zn>.<Tb>, <Zm>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

- <Zda>Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <T>Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Zn>Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Tb>Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

- <Zm>Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, 2*e + 0, esize DIV 2]);
    integer element2 = UInt(Elem[operand2, 2*e + 0, esize DIV 2]);
    bits(esize) product = (element1 * element2)<esize-1:0>;
    Elem[result, e, esize] = Elem[result, e, esize] + product;

Z[da] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:

- The values of the data supplied in any of its registers.
- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# UMLALB (indexed)

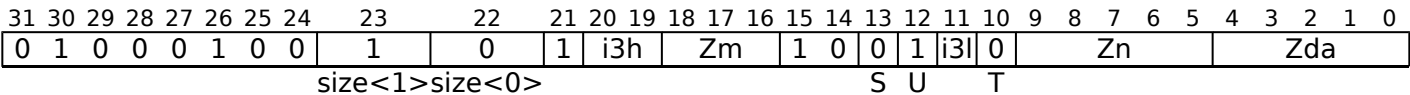
Unsigned multiply-add long to accumulator (bottom, indexed).

Multiply the even-numbered unsigned elements within each 128-bit segment of the first source vector by the specified unsigned element in the corresponding second source vector segment and destructively add to the overlapping double-width elements of the addend vector.

The elements within the second source vector are specified using an immediate index which selects the same element position within each 128-bit vector segment. The index range is from 0 to one less than the number of elements per 128-bit segment, encoded in 2 or 3 bits depending on the size of the element.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

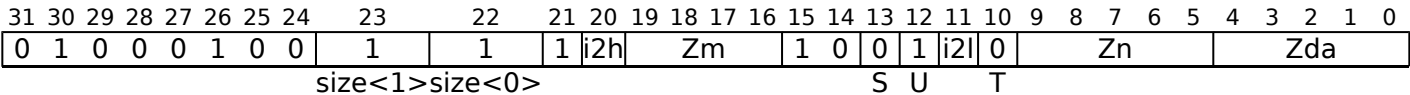


## 32-bit

UMLALB <Zda>.S, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 16;
integer index = UInt(i3h:i3l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel = 0;
```

## 64-bit



## 64-bit

UMLALB <Zda>.D, <Zn>.S, <Zm>.S[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2h:i2l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel = 0;
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> For the 32-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  
For the 64-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
- <imm> For the 32-bit variant: is the element index, in the range 0 to 7, encoded in the "i3h:i3l" fields.  
For the 64-bit variant: is the element index, in the range 0 to 3, encoded in the "i2h:i2l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
integer eltspersegment = 128 DIV (2 * esize);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer s = e - (e MOD eltspersegment);
    integer element1 = UInt(Elem[operand1, 2 * e + sel, esize]);
    integer element2 = UInt(Elem[operand2, 2 * s + index, esize]);
    bits(2*esize) product = (element1 * element2)<2*esize-1:0>;
    Elem[result, e, 2*esize] = Elem[result, e, 2*esize] + product;

Z[da] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is

UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

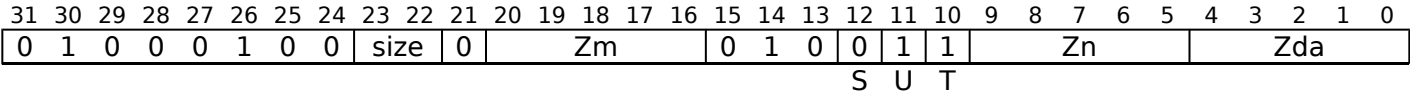
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# UMLALT (vectors)

Unsigned multiply-add long to accumulator (top).

Multiply the corresponding odd-numbered unsigned elements of the first and second source vectors and destructively add to the overlapping double-width elements of the addend vector. This instruction is unpredicated.



## SVE2

UMLALT <Zda>.<T>, <Zn>.<Tb>, <Zm>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, 2*e + 1, esize DIV 2]);
    integer element2 = UInt(Elem[operand2, 2*e + 1, esize DIV 2]);
    bits(esize) product = (element1 * element2)<esize-1:0>;
    Elem[result, e, esize] = Elem[result, e, esize] + product;

Z[da] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:

- The values of the data supplied in any of its registers.
- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# UMLALT (indexed)

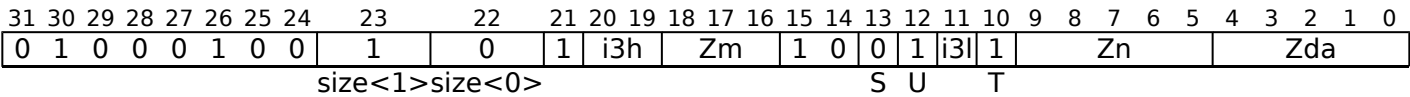
Unsigned multiply-add long to accumulator (top, indexed).

Multiply the odd-numbered unsigned elements within each 128-bit segment of the first source vector by the specified unsigned element in the corresponding second source vector segment and destructively add to the overlapping double-width elements of the addend vector.

The elements within the second source vector are specified using an immediate index which selects the same element position within each 128-bit vector segment. The index range is from 0 to one less than the number of elements per 128-bit segment, encoded in 2 or 3 bits depending on the size of the element.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

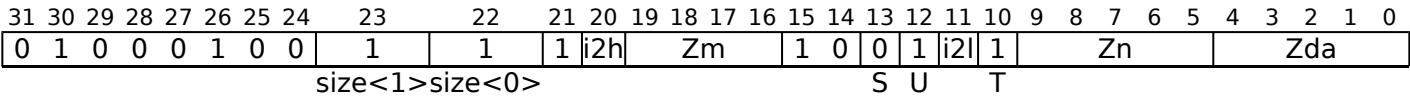


## 32-bit

UMLALT <Zda>.S, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 16;
integer index = UInt(i3h:i3l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel = 1;
```

## 64-bit



## 64-bit

UMLALT <Zda>.D, <Zn>.S, <Zm>.S[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2h:i2l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel = 1;
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> For the 32-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  
For the 64-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
- <imm> For the 32-bit variant: is the element index, in the range 0 to 7, encoded in the "i3h:i3l" fields.  
For the 64-bit variant: is the element index, in the range 0 to 3, encoded in the "i2h:i2l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
integer eltspersegment = 128 DIV (2 * esize);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer s = e - (e MOD eltspersegment);
    integer element1 = UInt(Elem[operand1, 2 * e + sel, esize]);
    integer element2 = UInt(Elem[operand2, 2 * s + index, esize]);
    bits(2*esize) product = (element1 * element2)<2*esize-1:0>;
    Elem[result, e, 2*esize] = Elem[result, e, 2*esize] + product;

Z[da] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is

UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

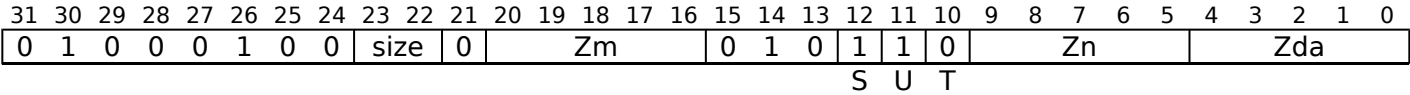
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# UMLSLB (vectors)

Unsigned multiply-subtract long from accumulator (bottom).

Multiply the corresponding even-numbered unsigned elements of the first and second source vectors and destructively subtract from the overlapping double-width elements of the addend vector. This instruction is unpredicated.



## SVE2

UMLSLB <Zda>.<T>, <Zn>.<Tb>, <Zm>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, 2*e + 0, esize DIV 2]);
    integer element2 = UInt(Elem[operand2, 2*e + 0, esize DIV 2]);
    bits(esize) product = (element1 * element2)<esize-1:0>;
    Elem[result, e, esize] = Elem[result, e, esize] - product;

Z[da] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:

- The values of the data supplied in any of its registers.
- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# UMLSLB (indexed)

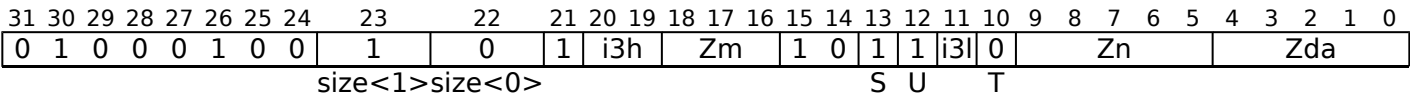
Unsigned multiply-subtract long from accumulator (bottom, indexed).

Multiply the even-numbered unsigned elements within each 128-bit segment of the first source vector by the specified unsigned element in the corresponding second source vector segment and destructively subtract from the overlapping double-width elements of the addend vector.

The elements within the second source vector are specified using an immediate index which selects the same element position within each 128-bit vector segment. The index range is from 0 to one less than the number of elements per 128-bit segment, encoded in 2 or 3 bits depending on the size of the element.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

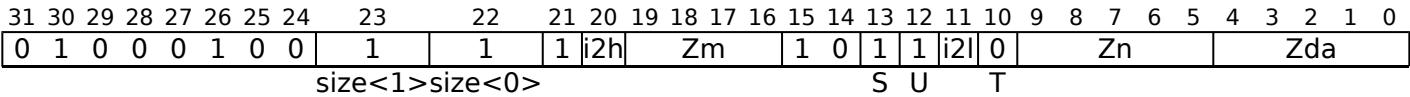


## 32-bit

UMLSLB <Zda>.S, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 16;
integer index = UInt(i3h:i3l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel = 0;
```

## 64-bit



## 64-bit

UMLSLB <Zda>.D, <Zn>.S, <Zm>.S[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2h:i2l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel = 0;
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> For the 32-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  
For the 64-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
- <imm> For the 32-bit variant: is the element index, in the range 0 to 7, encoded in the "i3h:i3l" fields.  
For the 64-bit variant: is the element index, in the range 0 to 3, encoded in the "i2h:i2l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
integer eltspersegment = 128 DIV (2 * esize);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer s = e - (e MOD eltspersegment);
    integer element1 = UInt(Elem[operand1, 2 * e + sel, esize]);
    integer element2 = UInt(Elem[operand2, 2 * s + index, esize]);
    bits(2*esize) product = (element1 * element2)<2*esize-1:0>;
    Elem[result, e, 2*esize] = Elem[result, e, 2*esize] - product;

Z[da] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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## UMLSLT (vectors)

Unsigned multiply-subtract long from accumulator (top).

Multiply the corresponding odd-numbered unsigned elements of the first and second source vectors and destructively subtract from the overlapping double-width elements of the addend vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0							
0	1	0	0	0	1	0	0	size	0	Zm				0	1	0	1	1	1	Zn				Zda														
																				S			U			T												

## SVE2

UMLSLT <Zda>.<T>, <Zn>.<Tb>, <Zm>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

**<Zda>** Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.

**<T>** Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<b>&lt;Zn&gt;</b>	Is the name of the first source scalable vector register, encoded in the "Zn" field.
-------------------	--

**<Tb>** Is the size specifier, encoded in “size”:

size	<Tb>
00	RESERVED
01	B
10	H
11	S

<b>&lt;Zm&gt;</b>	Is the name of the second source scalable vector register, encoded in the "Zm" field.
-------------------	---

## Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, 2*e + 1, esize DIV 2]);
    integer element2 = UInt(Elem[operand2, 2*e + 1, esize DIV 2]);
    bits(esize) product = (element1 * element2)<esize-1:0>;
    Elem[result, e, esize] = Elem[result, e, esize] - product;

Z[da] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:

- The values of the data supplied in any of its registers.
- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# UMLSLT (indexed)

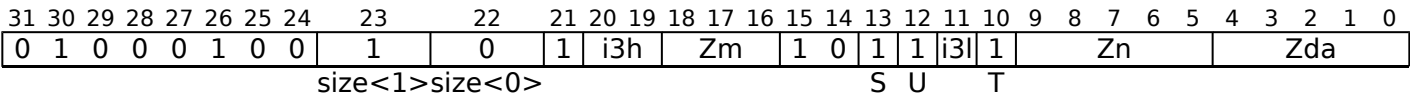
Unsigned multiply-subtract long from accumulator (top, indexed).

Multiply the odd-numbered unsigned elements within each 128-bit segment of the first source vector by the specified unsigned element in the corresponding second source vector segment and destructively subtract from the overlapping double-width elements of the addend vector.

The elements within the second source vector are specified using an immediate index which selects the same element position within each 128-bit vector segment. The index range is from 0 to one less than the number of elements per 128-bit segment, encoded in 2 or 3 bits depending on the size of the element.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

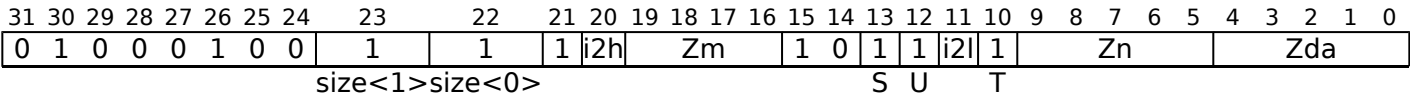


## 32-bit

UMLSLT <Zda>.S, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 16;
integer index = UInt(i3h:i3l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel = 1;
```

## 64-bit



## 64-bit

UMLSLT <Zda>.D, <Zn>.S, <Zm>.S[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2h:i2l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
integer sel = 1;
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> For the 32-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  
For the 64-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
- <imm> For the 32-bit variant: is the element index, in the range 0 to 7, encoded in the "i3h:i3l" fields.  
For the 64-bit variant: is the element index, in the range 0 to 3, encoded in the "i2h:i2l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
integer eltspersegment = 128 DIV (2 * esize);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Z[da];

for e = 0 to elements-1
    integer s = e - (e MOD eltspersegment);
    integer element1 = UInt(Elem[operand1, 2 * e + sel, esize]);
    integer element2 = UInt(Elem[operand2, 2 * s + index, esize]);
    bits(2*esize) product = (element1 * element2)<2*esize-1:0>;
    Elem[result, e, 2*esize] = Elem[result, e, 2*esize] - product;

Z[da] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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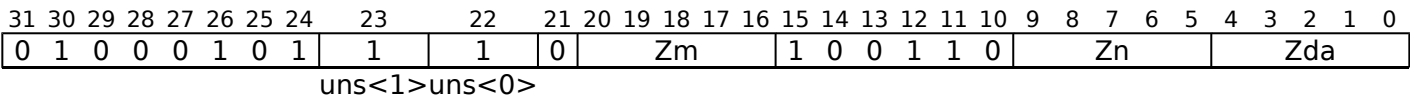
# UMMLA

Unsigned integer matrix multiply-accumulate.

The unsigned integer matrix multiply-accumulate instruction multiplies the 2×8 matrix of unsigned 8-bit integer values held in each 128-bit segment of the first source vector by the 8×2 matrix of unsigned 8-bit integer values in the corresponding segment of the second source vector. The resulting 2×2 widened 32-bit integer matrix product is then destructively added to the 32-bit integer matrix accumulator held in the corresponding segment of the addend and destination vector. This is equivalent to performing an 8-way dot product per destination element.

This instruction is unpredicated.

ID\_AA64ZFR0\_EL1.I8MM indicates whether this instruction is implemented.



## SVE

UMMLA <Zda>.S, <Zn>.B, <Zm>.B

```
if !HaveSVE() || !HaveInt8MatMulExt() then UNDEFINED;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean op1_unsigned = TRUE;
boolean op2_unsigned = TRUE;
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer segments = VL DIV 128;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result = Zeros();
bits(128) op1, op2;
bits(128) res, addend;

for s = 0 to segments-1
    op1 = Elem[operand1, s, 128];
    op2 = Elem[operand2, s, 128];
    addend = Elem[operand3, s, 128];
    res = MatMulAdd(addend, op1, op2, op1_unsigned, op2_unsigned);
    Elem[result, s, 128] = res;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

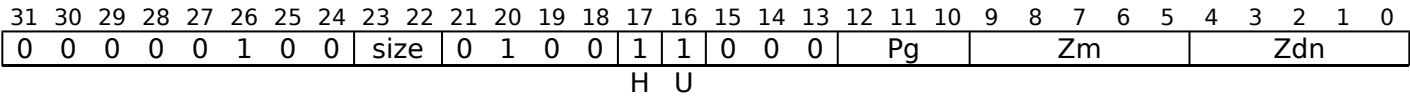




# UMULH (predicated)

Unsigned multiply returning high half (predicated).

Widening multiply unsigned integer values in active elements of the first source vector by corresponding elements of the second source vector and destructively place the high half of the result in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



## SVE

UMULH <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean unsigned = TRUE;
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    if ElemP[mask, e, esize] == '1' then
        integer product = (element1 * element2) >> esize;
        Elem[result, e, esize] = product<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];
Z[dn] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.

- The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

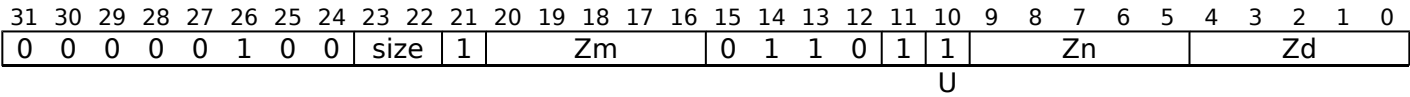
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# UMULH (unpredicated)

Unsigned multiply returning high half (unpredicated).

Widening multiply unsigned integer values of all elements of the first source vector by corresponding elements of the second source vector and place the high half of the result in the corresponding elements of the destination vector. This instruction is unpredicated.



## SVE2

UMULH <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
boolean unsigned = TRUE;
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    integer product = (element1 * element2) >> esize;
    Elem[result, e, esize] = product<esize-1:0>;

Z[d] = result;
```

## Operational information

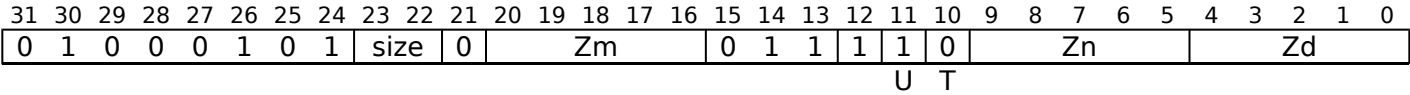
- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.



# UMULLB (vectors)

Unsigned multiply long (bottom).

Multiply the corresponding even-numbered unsigned elements of the first and second source vectors, and place the results in the overlapping double-width elements of the destination vector. This instruction is unpredicated.



## SVE2

UMULLB <Zd>.<T>, <Zn>.<Tb>, <Zm>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, 2*e + 0, esize DIV 2]);
    integer element2 = UInt(Elem[operand2, 2*e + 0, esize DIV 2]);
    integer res = element1 * element2;
    Elem[result, e, esize] = res<esize-1:0>;

Z[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:

- The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# UMULLB (indexed)

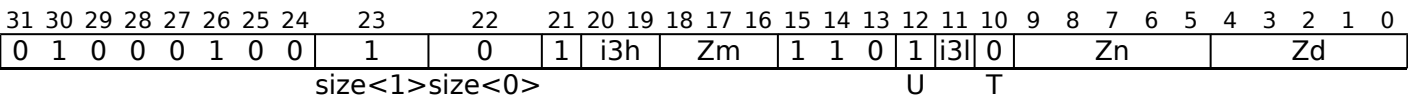
Unsigned multiply long (bottom, indexed).

Multiply the even-numbered unsigned elements within each 128-bit segment of the first source vector by the specified unsigned element in the corresponding second source vector segment, and place the results in the overlapping double-width elements of the destination vector register.

The elements within the second source vector are specified using an immediate index which selects the same element position within each 128-bit vector segment. The index range is from 0 to one less than the number of elements per 128-bit segment, encoded in 2 or 3 bits depending on the size of the element.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

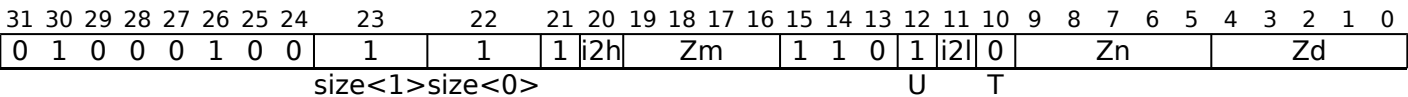


## 32-bit

UMULLB <Zd>.S, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 16;
integer index = UInt(i3h:i3l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer sel = 0;
```

## 64-bit



## 64-bit

UMULLB <Zd>.D, <Zn>.S, <Zm>.S[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2h:i2l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer sel = 0;
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> For the 32-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  
For the 64-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
- <imm> For the 32-bit variant: is the element index, in the range 0 to 7, encoded in the "i3h:i3l" fields.  
For the 64-bit variant: is the element index, in the range 0 to 3, encoded in the "i2h:i2l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
integer eltspersegment = 128 DIV (2 * esize);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer s = e - (e MOD eltspersegment);
    integer element1 = UInt(Elem[operand1, 2 * e + sel, esize]);
    integer element2 = UInt(Elem[operand2, 2 * s + index, esize]);
    integer res = element1 * element2;
    Elem[result, e, 2*esize] = res<2*esize-1:0>;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

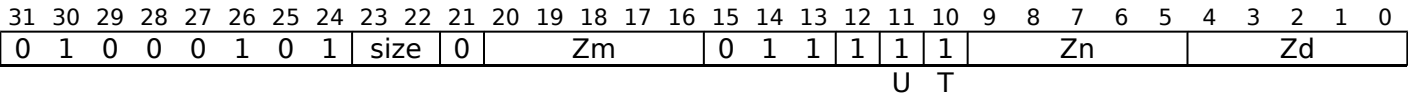
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# UMULLT (vectors)

Unsigned multiply long (top).

Multiply the corresponding odd-numbered unsigned elements of the first and second source vectors, and place the results in the overlapping double-width elements of the destination vector. This instruction is unpredicated.



## SVE2

```
UMULLT <Zd>.<T>, <Zn>.<Tb>, <Zm>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, 2*e + 1, esize DIV 2]);
    integer element2 = UInt(Elem[operand2, 2*e + 1, esize DIV 2]);
    integer res = element1 * element2;
    Elem[result, e, esize] = res<esize-1:0>;

Z[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:

- The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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# UMULLT (indexed)

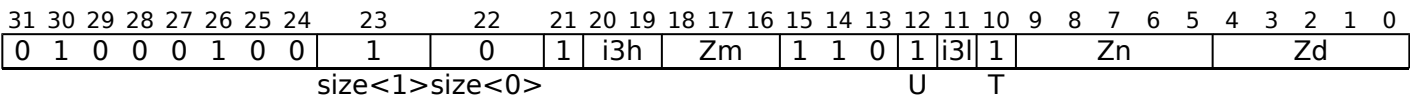
Unsigned multiply long (top, indexed).

Multiply the odd-numbered unsigned elements within each 128-bit segment of the first source vector by the specified unsigned element in the corresponding second source vector segment, and place the results in the overlapping double-width elements of the destination vector register.

The elements within the second source vector are specified using an immediate index which selects the same element position within each 128-bit vector segment. The index range is from 0 to one less than the number of elements per 128-bit segment, encoded in 2 or 3 bits depending on the size of the element.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

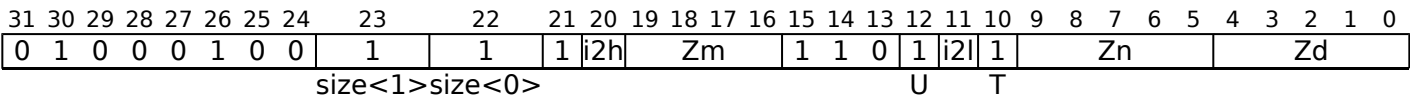


## 32-bit

UMULLT <Zd>.S, <Zn>.H, <Zm>.H[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 16;
integer index = UInt(i3h:i3l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer sel = 1;
```

## 64-bit



## 64-bit

UMULLT <Zd>.D, <Zn>.S, <Zm>.S[<imm>]

```
if !HaveSVE2() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2h:i2l);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer sel = 1;
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> For the 32-bit variant: is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.  
For the 64-bit variant: is the name of the second source scalable vector register Z0-Z15, encoded in the "Zm" field.
- <imm> For the 32-bit variant: is the element index, in the range 0 to 7, encoded in the "i3h:i3l" fields.  
For the 64-bit variant: is the element index, in the range 0 to 3, encoded in the "i2h:i2l" fields.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
integer eltspersegment = 128 DIV (2 * esize);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer s = e - (e MOD eltspersegment);
    integer element1 = UInt(Elem[operand1, 2 * e + sel, esize]);
    integer element2 = UInt(Elem[operand2, 2 * s + index, esize]);
    integer res = element1 * element2;
    Elem[result, e, 2*esize] = res<2*esize-1:0>;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

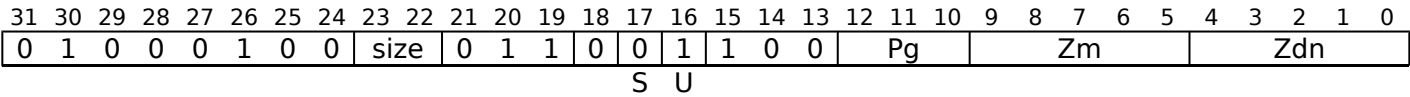
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# UQADD (vectors, predicated)

Unsigned saturating addition (predicated).

Add active unsigned elements of the first source vector to corresponding unsigned elements of the second source vector and destructively place the results in the corresponding elements of the first source vector. Each result element is saturated to the N-bit element's unsigned integer range 0 to (2<sup>N</sup>)-1. Inactive elements in the destination vector register remain unmodified.



## SVE2

UQADD <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean unsigned = TRUE;
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, e, esize]);
    if ElemP[mask, e, esize] == '1' then
        integer res = UInt(Sat(element1 + element2, esize, unsigned));
        Elem[result, e, esize] = res<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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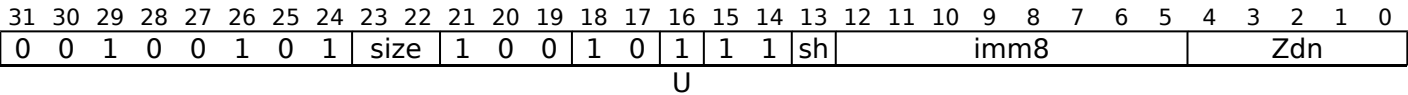
UQADD (immediate)

Unsigned saturating add immediate (unpredicated).

Unsigned saturating add of an unsigned immediate to each element of the source vector, and destructively place the results in the corresponding elements of the source vector. Each result element is saturated to the N-bit element's unsigned integer range 0 to (2<sup>N</sup>)-1. This instruction is unpredicated.

The immediate is an unsigned value in the range 0 to 255, and for element widths of 16 bits or higher it may also be a positive multiple of 256 in the range 256 to 65280.

The immediate is encoded in 8 bits with an optional left shift by 8. The preferred disassembly when the shift option is specified is "#<uimm8>, LSL #8". However an assembler and disassembler may also allow use of the shifted 16-bit value unless the immediate is 0 and the shift amount is 8, which must be unambiguously described as "#0, LSL #8".



SVE

```
UQADD <Zdn>.<T>, <Zdn>.<T>, #<imm>{, <shift>}
```

```
if !HaveSVE() then UNDEFINED;
if size:sh == '001' then UNDEFINED;
integer esize = 8 << UInt(size);
integer dn = UInt(Zdn);
integer imm = UInt(imm8);
if sh == '1' then imm = imm << 8;
boolean unsigned = TRUE;
```

Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <imm> Is an unsigned immediate in the range 0 to 255, encoded in the "imm8" field.
- <shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #8

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 + imm, esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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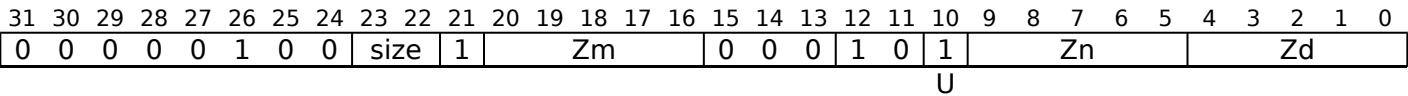
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# UQADD (vectors, unpredicated)

Unsigned saturating add vectors (unpredicated).

Unsigned saturating add all elements of the second source vector to corresponding elements of the first source vector and place the results in the corresponding elements of the destination vector. Each result element is saturated to the N-bit element's unsigned integer range 0 to (2<sup>N</sup>)-1. This instruction is unpredicated.



## SVE

UQADD <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
boolean unsigned = TRUE;
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 + element2, esize, unsigned);

Z[d] = result;
```

UQDECB

Unsigned saturating decrement scalar by multiple of 8-bit predicate constraint element count.

Determines the number of active 8-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement the scalar destination. The result is saturated to the general-purpose register's unsigned integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	1	0	imm4				1	1	1	1	1	1	pattern					Rdn				
size<1>size<0>								sf			D U																				

32-bit

UQDECB <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 32;
```

64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	1	1	imm4				1	1	1	1	1	1	pattern					Rdn				
size<1>size<0>								sf			D U																				

64-bit

UQDECB <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 64;
```

Assembler Symbols

- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 - (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

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# UQDECD (scalar)

Unsigned saturating decrement scalar by multiple of 64-bit predicate constraint element count.

Determines the number of active 64-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement the scalar destination. The result is saturated to the general-purpose register's unsigned integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	1	1	0	imm4				1	1	1	1	1	1	pattern					Rdn				
size<1>size<0>								sf			D U																				

## 32-bit

UQDECD <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	1	1	1	imm4				1	1	1	1	1	1	pattern					Rdn				
size<1>size<0>								sf			D U																				

## 64-bit

UQDECD <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 64;
```

## Assembler Symbols

- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 - (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

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UQDECD (vector)

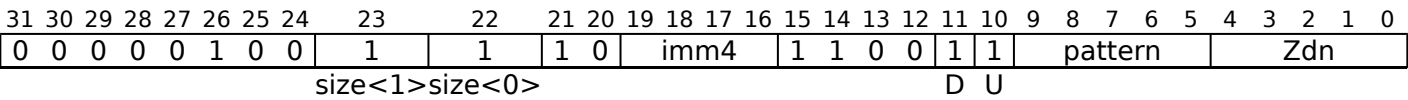
Unsigned saturating decrement vector by multiple of 64-bit predicate constraint element count.

Determines the number of active 64-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement all destination vector elements. The results are saturated to the 64-bit unsigned integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.



SVE

UQDECD <Zdn>.D{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
```

Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer count = DecodePredCount(pat, esize);
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 - (count * imm), esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# UQDECH (scalar)

Unsigned saturating decrement scalar by multiple of 16-bit predicate constraint element count.

Determines the number of active 16-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement the scalar destination. The result is saturated to the general-purpose register's unsigned integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	1	1	0	imm4				1	1	1	1	1	1	pattern					Rdn				
size<1>size<0>								sf			D U																				

## 32-bit

UQDECH <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	1	1	1	imm4				1	1	1	1	1	1	pattern					Rdn				
size<1>size<0>								sf			D U																				

## 64-bit

UQDECH <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 64;
```

## Assembler Symbols

- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":



pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 - (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

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UQDECH (vector)

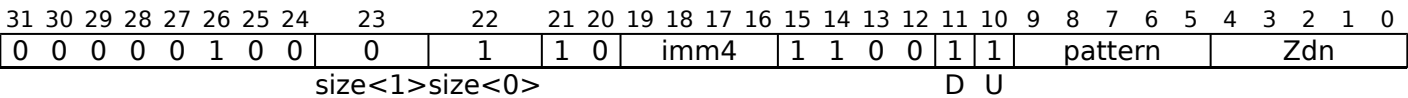
Unsigned saturating decrement vector by multiple of 16-bit predicate constraint element count.

Determines the number of active 16-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement all destination vector elements. The results are saturated to the 16-bit unsigned integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.



SVE

UQDECH <Zdn>.H{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
```

Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer count = DecodePredCount(pat, esize);
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 - (count * imm), esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# UQDECP (scalar)

Unsigned saturating decrement scalar by count of true predicate elements.

Counts the number of true elements in the source predicate and then uses the result to decrement the scalar destination. The result is saturated to the general-purpose register's unsigned integer range.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	0	1	0	1	1	1	0	0	0	1	0	0	0	Pm				Rdn				
D U														sf																	

## 32-bit

UQDECP <Wdn>, <Pm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Rdn);
boolean unsigned = TRUE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	0	1	0	1	1	1	0	0	0	1	1	0	Pm				Rdn					
D U														sf																	

## 64-bit

UQDECP <Xdn>, <Pm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Rdn);
boolean unsigned = TRUE;
integer ssize = 64;
```

## Assembler Symbols

- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Pm> Is the name of the source scalable predicate register, encoded in the "Pm" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(ssize) operand1 = X[dn];
bits(PL) operand2 = P[m];
bits(ssize) result;
integer count = 0;

for e = 0 to elements-1
    if ElemP[operand2, e, esize] == '1' then
        count = count + 1;

integer element = Int(operand1, unsigned);
(result, -) = Sat0(element - count, ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);
```

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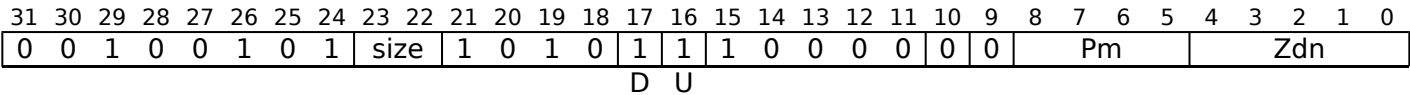
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# UQDECP (vector)

Unsigned saturating decrement vector by count of true predicate elements.

Counts the number of true elements in the source predicate and then uses the result to decrement all destination vector elements. The results are saturated to the element unsigned integer range.

The predicate size specifier may be omitted in assembler source code, but this is deprecated and will be prohibited in a future release of the architecture.



## SVE

UQDECP <Zdn>.<T>, <Pm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Zdn);
boolean unsigned = TRUE;
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pm> Is the name of the source scalable predicate register, encoded in the "Pm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(PL) operand2 = P[m];
bits(VL) result;
integer count = 0;

for e = 0 to elements-1
    if ElemP[operand2, e, esize] == '1' then
        count = count + 1;

for e = 0 to elements-1
    integer element = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = Sat0(element - count, esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.

- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# UQDECW (scalar)

Unsigned saturating decrement scalar by multiple of 32-bit predicate constraint element count.

Determines the number of active 32-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement the scalar destination. The result is saturated to the general-purpose register's unsigned integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	0	1	0	imm4				1	1	1	1	1	1	pattern					Rdn				
size<1>size<0>								sf			D U																				

## 32-bit

UQDECW <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	0	1	1	imm4				1	1	1	1	1	1	pattern					Rdn				
size<1>size<0>								sf			D U																				

## 64-bit

UQDECW <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 64;
```

## Assembler Symbols

- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":



pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 - (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

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UQDECW (vector)

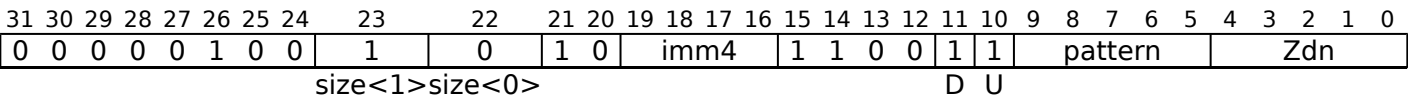
Unsigned saturating decrement vector by multiple of 32-bit predicate constraint element count.

Determines the number of active 32-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to decrement all destination vector elements. The results are saturated to the 32-bit unsigned integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.



SVE

```
UQDECW <Zdn>.S{, <pattern>{, MUL #<imm>}}
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
```

Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer count = DecodePredCount(pat, esize);
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 - (count * imm), esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# UQINCB

Unsigned saturating increment scalar by multiple of 8-bit predicate constraint element count.

Determines the number of active 8-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment the scalar destination. The result is saturated to the general-purpose register's unsigned integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	1	0	imm4				1	1	1	1	0	1	pattern					Rdn				
size<1>size<0>								sf			D U																				

## 32-bit

UQINCB <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	1	1	imm4				1	1	1	1	0	1	pattern					Rdn				
size<1>size<0>								sf			D U																				

## 64-bit

UQINCB <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 8;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 64;
```

## Assembler Symbols

- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 + (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

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# UQINCD (scalar)

Unsigned saturating increment scalar by multiple of 64-bit predicate constraint element count.

Determines the number of active 64-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment the scalar destination. The result is saturated to the general-purpose register's unsigned integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	1	1	0	imm4				1	1	1	1	0	1	pattern					Rdn				
size<1>size<0>								sf									D		U												

## 32-bit

UQINCD <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	1	1	1	imm4				1	1	1	1	0	1	pattern					Rdn				
size<1>size<0>								sf									D		U												

## 64-bit

UQINCD <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 64;
```

## Assembler Symbols

- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 + (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

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UQINCD (vector)

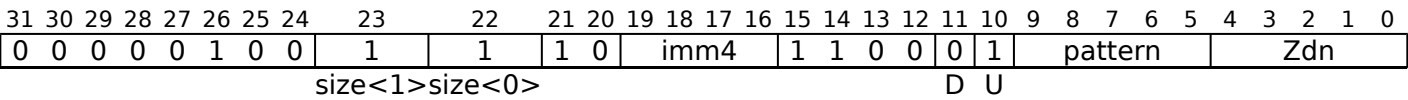
Unsigned saturating increment vector by multiple of 64-bit predicate constraint element count.

Determines the number of active 64-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment all destination vector elements. The results are saturated to the 64-bit unsigned integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.



SVE

```
UQINCD <Zdn>.D{, <pattern>{, MUL #<imm>}}
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 64;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
```

Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.



## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer count = DecodePredCount(pat, esize);
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 + (count * imm), esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# UQINCH (scalar)

Unsigned saturating increment scalar by multiple of 16-bit predicate constraint element count.

Determines the number of active 16-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment the scalar destination. The result is saturated to the general-purpose register's unsigned integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	1	1	0	imm4				1	1	1	1	0	1	pattern					Rdn				
size<1>size<0>								sf									D		U												

## 32-bit

UQINCH <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 32;
```

## 64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	1	1	1	imm4				1	1	1	1	0	1	pattern					Rdn				
size<1>size<0>								sf									D		U												

## 64-bit

UQINCH <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 64;
```

## Assembler Symbols

- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 + (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

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UQINCH (vector)

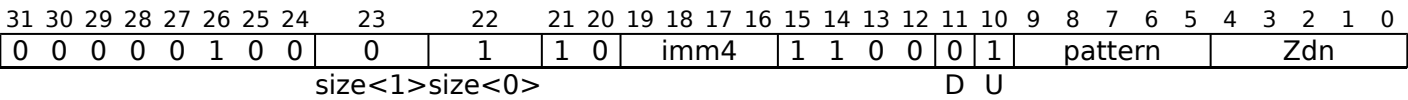
Unsigned saturating increment vector by multiple of 16-bit predicate constraint element count.

Determines the number of active 16-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment all destination vector elements. The results are saturated to the 16-bit unsigned integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.



SVE

```
UQINCH <Zdn>.H{, <pattern>{, MUL #<imm>}}
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 16;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
```

Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer count = DecodePredCount(pat, esize);
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 + (count * imm), esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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UQINCP (scalar)

Unsigned saturating increment scalar by count of true predicate elements.

Counts the number of true elements in the source predicate and then uses the result to increment the scalar destination. The result is saturated to the general-purpose register's unsigned integer range.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

32-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	0	1	0	0	1	1	0	0	0	1	0	0	0	Pm			Rdn					
D U														sf																	

32-bit

UQINCP <Wdn>, <Pm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Rdn);
boolean unsigned = TRUE;
integer ssize = 32;
```

64-bit

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	0	1	0	0	1	1	0	0	0	1	1	0	Pm			Rdn						
D U														sf																	

64-bit

UQINCP <Xdn>, <Pm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Rdn);
boolean unsigned = TRUE;
integer ssize = 64;
```

Assembler Symbols

- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Pm> Is the name of the source scalable predicate register, encoded in the "Pm" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(ssize) operand1 = X[dn];
bits(PL) operand2 = P[m];
bits(ssize) result;
integer count = 0;

for e = 0 to elements-1
    if ElemP[operand2, e, esize] == '1' then
        count = count + 1;

integer element = Int(operand1, unsigned);
(result, -) = Sat0(element + count, ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);
```

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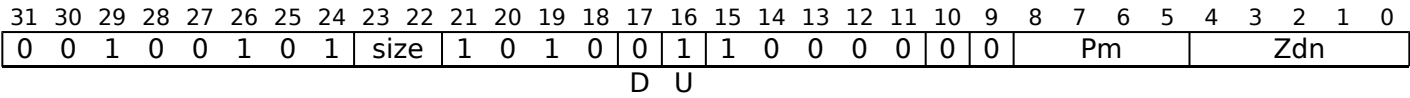
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# UQINCP (vector)

Unsigned saturating increment vector by count of true predicate elements.

Counts the number of true elements in the source predicate and then uses the result to increment all destination vector elements. The results are saturated to the element unsigned integer range.

The predicate size specifier may be omitted in assembler source code, but this is deprecated and will be prohibited in a future release of the architecture.



## SVE

UQINCP <Zdn>.<T>, <Pm>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer m = UInt(Pm);
integer dn = UInt(Zdn);
boolean unsigned = TRUE;
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Pm> Is the name of the source scalable predicate register, encoded in the "Pm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(PL) operand2 = P[m];
bits(VL) result;
integer count = 0;

for e = 0 to elements-1
    if ElemP[operand2, e, esize] == '1' then
        count = count + 1;

for e = 0 to elements-1
    integer element = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = Sat0(element + count, esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.



- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# UQINCW (scalar)

Unsigned saturating increment scalar by multiple of 32-bit predicate constraint element count.

Determines the number of active 32-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment the scalar destination. The result is saturated to the general-purpose register's unsigned integer range.

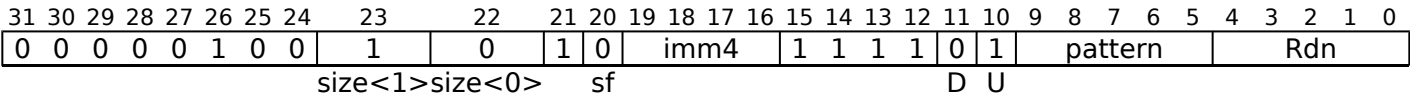
The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.

It has encodings from 2 classes: [32-bit](#) and [64-bit](#)

## 32-bit

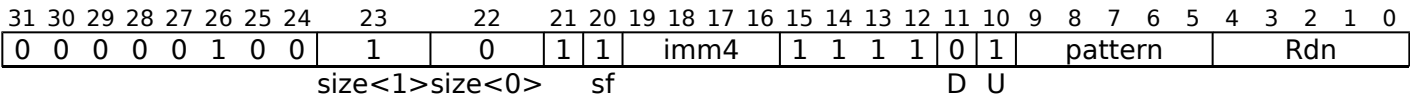


## 32-bit

UQINCW <Wdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 32;
```

## 64-bit



## 64-bit

UQINCW <Xdn>{, <pattern>{, MUL #<imm>}}

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Rdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
integer ssize = 64;
```

## Assembler Symbols

- <Wdn> Is the 32-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <Xdn> Is the 64-bit name of the source and destination general-purpose register, encoded in the "Rdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

<imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```

CheckSVEEnabled();
integer count = DecodePredCount(pat, esize);
bits(ssize) operand1 = X[dn];
bits(ssize) result;

integer element1 = Int(operand1, unsigned);
(result, -) = Sat0(element1 + (count * imm), ssize, unsigned);
X[dn] = Extend(result, 64, unsigned);

```

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UQINCW (vector)

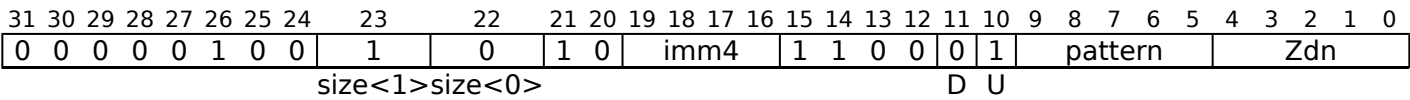
Unsigned saturating increment vector by multiple of 32-bit predicate constraint element count.

Determines the number of active 32-bit elements implied by the named predicate constraint, multiplies that by an immediate in the range 1 to 16 inclusive, and then uses the result to increment all destination vector elements. The results are saturated to the 32-bit unsigned integer range.

The named predicate constraint limits the number of active elements in a single predicate to:

- \* A fixed number (VL1 to VL256)
- \* The largest power of two (POW2)
- \* The largest multiple of three or four (MUL3 or MUL4)
- \* All available, implicitly a multiple of two (ALL).

Unspecified or out of range constraint encodings generate an empty predicate or zero element count rather than Undefined Instruction exception.



SVE

```
UQINCW <Zdn>.S{, <pattern>{, MUL #<imm>}}
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 32;
integer dn = UInt(Zdn);
bits(5) pat = pattern;
integer imm = UInt(imm4) + 1;
boolean unsigned = TRUE;
```

Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <pattern> Is the optional pattern specifier, defaulting to ALL, encoded in "pattern":

pattern	<pattern>
00000	POW2
00001	VL1
00010	VL2
00011	VL3
00100	VL4
00101	VL5
00110	VL6
00111	VL7
01000	VL8
01001	VL16
01010	VL32
01011	VL64
01100	VL128
01101	VL256
0111x	#uimm5
101x1	#uimm5
10110	#uimm5
1x0x1	#uimm5
1x010	#uimm5
1xx00	#uimm5
11101	MUL4
11110	MUL3
11111	ALL

- <imm> Is the immediate multiplier, in the range 1 to 16, defaulting to 1, encoded in the "imm4" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer count = DecodePredCount(pat, esize);
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 + (count * imm), esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# UQRSHL

Unsigned saturating rounding shift left by vector (predicated).

Shift active unsigned elements of the first source vector by corresponding elements of the second source vector and destructively place the rounded results in the corresponding elements of the first source vector. A positive shift amount performs a left shift, otherwise a right shift by the negated shift amount is performed. Each result element is saturated to the N-bit element's unsigned integer range 0 to (2<sup>N</sup>)-1. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size	0	0	1	0	1	1	1	0	0	Pg	Zm				Zdn								
Q R N U																															

## SVE2

UQRSHL <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer m = UInt(Zm);
integer dn = UInt(Zdn);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element = UInt(Elem[operand1, e, esize]);
    integer shift = ShiftSat(SInt(Elem[operand2, e, esize]), esize);
    integer round_const = 1 << (-shift - 1); // 0 for left shift, 2^(n-1) for right shift
    if ElemP[mask, e, esize] == '1' then
        integer res = (element + round_const) << shift;
        Elem[result, e, esize] = UnsignedSat(res, esize);
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];
Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# UQRSHLR

Unsigned saturating rounding shift left reversed vectors (predicated).

Shift active unsigned elements of the second source vector by corresponding elements of the first source vector and destructively place the rounded results in the corresponding elements of the first source vector. A positive shift amount performs a left shift, otherwise a right shift by the negated shift amount is performed. Each result element is saturated to the N-bit element's unsigned integer range 0 to (2<sup>N</sup>)-1. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size	0	0	1	1	1	1	1	0	0	Pg				Zm				Zdn					
																Q				R				N				U			

## SVE2

UQRSHLR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer m = UInt(Zm);
integer dn = UInt(Zdn);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[m];
bits(VL) operand2 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element = UInt(Elem[operand1, e, esize]);
    integer shift = ShiftSat(SInt(Elem[operand2, e, esize]), esize);
    integer round_const = 1 << (-shift - 1); // 0 for left shift, 2^(n-1) for right shift
    if ElemP[mask, e, esize] == '1' then
        integer res = (element + round_const) << shift;
        Elem[result, e, esize] = UnsignedSat(res, esize);
    else
        Elem[result, e, esize] = Elem[operand2, e, esize];
Z[dn] = result;
```



## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

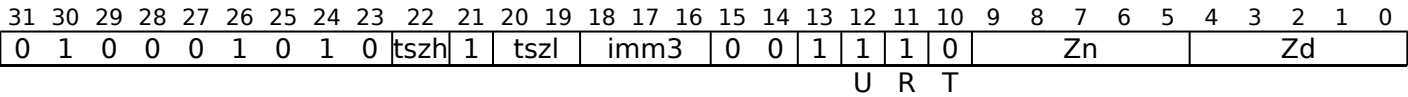
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UQRSHRNB

Unsigned saturating rounding shift right narrow by immediate (bottom).

Shift each unsigned integer value in the source vector elements right by an immediate value, and place the rounded results in the even-numbered half-width destination elements, while setting the odd-numbered elements to zero. Each result element is saturated to the half-width N-bit element's unsigned integer range 0 to (2<sup>N</sup>)-1. The immediate shift amount is an unsigned value in the range 1 to number of bits per element. This instruction is unpredicated.



SVE2

UQRSHRNB <Zd>.<T>, <Zn>.<Tb>, #<const>

```
if !HaveSVE2() then UNDEFINED;
bits(3) tsize = tszh:tszl;
case tsize of
    when '000' UNDEFINED;
    when '001' esize = 8;
    when '01x' esize = 16;
    when '1xx' esize = 32;
integer n = UInt(Zn);
integer d = UInt(Zd);
integer shift = (2 * esize) - UInt(tsize:imm3);
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
0	00	RESERVED
0	01	B
0	1x	H
1	xx	S

- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<Tb>
0	00	RESERVED
0	01	H
0	1x	S
1	xx	D

- <const> Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
bits(VL) operand = Z[n];
bits(VL) result;
integer round_const = 1 << (shift-1);

for e = 0 to elements-1
    bits(2*esize) element = Elem[operand, e, 2*esize];
    integer res = (UInt(element) + round_const) >> shift;
    Elem[result, 2*e + 0, esize] = UnsignedSat(res, esize);
    Elem[result, 2*e + 1, esize] = Zeros();

Z[d] = result;
```

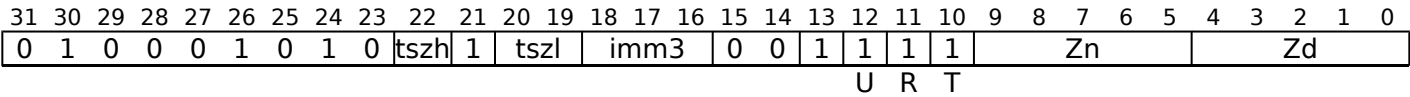
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# UQRSHRNT

Unsigned saturating rounding shift right narrow by immediate (top).

Shift each unsigned integer value in the source vector elements by an immediate value, and place the rounded results in the odd-numbered half-width destination elements, leaving the even-numbered elements unchanged. Each result element is saturated to the half-width N-bit element's unsigned integer range 0 to  $(2^N)-1$ . The immediate shift amount is an unsigned value in the range 1 to number of bits per element. This instruction is unpredicated.



## SVE2

UQRSHRNT <Zd>.<T>, <Zn>.<Tb>, #<const>

```
if !HaveSVE2() then UNDEFINED;
bits(3) tsize = tszh:tszl;
case tsize of
    when '000' UNDEFINED;
    when '001' esize = 8;
    when '01x' esize = 16;
    when '1xx' esize = 32;
integer n = UInt(Zn);
integer d = UInt(Zd);
integer shift = (2 * esize) - UInt(tsize:imm3);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
0	00	RESERVED
0	01	B
0	1x	H
1	xx	S

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<Tb>
0	00	RESERVED
0	01	H
0	1x	S
1	xx	D

<const> Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
bits(VL) operand = Z[n];
bits(VL) result = Z[d];
integer round_const = 1 << (shift-1);

for e = 0 to elements-1
    bits(2*esize) element = Elem[operand, e, 2*esize];
    integer res = (UInt(element) + round_const) >> shift;
    Elem[result, 2*e + 1, esize] = UnsignedSat(res, esize);

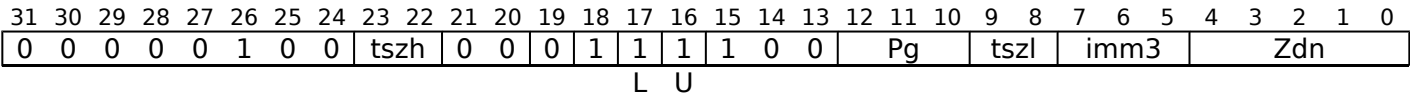
Z[d] = result;
```



# UQSHL (immediate)

Unsigned saturating shift left by immediate.

Shift left by immediate each active unsigned element of the source vector, and destructively place the results in the corresponding elements of the source vector. Each result element is saturated to the N-bit element's unsigned integer range 0 to (2<sup>N</sup>)-1. The immediate shift amount is an unsigned value in the range 0 to number of bits per element minus 1. Inactive elements in the destination vector register remain unmodified.



## SVE2

UQSHL <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, #<const>

```
if !HaveSVE2() then UNDEFINED;
bits(4) tsize = tszh:tszl;
case tsize of
    when '0000' UNDEFINED;
    when '0001' esize = 8;
    when '001x' esize = 16;
    when '01xx' esize = 32;
    when '1xxx' esize = 64;
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer shift = UInt(tsize:imm3) - esize;
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
00	00	RESERVED
00	01	B
00	1x	H
01	xx	S
1x	xx	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <const> Is the immediate shift amount, in the range 0 to number of bits per element minus 1, encoded in "tsz:imm3".

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(PL) mask = P[g];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, e, esize]);
    if ElemP[mask, e, esize] == '1' then
        integer res = element1 << shift;
        Elem[result, e, esize] = UnsignedSat(res, esize);
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# UQSHL (vectors)

Unsigned saturating shift left by vector (predicated).

Shift active unsigned elements of the first source vector by corresponding elements of the second source vector and destructively place the results in the corresponding elements of the first source vector. A positive shift amount performs a left shift, otherwise a right shift by the negated shift amount is performed. Each result element is saturated to the N-bit element's unsigned integer range 0 to (2<sup>N</sup>)-1. Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size	0	0	1	0	0	1	1	0	0	Pg	Zm				Zdn								
Q R N U																															

## SVE2

UQSHL <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer m = UInt(Zm);
integer dn = UInt(Zdn);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element = UInt(Elem[operand1, e, esize]);
    integer shift = ShiftSat(SInt(Elem[operand2, e, esize]), esize);
    if ElemP[mask, e, esize] == '1' then
        integer res = element << shift;
        Elem[result, e, esize] = UnsignedSat(res, esize);
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:



- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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# UQSHLR

Unsigned saturating shift left reversed vectors (predicated).

Shift active unsigned elements of the second source vector by corresponding elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. A positive shift amount performs a left shift, otherwise a right shift by the negated shift amount is performed. Each result element is saturated to the N-bit element's unsigned integer range 0 to  $(2^N)-1$ . Inactive elements in the destination vector register remain unmodified.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size	0	0	1	1	0	1	1	0	0	Pg	Zm				Zdn								
																Q R N U															

## SVE2

UQSHLR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer m = UInt(Zm);
integer dn = UInt(Zdn);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[m];
bits(VL) operand2 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element = UInt(Elem[operand1, e, esize]);
    integer shift = ShiftSat(SInt(Elem[operand2, e, esize]), esize);
    if ElemP[mask, e, esize] == '1' then
        integer res = element << shift;
        Elem[result, e, esize] = UnsignedSat(res, esize);
    else
        Elem[result, e, esize] = Elem[operand2, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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**UQSHRNT**

Unsigned saturating shift right narrow by immediate (top).

Shift each unsigned integer value in the source vector elements right by an immediate value, and place the truncated results in the odd-numbered half-width destination elements, leaving the even-numbered elements unchanged. Each result element is saturated to the half-width N-bit element's unsigned integer range 0 to  $(2^N)-1$ . The immediate shift amount is an unsigned value in the range 1 to number of bits per element. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0							
0	1	0	0	0	1	0	1	0	tszh	1	tszl	imm3			0		0	1	1	0	1	Zn				Zd												
U																					R		T															

## SVE2

UQSHRNT <Zd>.<T>, <Zn>.<Tb>, #<const>

```

if !HaveSVE2() then UNDEFINED;
bits(3) tsize = tszh:tszl;
case tsize of
  when '000' UNDEFINED;
  when '001' esize = 8;
  when '01x' esize = 16;
  when '1xx' esize = 32;
integer n = UInt(Zn);
integer d = UInt(Zd);
integer shift = (2 * esize) - UInt(tsize:imm3);

```

## Assembler Symbols

**<Zd>** Is the name of the destination scalable vector register, encoded in the "Zd" field.

**<T>** Is the size specifier, encoded in “tszh:tszl”:

tszh	tszl	<T>
0	00	RESERVED
0	01	B
0	1x	H
1	xx	S

<b>&lt;Zn&gt;</b>	Is the name of the first source scalable vector register, encoded in the "Zn" field.
-------------------	--

**<Tb>** Is the size specifier, encoded in “tszh:tszl”:

tszh	tszl	<Tb>
0	00	RESERVED
0	01	H
0	1x	S
1	xx	D

**<const>** Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    bits(2*esize) element = Elem[operand, e, 2*esize];
    integer res = UInt(element) >> shift;
    Elem[result, 2*e + 1, esize] = UnsignedSat(res, esize);

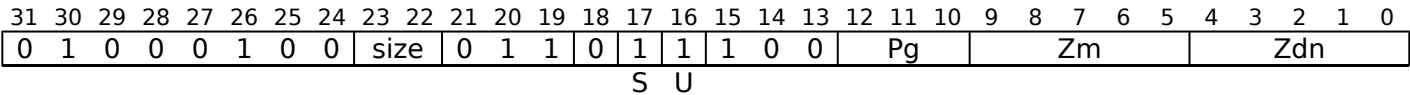
Z[d] = result;
```



# UQSUB (vectors, predicated)

Unsigned saturating subtraction (predicated).

Subtract active unsigned elements of the second source vector from corresponding unsigned elements of the first source vector and destructively place the results in the corresponding elements of the first source vector. Each result element is saturated to the N-bit element's unsigned integer range 0 to (2<sup>N</sup>)-1. Inactive elements in the destination vector register remain unmodified.



## SVE2

UQSUB <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean unsigned = TRUE;
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, e, esize]);
    if ElemP[mask, e, esize] == '1' then
        integer res = UInt(Sat(element1 - element2, esize, unsigned));
        Elem[result, e, esize] = res<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:



- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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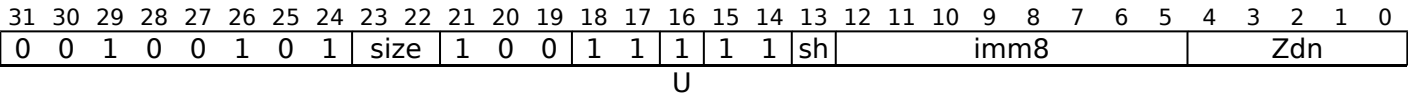
# UQSUB (immediate)

Unsigned saturating subtract immediate (unpredicated).

Unsigned saturating subtract an unsigned immediate from each element of the source vector, and destructively place the results in the corresponding elements of the source vector. Each result element is saturated to the N-bit element's unsigned integer range 0 to (2<sup>N</sup>)-1. This instruction is unpredicated.

The immediate is an unsigned value in the range 0 to 255, and for element widths of 16 bits or higher it may also be a positive multiple of 256 in the range 256 to 65280.

The immediate is encoded in 8 bits with an optional left shift by 8. The preferred disassembly when the shift option is specified is "#<uimm8>, LSL #8". However an assembler and disassembler may also allow use of the shifted 16-bit value unless the immediate is 0 and the shift amount is 8, which must be unambiguously described as "#0, LSL #8".



## SVE

UQSUB <Zdn>.<T>, <Zdn>.<T>, #<imm>{, <shift>}

```
if !HaveSVE() then UNDEFINED;
if size:sh == '001' then UNDEFINED;
integer esize = 8 << UInt(size);
integer dn = UInt(Zdn);
integer imm = UInt(imm8);
if sh == '1' then imm = imm << 8;
boolean unsigned = TRUE;
```

## Assembler Symbols

- <Zdn> Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <imm> Is an unsigned immediate in the range 0 to 255, encoded in the "imm8" field.
- <shift> Is the optional left shift to apply to the immediate, defaulting to LSL #0 and encoded in "sh":

sh	<shift>
0	LSL #0
1	LSL #8

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 - imm, esize, unsigned);

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

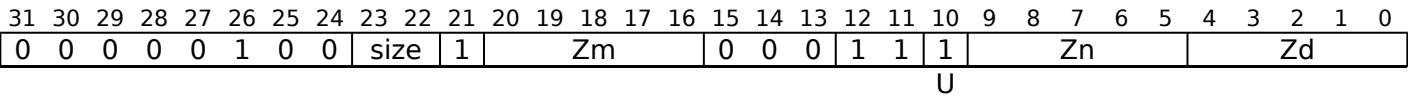
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UQSUB (vectors, unpredicated)

Unsigned saturating subtract vectors (unpredicated).

Unsigned saturating subtract all elements of the second source vector from corresponding elements of the first source vector and place the results in the corresponding elements of the destination vector. Each result element is saturated to the N-bit element's unsigned integer range 0 to (2<sup>N</sup>)-1. This instruction is unpredicated.



SVE

UQSUB <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
boolean unsigned = TRUE;
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

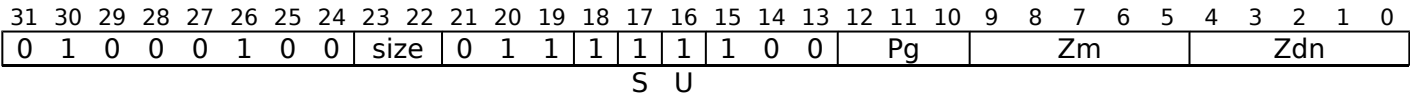
for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, e, esize], unsigned);
    integer element2 = Int(Elem[operand2, e, esize], unsigned);
    (Elem[result, e, esize], -) = SatQ(element1 - element2, esize, unsigned);

Z[d] = result;
```

# UQSUBR

Unsigned saturating subtraction reversed vectors (predicated).

Subtract active unsigned elements of the first source vector from corresponding unsigned elements of the second source vector and destructively place the results in the corresponding elements of the first source vector. Each result element is saturated to the N-bit element's unsigned integer range 0 to (2<sup>N</sup>)-1. Inactive elements in the destination vector register remain unmodified.



## SVE2

UQSUBR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
boolean unsigned = TRUE;
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, e, esize]);
    if ElemP[mask, e, esize] == '1' then
        integer res = UInt(Sat(element2 - element1, esize, unsigned));
        Elem[result, e, esize] = res<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

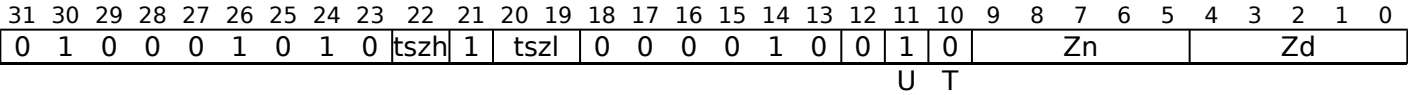
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UQXTNB

Unsigned saturating extract narrow (bottom).

Saturate the unsigned integer value in each source element to half the original source element width, and place the results in the even-numbered half-width destination elements, while setting the odd-numbered elements to zero.



SVE2

UQXTNB <Zd>.<T>, <Zn>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
bits(3) tsize = tszh:tszl;
case tsize of
    when '001' esize = 16;
    when '010' esize = 32;
    when '100' esize = 64;
    otherwise UNDEFINED;
integer n = UInt(Zn);
integer d = UInt(Zd);
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
0	00	RESERVED
0	01	B
0	10	H
x	11	RESERVED
1	00	S
1	01	RESERVED
1	10	RESERVED

- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<Tb>
0	00	RESERVED
0	01	H
0	10	S
x	11	RESERVED
1	00	D
1	01	RESERVED
1	10	RESERVED

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) result;
integer halfesize = esize DIV 2;

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, e, esize]);
    bits(halfesize) res = UnsignedSat(element1, halfesize);
    Elem[result, 2*e + 0, halfesize] = res;
    Elem[result, 2*e + 1, halfesize] = Zeros();

Z[d] = result;
```

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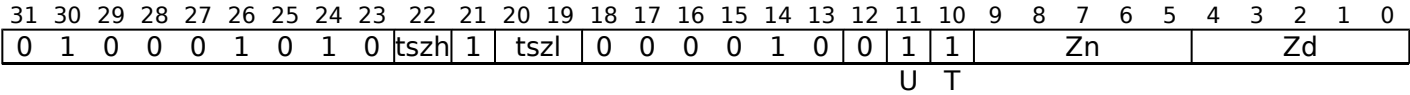
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UQXTNT

Unsigned saturating extract narrow (top).

Saturate the unsigned integer value in each source element to half the original source element width, and place the results in the odd-numbered half-width destination elements, leaving the even-numbered elements unchanged.



SVE2

UQXTNT <Zd>.<T>, <Zn>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
bits(3) tsize = tszh:tszl;
case tsize of
    when '001' esize = 16;
    when '010' esize = 32;
    when '100' esize = 64;
    otherwise UNDEFINED;
integer n = UInt(Zn);
integer d = UInt(Zd);
```

Assembler Symbols

- <Zd>Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T>Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
0	00	RESERVED
0	01	B
0	10	H
x	11	RESERVED
1	00	S
1	01	RESERVED
1	10	RESERVED

- <Zn>Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Tb>Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<Tb>
0	00	RESERVED
0	01	H
0	10	S
x	11	RESERVED
1	00	D
1	01	RESERVED
1	10	RESERVED

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) result = Z[d];
integer halfesize = esize DIV 2;

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, e, esize]);
    bits(halfesize) res = UnsignedSat(element1, halfesize);
    Elem[result, 2*e + 1, halfesize] = res;

Z[d] = result;
```

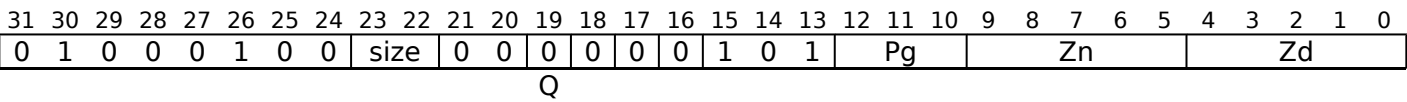
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URECPE

Unsigned reciprocal estimate (predicated).

Find the approximate reciprocal of each active unsigned element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.



SVE2

URECPE <Zd>.S, <Pg>/M, <Zn>.S

```
if !HaveSVE2() then UNDEFINED;
if size != '10' then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    bits(esize) element = Elem[operand, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = UnsignedRecipEstimate(element);

Z[d] = result;
```

Operational information

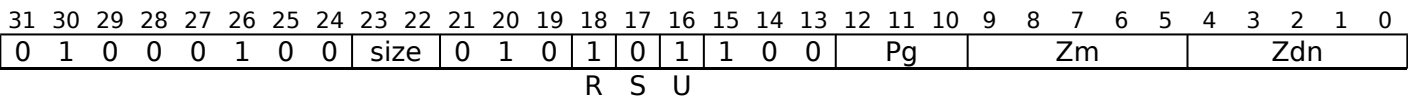
This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

# URHADD

Unsigned rounding halving addition.

Add active unsigned elements of the first source vector to corresponding unsigned elements of the second source vector, shift right one bit, and destructively place the rounded results in the corresponding elements of the first source vector. Inactive elements in the destination vector register remain unmodified.



## SVE2

URHADD <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;
integer round_const = 1;

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, e, esize]);
    if ElemP[mask, e, esize] == '1' then
        integer res = element1 + element2 + round_const;
        Elem[result, e, esize] = res<size:1>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

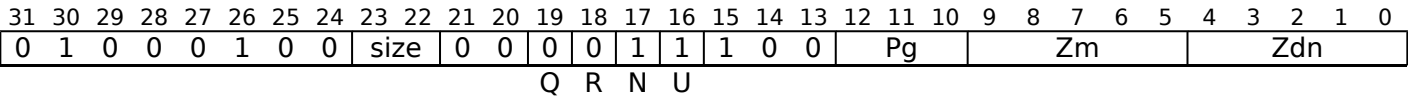
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URSHL

Unsigned rounding shift left by vector (predicated).

Shift active unsigned elements of the first source vector by corresponding elements of the second source vector and destructively place the rounded results in the corresponding elements of the first source vector. A positive shift amount performs a left shift, otherwise a right shift by the negated shift amount is performed. Inactive elements in the destination vector register remain unmodified.



SVE2

```
URSHL <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>
```

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer m = UInt(Zm);
integer dn = UInt(Zdn);
```

Assembler Symbols

- <Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element = UInt(Elem[operand1, e, esize]);
    integer shift = ShiftSat(SInt(Elem[operand2, e, esize]), esize);
    integer round_const = 1 << (-shift - 1); // 0 for left shift, 2^(n-1) for right shift
    if ElemP[mask, e, esize] == '1' then
        integer res = (element + round_const) << shift;
        Elem[result, e, esize] = res<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

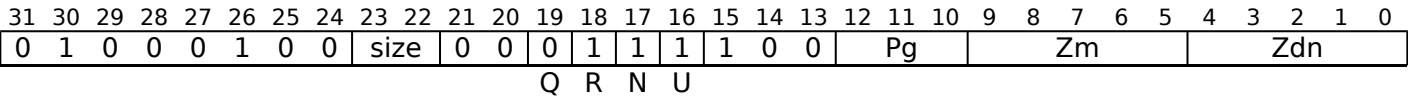
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# URSHLR

Unsigned rounding shift left reversed vectors (predicated).

Shift active unsigned elements of the second source vector by corresponding elements of the first source vector and destructively place the rounded results in the corresponding elements of the first source vector. A positive shift amount performs a left shift, otherwise a right shift by the negated shift amount is performed. Inactive elements in the destination vector register remain unmodified.



## SVE2

```
URSHLR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>
```

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer m = UInt(Zm);
integer dn = UInt(Zdn);
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[m];
bits(VL) operand2 = Z[dn];
bits(VL) result;

for e = 0 to elements-1
    integer element = UInt(Elem[operand1, e, esize]);
    integer shift = ShiftSat(SInt(Elem[operand2, e, esize]), esize);
    integer round_const = 1 << (-shift - 1); // 0 for left shift, 2^(n-1) for right shift
    if ElemP[mask, e, esize] == '1' then
        integer res = (element + round_const) << shift;
        Elem[result, e, esize] = res<esize-1:0>;
    else
        Elem[result, e, esize] = Elem[operand2, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:



- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

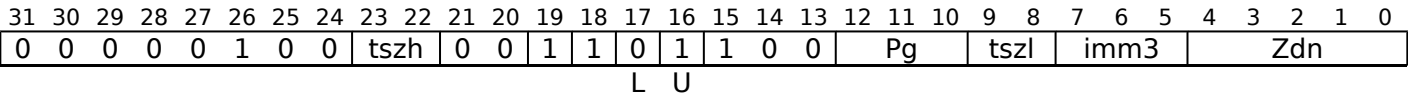
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URSHR

Unsigned rounding shift right by immediate.

Shift right by immediate each active unsigned element of the source vector, and destructively place the rounded results in the corresponding elements of the source vector. The immediate shift amount is an unsigned value in the range 1 to number of bits per element. Inactive elements in the destination vector register remain unmodified.



SVE2

```
URSHR <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, #<const>
```

```
if !HaveSVE2() then UNDEFINED;
bits(4) tsize = tszh:tszl;
case tsize of
  when '0000' UNDEFINED;
  when '0001' esize = 8;
  when '001x' esize = 16;
  when '01xx' esize = 32;
  when '1xxx' esize = 64;
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer shift = (2 * esize) - UInt(tsize:imm3);
```

Assembler Symbols

- <Zdn>

Is the name of the source and destination scalable vector register, encoded in the "Zdn" field.
- <T>

Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
00	00	RESERVED
00	01	B
00	1x	H
01	xx	S
1x	xx	D
- <Pg>

Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <const>

Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(PL) mask = P[g];
bits(VL) result;
integer round_const = 1 << (shift-1);

for e = 0 to elements-1
  integer element1 = UInt(Elem[operand1, e, esize]);
  if ElemP[mask, e, esize] == '1' then
    integer res = (element1 + round_const) >> shift;
    Elem[result, e, esize] = res<esize-1:0>;
  else
    Elem[result, e, esize] = Elem[operand1, e, esize];
Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a `MOVPRFX` instruction. The `MOVPRFX` instruction must conform to all of the following requirements, otherwise the behavior of the `MOVPRFX` and this instruction is UNPREDICTABLE:

- The `MOVPRFX` instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The `MOVPRFX` instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

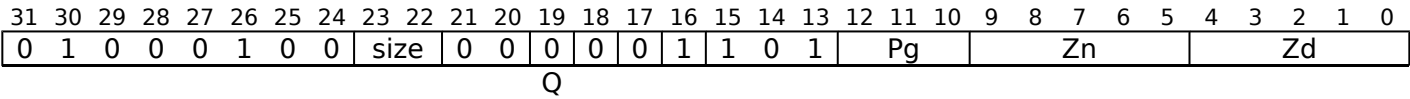
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# URSQRTE

Unsigned reciprocal square root estimate (predicated).

Find the approximate reciprocal square root of each active unsigned element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.



## SVE2

URSQRTE <Zd>.S, <Pg>/M, <Zn>.S

```
if !HaveSVE2() then UNDEFINED;
if size != '10' then UNDEFINED;
integer esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
```

## Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.
- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    bits(esize) element = Elem[operand, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = UnsignedRSqrtEstimate(element);

Z[d] = result;
```

## Operational information

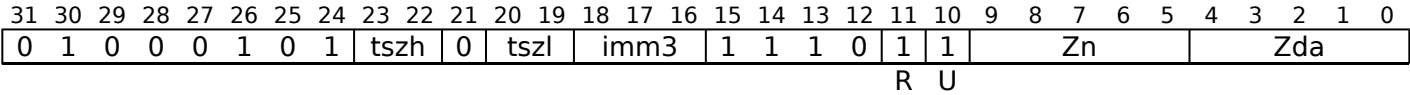
This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

URSRA

Unsigned rounding shift right and accumulate (immediate).

Shift right by immediate each unsigned element of the source vector, inserting zeroes, and add the rounded intermediate result destructively to the corresponding elements of the addend vector. The immediate shift amount is an unsigned value in the range 1 to number of bits per element. This instruction is unpredicated.



SVE2

```
URSRA <Zda>.<T>, <Zn>.<T>, #<const>
```

```
if !HaveSVE2() then UNDEFINED;
bits(4) tsize = tszh:tszl;
case tsize of
  when '0000' UNDEFINED;
  when '0001' esize = 8;
  when '001x' esize = 16;
  when '01xx' esize = 32;
  when '1xxx' esize = 64;
integer n = UInt(Zn);
integer da = UInt(Zda);
integer shift = (2 * esize) - UInt(tsize:imm3);
```

Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
00	00	RESERVED
00	01	B
00	1x	H
01	xx	S
1x	xx	D

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <const> Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[da];
bits(VL) result;
integer round_const = 1 << (shift - 1);

for e = 0 to elements-1
  integer element = (UInt(Elem[operand1, e, esize]) + round_const) >> shift;
  Elem[result, e, esize] = Elem[operand2, e, esize] + element<esize-1:0>;

Z[da] = result;
```

Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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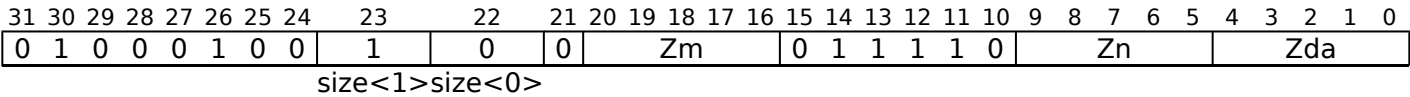
# USDOT (vectors)

Unsigned by signed integer dot product.

The unsigned by signed integer dot product instruction computes the dot product of a group of four unsigned 8-bit integer values held in each 32-bit element of the first source vector multiplied by a group of four signed 8-bit integer values in the corresponding 32-bit element of the second source vector, and then destructively adds the widened dot product to the corresponding 32-bit element of the destination vector.

This instruction is unpredicated.

ID\_AA64ZFR0\_EL1.I8MM indicates whether this instruction is implemented.



## SVE

USDOT <Zda>.S, <Zn>.B, <Zm>.B

```
if !HaveSVE() || !HaveInt8MatMulExt() then UNDEFINED;
integer esize = 32;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) res = Elem[operand3, e, esize];
    for i = 0 to 3
        integer element1 = UInt(Elem[operand1, 4 * e + i, esize DIV 4]);
        integer element2 = SInt(Elem[operand2, 4 * e + i, esize DIV 4]);
        res = res + element1 * element2;
    Elem[result, e, esize] = res;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

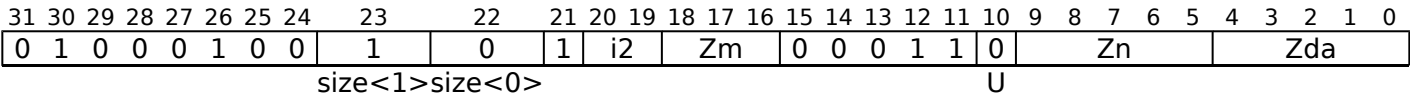
- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

# USDOT (indexed)

Unsigned by signed integer indexed dot product.

The unsigned by signed integer indexed dot product instruction computes the dot product of a group of four unsigned 8-bit integer values held in each 32-bit element of the first source vector multiplied by a group of four signed 8-bit integer values in an indexed 32-bit element of the second source vector, and then destructively adds the widened dot product to the corresponding 32-bit element of the destination vector.

The groups within the second source vector are specified using an immediate index which selects the same group position within each 128-bit vector segment. The index range is from 0 to 3. This instruction is unpredicated. ID\_AA64ZFR0\_EL1.I8MM indicates whether this instruction is implemented.



## SVE

USDOT <Zda>.S, <Zn>.B, <Zm>.B[<imm>]

```
if !HaveSVE() || !HaveInt8MatMulExt() then UNDEFINED;
integer esize = 32;
integer index = UInt(i2);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register Z0-Z7, encoded in the "Zm" field.
- <imm> Is the immediate index of a quadruplet of four 8-bit elements within each 128-bit vector segment, in the range 0 to 3, encoded in the "i2" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
integer eltsegment = 128 DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result;

for e = 0 to elements-1
    integer segmentbase = e - (e MOD eltsegment);
    integer s = segmentbase + index;
    bits(esize) res = Elem[operand3, e, esize];
    for i = 0 to 3
        integer element1 = UInt(Elem[operand1, 4 * e + i, esize DIV 4]);
        integer element2 = SInt(Elem[operand2, 4 * s + i, esize DIV 4]);
        res = res + element1 * element2;
    Elem[result, e, esize] = res;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:



- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

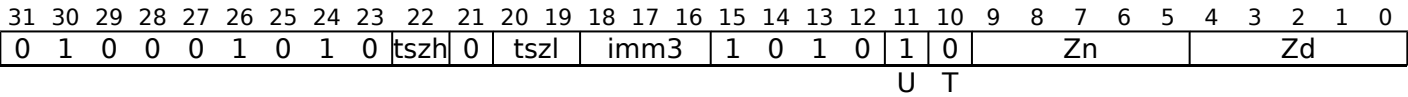
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USHLLB

Unsigned shift left long by immediate (bottom).

Shift left by immediate each even-numbered unsigned element of the source vector, and place the results in the overlapping double-width elements of the destination vector. The immediate shift amount is an unsigned value in the range 0 to number of bits per element minus 1. This instruction is unpredicated.



SVE2

```
USHLLB <Zd>.<T>, <Zn>.<Tb>, #<const>
```

```
if !HaveSVE2() then UNDEFINED;
bits(3) tsize = tszh:tszl;
case tsize of
  when '000' UNDEFINED;
  when '001' esize = 8;
  when '01x' esize = 16;
  when '1xx' esize = 32;
integer n = UInt(Zn);
integer d = UInt(Zd);
integer shift = UInt(tsize:imm3) - esize;
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
0	00	RESERVED
0	01	H
0	1x	S
1	xx	D

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<Tb>
0	00	RESERVED
0	01	B
0	1x	H
1	xx	S

<const> Is the immediate shift amount, in the range 0 to number of bits per element minus 1, encoded in "tsz:imm3".

Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
bits(VL) operand = Z[n];
bits(VL) result;

for e = 0 to elements-1
  bits(esize) element = Elem[operand, 2*e + 0, esize];
  integer shifted_value = UInt(element) << shift;
  Elem[result, e, 2*esize] = shifted_value<2*esize-1:0>;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

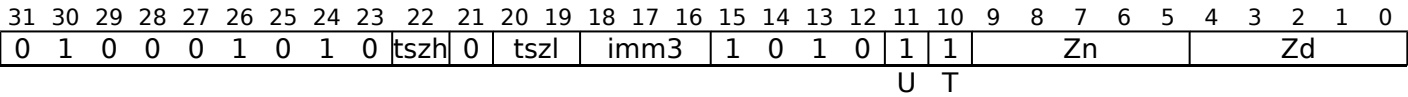
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USHLLT

Unsigned shift left long by immediate (top).

Shift left by immediate each odd-numbered unsigned element of the source vector, and place the results in the overlapping double-width elements of the destination vector. The immediate shift amount is an unsigned value in the range 0 to number of bits per element minus 1. This instruction is unpredicated.



SVE2

```
USHLLT <Zd>.<T>, <Zn>.<Tb>, #<const>
```

```
if !HaveSVE2() then UNDEFINED;
bits(3) tsize = tszh:tszl;
case tsize of
  when '000' UNDEFINED;
  when '001' esize = 8;
  when '01x' esize = 16;
  when '1xx' esize = 32;
integer n = UInt(Zn);
integer d = UInt(Zd);
integer shift = UInt(tsize:imm3) - esize;
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
0	00	RESERVED
0	01	H
0	1x	S
1	xx	D

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

<Tb> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<Tb>
0	00	RESERVED
0	01	B
0	1x	H
1	xx	S

<const> Is the immediate shift amount, in the range 0 to number of bits per element minus 1, encoded in "tsz:imm3".

Operation

```
CheckSVEEnabled();
integer elements = VL DIV (2 * esize);
bits(VL) operand = Z[n];
bits(VL) result;

for e = 0 to elements-1
  bits(esize) element = Elem[operand, 2*e + 1, esize];
  integer shifted_value = UInt(element) << shift;
  Elem[result, e, 2*esize] = shifted_value<2*esize-1:0>;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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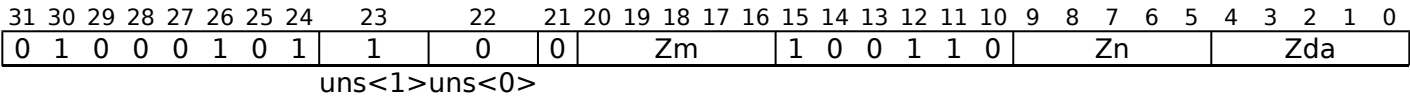
# USMMLA

Unsigned by signed integer matrix multiply-accumulate.

The unsigned by signed integer matrix multiply-accumulate instruction multiplies the 2×8 matrix of unsigned 8-bit integer values held in each 128-bit segment of the first source vector by the 8×2 matrix of signed 8-bit integer values in the corresponding segment of the second source vector. The resulting 2×2 widened 32-bit integer matrix product is then destructively added to the 32-bit integer matrix accumulator held in the corresponding segment of the addend and destination vector. This is equivalent to performing an 8-way dot product per destination element.

This instruction is unpredicated.

ID\_AA64ZFR0\_EL1.I8MM indicates whether this instruction is implemented.



## SVE

USMMLA <Zda>.S, <Zn>.B, <Zm>.B

```
if !HaveSVE() || !HaveInt8MatMulExt() then UNDEFINED;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer da = UInt(Zda);
boolean op1_unsigned = TRUE;
boolean op2_unsigned = FALSE;
```

## Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer segments = VL DIV 128;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) operand3 = Z[da];
bits(VL) result = Zeros();
bits(128) op1, op2;
bits(128) res, addend;

for s = 0 to segments-1
    op1 = Elem[operand1, s, 128];
    op2 = Elem[operand2, s, 128];
    addend = Elem[operand3, s, 128];
    res = MatMulAdd(addend, op1, op2, op1_unsigned, op2_unsigned);
    Elem[result, s, 128] = res;

Z[da] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

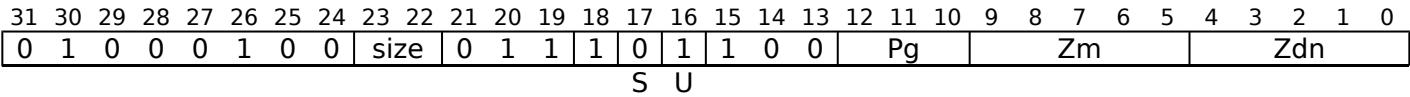
- The MOVPRFX instruction must be unpredicated.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.



# USQADD

Unsigned saturating addition of signed value.

Add active signed elements of the source vector to the corresponding unsigned elements of the addend vector, and destructively place the results in the corresponding elements of the addend vector. Each result element is saturated to the N-bit element's unsigned integer range 0 to (2<sup>N</sup>)-1. Inactive elements in the destination vector register remain unmodified.



## SVE2

USQADD <Zdn>.<T>, <Pg>/M, <Zdn>.<T>, <Zm>.<T>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer g = UInt(Pg);
integer dn = UInt(Zdn);
integer m = UInt(Zm);
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    bits(esize) element1 = Elem[operand1, e, esize];
    bits(esize) element2 = Elem[operand2, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = UnsignedSat(UInt(element1) + SInt(element2), esize);
    else
        Elem[result, e, esize] = Elem[operand1, e, esize];

Z[dn] = result;
```

## Operational information

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.



- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

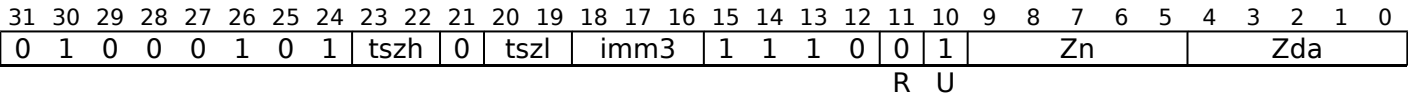
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USRA

Unsigned shift right and accumulate (immediate).

Shift right by immediate each unsigned element of the source vector, inserting zeroes, and add the truncated intermediate result destructively to the corresponding elements of the addend vector. The immediate shift amount is an unsigned value in the range 1 to number of bits per element. This instruction is unpredicated.



SVE2

```
USRA <Zda>.<T>, <Zn>.<T>, #<const>
```

```
if !HaveSVE2() then UNDEFINED;
bits(4) tsize = tszh:tszl;
case tsize of
  when '0000' UNDEFINED;
  when '0001' esize = 8;
  when '001x' esize = 16;
  when '01xx' esize = 32;
  when '1xxx' esize = 64;
integer n = UInt(Zn);
integer da = UInt(Zda);
integer shift = (2 * esize) - UInt(tsize:imm3);
```

Assembler Symbols

- <Zda> Is the name of the third source and destination scalable vector register, encoded in the "Zda" field.
- <T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
00	00	RESERVED
00	01	B
00	1x	H
01	xx	S
1x	xx	D

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <const> Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[da];
bits(VL) result;

for e = 0 to elements-1
  integer element = UInt(Elem[operand1, e, esize]) >> shift;
  Elem[result, e, esize] = Elem[operand2, e, esize] + element<esize-1:0>;

Z[da] = result;
```

Operational information

- If PSTATE.DIT is 1:
  - The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a **MOVPRFX** instruction. The **MOVPRFX** instruction must conform to all of the following requirements, otherwise the behavior of the **MOVPRFX** and this instruction is UNPREDICTABLE:

- The **MOVPRFX** instruction must be unpredicated.
- The **MOVPRFX** instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

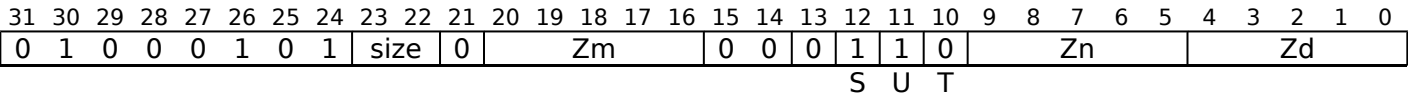
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USUBLB

Unsigned subtract long (bottom).

Subtract the even-numbered unsigned elements of the second source vector from the corresponding unsigned elements of the first source vector, and place the results in the overlapping double-width elements of the destination vector. This instruction is unpredicated.



SVE2

```
USUBLB <Zd>.<T>, <Zn>.<Tb>, <Zm>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer sel1 = 0;
integer sel2 = 0;
boolean unsigned = TRUE;
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, 2*e + sel1, esize DIV 2], unsigned);
    integer element2 = Int(Elem[operand2, 2*e + sel2, esize DIV 2], unsigned);
    integer res = element1 - element2;
    Elem[result, e, esize] = res<esize-1:0>;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

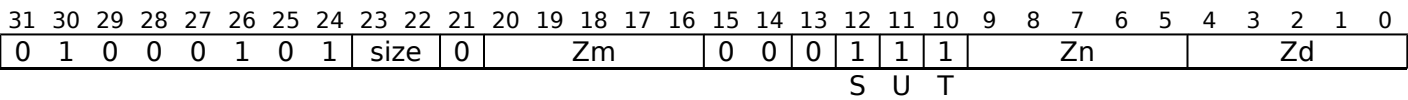
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USUBLT

Unsigned subtract long (top).

Subtract the odd-numbered unsigned elements of the second source vector from the corresponding unsigned elements of the first source vector, and place the results in the overlapping double-width elements of the destination vector. This instruction is unpredicated.



SVE2

```
USUBLT <Zd>.<T>, <Zn>.<Tb>, <Zm>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer sel1 = 1;
integer sel2 = 1;
boolean unsigned = TRUE;
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = Int(Elem[operand1, 2*e + sel1, esize DIV 2], unsigned);
    integer element2 = Int(Elem[operand2, 2*e + sel2, esize DIV 2], unsigned);
    integer res = element1 - element2;
    Elem[result, e, esize] = res<esize-1:0>;

Z[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

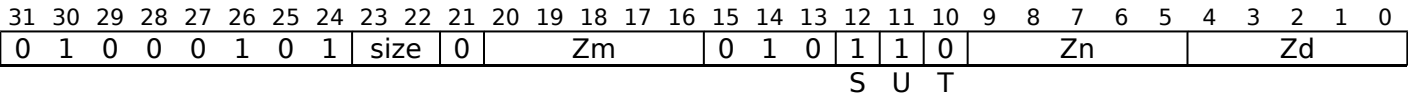
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# USUBWB

Unsigned subtract wide (bottom).

Subtract the even-numbered unsigned elements of the second source vector from the overlapping double-width elements of the first source vector and place the results in the corresponding double-width elements of the destination vector. This instruction is unpredicated.



## SVE2

USUBWB <Zd>.<T>, <Zn>.<T>, <Zm>.<Tb>

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

## Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, 2*e + 0, esize DIV 2]);
    Elem[result, e, esize] = (element1 - element2)<esize-1:0>;

Z[d] = result;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:



- The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

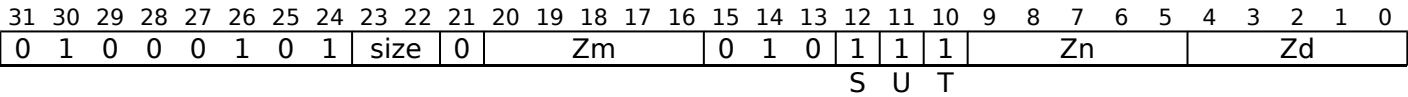
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USUBWT

Unsigned subtract wide (top).

Subtract the odd-numbered unsigned elements of the second source vector from the overlapping double-width elements of the first source vector and place the results in the corresponding double-width elements of the destination vector. This instruction is unpredicated. This instruction is unpredicated.



SVE2

```
USUBWT <Zd>.<T>, <Zn>.<T>, <Zm>.<Tb>
```

```
if !HaveSVE2() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

<Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

<Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
    integer element1 = UInt(Elem[operand1, e, esize]);
    integer element2 = UInt(Elem[operand2, 2*e + 1, esize DIV 2]);
    Elem[result, e, esize] = (element1 - element2)<esize-1:0>;

Z[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:

- The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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UUNPKHI, UUNPKLO

Unsigned unpack and extend half of vector.

Unpack elements from the lowest or highest half of the source vector and then zero-extend them to place in elements of twice their size within the destination vector. This instruction is unpredicated.

It has encodings from 2 classes: [High half](#) and [Low half](#)

High half

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	1	0	0	1	1	0	0	1	1	1	0	Zn				Zd						
														U	H																

High half

UUNPKHI <Zd>.<T>, <Zn>.<Tb>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean unsigned = TRUE;
boolean hi = TRUE;
```

Low half

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	1	0	0	1	0	0	0	1	1	1	0	Zn				Zd						
														U	H																

Low half

UUNPKLO <Zd>.<T>, <Zn>.<Tb>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean unsigned = TRUE;
boolean hi = FALSE;
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

- <Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.
- <Tb> Is the size specifier, encoded in "size":

size	<Tb>
00	RESERVED
01	B
10	H
11	S

## Operation

```

CheckSVEEnabled();
integer elements = VL DIV esize;
integer hsize = esize DIV 2;
bits(VL) operand = Z[n];
bits(VL) result;

for e = 0 to elements-1
    bits(hsize) element = if hi then Elem[operand, e + elements, hsize] else Elem[operand, e, hsize];
    Elem[result, e, esize] = Extend(element, esize, unsigned);

Z[d] = result;

```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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UXTB, UXTH, UXTW

Unsigned byte / halfword / word extend (predicated).

Zero-extend the least-significant sub-element of each active element of the source vector, and place the results in the corresponding elements of the destination vector. Inactive elements in the destination vector register remain unmodified.

It has encodings from 3 classes: [Byte](#) , [Halfword](#) and [Word](#)

Byte

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	0	0	0	0	1	1	0	1	Pg												
																U															

Byte

UXTB <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size == '00' then UNDEFINED;
integer esize = 8 << UInt(size);
integer s_esize = 8;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean unsigned = TRUE;
```

Halfword

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	0	0	1	1	1	0	1	Pg													
																U															

Halfword

UXTH <Zd>.<T>, <Pg>/M, <Zn>.<T>

```
if !HaveSVE() then UNDEFINED;
if size != '1x' then UNDEFINED;
integer esize = 8 << UInt(size);
integer s_esize = 16;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean unsigned = TRUE;
```

Word

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	0	1	0	1	1	0	1	Pg													
																U															

Word

```
UXTW <Zd>.D, <Pg>/M, <Zn>.D
```

```
if !HaveSVE() then UNDEFINED;
if size != '11' then UNDEFINED;
integer esize = 8 << UInt(size);
integer s_esize = 32;
integer g = UInt(Pg);
integer n = UInt(Zn);
integer d = UInt(Zd);
boolean unsigned = TRUE;
```

Assembler Symbols

<Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.

<T> For the byte variant: is the size specifier, encoded in "size":

size	<T>
00	RESERVED
01	H
10	S
11	D

For the halfword variant: is the size specifier, encoded in "size<0>":

size<0>	<T>
0	S
1	D

<Pg> Is the name of the governing scalable predicate register P0-P7, encoded in the "Pg" field.

<Zn> Is the name of the source scalable vector register, encoded in the "Zn" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = P[g];
bits(VL) operand = Z[n];
bits(VL) result = Z[d];

for e = 0 to elements-1
    bits(esize) element = Elem[operand, e, esize];
    if ElemP[mask, e, esize] == '1' then
        Elem[result, e, esize] = Extend(element<s_esize-1:0>, esize, unsigned);

Z[d] = result;
```

Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its operand registers when its governing predicate register contains the same value for each execution.
  - The values of the NZCV flags.

This instruction might be immediately preceded in program order by a MOVPRFX instruction. The MOVPRFX instruction must conform to all of the following requirements, otherwise the behavior of the MOVPRFX and this instruction is UNPREDICTABLE:

- The MOVPRFX instruction must be unpredicated, or be predicated using the same governing predicate register and source element size as this instruction.
- The MOVPRFX instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.





UZP1, UZP2 (predicates)

Concatenate even or odd elements from two predicates.

Concatenate adjacent even or odd-numbered elements from the first and second source predicates and place in elements of the destination predicate. This instruction is unpredicated.

It has encodings from 2 classes: [Even](#) and [Odd](#)

Even

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size		1	0	Pm				0	1	0	0	1	0	0	Pn				0	Pd			
H																															

Even

UZP1 [<Pd>.<T>](#), [<Pn>.<T>](#), [<Pm>.<T>](#)

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
integer part = 0;
```

Odd

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size		1	0	Pm				0	1	0	0	1	1	0	Pn				0	Pd			
H																															

Odd

UZP2 [<Pd>.<T>](#), [<Pn>.<T>](#), [<Pm>.<T>](#)

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
integer part = 1;
```

Assembler Symbols

- <Pd>

Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <Pn>

Is the name of the first source scalable predicate register, encoded in the "Pn" field.
- <Pm>

Is the name of the second source scalable predicate register, encoded in the "Pm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) operand1 = P[n];
bits(PL) operand2 = P[m];
bits(PL) result;

bits(PL*2) zipped = operand2:operand1;
for e = 0 to elements-1
    Elem[result, e, esize DIV 8] = Elem[zipped, 2*e+part, esize DIV 8];

P[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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# UZP1, UZP2 (vectors)

Concatenate even or odd elements from two vectors.

Concatenate adjacent even or odd-numbered elements from the first and second source vectors and place in elements of the destination vector. This instruction is unpredicated. The 128-bit element variant of this instruction requires that the current vector length is at least 256 bits, and if the current vector length is not an integer multiple of 256 bits then the trailing bits are set to zero.

ID\_AA64ZFR0\_EL1.F64MM indicates whether the 128-bit element variant of the instruction is implemented.

It has encodings from 4 classes: [Even](#) , [Even \(quadwords\)](#) , [Odd](#) and [Odd \(quadwords\)](#)

## Even

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size		1	Zm				0	1	1	0	1	0	Zn				Zd						
H																															

## Even

UZP1 <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer part = 0;
```

## Even (quadwords)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	0	0	0	0	1	0	1	1	0	1	Zm				0	0	0	0	1	0	Zn				Zd							
																					H											

## Even (quadwords)

UZP1 <Zd>.Q, <Zn>.Q, <Zm>.Q

```
if !HaveSVEFP64MatMulExt() then UNDEFINED;
integer esize = 128;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer part = 0;
```

## Odd

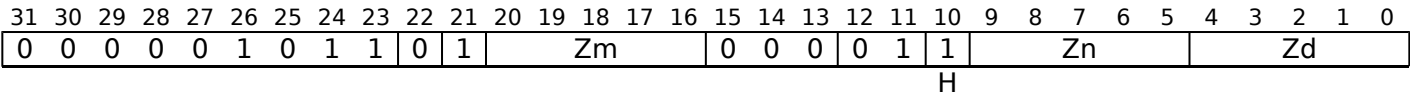
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	0	0	0	0	1	0	1	size		1	Zm				0	1	1	0	1	1	Zn				Zd							
																					H											

## Odd

UZP2 <Zd>.<T>, <Zn>.<T>, <Zm>.<T>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer part = 1;
```

Odd (quadwords)



Odd (quadwords)

```
UZP2 <Zd>.Q, <Zn>.Q, <Zm>.Q

if !HaveSVEFP64MatMulExt() then UNDEFINED;
integer esize = 128;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer part = 1;
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
if VL < esize * 2 then UNDEFINED;
integer elements = VL DIV esize;
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Zeros();

bits(VL*2) zipped = operand2:operand1;
for e = 0 to elements-1
    Elem[result, e, esize] = Elem[zipped, 2*e+part, esize];

Z[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

WHILEGE

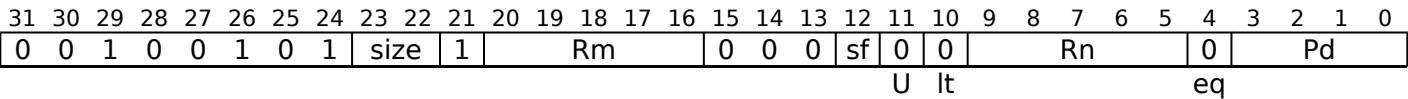
While decrementing signed scalar greater than or equal to scalar.

Generate a predicate that starting from the highest numbered element is true while the decrementing value of the first, signed scalar operand is greater than or equal to the second scalar operand and false thereafter down to the lowest numbered element.

If the second scalar operand is equal to the minimum signed integer value then a condition which includes an equality test can never fail and the result will be an all-true predicate.

The full width of the scalar operands is significant for the purposes of comparison, and the full width first operand is decremented by one for each destination predicate element, irrespective of the predicate result element size. The first general-purpose source register is not itself updated.

The predicate result is placed in the predicate destination register. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.



SVE2

WHILEGE <Pd>.<T>, <R><n>, <R><m>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer rsize = 32 << UInt(sf);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Pd);
boolean unsigned = FALSE;
SVEComp op = Cmp_GE;
```

Assembler Symbols

- <Pd>

Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <R>

Is a width specifier, encoded in "sf":

sf	<R>
0	W
1	X
- <n>

Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rn" field.
- <m>

Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = Ones(PL);
bits(rsize) operand1 = X[n];
bits(rsize) operand2 = X[m];
bits(PL) result;
boolean last = TRUE;

for e = elements-1 downto 0
    boolean cond;
    case op of
        when Cmp_GT cond = (Int(operand1, unsigned) > Int(operand2, unsigned));
        when Cmp_GE cond = (Int(operand1, unsigned) >= Int(operand2, unsigned));

    last = last && cond;
    ElemP[result, e, esize] = if last then '1' else '0';
    operand1 = operand1 - 1;

PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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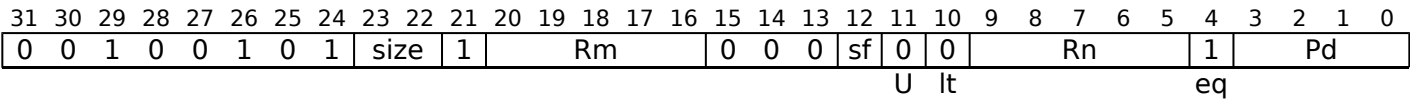
# WHILEGT

While decrementing signed scalar greater than scalar.

Generate a predicate that starting from the highest numbered element is true while the decrementing value of the first, signed scalar operand is greater than the second scalar operand and false thereafter down to the lowest numbered element.

The full width of the scalar operands is significant for the purposes of comparison, and the full width first operand is decremented by one for each destination predicate element, irrespective of the predicate result element size. The first general-purpose source register is not itself updated.

The predicate result is placed in the predicate destination register. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.



## SVE2

WHILEGT <Pd>.<T>, <R><n>, <R><m>

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer rsize = 32 << UInt(sf);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Pd);
boolean unsigned = FALSE;
SVEComp op = Cmp_GT;
```

## Assembler Symbols

- <Pd>

Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <R>

Is a width specifier, encoded in "sf":

sf	<R>
0	W
1	X
- <n>

Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rn" field.
- <m>

Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = Ones(PL);
bits(rsize) operand1 = X[n];
bits(rsize) operand2 = X[m];
bits(PL) result;
boolean last = TRUE;

for e = elements-1 downto 0
    boolean cond;
    case op of
        when Cmp_GT cond = (Int(operand1, unsigned) > Int(operand2, unsigned));
        when Cmp_GE cond = (Int(operand1, unsigned) >= Int(operand2, unsigned));

    last = last && cond;
    ElemP[result, e, esize] = if last then '1' else '0';
    operand1 = operand1 - 1;

PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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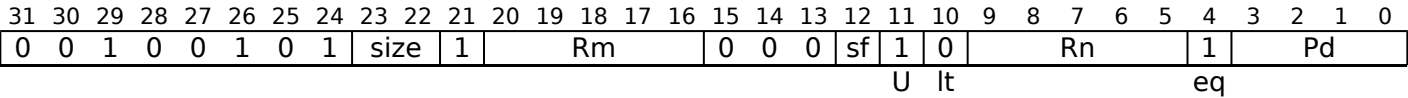
WHILEHI

While decrementing unsigned scalar higher than scalar.

Generate a predicate that starting from the highest numbered element is true while the decrementing value of the first, unsigned scalar operand is higher than the second scalar operand and false thereafter down to the lowest numbered element.

The full width of the scalar operands is significant for the purposes of comparison, and the full width first operand is decremented by one for each destination predicate element, irrespective of the predicate result element size. The first general-purpose source register is not itself updated.

The predicate result is placed in the predicate destination register. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.



SVE2

```
WHILEHI <Pd>.<T>, <R><n>, <R><m>
```

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer rsize = 32 << UInt(sf);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Pd);
boolean unsigned = TRUE;
SVECmp op = Cmp_GT;
```

Assembler Symbols

- <Pd>

Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <R>

Is a width specifier, encoded in "sf":

sf	<R>
0	W
1	X
- <n>

Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rn" field.
- <m>

Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = Ones(PL);
bits(rsize) operand1 = X[n];
bits(rsize) operand2 = X[m];
bits(PL) result;
boolean last = TRUE;

for e = elements-1 downto 0
    boolean cond;
    case op of
        when Cmp_GT cond = (Int(operand1, unsigned) > Int(operand2, unsigned));
        when Cmp_GE cond = (Int(operand1, unsigned) >= Int(operand2, unsigned));

    last = last && cond;
    ElemP[result, e, esize] = if last then '1' else '0';
    operand1 = operand1 - 1;

PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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WHILEHS

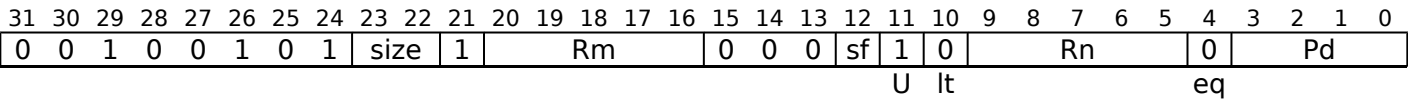
While decrementing unsigned scalar higher or same as scalar.

Generate a predicate that starting from the highest numbered element is true while the decrementing value of the first, unsigned scalar operand is higher or same as the second scalar operand and false thereafter down to the lowest numbered element.

If the second scalar operand is equal to the minimum unsigned integer value then a condition which includes an equality test can never fail and the result will be an all-true predicate.

The full width of the scalar operands is significant for the purposes of comparison, and the full width first operand is decremented by one for each destination predicate element, irrespective of the predicate result element size. The first general-purpose source register is not itself updated.

The predicate result is placed in the predicate destination register. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.



SVE2

```
WHILEHS <Pd>.<T>, <R><n>, <R><m>
```

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer rsize = 32 << UInt(sf);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Pd);
boolean unsigned = TRUE;
SVECmp op = Cmp_GE;
```

Assembler Symbols

- <Pd>

Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <R>

Is a width specifier, encoded in "sf":

sf	<R>
0	W
1	X
- <n>

Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rn" field.
- <m>

Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = Ones(PL);
bits(rsize) operand1 = X[n];
bits(rsize) operand2 = X[m];
bits(PL) result;
boolean last = TRUE;

for e = elements-1 downto 0
    boolean cond;
    case op of
        when Cmp_GT cond = (Int(operand1, unsigned) > Int(operand2, unsigned));
        when Cmp_GE cond = (Int(operand1, unsigned) >= Int(operand2, unsigned));

    last = last && cond;
    ElemP[result, e, esize] = if last then '1' else '0';
    operand1 = operand1 - 1;

PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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WHILELE

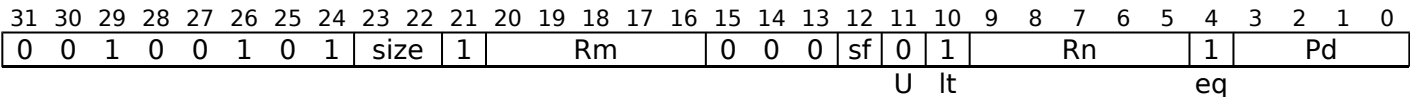
While incrementing signed scalar less than or equal to scalar.

Generate a predicate that starting from the lowest numbered element is true while the incrementing value of the first, signed scalar operand is less than or equal to the second scalar operand and false thereafter up to the highest numbered element.

If the second scalar operand is equal to the maximum signed integer value then a condition which includes an equality test can never fail and the result will be an all-true predicate.

The full width of the scalar operands is significant for the purposes of comparison, and the full width first operand is incremented by one for each destination predicate element, irrespective of the predicate result element size. The first general-purpose source register is not itself updated.

The predicate result is placed in the predicate destination register. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.



SVE

WHILELE <Pd>.<T>, <R><n>, <R><m>

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer rsize = 32 << UInt(sf);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Pd);
boolean unsigned = FALSE;
SVEComp op = Cmp_LE;
```

Assembler Symbols

- <Pd>

Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <R>

Is a width specifier, encoded in "sf":

sf	<R>
0	W
1	X
- <n>

Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rn" field.
- <m>

Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = Ones(PL);
bits(rsize) operand1 = X[n];
bits(rsize) operand2 = X[m];
bits(PL) result;
boolean last = TRUE;

for e = 0 to elements-1
    boolean cond;
    case op of
        when Cmp_LT cond = (Int(operand1, unsigned) < Int(operand2, unsigned));
        when Cmp_LE cond = (Int(operand1, unsigned) <= Int(operand2, unsigned));

    last = last && cond;
    ElemP[result, e, esize] = if last then '1' else '0';
    operand1 = operand1 + 1;

PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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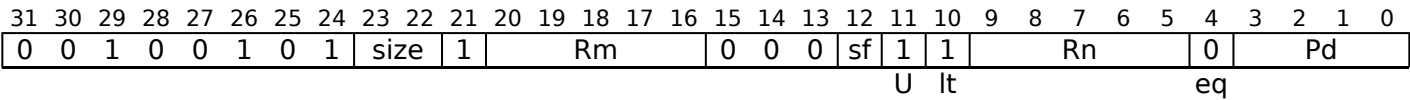
WHILELO

While incrementing unsigned scalar lower than scalar.

Generate a predicate that starting from the lowest numbered element is true while the incrementing value of the first, unsigned scalar operand is lower than the second scalar operand and false thereafter up to the highest numbered element.

The full width of the scalar operands is significant for the purposes of comparison, and the full width first operand is incremented by one for each destination predicate element, irrespective of the predicate result element size. The first general-purpose source register is not itself updated.

The predicate result is placed in the predicate destination register. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.



SVE

```
WHILELO <Pd>.<T>, <R><n>, <R><m>
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer rsize = 32 << UInt(sf);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Pd);
boolean unsigned = TRUE;
SVEComp op = Cmp_LT;
```

Assembler Symbols

- <Pd>

Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <R>

Is a width specifier, encoded in "sf":

sf	<R>
0	W
1	X
- <n>

Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rn" field.
- <m>

Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = Ones(PL);
bits(rsize) operand1 = X[n];
bits(rsize) operand2 = X[m];
bits(PL) result;
boolean last = TRUE;

for e = 0 to elements-1
    boolean cond;
    case op of
        when Cmp_LT cond = (Int(operand1, unsigned) < Int(operand2, unsigned));
        when Cmp_LE cond = (Int(operand1, unsigned) <= Int(operand2, unsigned));

    last = last && cond;
    ElemP[result, e, esize] = if last then '1' else '0';
    operand1 = operand1 + 1;

PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

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WHILELS

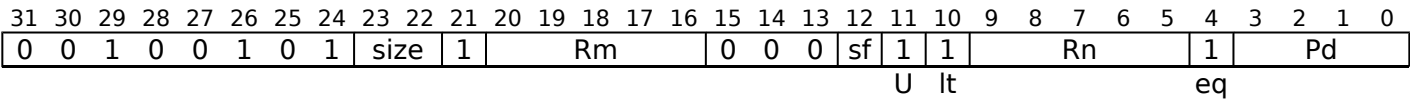
While incrementing unsigned scalar lower or same as scalar.

Generate a predicate that starting from the lowest numbered element is true while the incrementing value of the first, unsigned scalar operand is lower or same as the second scalar operand and false thereafter up to the highest numbered element.

If the second scalar operand is equal to the maximum unsigned integer value then a condition which includes an equality test can never fail and the result will be an all-true predicate.

The full width of the scalar operands is significant for the purposes of comparison, and the full width first operand is incremented by one for each destination predicate element, irrespective of the predicate result element size. The first general-purpose source register is not itself updated.

The predicate result is placed in the predicate destination register. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.



SVE

```
WHILELS <Pd>.<T>, <R><n>, <R><m>
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer rsize = 32 << UInt(sf);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Pd);
boolean unsigned = TRUE;
SVECmp op = Cmp_LE;
```

Assembler Symbols

- <Pd>

Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <R>

Is a width specifier, encoded in "sf":

sf	<R>
0	W
1	X
- <n>

Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rn" field.
- <m>

Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = Ones(PL);
bits(rsize) operand1 = X[n];
bits(rsize) operand2 = X[m];
bits(PL) result;
boolean last = TRUE;

for e = 0 to elements-1
    boolean cond;
    case op of
        when Cmp_LT cond = (Int(operand1, unsigned) < Int(operand2, unsigned));
        when Cmp_LE cond = (Int(operand1, unsigned) <= Int(operand2, unsigned));

    last = last && cond;
    ElemP[result, e, esize] = if last then '1' else '0';
    operand1 = operand1 + 1;

PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

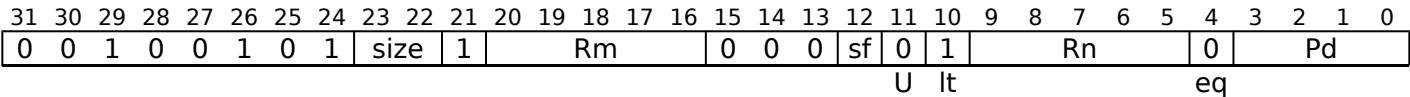
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WHILELT

While incrementing signed scalar less than scalar.

Generate a predicate that starting from the lowest numbered element is true while the incrementing value of the first, signed scalar operand is less than the second scalar operand and false thereafter up to the highest numbered element. The full width of the scalar operands is significant for the purposes of comparison, and the full width first operand is incremented by one for each destination predicate element, irrespective of the predicate result element size. The first general-purpose source register is not itself updated. The predicate result is placed in the predicate destination register. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.



SVE

```
WHILELT <Pd>.<T>, <R><n>, <R><m>
```

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer rsize = 32 << UInt(sf);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Pd);
boolean unsigned = FALSE;
SVEComp op = Cmp_LT;
```

Assembler Symbols

- <Pd>

Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <R>

Is a width specifier, encoded in "sf":

sf	<R>
0	W
1	X
- <n>

Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rn" field.
- <m>

Is the number [0-30] of the source general-purpose register or the name ZR (31), encoded in the "Rm" field.

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = Ones(PL);
bits(rsize) operand1 = X[n];
bits(rsize) operand2 = X[m];
bits(PL) result;
boolean last = TRUE;

for e = 0 to elements-1
    boolean cond;
    case op of
        when Cmp_LT cond = (Int(operand1, unsigned) < Int(operand2, unsigned));
        when Cmp_LE cond = (Int(operand1, unsigned) <= Int(operand2, unsigned));

    last = last && cond;
    ElemP[result, e, esize] = if last then '1' else '0';
    operand1 = operand1 + 1;

PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

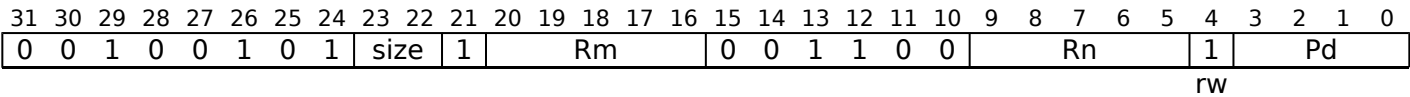
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WHILERW

While free of read-after-write conflicts.

This instruction checks two addresses for a conflict or overlap between address ranges of the form [addr,addr+VL÷8), where VL is the accessible vector length in bits, that could result in a loop-carried dependency through memory due to the use of these addresses by contiguous load and store instructions within the same iteration of a loop. Generate a predicate whose elements are true while the addresses cannot conflict within the same iteration, and false thereafter. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.



SVE2

```
WHILERW <Pd>.<T>, <Xn>, <Xm>
```

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Pd);
```

Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <Xn> Is the 64-bit name of the first source general-purpose register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second source general-purpose register, encoded in the "Rm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = Ones(PL);
bits(64) src1 = X[n];
bits(64) src2 = X[m];
integer operand1 = UInt(src1);
integer operand2 = UInt(src2);
bits(PL) result;

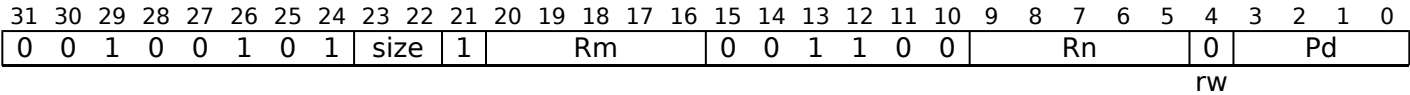
integer diff = Abs(operand2 - operand1) DIV (esize DIV 8);
for e = 0 to elements-1
  if diff == 0 || e < diff then
    ElemP[result, e, esize] = '1';
  else
    ElemP[result, e, esize] = '0';

PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

WHILEWR

While free of write-after-read/write conflicts.

This instruction checks two addresses for a conflict or overlap between address ranges of the form [addr,addr+VL÷8), where VL is the accessible vector length in bits, that could result in a loop-carried dependency through memory due to the use of these addresses by contiguous load and store instructions within the same iteration of a loop. Generate a predicate whose elements are true while the addresses cannot conflict within the same iteration, and false thereafter. Sets the FIRST (N), NONE (Z), !LAST (C) condition flags based on the predicate result, and the V flag to zero.



SVE2

```
WHILEWR <Pd>.<T>, <Xn>, <Xm>
```

```
if !HaveSVE2() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Rn);
integer m = UInt(Rm);
integer d = UInt(Pd);
```

Assembler Symbols

- <Pd> Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <Xn> Is the 64-bit name of the first source general-purpose register, encoded in the "Rn" field.
- <Xm> Is the 64-bit name of the second source general-purpose register, encoded in the "Rm" field.

Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(PL) mask = Ones(PL);
bits(64) src1 = X[n];
bits(64) src2 = X[m];
integer operand1 = UInt(src1);
integer operand2 = UInt(src2);
bits(PL) result;

integer diff = (operand2 - operand1) DIV (esize DIV 8);
for e = 0 to elements-1
  if diff <= 0 || e < diff then
    ElemP[result, e, esize] = '1';
  else
    ElemP[result, e, esize] = '0';

PSTATE.<N,Z,C,V> = PredTest(mask, result, esize);
P[d] = result;
```

# WRFFR

Write the first-fault register.

Read the source predicate register and place in the first-fault register (FFR). This instruction is intended to restore a saved FFR and is not recommended for general use by applications.

This instruction requires that the source predicate contains a MONOTONIC predicate value, in which starting from bit 0 there are zero or more 1 bits, followed only by 0 bits in any remaining bit positions. If the source is not a monotonic predicate value, then the resulting value in the FFR will be UNPREDICTABLE. It is not possible to generate a non-monotonic value in FFR when using SETFFR followed by first-fault or non-fault loads.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	0	1	0	1	0	0	0	1	0	0	1	0	0	0	Pn			0	0	0	0	0	

## SVE

WRFFR <Pn>.B

```
if !HaveSVE() then UNDEFINED;
integer n = UInt(Pn);
```

## Assembler Symbols

<Pn> Is the name of the source scalable predicate register, encoded in the "Pn" field.

## Operation

```
CheckSVEEnabled();
bits(PL) operand = P[n];

hsb = HighestSetBit(operand);
if hsb < 0 || IsOnes(operand<hsb:0>) then
    FFR[] = operand;
else // not a monotonic predicate
    FFR[] = bits(PL) UNKNOWN;
```

## Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

# XAR

Bitwise exclusive OR and rotate right by immediate.

Bitwise exclusive OR the corresponding elements of the first and second source vectors, then rotate each result element right by an immediate amount. The final results are destructively placed in the corresponding elements of the destination and first source vector. This instruction is unpredicated.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	tszh	1	tszl	imm3	0	0	1	1	0	1	Zm					Zdn								

## SVE2

XAR <Zdn>.<T>, <Zdn>.<T>, <Zm>.<T>, #<const>

```
if !HaveSVE2() then UNDEFINED;
bits(4) tsize = tszh:tszl;
case tsize of
  when '0000' UNDEFINED;
  when '0001' esize = 8;
  when '001x' esize = 16;
  when '01xx' esize = 32;
  when '1xxx' esize = 64;
integer m = UInt(Zm);
integer dn = UInt(Zdn);
integer rot = (2 * esize) - UInt(tsize:imm3);
```

## Assembler Symbols

<Zdn> Is the name of the first source and destination scalable vector register, encoded in the "Zdn" field.

<T> Is the size specifier, encoded in "tszh:tszl":

tszh	tszl	<T>
00	00	RESERVED
00	01	B
00	1x	H
01	xx	S
1x	xx	D

<Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

<const> Is the immediate shift amount, in the range 1 to number of bits per element, encoded in "tsz:imm3".

## Operation

```
CheckSVEEnabled();
integer elements = VL DIV esize;
bits(VL) operand1 = Z[dn];
bits(VL) operand2 = Z[m];
bits(VL) result;

for e = 0 to elements-1
  bits(esize) element1 = Elem[operand1, e, esize];
  bits(esize) element2 = Elem[operand2, e, esize];
  Elem[result, e, esize] = ROR(element1 EOR element2, rot);
Z[dn] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:



- The values of the data supplied in any of its registers.
- The values of the NZCV flags.

This instruction might be immediately preceded in program order by a **MOVPRFX** instruction. The **MOVPRFX** instruction must conform to all of the following requirements, otherwise the behavior of the **MOVPRFX** and this instruction is UNPREDICTABLE:

- The **MOVPRFX** instruction must be unpredicated.
- The **MOVPRFX** instruction must specify the same destination register as this instruction.
- The destination register must not refer to architectural register state referenced by any other source operand register of this instruction.

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## ZIP1, ZIP2 (predicates)

Interleave elements from two half predicates.

Interleave alternating elements from the lowest or highest halves of the first and second source predicates and place in elements of the destination predicate. This instruction is unpredicated.

It has encodings from 2 classes: [High halves](#) and [Low halves](#)

### High halves

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	Pm				0	1	0	0	0	1	0	Pn				0	Pd				
																								H							

### High halves

ZIP2 [<Pd>.<T>](#), [<Pn>.<T>](#), [<Pm>.<T>](#)

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
integer part = 1;
```

### Low halves

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	Pm				0	1	0	0	0	0	0	Pn				0	Pd				
																								H							

### Low halves

ZIP1 [<Pd>.<T>](#), [<Pn>.<T>](#), [<Pm>.<T>](#)

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Pn);
integer m = UInt(Pm);
integer d = UInt(Pd);
integer part = 0;
```

## Assembler Symbols

- <Pd>

Is the name of the destination scalable predicate register, encoded in the "Pd" field.
- <T>

Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D
- <Pn>

Is the name of the first source scalable predicate register, encoded in the "Pn" field.
- <Pm>

Is the name of the second source scalable predicate register, encoded in the "Pm" field.

## Operation

```
CheckSVEEnabled();
integer pairs = VL DIV (esize * 2);
bits(PL) operand1 = P[n];
bits(PL) operand2 = P[m];
bits(PL) result;

integer base = part * pairs;
for p = 0 to pairs-1
    Elem[result, 2*p+0, esize DIV 8] = Elem[operand1, base+p, esize DIV 8];
    Elem[result, 2*p+1, esize DIV 8] = Elem[operand2, base+p, esize DIV 8];

P[d] = result;
```

## Operational information

If PSTATE.DIT is 1:

- The execution time of this instruction is independent of:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.
- The response of this instruction to asynchronous exceptions does not vary based on:
  - The values of the data supplied in any of its registers.
  - The values of the NZCV flags.

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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## ZIP1, ZIP2 (vectors)

Interleave elements from two half vectors.

Interleave alternating elements from the lowest or highest halves of the first and second source vectors and place in elements of the destination vector. This instruction is unpredicated. The 128-bit element variant of this instruction requires that the current vector length is at least 256 bits, and if the current vector length is not an integer multiple of 256 bits then the trailing bits are set to zero.

ID\_AA64ZFR0\_EL1.F64MM indicates whether the 128-bit element variant of the instruction is implemented.

It has encodings from 4 classes: [High halves](#) , [High halves \(quadwords\)](#) , [Low halves](#) and [Low halves \(quadwords\)](#)

### High halves

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0						
0	0	0	0	0	1	0	1	size	1	Zm						0	1	1	0	0	1	Zn						Zd									
																						H															

### High halves

ZIP2 [<Zd>.<T>](#), [<Zn>.<T>](#), [<Zm>.<T>](#)

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer part = 1;
```

### High halves (quadwords)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0						
0	0	0	0	0	1	0	1	1	0	1	Zm					0	0	0	0	0	1	Zn					Zd										
																						H															

### High halves (quadwords)

ZIP2 [<Zd>.Q](#), [<Zn>.Q](#), [<Zm>.Q](#)

```
if !HaveSVEFP64MatMulExt() then UNDEFINED;
integer esize = 128;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer part = 1;
```

### Low halves

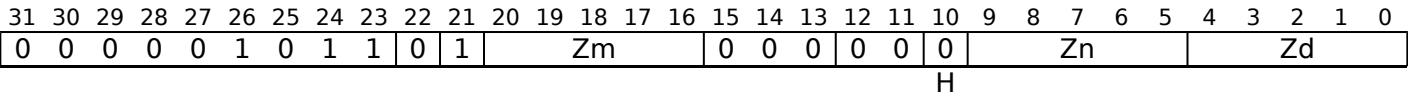
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	Zm			0	1	1	0	0	0	Zn			Zd									
																						H									

### Low halves

ZIP1 [<Zd>.<T>](#), [<Zn>.<T>](#), [<Zm>.<T>](#)

```
if !HaveSVE() then UNDEFINED;
integer esize = 8 << UInt(size);
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer part = 0;
```

Low halves (quadwords)



Low halves (quadwords)

```
ZIP1 <Zd>.Q, <Zn>.Q, <Zm>.Q

if !HaveSVEFP64MatMulExt() then UNDEFINED;
integer esize = 128;
integer n = UInt(Zn);
integer m = UInt(Zm);
integer d = UInt(Zd);
integer part = 0;
```

Assembler Symbols

- <Zd> Is the name of the destination scalable vector register, encoded in the "Zd" field.
- <T> Is the size specifier, encoded in "size":

size	<T>
00	B
01	H
10	S
11	D

- <Zn> Is the name of the first source scalable vector register, encoded in the "Zn" field.
- <Zm> Is the name of the second source scalable vector register, encoded in the "Zm" field.

Operation

```
CheckSVEEnabled();
if VL < esize * 2 then UNDEFINED;
integer pairs = VL DIV (esize * 2);
bits(VL) operand1 = Z[n];
bits(VL) operand2 = Z[m];
bits(VL) result = Zeros();

integer base = part * pairs;
for p = 0 to pairs-1
    Elem[result, 2*p+0, esize] = Elem[operand1, base+p, esize];
    Elem[result, 2*p+1, esize] = Elem[operand2, base+p, esize];

Z[d] = result;
```

Operational information

- If PSTATE.DIT is 1:
- The execution time of this instruction is independent of:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.
  - The response of this instruction to asynchronous exceptions does not vary based on:
    - The values of the data supplied in any of its registers.
    - The values of the NZCV flags.

## Top-level encodings for A64

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
op0																															

Decode fields op0	Instruction details
0000	<a href="#">Reserved</a>
0001	UNALLOCATED
0010	<a href="#">SVE encodings</a>
0011	UNALLOCATED
100x	<a href="#">Data Processing -- Immediate</a>
101x	<a href="#">Branches, Exception Generating and System instructions</a>
x1x0	<a href="#">Loads and Stores</a>
x101	<a href="#">Data Processing -- Register</a>
x111	<a href="#">Data Processing -- Scalar Floating-Point and Advanced SIMD</a>

### Reserved

These instructions are under the [top-level](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
op0						0000						op1																			

Decode fields op0	Decode fields op1	Instruction details
000	000000000	<a href="#">UDF</a>
	!= 000000000	UNALLOCATED
!= 000		UNALLOCATED

### SVE encodings

These instructions are under the [top-level](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
op0						0010						op1				op2				op3											

Decode fields op0	Decode fields op1	Decode fields op2	Decode fields op3	Instruction details
000	0x	0xxxx	x1xxxx	<a href="#">SVE Integer Multiply-Add - Predicated</a>
000	0x	0xxxx	000xxx	<a href="#">SVE Integer Binary Arithmetic - Predicated</a>
000	0x	0xxxx	001xxx	<a href="#">SVE Integer Reduction</a>
000	0x	0xxxx	100xxx	<a href="#">SVE Bitwise Shift - Predicated</a>
000	0x	0xxxx	101xxx	<a href="#">SVE Integer Unary Arithmetic - Predicated</a>
000	0x	1xxxx	000xxx	<a href="#">SVE integer add/subtract vectors (unpredicated)</a>
000	0x	1xxxx	001xxx	<a href="#">SVE Bitwise Logical - Unpredicated</a>
000	0x	1xxxx	0100xx	<a href="#">SVE Index Generation</a>
000	0x	1xxxx	0101xx	<a href="#">SVE Stack Allocation</a>
000	0x	1xxxx	011xxx	<a href="#">SVE2 Integer Multiply - Unpredicated</a>
000	0x	1xxxx	100xxx	<a href="#">SVE Bitwise Shift - Unpredicated</a>
000	0x	1xxxx	1010xx	<a href="#">SVE address generation</a>
000	0x	1xxxx	1011xx	<a href="#">SVE Integer Misc - Unpredicated</a>

000	0x	1xxxx	11xxxx	<a href="#">SVE Element Count</a>
000	1x	00xxx		<a href="#">SVE Bitwise Immediate</a>
000	1x	01xxx		<a href="#">SVE Integer Wide Immediate - Predicated</a>
000	1x	1xxxx	001xxx	<a href="#">SVE Permute Vector - Unpredicated</a>
000	1x	1xxxx	010xxx	<a href="#">SVE Permute Predicate</a>
000	1x	1xxxx	011xxx	<a href="#">SVE permute vector elements</a>
000	1x	1xxxx	10xxxx	<a href="#">SVE Permute Vector - Predicated</a>
000	1x	1xxxx	11xxxx	<a href="#">SEL (vectors)</a>
000	10	1xxxx	000xxx	<a href="#">SVE Permute Vector - Extract</a>
000	11	1xxxx	000xxx	<a href="#">SVE permute vector segments</a>
001	0x	0xxxx		<a href="#">SVE Integer Compare - Vectors</a>
001	0x	1xxxx		<a href="#">SVE integer compare with unsigned immediate</a>
001	1x	0xxxx	x0xxxx	<a href="#">SVE integer compare with signed immediate</a>
001	1x	00xxx	01xxxx	<a href="#">SVE predicate logical operations</a>
001	1x	00xxx	11xxxx	<a href="#">SVE Propagate Break</a>
001	1x	01xxx	01xxxx	<a href="#">SVE Partition Break</a>
001	1x	01xxx	11xxxx	<a href="#">SVE Predicate Misc</a>
001	1x	1xxxx	00xxxx	<a href="#">SVE Integer Compare - Scalars</a>
001	1x	1xxxx	01xxxx	UNALLOCATED
001	1x	1xxxx	11xxxx	<a href="#">SVE Integer Wide Immediate - Unpredicated</a>
001	1x	100xx	10xxxx	<a href="#">SVE predicate count</a>
001	1x	101xx	1000xx	<a href="#">SVE Inc/Dec by Predicate Count</a>
001	1x	101xx	1001xx	<a href="#">SVE Write FFR</a>
001	1x	101xx	101xxx	UNALLOCATED
001	1x	11xxx	10xxxx	UNALLOCATED
010	0x	0xxxx	0xxxxx	<a href="#">SVE Integer Multiply-Add - Unpredicated</a>
010	0x	0xxxx	10xxxx	<a href="#">SVE2 Integer - Predicated</a>
010	0x	0xxxx	11xxxx	UNALLOCATED
010	0x	1xxxx		<a href="#">SVE Multiply - Indexed</a>
010	1x	0xxxx	0xxxxx	<a href="#">SVE2 Widening Integer Arithmetic</a>
010	1x	0xxxx	10xxxx	<a href="#">SVE Misc</a>
010	1x	0xxxx	11xxxx	<a href="#">SVE2 Accumulate</a>
010	1x	1xxxx	0xxxxx	<a href="#">SVE2 Narrowing</a>
010	1x	1xxxx	100xxx	<a href="#">SVE2 character match</a>
010	1x	1xxxx	101xxx	<a href="#">SVE2 Histogram Computation - Segment</a>
010	1x	1xxxx	110xxx	<a href="#">HISTCNT</a>
010	1x	1xxxx	111xxx	<a href="#">SVE2 Crypto Extensions</a>
011	0x	0xxxx	0xxxxx	<a href="#">FCMLA (vectors)</a>
011	0x	00x1x	1xxxxx	UNALLOCATED
011	0x	00000	100xxx	<a href="#">FCADD</a>
011	0x	00000	101xxx	UNALLOCATED
011	0x	00000	11xxxx	UNALLOCATED
011	0x	00001	1xxxxx	UNALLOCATED
011	0x	0010x	100xxx	UNALLOCATED
011	0x	0010x	101xxx	<a href="#">SVE floating-point convert precision odd elements</a>
011	0x	0010x	11xxxx	UNALLOCATED
011	0x	010xx	100xxx	<a href="#">SVE2 floating-point pairwise operations</a>
011	0x	010xx	101xxx	UNALLOCATED
011	0x	010xx	11xxxx	UNALLOCATED

011	0x	011xx	1xxxxx	UNALLOCATED
011	0x	1xxxx	x0x01x	UNALLOCATED
011	0x	1xxxx	00000x	<a href="#">SVE floating-point multiply-add (indexed)</a>
011	0x	1xxxx	0001xx	<a href="#">SVE floating-point complex multiply-add (indexed)</a>
011	0x	1xxxx	001000	<a href="#">SVE floating-point multiply (indexed)</a>
011	0x	1xxxx	001001	UNALLOCATED
011	0x	1xxxx	0011xx	UNALLOCATED
011	0x	1xxxx	01x0xx	<a href="#">SVE Floating Point Widening Multiply-Add - Indexed</a>
011	0x	1xxxx	01x1xx	UNALLOCATED
011	0x	1xxxx	10x00x	<a href="#">SVE Floating Point Widening Multiply-Add</a>
011	0x	1xxxx	10x1xx	UNALLOCATED
011	0x	1xxxx	110xxx	UNALLOCATED
011	0x	1xxxx	111000	UNALLOCATED
011	0x	1xxxx	111001	<a href="#">SVE floating point matrix multiply accumulate</a>
011	0x	1xxxx	11101x	UNALLOCATED
011	0x	1xxxx	1111xx	UNALLOCATED
011	1x	0xxxx	x1xxxx	<a href="#">SVE floating-point compare vectors</a>
011	1x	0xxxx	000xxx	<a href="#">SVE floating-point arithmetic (unpredicated)</a>
011	1x	0xxxx	100xxx	<a href="#">SVE Floating Point Arithmetic - Predicated</a>
011	1x	0xxxx	101xxx	<a href="#">SVE Floating Point Unary Operations - Predicated</a>
011	1x	000xx	001xxx	<a href="#">SVE floating-point recursive reduction</a>
011	1x	001xx	0010xx	UNALLOCATED
011	1x	001xx	0011xx	<a href="#">SVE Floating Point Unary Operations - Unpredicated</a>
011	1x	010xx	001xxx	<a href="#">SVE Floating Point Compare - with Zero</a>
011	1x	011xx	001xxx	<a href="#">SVE floating-point serial reduction (predicated)</a>
011	1x	1xxxx		<a href="#">SVE Floating Point Multiply-Add</a>
100				<a href="#">SVE Memory - 32-bit Gather and Unsized Contiguous</a>
101				<a href="#">SVE Memory - Contiguous Load</a>
110				<a href="#">SVE Memory - 64-bit Gather</a>
111			0x0xxx	<a href="#">SVE Memory - Contiguous Store and Unsized Contiguous</a>
111			0x1xxx	<a href="#">SVE Memory - Non-temporal and Multi-register Store</a>
111			1x0xxx	<a href="#">SVE Memory - Scatter with Optional Sign Extend</a>
111			101xxx	<a href="#">SVE Memory - Scatter</a>
111			111xxx	<a href="#">SVE Memory - Contiguous Store with Immediate Offset</a>

## SVE Integer Multiply-Add - Predicated

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00000100										0	op0						1														

Decode fields  
op0

Instruction details

0	<a href="#">SVE integer multiply-accumulate writing addend (predicated)</a>
1	<a href="#">SVE integer multiply-add writing multiplicand (predicated)</a>

## SVE integer multiply-accumulate writing addend (predicated)

These instructions are under [SVE Integer Multiply-Add - Predicated](#).



31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0				Zm		0	1	op		Pg					Zn					Zda		

Decode fields op	Instruction Details
0	<a href="#">MLA (vectors)</a>
1	<a href="#">MLS (vectors)</a>

### SVE integer multiply-add writing multiplicand (predicated)

These instructions are under [SVE Integer Multiply-Add - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0				Zm		1	1	op		Pg					Za					Zdn		

Decode fields op	Instruction Details
0	<a href="#">MAD</a>
1	<a href="#">MSB</a>

### SVE Integer Binary Arithmetic - Predicated

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
										0		op0							000												

Decode fields op0	Instruction details
00x	<a href="#">SVE integer add/subtract vectors (predicated)</a>
01x	<a href="#">SVE integer min/max/difference (predicated)</a>
100	<a href="#">SVE integer multiply vectors (predicated)</a>
101	<a href="#">SVE integer divide vectors (predicated)</a>
11x	<a href="#">SVE bitwise logical operations (predicated)</a>

### SVE integer add/subtract vectors (predicated)

These instructions are under [SVE Integer Binary Arithmetic - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	0	0		opc		0	0	0		Pg					Zm					Zdn		

Decode fields opc	Instruction Details
000	<a href="#">ADD (vectors, predicated)</a>
001	<a href="#">SUB (vectors, predicated)</a>
010	UNALLOCATED
011	<a href="#">SUBR (vectors)</a>
1xx	UNALLOCATED

### SVE integer min/max/difference (predicated)

These instructions are under [SVE Integer Binary Arithmetic - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	0	1		opc	U	0	0	0		Pg					Zm					Zdn		

Decode fields opc	U	Instruction Details
00	0	<a href="#">SMAX (vectors)</a>
00	1	<a href="#">UMAX (vectors)</a>
01	0	<a href="#">SMIN (vectors)</a>
01	1	<a href="#">UMIN (vectors)</a>
10	0	<a href="#">SABD</a>
10	1	<a href="#">UABD</a>
11		UNALLOCATED

### SVE integer multiply vectors (predicated)

These instructions are under [SVE Integer Binary Arithmetic - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	0	0	H	U	0	0	0		Pg					Zm					Zdn		

Decode fields H	U	Instruction Details
0	0	<a href="#">MUL (vectors, predicated)</a>
0	1	UNALLOCATED
1	0	<a href="#">SMULH (predicated)</a>
1	1	<a href="#">UMULH (predicated)</a>

### SVE integer divide vectors (predicated)

These instructions are under [SVE Integer Binary Arithmetic - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	0	1	R	U	0	0	0		Pg					Zm					Zdn		

Decode fields R	U	Instruction Details
0	0	<a href="#">SDIV</a>
0	1	<a href="#">UDIV</a>
1	0	<a href="#">SDIVR</a>
1	1	<a href="#">UDIVR</a>

### SVE bitwise logical operations (predicated)

These instructions are under [SVE Integer Binary Arithmetic - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1		opc			0	0	0		Pg					Zm				Zdn		

Decode fields opc	Instruction Details
000	<a href="#">ORR (vectors, predicated)</a>
001	<a href="#">EOR (vectors, predicated)</a>
010	<a href="#">AND (vectors, predicated)</a>
011	<a href="#">BIC (vectors, predicated)</a>
1xx	UNALLOCATED

## SVE Integer Reduction

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00000100									0	op0						001															

Decode fields op0	Instruction details
00	<a href="#">SVE integer add reduction (predicated)</a>
01	<a href="#">SVE integer min/max reduction (predicated)</a>
10	<a href="#">SVE constructive prefix (predicated)</a>
11	<a href="#">SVE bitwise logical reduction (predicated)</a>

### SVE integer add reduction (predicated)

These instructions are under [SVE Integer Reduction](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	0	0	opc	U	0	0	1			Pg											Vd	

Decode fields opc	U	Instruction Details
00	0	<a href="#">SADDV</a>
00	1	<a href="#">UADDV</a>
01		UNALLOCATED
1x		UNALLOCATED

### SVE integer min/max reduction (predicated)

These instructions are under [SVE Integer Reduction](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	0	1	opc	U	0	0	1			Pg											Vd	

Decode fields opc	U	Instruction Details
00	0	<a href="#">SMAV</a>
00	1	<a href="#">UMAV</a>
01	0	<a href="#">SMINV</a>
01	1	<a href="#">UMINV</a>
1x		UNALLOCATED

### SVE constructive prefix (predicated)

These instructions are under [SVE Integer Reduction](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	0	opc	M	0	0	1			Pg											Zd	

Decode fields opc	Instruction Details
00	<a href="#">MOVPRFX (predicated)</a>
01	UNALLOCATED
1x	UNALLOCATED

**SVE bitwise logical reduction (predicated)**

These instructions are under [SVE Integer Reduction](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	opc	0	0	1	Pg	Zn			Vd											

Decode fields opc	Instruction Details
000	<a href="#">ORV</a>
001	<a href="#">EORV</a>
010	<a href="#">ANDV</a>
011	UNALLOCATED
1XX	UNALLOCATED

**SVE Bitwise Shift - Predicated**

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00000100									0	op0						100															

Decode fields op0	Instruction details
0x	<a href="#">SVE bitwise shift by immediate (predicated)</a>
10	<a href="#">SVE bitwise shift by vector (predicated)</a>
11	<a href="#">SVE bitwise shift by wide elements (predicated)</a>

**SVE bitwise shift by immediate (predicated)**

These instructions are under [SVE Bitwise Shift - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	tszh	0	0	opc	L	U	1	0	0	Pg	tszl	imm3	Zdn											

Decode fields opc	L	U	Instruction Details
00	0	0	<a href="#">ASR (immediate, predicated)</a>
00	0	1	<a href="#">LSR (immediate, predicated)</a>
00	1	0	UNALLOCATED
00	1	1	<a href="#">LSL (immediate, predicated)</a>
01	0	0	<a href="#">ASRD</a>
01	0	1	UNALLOCATED
01	1	0	<a href="#">SQSHL (immediate)</a>
01	1	1	<a href="#">UQSHL (immediate)</a>
10			UNALLOCATED
11	0	0	<a href="#">SRSHR</a>
11	0	1	<a href="#">URSHR</a>
11	1	0	UNALLOCATED
11	1	1	<a href="#">SQSHLU</a>

**SVE bitwise shift by vector (predicated)**

These instructions are under [SVE Bitwise Shift - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	0	R	L	U	1	0	0	Pg	Zm			Zdn									

Decode fields			Instruction Details
R	L	U	
	1	0	UNALLOCATED
0	0	0	<a href="#">ASR (vectors)</a>
0	0	1	<a href="#">LSR (vectors)</a>
0	1	1	<a href="#">LSL (vectors)</a>
1	0	0	<a href="#">ASRR</a>
1	0	1	<a href="#">LSRR</a>
1	1	1	<a href="#">LSLR</a>

## SVE bitwise shift by wide elements (predicated)

These instructions are under [SVE Bitwise Shift - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	R	L	U	1	0	0	Pg					Zm				Zdn				

Decode fields			Instruction Details
R	L	U	
0	0	0	<a href="#">ASR (wide elements, predicated)</a>
0	0	1	<a href="#">LSR (wide elements, predicated)</a>
0	1	0	UNALLOCATED
0	1	1	<a href="#">LSL (wide elements, predicated)</a>
1			UNALLOCATED

## SVE Integer Unary Arithmetic - Predicated

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
										0	op0							101													

Decode fields		Instruction details
op0		
0x		UNALLOCATED
10		<a href="#">SVE integer unary operations (predicated)</a>
11		<a href="#">SVE bitwise unary operations (predicated)</a>

## SVE integer unary operations (predicated)

These instructions are under [SVE Integer Unary Arithmetic - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	0	opc	1	0	1	Pg	Zn					Zd									

Decode fields		Instruction Details
opc		
000		<a href="#">SXTB, SXTH, SXTW</a> — <a href="#">SXTB</a>
001		<a href="#">UXTB, UXTH, UXTW</a> — <a href="#">UXTB</a>
010		<a href="#">SXTB, SXTH, SXTW</a> — <a href="#">SXTH</a>
011		<a href="#">UXTB, UXTH, UXTW</a> — <a href="#">UXTH</a>
100		<a href="#">SXTB, SXTH, SXTW</a> — <a href="#">SXTW</a>

Decode fields opc	Instruction Details
101	<a href="#">UXTB, UXTH, UXTW</a> — <a href="#">UXTW</a>
110	<a href="#">ABS</a>
111	<a href="#">NEG</a>

### SVE bitwise unary operations (predicated)

These instructions are under [SVE Integer Unary Arithmetic - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	0	1	1	opc	1	0	1	Pg	Zn				Zd										

Decode fields opc	Instruction Details
000	<a href="#">CLS</a>
001	<a href="#">CLZ</a>
010	<a href="#">CNT</a>
011	<a href="#">CNOT</a>
100	<a href="#">FABS</a>
101	<a href="#">FNEG</a>
110	<a href="#">NOT (vector)</a>
111	UNALLOCATED

### SVE integer add/subtract vectors (unpredicated)

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	1	Zm				0	0	0	opc		Zn				Zd								

Decode fields opc	Instruction Details
000	<a href="#">ADD (vectors, unpredicated)</a>
001	<a href="#">SUB (vectors, unpredicated)</a>
01x	UNALLOCATED
100	<a href="#">SQADD (vectors, unpredicated)</a>
101	<a href="#">UQADD (vectors, unpredicated)</a>
110	<a href="#">SQSUB (vectors, unpredicated)</a>
111	<a href="#">UQSUB (vectors, unpredicated)</a>

### SVE Bitwise Logical - Unpredicated

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00000100									1					001	op0																

Decode fields op0	Instruction details
0xx	UNALLOCATED
100	<a href="#">SVE bitwise logical operations (unpredicated)</a>
101	<a href="#">XAR</a>
11x	<a href="#">SVE2 bitwise ternary operations</a>

## SVE bitwise logical operations (unpredicated)

These instructions are under [SVE Bitwise Logical - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	opc	1	Zm					0	0	1	1	0	0	Zn					Zd					

Decode fields opc	Instruction Details
00	<a href="#">AND (vectors, unpredicated)</a>
01	<a href="#">ORR (vectors, unpredicated)</a>
10	<a href="#">EOR (vectors, unpredicated)</a>
11	<a href="#">BIC (vectors, unpredicated)</a>

## SVE2 bitwise ternary operations

These instructions are under [SVE Bitwise Logical - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	opc	1	Zm					0	0	1	1	1	o2	Zk					Zdn					

Decode fields opc	o2	Instruction Details
00	0	<a href="#">EOR3</a>
00	1	<a href="#">BSL</a>
01	0	<a href="#">BCAX</a>
01	1	<a href="#">BSL1N</a>
1x	0	UNALLOCATED
10	1	<a href="#">BSL2N</a>
11	1	<a href="#">NBSL</a>

## SVE Index Generation

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00000100									1						0100			op0													

Decode fields op0	Instruction details
00	<a href="#">INDEX (immediates)</a>
01	<a href="#">INDEX (scalar, immediate)</a>
10	<a href="#">INDEX (immediate, scalar)</a>
11	<a href="#">INDEX (scalars)</a>

## SVE Stack Allocation

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00000100								op0		1						0101			op1												

Decode fields op0	op1	Instruction details
0	0	<a href="#">SVE stack frame adjustment</a>
1	0	<a href="#">SVE stack frame size</a>

	1	UNALLOCATED
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## SVE stack frame adjustment

These instructions are under [SVE Stack Allocation](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	op	1				Rn		0	1	0	1	0					imm6					Rd	

Decode fields		Instruction Details
op		
0		<a href="#">ADDVL</a>
1		<a href="#">ADDPL</a>

## SVE stack frame size

These instructions are under [SVE Stack Allocation](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	op	1				opc2		0	1	0	1	0					imm6					Rd	

Decode fields		Instruction Details
op	opc2	
0	0XXXX	UNALLOCATED
0	10XXX	UNALLOCATED
0	110XX	UNALLOCATED
0	1110x	UNALLOCATED
0	11110	UNALLOCATED
0	11111	<a href="#">RDVL</a>
1		UNALLOCATED

## SVE2 Integer Multiply - Unpredicated

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
					00000100					1							011		op0												

Decode fields		Instruction details
op0		
0x		<a href="#">SVE2 integer multiply vectors (unpredicated)</a>
10		<a href="#">SVE2 signed saturating doubling multiply high (unpredicated)</a>
11		UNALLOCATED

## SVE2 integer multiply vectors (unpredicated)

These instructions are under [SVE2 Integer Multiply - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0		size	1				Zm		0	1	1	0	opc					Zn					Zd	

Decode fields		Instruction Details
size	opc	
	00	<a href="#">MUL (vectors, unpredicated)</a>
	10	<a href="#">SMULH (unpredicated)</a>



Decode fields size	opc	Instruction Details
	11	<a href="#">UMULH (unpredicated)</a>
00	01	<a href="#">PMUL</a>
01	01	UNALLOCATED
1x	01	UNALLOCATED

## SVE2 signed saturating doubling multiply high (unpredicated)

These instructions are under [SVE2 Integer Multiply - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	1			Zm				0	1	1	1	0	R			Zn					Zd		

Decode fields R	Instruction Details
0	<a href="#">SQDMULH (vectors)</a>
1	<a href="#">SQORDMULH (vectors)</a>

## SVE Bitwise Shift - Unpredicated

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
										1						100			op0												

Decode fields op0	Instruction details
0	<a href="#">SVE bitwise shift by wide elements (unpredicated)</a>
1	<a href="#">SVE bitwise shift by immediate (unpredicated)</a>

## SVE bitwise shift by wide elements (unpredicated)

These instructions are under [SVE Bitwise Shift - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	1			Zm				1	0	0	0	opc				Zn					Zd		

Decode fields opc	Instruction Details
00	<a href="#">ASR (wide elements, unpredicated)</a>
01	<a href="#">LSR (wide elements, unpredicated)</a>
10	UNALLOCATED
11	<a href="#">LSL (wide elements, unpredicated)</a>

## SVE bitwise shift by immediate (unpredicated)

These instructions are under [SVE Bitwise Shift - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	tszh	1	tszl		imm3				1	0	0	1	opc				Zn					Zd		

Decode fields opc	Instruction Details
00	<a href="#">ASR (immediate, unpredicated)</a>

Decode fields	Instruction Details
<b>opc</b>	
01	<a href="#">LSR (immediate, unpredicated)</a>
10	UNALLOCATED
11	<a href="#">LSL (immediate, unpredicated)</a>

## SVE address generation

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	opc	1				Zm			1	0	1	0	msz				Zn					Zd		

Decode fields	Instruction Details
<b>opc</b>	
00	<a href="#">ADR — Unpacked 32-bit signed offsets</a>
01	<a href="#">ADR — Unpacked 32-bit unsigned offsets</a>
1x	<a href="#">ADR — Packed offsets</a>

## SVE Integer Misc - Unpredicated

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
						00000100				1								1011		op0											

Decode fields	Instruction details
<b>op0</b>	
0x	<a href="#">SVE floating-point trig select coefficient</a>
10	<a href="#">SVE floating-point exponential accelerator</a>
11	<a href="#">SVE constructive prefix (unpredicated)</a>

## SVE floating-point trig select coefficient

These instructions are under [SVE Integer Misc - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	1				Zm			1	0	1	1	0	op				Zn				Zd		

Decode fields	Instruction Details
<b>op</b>	
0	<a href="#">FTSSEL</a>
1	UNALLOCATED

## SVE floating-point exponential accelerator

These instructions are under [SVE Integer Misc - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	1				opc			1	0	1	1	1	0				Zn				Zd		

Decode fields	Instruction Details
<b>opc</b>	
00000	<a href="#">FEXPA</a>
00001	UNALLOCATED

Decode fields opc	Instruction Details
0001x	UNALLOCATED
001xx	UNALLOCATED
01xxx	UNALLOCATED
1xxxx	UNALLOCATED

### SVE constructive prefix (unpredicated)

These instructions are under [SVE Integer Misc - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	opc	1			opc2				1	0	1	1	1	1			Zn					Zd		

Decode fields opc	Decode fields opc2	Instruction Details
00	00000	<a href="#">MOVPREX (unpredicated)</a>
00	00001	UNALLOCATED
00	0001x	UNALLOCATED
00	001xx	UNALLOCATED
00	01xxx	UNALLOCATED
00	1xxxx	UNALLOCATED
01		UNALLOCATED
1x		UNALLOCATED

### SVE Element Count

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
						00000100				1	op0						11		op1												

Decode fields op0	Decode fields op1	Instruction details
0	00x	<a href="#">SVE saturating inc/dec vector by element count</a>
0	100	<a href="#">SVE element count</a>
0	101	UNALLOCATED
1	000	<a href="#">SVE inc/dec vector by element count</a>
1	100	<a href="#">SVE inc/dec register by element count</a>
1	x01	UNALLOCATED
	01x	UNALLOCATED
	11x	<a href="#">SVE saturating inc/dec register by element count</a>

### SVE saturating inc/dec vector by element count

These instructions are under [SVE Element Count](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	1	0		imm4				1	1	0	0	D	U			pattern					Zdn		

Decode fields size	Decode fields D	Decode fields U	Instruction Details
00			UNALLOCATED
01	0	0	<a href="#">SQINCH (vector)</a>

Decode fields size	D	U	Instruction Details
01	0	1	<a href="#">UQINCH (vector)</a>
01	1	0	<a href="#">SQDECH (vector)</a>
01	1	1	<a href="#">UQDECH (vector)</a>
10	0	0	<a href="#">SQINCW (vector)</a>
10	0	1	<a href="#">UQINCW (vector)</a>
10	1	0	<a href="#">SQDECW (vector)</a>
10	1	1	<a href="#">UQDECW (vector)</a>
11	0	0	<a href="#">SQINCD (vector)</a>
11	0	1	<a href="#">UQINCD (vector)</a>
11	1	0	<a href="#">SQDECD (vector)</a>
11	1	1	<a href="#">UQDECD (vector)</a>

### SVE element count

These instructions are under [SVE Element Count](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	1	0		imm4	1	1	1	0	0	op		pattern											Rd

Decode fields size	op	Instruction Details
	1	UNALLOCATED
00	0	<a href="#">CNTB, CNTD, CNTH, CNTW</a> — <a href="#">CNTB</a>
01	0	<a href="#">CNTB, CNTD, CNTH, CNTW</a> — <a href="#">CNTH</a>
10	0	<a href="#">CNTB, CNTD, CNTH, CNTW</a> — <a href="#">CNTW</a>
11	0	<a href="#">CNTB, CNTD, CNTH, CNTW</a> — <a href="#">CNTD</a>

### SVE inc/dec vector by element count

These instructions are under [SVE Element Count](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	1	1		imm4	1	1	0	0	0	D		pattern											Zdn

Decode fields size	D	Instruction Details
00		UNALLOCATED
01	0	<a href="#">INCD, INCH, INCW (vector)</a> — <a href="#">INCH</a>
01	1	<a href="#">DECD, DECH, DECW (vector)</a> — <a href="#">DECH</a>
10	0	<a href="#">INCD, INCH, INCW (vector)</a> — <a href="#">INCW</a>
10	1	<a href="#">DECD, DECH, DECW (vector)</a> — <a href="#">DECW</a>
11	0	<a href="#">INCD, INCH, INCW (vector)</a> — <a href="#">INCD</a>
11	1	<a href="#">DECD, DECH, DECW (vector)</a> — <a href="#">DECD</a>

### SVE inc/dec register by element count

These instructions are under [SVE Element Count](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	1	1		imm4	1	1	1	0	0	D		pattern											Rdn

Decode fields size	D	Instruction Details
00	0	<a href="#">INCB, INCD, INCH, INCW (scalar)</a> — <a href="#">INCB</a>
00	1	<a href="#">DECB, DECD, DECH, DECW (scalar)</a> — <a href="#">DECB</a>
01	0	<a href="#">INCB, INCD, INCH, INCW (scalar)</a> — <a href="#">INCH</a>
01	1	<a href="#">DECB, DECD, DECH, DECW (scalar)</a> — <a href="#">DECH</a>
10	0	<a href="#">INCB, INCD, INCH, INCW (scalar)</a> — <a href="#">INCW</a>
10	1	<a href="#">DECB, DECD, DECH, DECW (scalar)</a> — <a href="#">DECW</a>
11	0	<a href="#">INCB, INCD, INCH, INCW (scalar)</a> — <a href="#">INCD</a>
11	1	<a href="#">DECB, DECD, DECH, DECW (scalar)</a> — <a href="#">DECD</a>

### SVE saturating inc/dec register by element count

These instructions are under [SVE Element Count](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	size	1	sf	imm4				1	1	1	1	D	U	pattern				Rdn						

Decode fields size	sf	D	U	Instruction Details
00	0	0	0	<a href="#">SQINCB</a> — 32-bit
00	0	0	1	<a href="#">UQINCB</a> — 32-bit
00	0	1	0	<a href="#">SQDECB</a> — 32-bit
00	0	1	1	<a href="#">UQDECB</a> — 32-bit
00	1	0	0	<a href="#">SQINCB</a> — 64-bit
00	1	0	1	<a href="#">UQINCB</a> — 64-bit
00	1	1	0	<a href="#">SQDECB</a> — 64-bit
00	1	1	1	<a href="#">UQDECB</a> — 64-bit
01	0	0	0	<a href="#">SQINCH (scalar)</a> — 32-bit
01	0	0	1	<a href="#">UQINCH (scalar)</a> — 32-bit
01	0	1	0	<a href="#">SQDECH (scalar)</a> — 32-bit
01	0	1	1	<a href="#">UQDECH (scalar)</a> — 32-bit
01	1	0	0	<a href="#">SQINCH (scalar)</a> — 64-bit
01	1	0	1	<a href="#">UQINCH (scalar)</a> — 64-bit
01	1	1	0	<a href="#">SQDECH (scalar)</a> — 64-bit
01	1	1	1	<a href="#">UQDECH (scalar)</a> — 64-bit
10	0	0	0	<a href="#">SQINCW (scalar)</a> — 32-bit
10	0	0	1	<a href="#">UQINCW (scalar)</a> — 32-bit
10	0	1	0	<a href="#">SQDECW (scalar)</a> — 32-bit
10	0	1	1	<a href="#">UQDECW (scalar)</a> — 32-bit
10	1	0	0	<a href="#">SQINCW (scalar)</a> — 64-bit
10	1	0	1	<a href="#">UQINCW (scalar)</a> — 64-bit
10	1	1	0	<a href="#">SQDECW (scalar)</a> — 64-bit
10	1	1	1	<a href="#">UQDECW (scalar)</a> — 64-bit
11	0	0	0	<a href="#">SQINCD (scalar)</a> — 32-bit
11	0	0	1	<a href="#">UQINCD (scalar)</a> — 32-bit
11	0	1	0	<a href="#">SQDECD (scalar)</a> — 32-bit
11	0	1	1	<a href="#">UQDECD (scalar)</a> — 32-bit
11	1	0	0	<a href="#">SQINCD (scalar)</a> — 64-bit
11	1	0	1	<a href="#">UQINCD (scalar)</a> — 64-bit
11	1	1	0	<a href="#">SQDECD (scalar)</a> — 64-bit

Decode fields				Instruction Details
size	sf	D	U	
11	1	1	1	<a href="#">UQDECD (scalar) — 64-bit</a>

## SVE Bitwise Immediate

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00000101								op0		00		op1																			

Decode fields		Instruction details
op0	op1	
11	00	<a href="#">DUPM</a>
!= 11	00	<a href="#">SVE bitwise logical with immediate (unpredicated)</a>
	!= 00	UNALLOCATED

## SVE bitwise logical with immediate (unpredicated)

These instructions are under [SVE Bitwise Immediate](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	!= 11	0	0	0	0	imm13												Zdn						
								opc																							

The following constraints also apply to this encoding: `opc != 11 && opc != 11`

Decode fields	Instruction Details
opc	
00	<a href="#">ORR (immediate)</a>
01	<a href="#">EOR (immediate)</a>
10	<a href="#">AND (immediate)</a>

## SVE Integer Wide Immediate - Predicated

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00000101										01				op0																	

Decode fields	Instruction details
op0	
0xx	<a href="#">SVE copy integer immediate (predicated)</a>
10x	UNALLOCATED
110	<a href="#">FCPY</a>
111	UNALLOCATED

## SVE copy integer immediate (predicated)

These instructions are under [SVE Integer Wide Immediate - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size		0	1	Pg		0	M	sh	imm8								Zd						

Decode fields M	Instruction Details
0	<a href="#">CPY (immediate, zeroing)</a>
1	<a href="#">CPY (immediate, merging)</a>

## SVE Permute Vector - Unpredicated

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00000101										1	op0	op1	op2		001				op3												

op0	Decode fields op1	op2	op3	Instruction details
00	00	0	110	<a href="#">DUP (scalar)</a>
00	10	0	110	<a href="#">INSR (scalar)</a>
00	x0	0	001	UNALLOCATED
00	x0	0	1x1	UNALLOCATED
00	x1		11x	UNALLOCATED
00	x1		x01	UNALLOCATED
00		1	11x	UNALLOCATED
00		1	x01	UNALLOCATED
01			11x	UNALLOCATED
01			x01	UNALLOCATED
10	0x		001	UNALLOCATED
10	0x		110	<a href="#">SVE unpack vector elements</a>
10	0x		1x1	UNALLOCATED
10	10	0	001	UNALLOCATED
10	10	0	110	<a href="#">INSR (SIMD&amp;FP scalar)</a>
10	10	0	1x1	UNALLOCATED
10	11		11x	UNALLOCATED
10	11		x01	UNALLOCATED
10	1x	1	11x	UNALLOCATED
10	1x	1	x01	UNALLOCATED
11	00	0	001	UNALLOCATED
11	00	0	110	<a href="#">REV (vector)</a>
11	00	0	1x1	UNALLOCATED
11	0x	1	11x	UNALLOCATED
11	0x	1	x01	UNALLOCATED
11	!= 00		11x	UNALLOCATED
11	!= 00		x01	UNALLOCATED
			000	<a href="#">DUP (indexed)</a>
			01x	<a href="#">SVE table lookup (three sources)</a>
			100	<a href="#">TBL</a> — <a href="#">SVE</a>

## SVE unpack vector elements

These instructions are under [SVE Permute Vector - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size		1	1	0	0	U	H	0	0	1	1	1	0	Zn				Zd					

Decode fields		Instruction Details
U	H	
0	0	<a href="#">SUNPKHL, SUNPKLO</a> — <a href="#">SUNPKLO</a>
0	1	<a href="#">SUNPKHL, SUNPKLO</a> — <a href="#">SUNPKHI</a>
1	0	<a href="#">UUNPKHL, UUNPKLO</a> — <a href="#">UUNPKLO</a>
1	1	<a href="#">UUNPKHL, UUNPKLO</a> — <a href="#">UUNPKHI</a>

### SVE table lookup (three sources)

These instructions are under [SVE Permute Vector - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1				Zm			0	0	1	0	1	op			Zn					Zd		

Decode fields		Instruction Details
op		
0		<a href="#">TBL</a>
1		<a href="#">TBX</a>

### SVE Permute Predicate

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
					00000101			op0	1		op1			010		op2										op3					

Decode fields				Instruction details
op0	op1	op2	op3	
00	1000x	0000	0	<a href="#">SVE unpack predicate elements</a>
01	1000x	0000	0	UNALLOCATED
10	1000x	0000	0	UNALLOCATED
11	1000x	0000	0	UNALLOCATED
	0xxxx	xxx0	0	<a href="#">SVE permute predicate elements</a>
	0xxxx	xxx1	0	UNALLOCATED
	10100	0000	0	<a href="#">REV (predicate)</a>
	10101	0000	0	UNALLOCATED
	10x0x	1000	0	UNALLOCATED
	10x0x	x100	0	UNALLOCATED
	10x0x	xx10	0	UNALLOCATED
	10x0x	xxx1	0	UNALLOCATED
	10x1x		0	UNALLOCATED
	11xxx		0	UNALLOCATED
			1	UNALLOCATED

### SVE unpack predicate elements

These instructions are under [SVE Permute Predicate](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	0	0	1	1	0	0	0	H	0	1	0	0	0	0	0			Pn		0			Pd	

Decode fields		Instruction Details
H		
0		<a href="#">PUNPKHL, PUNPKLO</a> — <a href="#">PUNPKLO</a>



**Decode fields**  
**H**
**Instruction Details**

1	<a href="#">PUNPKHI, PUNPKLO</a> — <a href="#">PUNPKHI</a>
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**SVE permute predicate elements**

These instructions are under [SVE Permute Predicate](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0		Pm				0	1	0	opc	H	0		Pn			0			Pd		

**Decode fields**  
**opc**      **H**
**Instruction Details**

00	0	<a href="#">ZIP1, ZIP2 (predicates)</a> — <a href="#">ZIP1</a>
00	1	<a href="#">ZIP1, ZIP2 (predicates)</a> — <a href="#">ZIP2</a>
01	0	<a href="#">UZP1, UZP2 (predicates)</a> — <a href="#">UZP1</a>
01	1	<a href="#">UZP1, UZP2 (predicates)</a> — <a href="#">UZP2</a>
10	0	<a href="#">TRN1, TRN2 (predicates)</a> — <a href="#">TRN1</a>
10	1	<a href="#">TRN1, TRN2 (predicates)</a> — <a href="#">TRN2</a>
11		UNALLOCATED

**SVE permute vector elements**

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1			Zm				0	1	1	opc				Zn						Zd		

**Decode fields**  
**opc**
**Instruction Details**

000	<a href="#">ZIP1, ZIP2 (vectors)</a> — <a href="#">ZIP1</a>
001	<a href="#">ZIP1, ZIP2 (vectors)</a> — <a href="#">ZIP2</a>
010	<a href="#">UZP1, UZP2 (vectors)</a> — <a href="#">UZP1</a>
011	<a href="#">UZP1, UZP2 (vectors)</a> — <a href="#">UZP2</a>
100	<a href="#">TRN1, TRN2 (vectors)</a> — <a href="#">TRN1</a>
101	<a href="#">TRN1, TRN2 (vectors)</a> — <a href="#">TRN2</a>
11x	UNALLOCATED

**SVE Permute Vector - Predicated**

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
										1	op0	op1	op2	10	op3																

Decode fields				Instruction details
op0	op1	op2	op3	
0	000	0	0	<a href="#">CPY (SIMD&amp;FP scalar)</a>
0	000	1	0	<a href="#">COMPACT</a>
0	000		1	<a href="#">SVE extract element to general register</a>
0	001		0	<a href="#">SVE extract element to SIMD&amp;FP scalar register</a>
0	01x		0	<a href="#">SVE reverse within elements</a>
0	01x		1	UNALLOCATED
0	100	0	1	<a href="#">CPY (scalar)</a>

0	100	1	1	UNALLOCATED
0	100		0	<a href="#">SVE conditionally broadcast element to vector</a>
0	101		0	<a href="#">SVE conditionally extract element to SIMD&amp;FP scalar</a>
0	110	0	0	<a href="#">SPLICE — Destructive</a>
0	110	1	0	<a href="#">SPLICE — Constructive</a>
0	110		1	UNALLOCATED
0	111	0		UNALLOCATED
0	111	1		UNALLOCATED
0	x01		1	UNALLOCATED
1	000		0	UNALLOCATED
1	000		1	<a href="#">SVE conditionally extract element to general register</a>
1	!= 000			UNALLOCATED

### SVE extract element to general register

These instructions are under [SVE Permute Vector - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	0	0	0	B	1	0	1	Pg													
																Zn		Rd													

Decode fields B	Instruction Details
0	<a href="#">LASTA (scalar)</a>
1	<a href="#">LASTB (scalar)</a>

### SVE extract element to SIMD&FP scalar register

These instructions are under [SVE Permute Vector - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size		1	0	0	0	1	B	1	0	0	Pg		Zn					Vd					

Decode fields B	Instruction Details
0	<a href="#">LASTA (SIMD&amp;FP scalar)</a>
1	<a href="#">LASTB (SIMD&amp;FP scalar)</a>

### SVE reverse within elements

These instructions are under [SVE Permute Vector - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	0	1	opc	1	0	0	Pg		Zn					Zd							

Decode fields opc	Instruction Details
00	<a href="#">REVB, REVH, REVW — REVB</a>
01	<a href="#">REVB, REVH, REVW — REVH</a>
10	<a href="#">REVB, REVH, REVW — REVW</a>
11	<a href="#">RBIT</a>

### SVE conditionally broadcast element to vector

These instructions are under [SVE Permute Vector - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	1	0	0	B	1	0	0	Pg							Zm					Zdn	

Decode fields	Instruction Details
<b>B</b>	
0	<a href="#">CLASTA (vectors)</a>
1	<a href="#">CLASTB (vectors)</a>

## SVE conditionally extract element to SIMD&FP scalar

These instructions are under [SVE Permute Vector - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	0	1	0	1	B	1	0	0	Pg							Zm					Vdn	

Decode fields	Instruction Details
<b>B</b>	
0	<a href="#">CLASTA (SIMD&amp;FP scalar)</a>
1	<a href="#">CLASTB (SIMD&amp;FP scalar)</a>

## SVE conditionally extract element to general register

These instructions are under [SVE Permute Vector - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	size	1	1	0	0	0	B	1	0	1	Pg							Zm					Rdn	

Decode fields	Instruction Details
<b>B</b>	
0	<a href="#">CLASTA (scalar)</a>
1	<a href="#">CLASTB (scalar)</a>

## SVE Permute Vector - Extract

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
									000001010	op0	1								000												

Decode fields	Instruction details
<b>op0</b>	
0	<a href="#">EXT</a> — <a href="#">Destructive</a>
1	<a href="#">EXT</a> — <a href="#">Constructive</a>

## SVE permute vector segments

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	1	op	1					Zm				0	0	0	opc2				Zn				Zd	

Decode fields		Instruction Details
op	opc2	
0	000	<a href="#">ZIP1, ZIP2 (vectors)</a> — <a href="#">ZIP1</a>
0	001	<a href="#">ZIP1, ZIP2 (vectors)</a> — <a href="#">ZIP2</a>
0	010	<a href="#">UZP1, UZP2 (vectors)</a> — <a href="#">UZP1</a>
0	011	<a href="#">UZP1, UZP2 (vectors)</a> — <a href="#">UZP2</a>

Decode fields		Instruction Details
op	opc2	
0	10x	UNALLOCATED
0	110	<a href="#">TRN1, TRN2 (vectors) — TRN1</a>
0	111	<a href="#">TRN1, TRN2 (vectors) — TRN2</a>
1		UNALLOCATED

## SVE Integer Compare - Vectors

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00100100										0	op0																				

Decode fields		Instruction details
op0		
0		<a href="#">SVE integer compare vectors</a>
1		<a href="#">SVE integer compare with wide elements</a>

## SVE integer compare vectors

These instructions are under [SVE Integer Compare - Vectors](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size	0	Zm			op	0	o2	Pg			Zn			ne	Pd								

Decode fields			Instruction Details
op	o2	ne	
0	0	0	<a href="#">CMP&lt;cc&gt; (vectors) — CMPHS</a>
0	0	1	<a href="#">CMP&lt;cc&gt; (vectors) — CMPHI</a>
0	1	0	<a href="#">CMP&lt;cc&gt; (wide elements) — CMPEQ</a>
0	1	1	<a href="#">CMP&lt;cc&gt; (wide elements) — CMPNE</a>
1	0	0	<a href="#">CMP&lt;cc&gt; (vectors) — CMPGE</a>
1	0	1	<a href="#">CMP&lt;cc&gt; (vectors) — CMPGT</a>
1	1	0	<a href="#">CMP&lt;cc&gt; (vectors) — CMPEQ</a>
1	1	1	<a href="#">CMP&lt;cc&gt; (vectors) — CMPNE</a>

## SVE integer compare with wide elements

These instructions are under [SVE Integer Compare - Vectors](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size	0	Zm			U	1	lt	Pg		Zn				ne		Pd							

Decode fields			Instruction Details
U	lt	ne	
0	0	0	<a href="#">CMP&lt;cc&gt; (wide elements) — CMPGE</a>
0	0	1	<a href="#">CMP&lt;cc&gt; (wide elements) — CMPGT</a>
0	1	0	<a href="#">CMP&lt;cc&gt; (wide elements) — CMPLT</a>
0	1	1	<a href="#">CMP&lt;cc&gt; (wide elements) — CMPLT</a>
1	0	0	<a href="#">CMP&lt;cc&gt; (wide elements) — CMPHS</a>
1	0	1	<a href="#">CMP&lt;cc&gt; (wide elements) — CMPHI</a>
1	1	0	<a href="#">CMP&lt;cc&gt; (wide elements) — CMPLO</a>
1	1	1	<a href="#">CMP&lt;cc&gt; (wide elements) — CMPLS</a>

**SVE integer compare with unsigned immediate**

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	0	size	1	imm7								lt	Pg		Zn				ne	Pd					

Decode fields		Instruction Details
lt	ne	
0	0	<a href="#">CMP&lt;cc&gt; (immediate)</a> — <a href="#">CMPHS</a>
0	1	<a href="#">CMP&lt;cc&gt; (immediate)</a> — <a href="#">CMPHI</a>
1	0	<a href="#">CMP&lt;cc&gt; (immediate)</a> — <a href="#">CMPLO</a>
1	1	<a href="#">CMP&lt;cc&gt; (immediate)</a> — <a href="#">CMPLS</a>

**SVE integer compare with signed immediate**

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	0	imm5			op	0	o2	Pg		Zn			ne		Pd								

Decode fields			Instruction Details
op	o2	ne	
0	0	0	<a href="#">CMP&lt;cc&gt; (immediate)</a> — <a href="#">CMPGE</a>
0	0	1	<a href="#">CMP&lt;cc&gt; (immediate)</a> — <a href="#">CMPGT</a>
0	1	0	<a href="#">CMP&lt;cc&gt; (immediate)</a> — <a href="#">CMPLT</a>
0	1	1	<a href="#">CMP&lt;cc&gt; (immediate)</a> — <a href="#">CMPLE</a>
1	0	0	<a href="#">CMP&lt;cc&gt; (immediate)</a> — <a href="#">CMPEQ</a>
1	0	1	<a href="#">CMP&lt;cc&gt; (immediate)</a> — <a href="#">CMPNE</a>
1	1		UNALLOCATED

**SVE predicate logical operations**

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	op	S	0	0			Pm		0	1		Pg				o2			Pn		o3			Pd

Decode fields				Instruction Details
op	S	o2	o3	
0	0	0	0	<a href="#">AND, ANDS (predicates)</a> — <a href="#">not setting the condition flags</a>
0	0	0	1	<a href="#">BIC, BICS (predicates)</a> — <a href="#">not setting the condition flags</a>
0	0	1	0	<a href="#">EOR, EORS (predicates)</a> — <a href="#">not setting the condition flags</a>
0	0	1	1	<a href="#">SEL (predicates)</a>
0	1	0	0	<a href="#">AND, ANDS (predicates)</a> — <a href="#">setting the condition flags</a>
0	1	0	1	<a href="#">BIC, BICS (predicates)</a> — <a href="#">setting the condition flags</a>
0	1	1	0	<a href="#">EOR, EORS (predicates)</a> — <a href="#">setting the condition flags</a>
0	1	1	1	UNALLOCATED
1	0	0	0	<a href="#">ORR, ORRS (predicates)</a> — <a href="#">not setting the condition flags</a>
1	0	0	1	<a href="#">ORN, ORNS (predicates)</a> — <a href="#">not setting the condition flags</a>
1	0	1	0	<a href="#">NOR, NORs</a> — <a href="#">not setting the condition flags</a>
1	0	1	1	<a href="#">NAND, NANDS</a> — <a href="#">not setting the condition flags</a>
1	1	0	0	<a href="#">ORR, ORRS (predicates)</a> — <a href="#">setting the condition flags</a>
1	1	0	1	<a href="#">ORN, ORNS (predicates)</a> — <a href="#">setting the condition flags</a>
1	1	1	0	<a href="#">NOR, NORs</a> — <a href="#">setting the condition flags</a>

Decode fields				Instruction Details
op	S	o2	o3	
1	1	1	1	<a href="#">NAND, NANDS — setting the condition flags</a>

## SVE Propagate Break

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
00100101										00						11						op0										

Decode fields		Instruction details
op0		
0		<a href="#">SVE propagate break from previous partition</a>
1		UNALLOCATED

## SVE propagate break from previous partition

These instructions are under [SVE Propagate Break](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	op	S	0	0	Pm				1	1	Pg				0	Pn				B	Pd			

Decode fields			Instruction Details
op	S	B	
0	0	0	<a href="#">BRKPA, BRKPAS — not setting the condition flags</a>
0	0	1	<a href="#">BRKPB, BRKPBS — not setting the condition flags</a>
0	1	0	<a href="#">BRKPA, BRKPAS — setting the condition flags</a>
0	1	1	<a href="#">BRKPB, BRKPBS — setting the condition flags</a>
1			UNALLOCATED

## SVE Partition Break

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00100101								op0	01		op1		01		op2				op3												

Decode fields				Instruction details
op0	op1	op2	op3	
0	1000	0	0	<a href="#">SVE propagate break to next partition</a>
0	1000	0	1	UNALLOCATED
0	x000	1		UNALLOCATED
0	x1xx			UNALLOCATED
0	xx1x			UNALLOCATED
0	xxx1			UNALLOCATED
1	0000	1		UNALLOCATED
1	!= 0000			UNALLOCATED
	0000	0		<a href="#">SVE partition break condition</a>

## SVE propagate break to next partition

These instructions are under [SVE Partition Break](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	0	S	0	1	1	0	0	0	0	1	Pg			0	Pn			0	Pdm					

**Decode fields****S****Instruction Details**

0	<a href="#">BRKN, BRKNS</a> — <a href="#">not setting the condition flags</a>
1	<a href="#">BRKN, BRKNS</a> — <a href="#">setting the condition flags</a>

**SVE partition break condition**

These instructions are under [SVE Partition Break](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	B	S	0	1	0	0	0	0	0	1	Pg			0	Pn			M	Pd					

**Decode fields****B S M****Instruction Details**

	1	1	UNALLOCATED
0	0		<a href="#">BRKA, BRKAS</a> — <a href="#">not setting the condition flags</a>
0	1	0	<a href="#">BRKA, BRKAS</a> — <a href="#">setting the condition flags</a>
1	0		<a href="#">BRKB, BRKBS</a> — <a href="#">not setting the condition flags</a>
1	1	0	<a href="#">BRKB, BRKBS</a> — <a href="#">setting the condition flags</a>

**SVE Predicate Misc**

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00100101										01	op0				11	op1		op2		op3			op4								

**Decode fields****op0****op1****op2****op3****op4****Instruction details**

0000		x0		0	<a href="#">SVE predicate test</a>
0100		x0		0	UNALLOCATED
0x10		x0		0	UNALLOCATED
0xx1		x0		0	UNALLOCATED
0xxx		x1		0	UNALLOCATED
1000	000	00		0	<a href="#">SVE predicate first active</a>
1000	000	!= 00		0	UNALLOCATED
1000	100	10	0000	0	<a href="#">SVE predicate zero</a>
1000	100	10	!= 0000	0	UNALLOCATED
1000	110	00		0	<a href="#">SVE predicate read from FFR (predicated)</a>
1001	000	0x		0	UNALLOCATED
1001	000	10		0	<a href="#">PNEXT</a>
1001	000	11		0	UNALLOCATED
1001	100	10		0	UNALLOCATED
1001	110	00	0000	0	<a href="#">SVE predicate read from FFR (unpredicated)</a>
1001	110	00	!= 0000	0	UNALLOCATED
100x	010			0	UNALLOCATED
100x	100	0x		0	<a href="#">SVE predicate initialize</a>
100x	100	11		0	UNALLOCATED
100x	110	!= 00		0	UNALLOCATED
100x	xx1			0	UNALLOCATED
110x				0	UNALLOCATED

1x1x				0	UNALLOCATED
				1	UNALLOCATED

### SVE predicate test

These instructions are under [SVE Predicate Misc.](#)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	op	S	0	1	0	0	0	0	1	1		Pg		0			Pn		0			opc2		

Decode fields			Instruction Details
op	S	opc2	
0	0		UNALLOCATED
0	1	0000	<a href="#">PTEST</a>
0	1	0001	UNALLOCATED
0	1	001x	UNALLOCATED
0	1	01xx	UNALLOCATED
0	1	1xxx	UNALLOCATED
1			UNALLOCATED

### SVE predicate first active

These instructions are under [SVE Predicate Misc.](#)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	op	S	0	1	1	0	0	0	1	1	0	0	0	0	0	0		Pg		0			Pdn	

Decode fields		Instruction Details
op	S	
0	0	UNALLOCATED
0	1	<a href="#">PEIRST</a>
1		UNALLOCATED

### SVE predicate zero

These instructions are under [SVE Predicate Misc.](#)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	op	S	0	1	1	0	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	Pd		

Decode fields		Instruction Details
op	S	
0	0	<a href="#">PFALSE</a>
0	1	UNALLOCATED
1		UNALLOCATED

### SVE predicate read from FFR (predicated)

These instructions are under [SVE Predicate Misc.](#)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	op	S	0	1	1	0	0	0	1	1	1	1	0	0	0			Pg		0			Pd	



Decode fields		Instruction Details
op	S	
0	0	<a href="#">RDFFR, RDFFRS (predicated)</a> — <a href="#">not setting the condition flags</a>
0	1	<a href="#">RDFFR, RDFFRS (predicated)</a> — <a href="#">setting the condition flags</a>
1		UNALLOCATED

### SVE predicate read from FFR (unpredicated)

These instructions are under [SVE Predicate Misc](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	op	S	0	1	1	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0				Pd

Decode fields		Instruction Details
op	S	
0	0	<a href="#">RDFFR (unpredicated)</a>
0	1	UNALLOCATED
1		UNALLOCATED

### SVE predicate initialize

These instructions are under [SVE Predicate Misc](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size		0	1	1	0	0	S	1	1	1	0	0	0				pattern		0				Pd

Decode fields		Instruction Details
S		
0		<a href="#">PTRUE, PTRUES</a> — <a href="#">not setting the condition flags</a>
1		<a href="#">PTRUE, PTRUES</a> — <a href="#">setting the condition flags</a>

### SVE Integer Compare - Scalars

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
										1						00		op0		op1											op2

Decode fields			Instruction details
op0	op1	op2	
0x			<a href="#">SVE integer compare scalar count and limit</a>
10	00	0000	<a href="#">SVE conditionally terminate scalars</a>
10	00	!= 0000	UNALLOCATED
11	00		<a href="#">SVE pointer conflict compare</a>
1x	!= 00		UNALLOCATED

### SVE integer compare scalar count and limit

These instructions are under [SVE Integer Compare - Scalars](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	Rm			0	0	0	sf	U	lt	Rn			eq	Pd								

Decode fields			Instruction Details
U	lt	eq	
0	0	0	<a href="#">WHILEGE</a>
0	0	1	<a href="#">WHILEGT</a>
0	1	0	<a href="#">WHILELT</a>
0	1	1	<a href="#">WHILELE</a>
1	0	0	<a href="#">WHILEHS</a>
1	0	1	<a href="#">WHILEHI</a>
1	1	0	<a href="#">WHILELO</a>
1	1	1	<a href="#">WHILELS</a>

### SVE conditionally terminate scalars

These instructions are under [SVE Integer Compare - Scalars](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	op	sz	1	Rm					0	0	1	0	0	0	Rn					ne	0	0	0	0

Decode fields		Instruction Details
op	ne	
0		UNALLOCATED
1	0	<a href="#">CTERMEQ, CTERMNE</a> — <a href="#">CTERMEQ</a>
1	1	<a href="#">CTERMEQ, CTERMNE</a> — <a href="#">CTERMNE</a>

### SVE pointer conflict compare

These instructions are under [SVE Integer Compare - Scalars](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	0	1	0	0	1	0	1	size	1	Rm						0	0	1	1	0	0	Rn						rw	Pd			

Decode fields		Instruction Details
rw		
0		<a href="#">WHILEWR</a>
1		<a href="#">WHILERW</a>

### SVE Integer Wide Immediate - Unpredicated

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
					00100101					1	op0			op1	11																

Decode fields		Instruction details
op0	op1	
00		<a href="#">SVE integer add/subtract immediate (unpredicated)</a>
01		<a href="#">SVE integer min/max immediate (unpredicated)</a>
10		<a href="#">SVE integer multiply immediate (unpredicated)</a>
11	0	<a href="#">SVE broadcast integer immediate (unpredicated)</a>
11	1	<a href="#">SVE broadcast floating-point immediate (unpredicated)</a>

### SVE integer add/subtract immediate (unpredicated)

These instructions are under [SVE Integer Wide Immediate - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size		1	0	0	opc		1	1	sh	imm8								Zdn					

Decode fields opc	Instruction Details
000	<a href="#">ADD (immediate)</a>
001	<a href="#">SUB (immediate)</a>
010	UNALLOCATED
011	<a href="#">SUBR (immediate)</a>
100	<a href="#">SQADD (immediate)</a>
101	<a href="#">UQADD (immediate)</a>
110	<a href="#">SQSUB (immediate)</a>
111	<a href="#">UQSUB (immediate)</a>

**SVE integer min/max immediate (unpredicated)**

These instructions are under [SVE Integer Wide Immediate - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size		1	0	1	opc		1		1	o2	imm8								Zdn				

Decode fields opc	o2	Instruction Details
0xx	1	UNALLOCATED
000	0	<a href="#">SMAX (immediate)</a>
001	0	<a href="#">UMAX (immediate)</a>
010	0	<a href="#">SMIN (immediate)</a>
011	0	<a href="#">UMIN (immediate)</a>
1xx		UNALLOCATED

**SVE integer multiply immediate (unpredicated)**

These instructions are under [SVE Integer Wide Immediate - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size		1	1	0	opc		1	1	o2	imm8								Zdn					

Decode fields opc	o2	Instruction Details
000	0	<a href="#">MUL (immediate)</a>
000	1	UNALLOCATED
001		UNALLOCATED
01x		UNALLOCATED
1xx		UNALLOCATED

**SVE broadcast integer immediate (unpredicated)**

These instructions are under [SVE Integer Wide Immediate - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size		1	1	1	opc		0	1	1	sh	imm8								Zd				

Decode fields opc	Instruction Details
00	<a href="#">DUP (immediate)</a>

Decode fields	Instruction Details
opc	
01	UNALLOCATED
1x	UNALLOCATED

## SVE broadcast floating-point immediate (unpredicated)

These instructions are under [SVE Integer Wide Immediate - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	1	1	opc	1	1	1	o2	imm8								Zd						

Decode fields	Instruction Details
opc o2	
00 0	<a href="#">FDUP</a>
00 1	UNALLOCATED
01	UNALLOCATED
1x	UNALLOCATED

## SVE predicate count

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	0	0	opc	1	0	Pg		o2	Pn			Rd										

Decode fields	Instruction Details
opc o2	
000 0	<a href="#">CNTp</a>
000 1	UNALLOCATED
001	UNALLOCATED
01x	UNALLOCATED
1xx	UNALLOCATED

## SVE Inc/Dec by Predicate Count

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00100101									101		op0			1000				op1													

Decode fields	Instruction details
op0 op1	
0 0	<a href="#">SVE saturating inc/dec vector by predicate count</a>
0 1	<a href="#">SVE saturating inc/dec register by predicate count</a>
1 0	<a href="#">SVE inc/dec vector by predicate count</a>
1 1	<a href="#">SVE inc/dec register by predicate count</a>

## SVE saturating inc/dec vector by predicate count

These instructions are under [SVE Inc/Dec by Predicate Count](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	0	1	0	D	U	1	0	0	0	0	opc	Pm			Zdn							

Decode fields			Instruction Details
D	U	opc	
		01	UNALLOCATED
		1x	UNALLOCATED
0	0	00	<a href="#">SQINCP (vector)</a>
0	1	00	<a href="#">UQINCP (vector)</a>
1	0	00	<a href="#">SQDECP (vector)</a>
1	1	00	<a href="#">UQDECP (vector)</a>

### SVE saturating inc/dec register by predicate count

These instructions are under [SVE Inc/Dec by Predicate Count](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	0	1	0	D	U	1	0	0	0	1	sf	op	Pm			Rdn						

Decode fields				Instruction Details
D	U	sf	op	
			1	UNALLOCATED
0	0	0	0	<a href="#">SQINCP (scalar) — 32-bit</a>
0	0	1	0	<a href="#">SQINCP (scalar) — 64-bit</a>
0	1	0	0	<a href="#">UQINCP (scalar) — 32-bit</a>
0	1	1	0	<a href="#">UQINCP (scalar) — 64-bit</a>
1	0	0	0	<a href="#">SQDECP (scalar) — 32-bit</a>
1	0	1	0	<a href="#">SQDECP (scalar) — 64-bit</a>
1	1	0	0	<a href="#">UQDECP (scalar) — 32-bit</a>
1	1	1	0	<a href="#">UQDECP (scalar) — 64-bit</a>

### SVE inc/dec vector by predicate count

These instructions are under [SVE Inc/Dec by Predicate Count](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	0	1	1	op	D	1	0	0	0	0	opc2	Pm			Zdn							

Decode fields			Instruction Details
op	D	opc2	
0		01	UNALLOCATED
0		1x	UNALLOCATED
0	0	00	<a href="#">INCP (vector)</a>
0	1	00	<a href="#">DECP (vector)</a>
1			UNALLOCATED

### SVE inc/dec register by predicate count

These instructions are under [SVE Inc/Dec by Predicate Count](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	size	1	0	1	1	op	D	1	0	0	0	1	opc2	Pm			Rdn							

Decode fields			Instruction Details
op	D	opc2	
0		01	UNALLOCATED
0		1x	UNALLOCATED

Decode fields			Instruction Details
op	D	opc2	
0	0	00	<a href="#">INCP (scalar)</a>
0	1	00	<a href="#">DECP (scalar)</a>
1			UNALLOCATED

## SVE Write FFR

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
00100101										101		op0	op1			1001				op2				op3					op4		

Decode fields					Instruction details
op0	op1	op2	op3	op4	
0	00	000		00000	<a href="#">SVE FFR write from predicate</a>
1	00	000	0000	00000	<a href="#">SVE FFR initialise</a>
1	00	000	1xxx	00000	UNALLOCATED
1	00	000	x1xx	00000	UNALLOCATED
1	00	000	xx1x	00000	UNALLOCATED
1	00	000	xxx1	00000	UNALLOCATED
	00	000		!= 00000	UNALLOCATED
	00	!= 000			UNALLOCATED
	!= 00				UNALLOCATED

## SVE FFR write from predicate

These instructions are under [SVE Write FFR](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	opc	1	0	1	0	0	0	1	0	0	1	0	0	0	0		Pn		0	0	0	0	0	0

Decode fields	Instruction Details
opc	
00	<a href="#">WRFFR</a>
01	UNALLOCATED
1x	UNALLOCATED

## SVE FFR initialise

These instructions are under [SVE Write FFR](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	1	0	1	opc	1	0	1	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

Decode fields	Instruction Details
opc	
00	<a href="#">SETFFR</a>
01	UNALLOCATED
1x	UNALLOCATED

## SVE Integer Multiply-Add - Unpredicated

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
01000100										0					0	op0															

Decode fields op0	Instruction details
0000x	<a href="#">SVE integer dot product (unpredicated)</a>
0001x	<a href="#">SVE2 saturating multiply-add interleaved long</a>
001xx	<a href="#">CDOT (vectors)</a>
01xxx	<a href="#">SVE2 complex integer multiply-add</a>
10xxx	<a href="#">SVE2 integer multiply-add long</a>
110xx	<a href="#">SVE2 saturating multiply-add long</a>
1110x	<a href="#">SVE2 saturating multiply-add high</a>
11110	<a href="#">SVE mixed sign dot product</a>
11111	UNALLOCATED

### SVE integer dot product (unpredicated)

These instructions are under [SVE Integer Multiply-Add - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size	0	Zm				0	0	0	0	0	U	Zn				Zda							

Decode fields U	Instruction Details
0	<a href="#">SDOT (vectors)</a>
1	<a href="#">UDOT (vectors)</a>

### SVE2 saturating multiply-add interleaved long

These instructions are under [SVE Integer Multiply-Add - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size	0	Zm				0	0	0	0	1	S	Zn				Zda							

Decode fields S	Instruction Details
0	<a href="#">SQDMLALBT</a>
1	<a href="#">SQDMLSLBT</a>

### SVE2 complex integer multiply-add

These instructions are under [SVE Integer Multiply-Add - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size	0	Zm				0	0	1	op	rot	Zn				Zda								

Decode fields op	Instruction Details
0	<a href="#">CMLA (vectors)</a>
1	<a href="#">SQRDCMLAH (vectors)</a>

### SVE2 integer multiply-add long

These instructions are under [SVE Integer Multiply-Add - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size	0	Zm				0	1	0	S	U	T	Zn				Zda							

Decode fields			Instruction Details
S	U	T	
0	0	0	<a href="#">SMLALB (vectors)</a>
0	0	1	<a href="#">SMLALT (vectors)</a>
0	1	0	<a href="#">UMLALB (vectors)</a>
0	1	1	<a href="#">UMLALT (vectors)</a>
1	0	0	<a href="#">SMLSLB (vectors)</a>
1	0	1	<a href="#">SMLSLT (vectors)</a>
1	1	0	<a href="#">UMLSLB (vectors)</a>
1	1	1	<a href="#">UMLSLT (vectors)</a>

## SVE2 saturating multiply-add long

These instructions are under [SVE Integer Multiply-Add - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size	0	Zm						0	1	1	0	S	T	Zn						Zda			

Decode fields		Instruction Details
S	T	
0	0	<a href="#">SQDMLALB (vectors)</a>
0	1	<a href="#">SQDMLALT (vectors)</a>
1	0	<a href="#">SQDMLSLB (vectors)</a>
1	1	<a href="#">SQDMLSLT (vectors)</a>

## SVE2 saturating multiply-add high

These instructions are under [SVE Integer Multiply-Add - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	1	0	0	0	1	0	0	size	0	Zm						0	1	1	1	0	S	Zn						Zda				

Decode fields		Instruction Details
S		
0		<a href="#">SQRDMLAH (vectors)</a>
1		<a href="#">SQRDMLSH (vectors)</a>

## SVE mixed sign dot product

These instructions are under [SVE Integer Multiply-Add - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	1	0	0	0	1	0	0	size	0	Zm						0	1	1	1	1	0	Zn						Zda				

Decode fields		Instruction Details
size		
0x		UNALLOCATED
10		<a href="#">USDOT (vectors)</a>
11		UNALLOCATED

## SVE2 Integer - Predicated

These instructions are under [SVE encodings](#).



31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
01000100										0	op0					10	op1														

Decode fields		Instruction details
op0	op1	
0010	1	<a href="#">SVE2 integer pairwise add and accumulate long</a>
0011	1	UNALLOCATED
011x	1	UNALLOCATED
0x0x	1	<a href="#">SVE2 integer unary operations (predicated)</a>
0xxx	0	<a href="#">SVE2 saturating/rounding bitwise shift left (predicated)</a>
10xx	0	<a href="#">SVE2 integer halving add/subtract (predicated)</a>
10xx	1	<a href="#">SVE2 integer pairwise arithmetic</a>
11xx	0	<a href="#">SVE2 saturating add/subtract</a>
11xx	1	UNALLOCATED

### SVE2 integer pairwise add and accumulate long

These instructions are under [SVE2 Integer - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size		0	0	0	1	0	U	1	0	1		Pg					Zn					Zda	

Decode fields		Instruction Details
U		
0		<a href="#">SADALP</a>
1		<a href="#">UADALP</a>

### SVE2 integer unary operations (predicated)

These instructions are under [SVE2 Integer - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size		0	0	Q	0	opc		1	0	1		Pg					Zn					Zd	

Decode fields		Instruction Details
Q	opc	
	1x	UNALLOCATED
0	00	<a href="#">URECPE</a>
0	01	<a href="#">URSQRTE</a>
1	00	<a href="#">SQABS</a>
1	01	<a href="#">SQNEG</a>

### SVE2 saturating/rounding bitwise shift left (predicated)

These instructions are under [SVE2 Integer - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size		0	0	Q	R	N	U	1	0	0		Pg					Zm					Zdn	

Decode fields				Instruction Details
Q	R	N	U	
0		0		UNALLOCATED
0	0	1	0	<a href="#">SRSHL</a>
0	0	1	1	<a href="#">URSHL</a>
0	1	1	0	<a href="#">SRSHLR</a>

Decode fields				Instruction Details
Q	R	N	U	
0	1	1	1	<a href="#">URSHLR</a>
1	0	0	0	<a href="#">SQSHL (vectors)</a>
1	0	0	1	<a href="#">UQSHL (vectors)</a>
1	0	1	0	<a href="#">SQRSHL</a>
1	0	1	1	<a href="#">UQRSHL</a>
1	1	0	0	<a href="#">SQSHLR</a>
1	1	0	1	<a href="#">UQSHLR</a>
1	1	1	0	<a href="#">SQRSHLR</a>
1	1	1	1	<a href="#">UQRSHLR</a>

## SVE2 integer halving add/subtract (predicated)

These instructions are under [SVE2 Integer - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size	0	1	0	R	S	U	1	0	0		Pg												

Decode fields			Instruction Details
R	S	U	
0	0	0	<a href="#">SHADD</a>
0	0	1	<a href="#">UHADD</a>
0	1	0	<a href="#">SHSUB</a>
0	1	1	<a href="#">UHSUB</a>
1	0	0	<a href="#">SRHADD</a>
1	0	1	<a href="#">URHADD</a>
1	1	0	<a href="#">SHSUBR</a>
1	1	1	<a href="#">UHSUBR</a>

## SVE2 integer pairwise arithmetic

These instructions are under [SVE2 Integer - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size	0	1	0	opc	U	1	0	1			Pg												

Decode fields		Instruction Details
opc	U	
00	0	UNALLOCATED
00	1	<a href="#">ADDP</a>
01		UNALLOCATED
10	0	<a href="#">SMAXP</a>
10	1	<a href="#">UMAXP</a>
11	0	<a href="#">SMINP</a>
11	1	<a href="#">UMINP</a>

## SVE2 saturating add/subtract

These instructions are under [SVE2 Integer - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size	0	1	1	op	S	U	1	0	0		Pg												

Decode fields			Instruction Details
op	S	U	
0	0	0	<a href="#">SQADD (vectors, predicated)</a>
0	0	1	<a href="#">UQADD (vectors, predicated)</a>
0	1	0	<a href="#">SQSUB (vectors, predicated)</a>
0	1	1	<a href="#">UQSUB (vectors, predicated)</a>
1	0	0	<a href="#">SUQADD</a>
1	0	1	<a href="#">USQADD</a>
1	1	0	<a href="#">SQSUBR</a>
1	1	1	<a href="#">UQSUBR</a>

## SVE Multiply - Indexed

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
01000100										1																					
																op0															

Decode fields		Instruction details
op0		
00000x		<a href="#">SVE integer dot product (indexed)</a>
00001x		<a href="#">SVE2 integer multiply-add (indexed)</a>
00010x		<a href="#">SVE2 saturating multiply-add high (indexed)</a>
00011x		<a href="#">SVE mixed sign dot product (indexed)</a>
001xxx		<a href="#">SVE2 saturating multiply-add (indexed)</a>
0100xx		<a href="#">SVE2 complex integer dot product (indexed)</a>
0101xx		UNALLOCATED
0110xx		<a href="#">SVE2 complex integer multiply-add (indexed)</a>
0111xx		<a href="#">SVE2 complex saturating multiply-add (indexed)</a>
10xxxx		<a href="#">SVE2 integer multiply-add long (indexed)</a>
110xxx		<a href="#">SVE2 integer multiply long (indexed)</a>
1110xx		<a href="#">SVE2 saturating multiply (indexed)</a>
11110x		<a href="#">SVE2 saturating multiply high (indexed)</a>
111110		<a href="#">SVE2 integer multiply (indexed)</a>
111111		UNALLOCATED

## SVE integer dot product (indexed)

These instructions are under [SVE Multiply - Indexed](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size	1	opc				0	0	0	0	0	U	Zn				Zda							

Decode fields		Instruction Details
size	U	
0x		UNALLOCATED
10	0	<a href="#">SDOT (indexed) — 32-bit</a>
10	1	<a href="#">UDOT (indexed) — 32-bit</a>
11	0	<a href="#">SDOT (indexed) — 64-bit</a>
11	1	<a href="#">UDOT (indexed) — 64-bit</a>

**SVE2 integer multiply-add (indexed)**

These instructions are under [SVE Multiply - Indexed](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size	1			opc				0	0	0	0	1	S			Zn					Zda		

Decode fields size	S	Instruction Details
0x	0	<a href="#">MLA (indexed) — 16-bit</a>
0x	1	<a href="#">MLS (indexed) — 16-bit</a>
10	0	<a href="#">MLA (indexed) — 32-bit</a>
10	1	<a href="#">MLS (indexed) — 32-bit</a>
11	0	<a href="#">MLA (indexed) — 64-bit</a>
11	1	<a href="#">MLS (indexed) — 64-bit</a>

**SVE2 saturating multiply-add high (indexed)**

These instructions are under [SVE Multiply - Indexed](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size	1			opc				0	0	0	1	0	S			Zn					Zda		

Decode fields size	S	Instruction Details
0x	0	<a href="#">SQRDMLAH (indexed) — 16-bit</a>
0x	1	<a href="#">SQRDMLSH (indexed) — 16-bit</a>
10	0	<a href="#">SQRDMLAH (indexed) — 32-bit</a>
10	1	<a href="#">SQRDMLSH (indexed) — 32-bit</a>
11	0	<a href="#">SQRDMLAH (indexed) — 64-bit</a>
11	1	<a href="#">SQRDMLSH (indexed) — 64-bit</a>

**SVE mixed sign dot product (indexed)**

These instructions are under [SVE Multiply - Indexed](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size	1			opc				0	0	0	1	1	U			Zn					Zda		

Decode fields size	U	Instruction Details
0x		UNALLOCATED
10	0	<a href="#">USDOT (indexed)</a>
10	1	<a href="#">SUDOT</a>
11		UNALLOCATED

**SVE2 saturating multiply-add (indexed)**

These instructions are under [SVE Multiply - Indexed](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size	1			opc				0	0	1	S	il	T			Zn					Zda		

Decode fields size	S	T	Instruction Details
0x			UNALLOCATED

Decode fields size	S	T	Instruction Details
10	0	0	<a href="#">SQDMLALB (indexed) — 32-bit</a>
10	0	1	<a href="#">SQDMLALT (indexed) — 32-bit</a>
10	1	0	<a href="#">SQDMLSLB (indexed) — 32-bit</a>
10	1	1	<a href="#">SQDMLSLT (indexed) — 32-bit</a>
11	0	0	<a href="#">SQDMLALB (indexed) — 64-bit</a>
11	0	1	<a href="#">SQDMLALT (indexed) — 64-bit</a>
11	1	0	<a href="#">SQDMLSLB (indexed) — 64-bit</a>
11	1	1	<a href="#">SQDMLSLT (indexed) — 64-bit</a>

### SVE2 complex integer dot product (indexed)

These instructions are under [SVE Multiply - Indexed](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	1	0	0	0	1	0	0	size	1	opc						0	1	0	0	rot	Zn						Zda					

Decode fields size	Instruction Details
0x	UNALLOCATED
10	<a href="#">CDOT (indexed) — 32-bit</a>
11	<a href="#">CDOT (indexed) — 64-bit</a>

### SVE2 complex integer multiply-add (indexed)

These instructions are under [SVE Multiply - Indexed](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size	1	opc			0	1	1	0	rot		Zn				Zda								

Decode fields size	Instruction Details
0x	UNALLOCATED
10	<a href="#">CMLA (indexed) — 16-bit</a>
11	<a href="#">CMLA (indexed) — 32-bit</a>

### SVE2 complex saturating multiply-add (indexed)

These instructions are under [SVE Multiply - Indexed](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	1	0	0	0	1	0	0	size	1	opc						0	1	1	1	rot	Zn						Zda					

Decode fields size	Instruction Details
0x	UNALLOCATED
10	<a href="#">SQRDCMLAH (indexed) — 16-bit</a>
11	<a href="#">SQRDCMLAH (indexed) — 32-bit</a>

### SVE2 integer multiply-add long (indexed)

These instructions are under [SVE Multiply - Indexed](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	1	0	0	0	1	0	0	size	1	opc						1	0	S	U	il	T	Zn						Zda					

Decode fields				Instruction Details
size	S	U	T	
0x				UNALLOCATED
10	0	0	0	<a href="#">SMLALB (indexed) — 32-bit</a>
10	0	0	1	<a href="#">SMLALT (indexed) — 32-bit</a>
10	0	1	0	<a href="#">UMLALB (indexed) — 32-bit</a>
10	0	1	1	<a href="#">UMLALT (indexed) — 32-bit</a>
10	1	0	0	<a href="#">SMLSLB (indexed) — 32-bit</a>
10	1	0	1	<a href="#">SMLSLT (indexed) — 32-bit</a>
10	1	1	0	<a href="#">UMLSLB (indexed) — 32-bit</a>
10	1	1	1	<a href="#">UMLSLT (indexed) — 32-bit</a>
11	0	0	0	<a href="#">SMLALB (indexed) — 64-bit</a>
11	0	0	1	<a href="#">SMLALT (indexed) — 64-bit</a>
11	0	1	0	<a href="#">UMLALB (indexed) — 64-bit</a>
11	0	1	1	<a href="#">UMLALT (indexed) — 64-bit</a>
11	1	0	0	<a href="#">SMLSLB (indexed) — 64-bit</a>
11	1	0	1	<a href="#">SMLSLT (indexed) — 64-bit</a>
11	1	1	0	<a href="#">UMLSLB (indexed) — 64-bit</a>
11	1	1	1	<a href="#">UMLSLT (indexed) — 64-bit</a>

### SVE2 integer multiply long (indexed)

These instructions are under [SVE Multiply - Indexed](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size	1	opc			1	1	0	U	il	T	Zn					Zd							

Decode fields			Instruction Details
size	U	T	
0x			UNALLOCATED
10	0	0	<a href="#">SMULLB (indexed) — 32-bit</a>
10	0	1	<a href="#">SMULLT (indexed) — 32-bit</a>
10	1	0	<a href="#">UMULLB (indexed) — 32-bit</a>
10	1	1	<a href="#">UMULLT (indexed) — 32-bit</a>
11	0	0	<a href="#">SMULLB (indexed) — 64-bit</a>
11	0	1	<a href="#">SMULLT (indexed) — 64-bit</a>
11	1	0	<a href="#">UMULLB (indexed) — 64-bit</a>
11	1	1	<a href="#">UMULLT (indexed) — 64-bit</a>

### SVE2 saturating multiply (indexed)

These instructions are under [SVE Multiply - Indexed](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size	1	opc			1	1	1	0	il	T	Zn					Zd							

Decode fields		Instruction Details
size	T	
0x		UNALLOCATED
10	0	<a href="#">SQDMULLB (indexed) — 32-bit</a>
10	1	<a href="#">SQDMULLT (indexed) — 32-bit</a>

Decode fields size	T	Instruction Details
11	0	<a href="#">SQDMULLB (indexed) — 64-bit</a>
11	1	<a href="#">SQDMULLT (indexed) — 64-bit</a>

### SVE2 saturating multiply high (indexed)

These instructions are under [SVE Multiply - Indexed](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size	1		opc		1	1	1	1	0	R													

Decode fields size	R	Instruction Details
0x	0	<a href="#">SQDMULH (indexed) — 16-bit</a>
0x	1	<a href="#">SQORDMULH (indexed) — 16-bit</a>
10	0	<a href="#">SQDMULH (indexed) — 32-bit</a>
10	1	<a href="#">SQORDMULH (indexed) — 32-bit</a>
11	0	<a href="#">SQDMULH (indexed) — 64-bit</a>
11	1	<a href="#">SQORDMULH (indexed) — 64-bit</a>

### SVE2 integer multiply (indexed)

These instructions are under [SVE Multiply - Indexed](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	0	size	1		opc		1	1	1	1	1	0													

Decode fields size	Instruction Details
0x	<a href="#">MUL (indexed) — 16-bit</a>
10	<a href="#">MUL (indexed) — 32-bit</a>
11	<a href="#">MUL (indexed) — 64-bit</a>

## SVE2 Widening Integer Arithmetic

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
										0						0	op0														

Decode fields op0	Instruction details
0x	<a href="#">SVE2 integer add/subtract long</a>
10	<a href="#">SVE2 integer add/subtract wide</a>
11	<a href="#">SVE2 integer multiply long</a>

### SVE2 integer add/subtract long

These instructions are under [SVE2 Widening Integer Arithmetic](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	size	0								0	0	op	S	U	T									

Decode fields				Instruction Details
op	S	U	T	
0	0	0	0	<a href="#">SADDLB</a>
0	0	0	1	<a href="#">SADDLT</a>
0	0	1	0	<a href="#">UADDLB</a>
0	0	1	1	<a href="#">UADDLT</a>
0	1	0	0	<a href="#">SSUBLB</a>
0	1	0	1	<a href="#">SSUBLT</a>
0	1	1	0	<a href="#">USUBLB</a>
0	1	1	1	<a href="#">USUBLT</a>
1	0			UNALLOCATED
1	1	0	0	<a href="#">SABDLB</a>
1	1	0	1	<a href="#">SABDLT</a>
1	1	1	0	<a href="#">UABDLB</a>
1	1	1	1	<a href="#">UABDLT</a>

## SVE2 integer add/subtract wide

These instructions are under [SVE2 Widening Integer Arithmetic](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	size	0	Zm						0	1	0	S	U	T	Zn						Zd			

Decode fields			Instruction Details
S	U	T	
0	0	0	<a href="#">SADDWB</a>
0	0	1	<a href="#">SADDWT</a>
0	1	0	<a href="#">UADDWB</a>
0	1	1	<a href="#">UADDWT</a>
1	0	0	<a href="#">SSUBWB</a>
1	0	1	<a href="#">SSUBWT</a>
1	1	0	<a href="#">USUBWB</a>
1	1	1	<a href="#">USUBWT</a>

## SVE2 integer multiply long

These instructions are under [SVE2 Widening Integer Arithmetic](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	size	0	Zm						0	1	1	op	U	T	Zn						Zd			

Decode fields			Instruction Details
op	U	T	
0	0	0	<a href="#">SQDMULLB (vectors)</a>
0	0	1	<a href="#">SQDMULLT (vectors)</a>
0	1	0	<a href="#">PMULLB</a>
0	1	1	<a href="#">PMULLT</a>
1	0	0	<a href="#">SMULLB (vectors)</a>
1	0	1	<a href="#">SMULLT (vectors)</a>
1	1	0	<a href="#">UMULLB (vectors)</a>
1	1	1	<a href="#">UMULLT (vectors)</a>



## SVE Misc

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
01000101								op0		0					10	op1															

Decode fields		Instruction details
op0	op1	
0	10xx	<a href="#">SVE2 bitwise shift left long</a>
1	10xx	UNALLOCATED
	00xx	<a href="#">SVE2 integer add/subtract interleaved long</a>
	010x	<a href="#">SVE2 bitwise exclusive-or interleaved</a>
	0110	<a href="#">SVE integer matrix multiply accumulate</a>
	0111	UNALLOCATED
	11xx	<a href="#">SVE2 bitwise permute</a>

### SVE2 bitwise shift left long

These instructions are under [SVE Misc](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	0	tszh	0	tszl	imm3			1	0	1	0	U	T	Zn				Zd						

Decode fields		Instruction Details
U	T	
0	0	<a href="#">SSHLLB</a>
0	1	<a href="#">SSHLLT</a>
1	0	<a href="#">USHLLB</a>
1	1	<a href="#">USHLLT</a>

### SVE2 integer add/subtract interleaved long

These instructions are under [SVE Misc](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	size		0	Zm				1	0	0	0	S	tb	Zn				Zd						

Decode fields		Instruction Details
S	tb	
0	0	<a href="#">SADDLBT</a>
0	1	UNALLOCATED
1	0	<a href="#">SSUBLBT</a>
1	1	<a href="#">SSUBLTB</a>

### SVE2 bitwise exclusive-or interleaved

These instructions are under [SVE Misc](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	size		0	Zm				1	0	0	1	0	tb	Zn				Zd						

Decode fields		Instruction Details
tb		
0		<a href="#">EORBT</a>
1		<a href="#">EORTB</a>

**SVE integer matrix multiply accumulate**

These instructions are under [SVE Misc](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	uns	0				Zm			1	0	0	1	1	0			Zn					Zd		

Decode fields uns	Instruction Details
00	<a href="#">SMMLA</a>
01	UNALLOCATED
10	<a href="#">USMMLA</a>
11	<a href="#">UMMLA</a>

**SVE2 bitwise permute**

These instructions are under [SVE Misc](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	size	0	Zm						1	0	1	1	opc	Zn						Zd				

Decode fields opc	Instruction Details
00	<a href="#">BEXT</a>
01	<a href="#">BDEP</a>
10	<a href="#">BGRP</a>
11	UNALLOCATED

**SVE2 Accumulate**

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
										0		op0				11			op1												

Decode fields op0	op1	Instruction details
0000	011	<a href="#">SVE2 complex integer add</a>
!= 0000	011	UNALLOCATED
	00x	<a href="#">SVE2 integer absolute difference and accumulate long</a>
	010	<a href="#">SVE2 integer add/subtract long with carry</a>
	10x	<a href="#">SVE2 bitwise shift right and accumulate</a>
	110	<a href="#">SVE2 bitwise shift and insert</a>
	111	<a href="#">SVE2 integer absolute difference and accumulate</a>

**SVE2 complex integer add**

These instructions are under [SVE2 Accumulate](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	size	0	0	0	0	0	0	op	1	1	0	1	1	rot			Zm					Zdn		

Decode fields op	Instruction Details
0	<a href="#">CADD</a>
1	<a href="#">SQCADD</a>

**SVE2 integer absolute difference and accumulate long**

These instructions are under [SVE2 Accumulate](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	size	0				Zm			1	1	0	0	U	T			Zn					Zda		

Decode fields		Instruction Details
U	T	
0	0	<a href="#">SABALB</a>
0	1	<a href="#">SABALT</a>
1	0	<a href="#">UABALB</a>
1	1	<a href="#">UABALT</a>

**SVE2 integer add/subtract long with carry**

These instructions are under [SVE2 Accumulate](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	size	0				Zm			1	1	0	1	0	T			Zn					Zda		

Decode fields		Instruction Details
size	T	
0x	0	<a href="#">ADCLB</a>
0x	1	<a href="#">ADCLT</a>
1x	0	<a href="#">SBCLB</a>
1x	1	<a href="#">SBCLT</a>

**SVE2 bitwise shift right and accumulate**

These instructions are under [SVE2 Accumulate](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	tszh	0	tszl			imm3			1	1	1	0	R	U			Zn					Zda		

Decode fields		Instruction Details
R	U	
0	0	<a href="#">SSRA</a>
0	1	<a href="#">USRA</a>
1	0	<a href="#">SRSRA</a>
1	1	<a href="#">URSRA</a>

**SVE2 bitwise shift and insert**

These instructions are under [SVE2 Accumulate](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	tszh	0	tszl			imm3			1	1	1	1	0	op			Zn					Zd		

Decode fields		Instruction Details
op		
0		<a href="#">SRI</a>
1		<a href="#">SLI</a>

**SVE2 integer absolute difference and accumulate**

These instructions are under [SVE2 Accumulate](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	size	0				Zm			1	1	1	1	1	U				Zn				Zda		

Decode fields	Instruction Details
U	
0	<a href="#">SABA</a>
1	<a href="#">UABA</a>

## SVE2 Narrowing

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
01000101								op0		1			op1		0	op2															

Decode fields			Instruction details
op0	op1	op2	
0	000	10	<a href="#">SVE2 saturating extract narrow</a>
0	!= 000	10	UNALLOCATED
0		0x	<a href="#">SVE2 bitwise shift right narrow</a>
1		0x	UNALLOCATED
1		10	UNALLOCATED
		11	<a href="#">SVE2 integer add/subtract narrow high part</a>

## SVE2 saturating extract narrow

These instructions are under [SVE2 Narrowing](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	0	tszh	1	tszl		0	0	0	0	1	0	opc	T				Zn					Zd		

Decode fields		Instruction Details
opc	T	
00	0	<a href="#">SQXTNB</a>
00	1	<a href="#">SQXTNT</a>
01	0	<a href="#">UQXTNB</a>
01	1	<a href="#">UQXTNT</a>
10	0	<a href="#">SQXTUNB</a>
10	1	<a href="#">SQXTUNT</a>
11		UNALLOCATED

## SVE2 bitwise shift right narrow

These instructions are under [SVE2 Narrowing](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	0	tszh	1	tszl		imm3		0	0	op	U	R	T				Zn					Zd		

Decode fields				Instruction Details
op	U	R	T	
0	0	0	0	<a href="#">SQSHRUNB</a>
0	0	0	1	<a href="#">SQSHRUNT</a>
0	0	1	0	<a href="#">SQRSHRUNB</a>
0	0	1	1	<a href="#">SQRSHRUNT</a>
0	1	0	0	<a href="#">SHRNB</a>

Decode fields				Instruction Details
op	U	R	T	
0	1	0	1	<a href="#">SHRNT</a>
0	1	1	0	<a href="#">RSHRNB</a>
0	1	1	1	<a href="#">RSHRNT</a>
1	0	0	0	<a href="#">SQSHRNB</a>
1	0	0	1	<a href="#">SQSHRNT</a>
1	0	1	0	<a href="#">SQRSHRNB</a>
1	0	1	1	<a href="#">SQRSHRNT</a>
1	1	0	0	<a href="#">UQSHRNB</a>
1	1	0	1	<a href="#">UQSHRNT</a>
1	1	1	0	<a href="#">UQRSHRNB</a>
1	1	1	1	<a href="#">UQRSHRNT</a>

## SVE2 integer add/subtract narrow high part

These instructions are under [SVE2 Narrowing](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	size	1	Zm						0	1	1	S	R	T	Zn						Zd			

Decode fields			Instruction Details
S	R	T	
0	0	0	<a href="#">ADDHNB</a>
0	0	1	<a href="#">ADDHNT</a>
0	1	0	<a href="#">RADDHNB</a>
0	1	1	<a href="#">RADDHNT</a>
1	0	0	<a href="#">SUBHNB</a>
1	0	1	<a href="#">SUBHNT</a>
1	1	0	<a href="#">RSUBHNB</a>
1	1	1	<a href="#">RSUBHNT</a>

## SVE2 character match

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	size	1	Zm			1	0	0	Pg		Zn			op		Pd								

Decode fields		Instruction Details
op		
0		<a href="#">MATCH</a>
1		<a href="#">NMATCH</a>

## SVE2 Histogram Computation - Segment

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
						01000101				1									101		op0										

Decode fields		Instruction details
op0		
000		<a href="#">HISTSEG</a>

!= 000	UNALLOCATED
--------	-------------

## SVE2 Crypto Extensions

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
01000101									1	op0		op1		111		op2			op3												

Decode fields				Instruction details
op0	op1	op2	op3	
000	00	00	00000	<a href="#">SVE2 crypto unary operations</a>
000	00	00	!= 00000	UNALLOCATED
000	00	x1		UNALLOCATED
000	01	0x		UNALLOCATED
000	01	11		UNALLOCATED
000	1x	00		<a href="#">SVE2 crypto destructive binary operations</a>
000	1x	x1		UNALLOCATED
!= 000		0x		UNALLOCATED
!= 000		11		UNALLOCATED
		10		<a href="#">SVE2 crypto constructive binary operations</a>

## SVE2 crypto unary operations

These instructions are under [SVE2 Crypto Extensions](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	size		1	0	0	0	0	0	1	1	1	0	0	op	0	0	0	0	0	Zdn				

Decode fields		Instruction Details
size	op	
00	0	<a href="#">AESMC</a>
00	1	<a href="#">AESIMC</a>
01		UNALLOCATED
1x		UNALLOCATED

## SVE2 crypto destructive binary operations

These instructions are under [SVE2 Crypto Extensions](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	size		1	0	0	0	1	op	1	1	1	0	0	o2	Zm				Zdn					

Decode fields			Instruction Details
size	op	o2	
00	0	0	<a href="#">AESE</a>
00	0	1	<a href="#">AESD</a>
00	1	0	<a href="#">SM4E</a>
00	1	1	UNALLOCATED
01			UNALLOCATED
1x			UNALLOCATED

**SVE2 crypto constructive binary operations**

These instructions are under [SVE2 Crypto Extensions](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	0	1	0	1	size	1				Zm			1	1	1	1	0	op				Zn				Zd		

Decode fields size	op	Instruction Details
00	0	<a href="#">SM4EKEY</a>
00	1	<a href="#">RAX1</a>
01		UNALLOCATED
1x		UNALLOCATED

**SVE floating-point convert precision odd elements**

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	opc		0	0	1	0	opc2		1	0	1		Pg				Zn					Zd		

Decode fields opc	opc2	Instruction Details
x0	11	UNALLOCATED
00	0x	UNALLOCATED
00	10	<a href="#">FCVTXNT</a>
01		UNALLOCATED
10	00	<a href="#">FCVTNT</a> — <a href="#">single-precision to half-precision</a>
10	01	<a href="#">FCVTLT</a> — <a href="#">half-precision to single-precision</a>
10	10	<a href="#">BFCVTNT</a>
11	0x	UNALLOCATED
11	10	<a href="#">FCVTNT</a> — <a href="#">double-precision to single-precision</a>
11	11	<a href="#">FCVTLT</a> — <a href="#">single-precision to double-precision</a>

**SVE2 floating-point pairwise operations**

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	size	0	1	0		opc	1	0	0				Pg				Zm				Zdn			

Decode fields opc	Instruction Details
000	<a href="#">FADDP</a>
001	UNALLOCATED
01x	UNALLOCATED
100	<a href="#">FMAXNMP</a>
101	<a href="#">FMINNMP</a>
110	<a href="#">FMAXP</a>
111	<a href="#">FMINP</a>

**SVE floating-point multiply-add (indexed)**

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	size	1				opc			0	0	0	0	0	op				Zn				Zda		

Decode fields		Instruction Details
size	op	
0x	0	<a href="#">FMLA (indexed) — half-precision</a>
0x	1	<a href="#">FMLS (indexed) — half-precision</a>
10	0	<a href="#">FMLA (indexed) — single-precision</a>
10	1	<a href="#">FMLS (indexed) — single-precision</a>
11	0	<a href="#">FMLA (indexed) — double-precision</a>
11	1	<a href="#">FMLS (indexed) — double-precision</a>

### SVE floating-point complex multiply-add (indexed)

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	1	1	0	0	1	0	0	size	1	opc						0	0	0	1	rot	Zn						Zda					

Decode fields		Instruction Details
size		
0x		UNALLOCATED
10		<a href="#">FCMLA (indexed) — half-precision</a>
11		<a href="#">FCMLA (indexed) — single-precision</a>

### SVE floating-point multiply (indexed)

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	size	1	opc						0	0	1	0	0	0	Zn						Zd			

Decode fields		Instruction Details
size		
0x		<a href="#">FMUL (indexed) — half-precision</a>
10		<a href="#">FMUL (indexed) — single-precision</a>
11		<a href="#">FMUL (indexed) — double-precision</a>

### SVE Floating Point Widening Multiply-Add - Indexed

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
								01100100	op0		1						01	op1	0	op2											

Decode fields			Instruction details
op0	op1	op2	
0	0	00	<a href="#">SVE BFloat16 floating-point dot product (indexed)</a>
0	0	!= 00	UNALLOCATED
0	1		UNALLOCATED
1			<a href="#">SVE floating-point multiply-add long (indexed)</a>

### SVE floating-point multiply-add long (indexed)

These instructions are under [SVE encodings](#).



31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	1	o2	1	i3h		Zm		0	1	op	0	i3l	T					Zn					Zda	

Decode fields			Instruction Details
o2	op	T	
0	0	0	<a href="#">FMLALB (indexed)</a>
0	0	1	<a href="#">FMLALT (indexed)</a>
0	1	0	<a href="#">FMLSBL (indexed)</a>
0	1	1	<a href="#">FMSLST (indexed)</a>
1	0	0	<a href="#">BFMLALB (indexed)</a>
1	0	1	<a href="#">BFMLALT (indexed)</a>
1	1		UNALLOCATED

### SVE BFloat16 floating-point dot product (indexed)

These instructions are under [SVE Floating Point Widening Multiply-Add - Indexed](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	0	op	1	i2		Zm		0	1	0	0	0	0					Zn					Zda	

Decode fields		Instruction Details
op		
0		UNALLOCATED
1		<a href="#">BFDOT (indexed)</a>

### SVE floating-point multiply-add long (indexed)

These instructions are under [SVE Floating Point Widening Multiply-Add - Indexed](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	1	o2	1	i3h		Zm		0	1	op	0	i3l	T					Zn					Zda	

Decode fields			Instruction Details
o2	op	T	
0	0	0	<a href="#">FMLALB (indexed)</a>
0	0	1	<a href="#">FMLALT (indexed)</a>
0	1	0	<a href="#">FMLSBL (indexed)</a>
0	1	1	<a href="#">FMSLST (indexed)</a>
1	0	0	<a href="#">BFMLALB (indexed)</a>
1	0	1	<a href="#">BFMLALT (indexed)</a>
1	1		UNALLOCATED

### SVE Floating Point Widening Multiply-Add

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
									op0		1						10	op1	00	op2											

Decode fields			Instruction details
op0	op1	op2	
0	0	0	<a href="#">SVE BFloat16 floating-point dot product</a>
0	0	1	UNALLOCATED
0	1		UNALLOCATED
1			<a href="#">SVE floating-point multiply-add long</a>

**SVE floating-point multiply-add long**

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	1	o2	1	Zm					1	0	op	0	0	T	Zn					Zda				

Decode fields			Instruction Details
o2	op	T	
0	0	0	<a href="#">FMLALB (vectors)</a>
0	0	1	<a href="#">FMLALT (vectors)</a>
0	1	0	<a href="#">FMLSBL (vectors)</a>
0	1	1	<a href="#">FMLSLL (vectors)</a>
1	0	0	<a href="#">BFMLALB (vectors)</a>
1	0	1	<a href="#">BFMLALT (vectors)</a>
1	1		UNALLOCATED

**SVE BFloat16 floating-point dot product**

These instructions are under [SVE Floating Point Widening Multiply-Add](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	0	op	1	Zm					1	0	0	0	0	0	Zn					Zda				

Decode fields		Instruction Details
op		
0		UNALLOCATED
1		<a href="#">BFDOT (vectors)</a>

**SVE floating-point multiply-add long**

These instructions are under [SVE Floating Point Widening Multiply-Add](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	1	o2	1	Zm					1	0	op	0	0	T	Zn					Zda				

Decode fields			Instruction Details
o2	op	T	
0	0	0	<a href="#">FMLALB (vectors)</a>
0	0	1	<a href="#">FMLALT (vectors)</a>
0	1	0	<a href="#">FMLSBL (vectors)</a>
0	1	1	<a href="#">FMLSLL (vectors)</a>
1	0	0	<a href="#">BFMLALB (vectors)</a>
1	0	1	<a href="#">BFMLALT (vectors)</a>
1	1		UNALLOCATED

**SVE floating point matrix multiply accumulate**

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	1	1	0	0	1	0	0	opc	1	Zm						1	1	1	0	0	1	Zn						Zda				

Decode fields		Instruction Details
opc		
00		UNALLOCATED

Decode fields opc	Instruction Details
01	<a href="#">BFMMLA</a>
10	<a href="#">FMMLA</a> — 32-bit element
11	<a href="#">FMMLA</a> — 64-bit element

## SVE floating-point compare vectors

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	Zm			op	1	o2	Pg			Zn			o3	Pd								

Decode fields op	o2	o3	Instruction Details
0	0	0	<a href="#">FCM&lt;cc&gt; (vectors)</a> — <a href="#">FCMGE</a>
0	0	1	<a href="#">FCM&lt;cc&gt; (vectors)</a> — <a href="#">FCMGT</a>
0	1	0	<a href="#">FCM&lt;cc&gt; (vectors)</a> — <a href="#">FCMEQ</a>
0	1	1	<a href="#">FCM&lt;cc&gt; (vectors)</a> — <a href="#">FCMNE</a>
1	0	0	<a href="#">FCM&lt;cc&gt; (vectors)</a> — <a href="#">FCMUO</a>
1	0	1	<a href="#">FAC&lt;cc&gt;</a> — <a href="#">FACGE</a>
1	1	0	UNALLOCATED
1	1	1	<a href="#">FAC&lt;cc&gt;</a> — <a href="#">FACGT</a>

## SVE floating-point arithmetic (unpredicated)

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	Zm			0	0	0	opc			Zn			Zd									

Decode fields opc	Instruction Details
000	<a href="#">FADD (vectors, unpredicated)</a>
001	<a href="#">FSUB (vectors, unpredicated)</a>
010	<a href="#">FMUL (vectors, unpredicated)</a>
011	<a href="#">FTSMUL</a>
10x	UNALLOCATED
110	<a href="#">FRECPS</a>
111	<a href="#">FRSORTS</a>

## SVE Floating Point Arithmetic - Predicated

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
										0	op0						100		op1			op2									

Decode fields op0	op1	op2	Instruction details
0x			<a href="#">SVE floating-point arithmetic (predicated)</a>
10	000		<a href="#">FTMAD</a>
10	!= 000		UNALLOCATED
11		0000	<a href="#">SVE floating-point arithmetic with immediate (predicated)</a>

11		!= 0000	UNALLOCATED
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## SVE floating-point arithmetic (predicated)

These instructions are under [SVE Floating Point Arithmetic - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size		0	0	opc			1			0	0	Pg			Zm			Zdn					

Decode fields opc	Instruction Details
0000	<a href="#">FADD (vectors, predicated)</a>
0001	<a href="#">FSUB (vectors, predicated)</a>
0010	<a href="#">FMUL (vectors, predicated)</a>
0011	<a href="#">FSUBR (vectors)</a>
0100	<a href="#">FMAXNM (vectors)</a>
0101	<a href="#">FMINNM (vectors)</a>
0110	<a href="#">FMAX (vectors)</a>
0111	<a href="#">FMIN (vectors)</a>
1000	<a href="#">FABD</a>
1001	<a href="#">FSCALE</a>
1010	<a href="#">FMULX</a>
1011	UNALLOCATED
1100	<a href="#">FDIVR</a>
1101	<a href="#">FDIV</a>
111x	UNALLOCATED

## SVE floating-point arithmetic with immediate (predicated)

These instructions are under [SVE Floating Point Arithmetic - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	1	1	opc	1	0	0	Pg	0	0	0	0	i1	Zdn									

Decode fields opc	Instruction Details
000	<a href="#">FADD (immediate)</a>
001	<a href="#">FSUB (immediate)</a>
010	<a href="#">FMUL (immediate)</a>
011	<a href="#">FSUBR (immediate)</a>
100	<a href="#">FMAXNM (immediate)</a>
101	<a href="#">FMINNM (immediate)</a>
110	<a href="#">FMAX (immediate)</a>
111	<a href="#">FMIN (immediate)</a>

## SVE Floating Point Unary Operations - Predicated

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
01100101									0	op0					101																

Decode fields      Instruction details

**op0**

00x	<a href="#">SVE floating-point round to integral value</a>
010	<a href="#">SVE floating-point convert precision</a>
011	<a href="#">SVE floating-point unary operations</a>
10x	<a href="#">SVE integer convert to floating-point</a>
11x	<a href="#">SVE floating-point convert to integer</a>

**SVE floating-point round to integral value**

These instructions are under [SVE Floating Point Unary Operations - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	opc	1	0	1	Pg	Zn			Zd											

**Decode fields****Instruction Details**

<b>opc</b>	
000	<a href="#">FRINT&lt;r&gt; — nearest with ties to even</a>
001	<a href="#">FRINT&lt;r&gt; — toward plus infinity</a>
010	<a href="#">FRINT&lt;r&gt; — toward minus infinity</a>
011	<a href="#">FRINT&lt;r&gt; — toward zero</a>
100	<a href="#">FRINT&lt;r&gt; — nearest with ties to away</a>
101	UNALLOCATED
110	<a href="#">FRINT&lt;r&gt; — current mode signalling inexact</a>
111	<a href="#">FRINT&lt;r&gt; — current mode</a>

**SVE floating-point convert precision**

These instructions are under [SVE Floating Point Unary Operations - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	opc	0	0	1	0	opc2	1	0	1	Pg	Zn			Zd										

**Decode fields****Instruction Details**

<b>opc</b>	<b>opc2</b>	
x0	11	UNALLOCATED
00	0x	UNALLOCATED
00	10	<a href="#">FCVTX</a>
01		UNALLOCATED
10	00	<a href="#">FCVT — single-precision to half-precision</a>
10	01	<a href="#">FCVT — half-precision to single-precision</a>
10	10	<a href="#">BFCVT</a>
11	00	<a href="#">FCVT — double-precision to half-precision</a>
11	01	<a href="#">FCVT — half-precision to double-precision</a>
11	10	<a href="#">FCVT — double-precision to single-precision</a>
11	11	<a href="#">FCVT — single-precision to double-precision</a>

**SVE floating-point unary operations**

These instructions are under [SVE Floating Point Unary Operations - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	1	1	opc	1	0	1	Pg	Zn			Zd										

Decode fields	Instruction Details
opc	
00	<a href="#">FRECPIX</a>
01	<a href="#">FSQRT</a>
1x	UNALLOCATED

### SVE integer convert to floating-point

These instructions are under [SVE Floating Point Unary Operations - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	opc	0	1	0	opc2	U	1	0	1	Pg														

Decode fields	Instruction Details		
opc	opc2	U	
00			UNALLOCATED
01	00		UNALLOCATED
01	01	0	<a href="#">SCVTF — 16-bit to half-precision</a>
01	01	1	<a href="#">UCVTF — 16-bit to half-precision</a>
01	10	0	<a href="#">SCVTF — 32-bit to half-precision</a>
01	10	1	<a href="#">UCVTF — 32-bit to half-precision</a>
01	11	0	<a href="#">SCVTF — 64-bit to half-precision</a>
01	11	1	<a href="#">UCVTF — 64-bit to half-precision</a>
10	0x		UNALLOCATED
10	10	0	<a href="#">SCVTF — 32-bit to single-precision</a>
10	10	1	<a href="#">UCVTF — 32-bit to single-precision</a>
10	11		UNALLOCATED
11	00	0	<a href="#">SCVTF — 32-bit to double-precision</a>
11	00	1	<a href="#">UCVTF — 32-bit to double-precision</a>
11	01		UNALLOCATED
11	10	0	<a href="#">SCVTF — 64-bit to single-precision</a>
11	10	1	<a href="#">UCVTF — 64-bit to single-precision</a>
11	11	0	<a href="#">SCVTF — 64-bit to double-precision</a>
11	11	1	<a href="#">UCVTF — 64-bit to double-precision</a>

### SVE floating-point convert to integer

These instructions are under [SVE Floating Point Unary Operations - Predicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	opc	0	1	1	opc2	U	1	0	1	Pg														

Decode fields	Instruction Details		
opc	opc2	U	
00		0	<a href="#">FLOGB</a>
00		1	UNALLOCATED
01	00		UNALLOCATED
01	01	0	<a href="#">FCVTZS — half-precision to 16-bit</a>
01	01	1	<a href="#">FCVTZU — half-precision to 16-bit</a>
01	10	0	<a href="#">FCVTZS — half-precision to 32-bit</a>
01	10	1	<a href="#">FCVTZU — half-precision to 32-bit</a>
01	11	0	<a href="#">FCVTZS — half-precision to 64-bit</a>

Decode fields			Instruction Details
opc	opc2	U	
01	11	1	<a href="#">FCVTZU — half-precision to 64-bit</a>
10	0x		UNALLOCATED
10	10	0	<a href="#">FCVTZS — single-precision to 32-bit</a>
10	10	1	<a href="#">FCVTZU — single-precision to 32-bit</a>
10	11		UNALLOCATED
11	00	0	<a href="#">FCVTZS — double-precision to 32-bit</a>
11	00	1	<a href="#">FCVTZU — double-precision to 32-bit</a>
11	01		UNALLOCATED
11	10	0	<a href="#">FCVTZS — single-precision to 64-bit</a>
11	10	1	<a href="#">FCVTZU — single-precision to 64-bit</a>
11	11	0	<a href="#">FCVTZS — double-precision to 64-bit</a>
11	11	1	<a href="#">FCVTZU — double-precision to 64-bit</a>

## SVE floating-point recursive reduction

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	0	opc	0	0	1	Pg	Zn			Vd											

Decode fields		Instruction Details
opc		
000		<a href="#">FADDV</a>
001		UNALLOCATED
01x		UNALLOCATED
100		<a href="#">FMAXNMV</a>
101		<a href="#">FMINNMV</a>
110		<a href="#">FMAXV</a>
111		<a href="#">FMINV</a>

## SVE Floating Point Unary Operations - Unpredicated

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
01100101									001				0011			op0															

Decode fields		Instruction details
op0		
00		<a href="#">SVE floating-point reciprocal estimate (unpredicated)</a>
!= 00		UNALLOCATED

## SVE floating-point reciprocal estimate (unpredicated)

These instructions are under [SVE Floating Point Unary Operations - Unpredicated](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	0	0	1	opc	0	0	1	1	0	0	Zn			Zd									

Decode fields		Instruction Details
opc		
0xx		UNALLOCATED

Decode fields opc	Instruction Details
10x	UNALLOCATED
110	<a href="#">FRECPE</a>
111	<a href="#">ERSQRT</a>

## SVE Floating Point Compare - with Zero

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1			0	1	0	op0			0	0	1													

Decode fields op0	Instruction details
0	<a href="#">SVE floating-point compare with zero</a>
1	UNALLOCATED

## SVE floating-point compare with zero

These instructions are under [SVE Floating Point Compare - with Zero](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size		0	1	0	0	eq	lt	0	0	1	Pg					Zn		ne			Pd		

Decode fields eq lt ne	Instruction Details
0 0 0	<a href="#">FCM&lt;cc&gt; (zero) — FCMGE</a>
0 0 1	<a href="#">FCM&lt;cc&gt; (zero) — FCMGT</a>
0 1 0	<a href="#">FCM&lt;cc&gt; (zero) — FCMLT</a>
0 1 1	<a href="#">FCM&lt;cc&gt; (zero) — FCMLE</a>
1 0 0	UNALLOCATED
1 0 1	<a href="#">FCM&lt;cc&gt; (zero) — FCMEQ</a>
1 1 0	<a href="#">FCM&lt;cc&gt; (zero) — FCMNE</a>

## SVE floating-point serial reduction (predicated)

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size		0	1	1	opc			0	0	1	Pg					Zm				Vdn			

Decode fields opc	Instruction Details
000	<a href="#">FADDA</a>
001	UNALLOCATED
01x	UNALLOCATED
1xx	UNALLOCATED

## SVE Floating Point Multiply-Add

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1			1						op0															



Decode fields op0	Instruction details
0	<a href="#">SVE floating-point multiply-accumulate writing addend</a>
1	<a href="#">SVE floating-point multiply-accumulate writing multiplicand</a>

## SVE floating-point multiply-accumulate writing addend

These instructions are under [SVE Floating Point Multiply-Add](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	1				Zm		0	opc		Pg						Zn					Zda		

Decode fields opc	Instruction Details
00	<a href="#">FMLA (vectors)</a>
01	<a href="#">FMLS (vectors)</a>
10	<a href="#">FNMLA</a>
11	<a href="#">FNMLS</a>

## SVE floating-point multiply-accumulate writing multiplicand

These instructions are under [SVE Floating Point Multiply-Add](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	1	size	1				Za		1	opc		Pg						Zm					Zdn		

Decode fields opc	Instruction Details
00	<a href="#">FMAD</a>
01	<a href="#">FMSB</a>
10	<a href="#">ENMAD</a>
11	<a href="#">FNMSB</a>

## SVE Memory - 32-bit Gather and Unsized Contiguous

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Decode fields				Instruction details			
op0	op1	op2	op3				
00	x1	0xx	0	<a href="#">SVE 32-bit gather prefetch (scalar plus 32-bit scaled offsets)</a>			
00	x1	0xx	1	UNALLOCATED			
01	x1	0xx		<a href="#">SVE 32-bit gather load halfwords (scalar plus 32-bit scaled offsets)</a>			
10	x1	0xx		<a href="#">SVE 32-bit gather load words (scalar plus 32-bit scaled offsets)</a>			
11	0x	000	0	<a href="#">LDR (predicate)</a>			
11	0x	000	1	UNALLOCATED			
11	0x	010		<a href="#">LDR (vector)</a>			
11	0x	0x1		UNALLOCATED			
11	1x	0xx	0	<a href="#">SVE contiguous prefetch (scalar plus immediate)</a>			
11	1x	0xx	1	UNALLOCATED			
!= 11	x0	0xx		<a href="#">SVE 32-bit gather load (scalar plus 32-bit unscaled offsets)</a>			
	00	10x		<a href="#">SVE2 32-bit gather non-temporal load (scalar plus 32-bit unscaled offsets)</a>			

	00	110	0	<a href="#">SVE contiguous prefetch (scalar plus scalar)</a>
	00	111	0	<a href="#">SVE 32-bit gather prefetch (vector plus immediate)</a>
	00	11x	1	UNALLOCATED
	01	1xx		<a href="#">SVE 32-bit gather load (vector plus immediate)</a>
	1x	1xx		<a href="#">SVE load and broadcast element</a>

### SVE 32-bit gather prefetch (scalar plus 32-bit scaled offsets)

These instructions are under [SVE Memory - 32-bit Gather and Unsized Contiguous](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	0	xs	1	Zm			0	msz		Pg			Rn			0	prfop							

Decode fields msz	Instruction Details
00	<a href="#">PRFB (scalar plus vector)</a>
01	<a href="#">PRFH (scalar plus vector)</a>
10	<a href="#">PRFW (scalar plus vector)</a>
11	<a href="#">PRFD (scalar plus vector)</a>

### SVE 32-bit gather load halfwords (scalar plus 32-bit scaled offsets)

These instructions are under [SVE Memory - 32-bit Gather and Unsized Contiguous](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	0	1	xs	1	Zm			0	U	ff	Pg			Rn			Zt								

Decode fields U ff	Instruction Details
0 0	<a href="#">LD1SH (scalar plus vector)</a>
0 1	<a href="#">LDFF1SH (scalar plus vector)</a>
1 0	<a href="#">LD1H (scalar plus vector)</a>
1 1	<a href="#">LDFF1H (scalar plus vector)</a>

### SVE 32-bit gather load words (scalar plus 32-bit scaled offsets)

These instructions are under [SVE Memory - 32-bit Gather and Unsized Contiguous](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	1	0	xs	1	Zm			0	U	ff	Pg			Rn			Zt								

Decode fields U ff	Instruction Details
0	UNALLOCATED
1 0	<a href="#">LD1W (scalar plus vector)</a>
1 1	<a href="#">LDFF1W (scalar plus vector)</a>

### SVE contiguous prefetch (scalar plus immediate)

These instructions are under [SVE Memory - 32-bit Gather and Unsized Contiguous](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	1	1	1				imm6		0	msz		Pg							Rn		0			prfop	

Decode fields msz	Instruction Details
00	<a href="#">PRFB (scalar plus immediate)</a>
01	<a href="#">PRFH (scalar plus immediate)</a>
10	<a href="#">PRFW (scalar plus immediate)</a>
11	<a href="#">PRFD (scalar plus immediate)</a>

### SVE 32-bit gather load (scalar plus 32-bit unscaled offsets)

These instructions are under [SVE Memory - 32-bit Gather and Unsized Contiguous](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	!= 11	xs	0			Zm		0	U	ff		Pg					Rn						Zt		
opc																															

The following constraints also apply to this encoding: `opc != 11 && opc != 11`

Decode fields opc	U	ff	Instruction Details
00	0	0	<a href="#">LD1SB (scalar plus vector)</a>
00	0	1	<a href="#">LDFF1SB (scalar plus vector)</a>
00	1	0	<a href="#">LD1B (scalar plus vector)</a>
00	1	1	<a href="#">LDFF1B (scalar plus vector)</a>
01	0	0	<a href="#">LD1SH (scalar plus vector)</a>
01	0	1	<a href="#">LDFF1SH (scalar plus vector)</a>
01	1	0	<a href="#">LD1H (scalar plus vector)</a>
01	1	1	<a href="#">LDFF1H (scalar plus vector)</a>
10	0		UNALLOCATED
10	1	0	<a href="#">LD1W (scalar plus vector)</a>
10	1	1	<a href="#">LDFF1W (scalar plus vector)</a>

### SVE2 32-bit gather non-temporal load (scalar plus 32-bit unscaled offsets)

These instructions are under [SVE Memory - 32-bit Gather and Unsized Contiguous](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	msz	0	0			Rm		1	0	U		Pg					Zn						Zt		

Decode fields msz	U	Instruction Details
00	0	<a href="#">LDNT1SB</a>
00	1	<a href="#">LDNT1B (vector plus scalar)</a>
01	0	<a href="#">LDNT1SH</a>
01	1	<a href="#">LDNT1H (vector plus scalar)</a>
10	0	UNALLOCATED
10	1	<a href="#">LDNT1W (vector plus scalar)</a>
11		UNALLOCATED

### SVE contiguous prefetch (scalar plus scalar)

These instructions are under [SVE Memory - 32-bit Gather and Unsized Contiguous](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	msz	0	0			Rm		1	1	0		Pg					Rn			0			prfop		

Decode fields msz	Instruction Details
00	<a href="#">PRFB (scalar plus scalar)</a>
01	<a href="#">PRFH (scalar plus scalar)</a>
10	<a href="#">PRFW (scalar plus scalar)</a>
11	<a href="#">PRFD (scalar plus scalar)</a>

### SVE 32-bit gather prefetch (vector plus immediate)

These instructions are under [SVE Memory - 32-bit Gather and Unsized Contiguous](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	msz		0	0	imm5					1	1	1	Pg			Zn			0	prfop					

Decode fields msz	Instruction Details
00	<a href="#">PRFB (vector plus immediate)</a>
01	<a href="#">PRFH (vector plus immediate)</a>
10	<a href="#">PRFW (vector plus immediate)</a>
11	<a href="#">PRFD (vector plus immediate)</a>

### SVE 32-bit gather load (vector plus immediate)

These instructions are under [SVE Memory - 32-bit Gather and Unsized Contiguous](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	msz		0	1	imm5					1	U	ff	Pg			Zn			Zt						

Decode fields msz	U	ff	Instruction Details
00	0	0	<a href="#">LD1SB (vector plus immediate)</a>
00	0	1	<a href="#">LDFF1SB (vector plus immediate)</a>
00	1	0	<a href="#">LD1B (vector plus immediate)</a>
00	1	1	<a href="#">LDFF1B (vector plus immediate)</a>
01	0	0	<a href="#">LD1SH (vector plus immediate)</a>
01	0	1	<a href="#">LDFF1SH (vector plus immediate)</a>
01	1	0	<a href="#">LD1H (vector plus immediate)</a>
01	1	1	<a href="#">LDFF1H (vector plus immediate)</a>
10	0		UNALLOCATED
10	1	0	<a href="#">LD1W (vector plus immediate)</a>
10	1	1	<a href="#">LDFF1W (vector plus immediate)</a>
11			UNALLOCATED

### SVE load and broadcast element

These instructions are under [SVE Memory - 32-bit Gather and Unsized Contiguous](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	0	1	0	dtypeh		1	imm6					1	dtypel		Pg			Rn			Zt							

Decode fields dtypeh	dtypel	Instruction Details
00	00	<a href="#">LD1RB — 8-bit element</a>
00	01	<a href="#">LD1RB — 16-bit element</a>

Decode fields		Instruction Details
dtypeh	dtypel	
00	10	<a href="#">LD1RB — 32-bit element</a>
00	11	<a href="#">LD1RB — 64-bit element</a>
01	00	<a href="#">LD1RSW</a>
01	01	<a href="#">LD1RH — 16-bit element</a>
01	10	<a href="#">LD1RH — 32-bit element</a>
01	11	<a href="#">LD1RH — 64-bit element</a>
10	00	<a href="#">LD1RSH — 64-bit element</a>
10	01	<a href="#">LD1RSH — 32-bit element</a>
10	10	<a href="#">LD1RW — 32-bit element</a>
10	11	<a href="#">LD1RW — 64-bit element</a>
11	00	<a href="#">LD1RSB — 64-bit element</a>
11	01	<a href="#">LD1RSB — 32-bit element</a>
11	10	<a href="#">LD1RSB — 16-bit element</a>
11	11	<a href="#">LD1RD</a>

## SVE Memory - Contiguous Load

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1010010								op0		op1		op2																			

Decode fields			Instruction details
op0	op1	op2	
00	0	111	<a href="#">SVE contiguous non-temporal load (scalar plus immediate)</a>
00		110	<a href="#">SVE contiguous non-temporal load (scalar plus scalar)</a>
!= 00	0	111	<a href="#">SVE load multiple structures (scalar plus immediate)</a>
!= 00		110	<a href="#">SVE load multiple structures (scalar plus scalar)</a>
	0	001	<a href="#">SVE load and broadcast quadword (scalar plus immediate)</a>
	0	101	<a href="#">SVE contiguous load (scalar plus immediate)</a>
	1	001	UNALLOCATED
	1	101	<a href="#">SVE contiguous non-fault load (scalar plus immediate)</a>
	1	111	UNALLOCATED
		000	<a href="#">SVE load and broadcast quadword (scalar plus scalar)</a>
		010	<a href="#">SVE contiguous load (scalar plus scalar)</a>
		011	<a href="#">SVE contiguous first-fault load (scalar plus scalar)</a>
		100	UNALLOCATED

## SVE contiguous non-temporal load (scalar plus immediate)

These instructions are under [SVE Memory - Contiguous Load](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	msz	0	0	0	imm4			1	1	1	Pg			Rn			Zt								

Decode fields		Instruction Details
msz		
00		<a href="#">LDNT1B (scalar plus immediate)</a>
01		<a href="#">LDNT1H (scalar plus immediate)</a>
10		<a href="#">LDNT1W (scalar plus immediate)</a>

Decode fields	Instruction Details
msz	
11	<a href="#">LDNT1D (scalar plus immediate)</a>

### SVE contiguous non-temporal load (scalar plus scalar)

These instructions are under [SVE Memory - Contiguous Load](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	msz	0	0		Rm		1	1	0		Pg			Rn							Zt				

Decode fields	Instruction Details
msz	
00	<a href="#">LDNT1B (scalar plus scalar)</a>
01	<a href="#">LDNT1H (scalar plus scalar)</a>
10	<a href="#">LDNT1W (scalar plus scalar)</a>
11	<a href="#">LDNT1D (scalar plus scalar)</a>

### SVE load multiple structures (scalar plus immediate)

These instructions are under [SVE Memory - Contiguous Load](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	msz	!= 00	0		imm4		1	1	1		Pg			Rn							Zt				
opc																															

The following constraints also apply to this encoding: `opc != 00 && opc != 00`

Decode fields	Instruction Details
msz    opc	
00    01	<a href="#">LD2B (scalar plus immediate)</a>
00    10	<a href="#">LD3B (scalar plus immediate)</a>
00    11	<a href="#">LD4B (scalar plus immediate)</a>
01    01	<a href="#">LD2H (scalar plus immediate)</a>
01    10	<a href="#">LD3H (scalar plus immediate)</a>
01    11	<a href="#">LD4H (scalar plus immediate)</a>
10    01	<a href="#">LD2W (scalar plus immediate)</a>
10    10	<a href="#">LD3W (scalar plus immediate)</a>
10    11	<a href="#">LD4W (scalar plus immediate)</a>
11    01	<a href="#">LD2D (scalar plus immediate)</a>
11    10	<a href="#">LD3D (scalar plus immediate)</a>
11    11	<a href="#">LD4D (scalar plus immediate)</a>

### SVE load multiple structures (scalar plus scalar)

These instructions are under [SVE Memory - Contiguous Load](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	msz	!= 00		Rm		1	1	0		Pg			Rn								Zt				
opc																															

The following constraints also apply to this encoding: `opc != 00 && opc != 00`

Decode fields		Instruction Details
msz	opc	
00	01	<a href="#">LD2B (scalar plus scalar)</a>
00	10	<a href="#">LD3B (scalar plus scalar)</a>
00	11	<a href="#">LD4B (scalar plus scalar)</a>
01	01	<a href="#">LD2H (scalar plus scalar)</a>
01	10	<a href="#">LD3H (scalar plus scalar)</a>
01	11	<a href="#">LD4H (scalar plus scalar)</a>
10	01	<a href="#">LD2W (scalar plus scalar)</a>
10	10	<a href="#">LD3W (scalar plus scalar)</a>
10	11	<a href="#">LD4W (scalar plus scalar)</a>
11	01	<a href="#">LD2D (scalar plus scalar)</a>
11	10	<a href="#">LD3D (scalar plus scalar)</a>
11	11	<a href="#">LD4D (scalar plus scalar)</a>

### SVE load and broadcast quadword (scalar plus immediate)

These instructions are under [SVE Memory - Contiguous Load](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	msz		ssz		0	imm4				0		0	1	Pg			Rn				Zt				

Decode fields		Instruction Details
msz	ssz	
	1x	UNALLOCATED
00	00	<a href="#">LD1RQB (scalar plus immediate)</a>
00	01	<a href="#">LD1ROB (scalar plus immediate)</a>
01	00	<a href="#">LD1RQH (scalar plus immediate)</a>
01	01	<a href="#">LD1ROH (scalar plus immediate)</a>
10	00	<a href="#">LD1RQW (scalar plus immediate)</a>
10	01	<a href="#">LD1ROW (scalar plus immediate)</a>
11	00	<a href="#">LD1RQD (scalar plus immediate)</a>
11	01	<a href="#">LD1ROD (scalar plus immediate)</a>

### SVE contiguous load (scalar plus immediate)

These instructions are under [SVE Memory - Contiguous Load](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	dtype		0		imm4				1	0	1	Pg			Rn				Zt						

Decode fields	Instruction Details
dtype	
0000	<a href="#">LD1B (scalar plus immediate)</a> — 8-bit element
0001	<a href="#">LD1B (scalar plus immediate)</a> — 16-bit element
0010	<a href="#">LD1B (scalar plus immediate)</a> — 32-bit element
0011	<a href="#">LD1B (scalar plus immediate)</a> — 64-bit element
0100	<a href="#">LD1SW (scalar plus immediate)</a>
0101	<a href="#">LD1H (scalar plus immediate)</a> — 16-bit element
0110	<a href="#">LD1H (scalar plus immediate)</a> — 32-bit element
0111	<a href="#">LD1H (scalar plus immediate)</a> — 64-bit element
1000	<a href="#">LD1SH (scalar plus immediate)</a> — 64-bit element

Decode fields	Instruction Details
dtype	
1001	<a href="#">LD1SH (scalar plus immediate) — 32-bit element</a>
1010	<a href="#">LD1W (scalar plus immediate) — 32-bit element</a>
1011	<a href="#">LD1W (scalar plus immediate) — 64-bit element</a>
1100	<a href="#">LD1SB (scalar plus immediate) — 64-bit element</a>
1101	<a href="#">LD1SB (scalar plus immediate) — 32-bit element</a>
1110	<a href="#">LD1SB (scalar plus immediate) — 16-bit element</a>
1111	<a href="#">LD1D (scalar plus immediate)</a>

### SVE contiguous non-fault load (scalar plus immediate)

These instructions are under [SVE Memory - Contiguous Load](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0			dtype		1			imm4		1	0	1		Pg				Rn					Zt		

Decode fields	Instruction Details
dtype	
0000	<a href="#">LDNF1B — 8-bit element</a>
0001	<a href="#">LDNF1B — 16-bit element</a>
0010	<a href="#">LDNF1B — 32-bit element</a>
0011	<a href="#">LDNF1B — 64-bit element</a>
0100	<a href="#">LDNF1SW</a>
0101	<a href="#">LDNF1H — 16-bit element</a>
0110	<a href="#">LDNF1H — 32-bit element</a>
0111	<a href="#">LDNF1H — 64-bit element</a>
1000	<a href="#">LDNF1SH — 64-bit element</a>
1001	<a href="#">LDNF1SH — 32-bit element</a>
1010	<a href="#">LDNF1W — 32-bit element</a>
1011	<a href="#">LDNF1W — 64-bit element</a>
1100	<a href="#">LDNF1SB — 64-bit element</a>
1101	<a href="#">LDNF1SB — 32-bit element</a>
1110	<a href="#">LDNF1SB — 16-bit element</a>
1111	<a href="#">LDNF1D</a>

### SVE load and broadcast quadword (scalar plus scalar)

These instructions are under [SVE Memory - Contiguous Load](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0		msz	ssz				Rm			0	0	0		Pg				Rn					Zt		

Decode fields		Instruction Details
msz	ssz	
	1x	UNALLOCATED
00	00	<a href="#">LD1RQB (scalar plus scalar)</a>
00	01	<a href="#">LD1ROB (scalar plus scalar)</a>
01	00	<a href="#">LD1RQH (scalar plus scalar)</a>
01	01	<a href="#">LD1ROH (scalar plus scalar)</a>
10	00	<a href="#">LD1RQW (scalar plus scalar)</a>
10	01	<a href="#">LD1ROW (scalar plus scalar)</a>



Decode fields		Instruction Details
msz	ssz	
11	00	<a href="#">LD1RQD (scalar plus scalar)</a>
11	01	<a href="#">LD1ROD (scalar plus scalar)</a>

### SVE contiguous load (scalar plus scalar)

These instructions are under [SVE Memory - Contiguous Load](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	dtype				Rm				0	1	0	Pg			Rn				Zt						

Decode fields dtype	Instruction Details
0000	<a href="#">LD1B (scalar plus scalar)</a> — 8-bit element
0001	<a href="#">LD1B (scalar plus scalar)</a> — 16-bit element
0010	<a href="#">LD1B (scalar plus scalar)</a> — 32-bit element
0011	<a href="#">LD1B (scalar plus scalar)</a> — 64-bit element
0100	<a href="#">LD1SW (scalar plus scalar)</a>
0101	<a href="#">LD1H (scalar plus scalar)</a> — 16-bit element
0110	<a href="#">LD1H (scalar plus scalar)</a> — 32-bit element
0111	<a href="#">LD1H (scalar plus scalar)</a> — 64-bit element
1000	<a href="#">LD1SH (scalar plus scalar)</a> — 64-bit element
1001	<a href="#">LD1SH (scalar plus scalar)</a> — 32-bit element
1010	<a href="#">LD1W (scalar plus scalar)</a> — 32-bit element
1011	<a href="#">LD1W (scalar plus scalar)</a> — 64-bit element
1100	<a href="#">LD1SB (scalar plus scalar)</a> — 64-bit element
1101	<a href="#">LD1SB (scalar plus scalar)</a> — 32-bit element
1110	<a href="#">LD1SB (scalar plus scalar)</a> — 16-bit element
1111	<a href="#">LD1D (scalar plus scalar)</a>

### SVE contiguous first-fault load (scalar plus scalar)

These instructions are under [SVE Memory - Contiguous Load](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	dtype				Rm				0	1	1	Pg			Rn				Zt						

Decode fields	Instruction Details
dtype	
0000	<a href="#">LDFF1B (scalar plus scalar) — 8-bit element</a>
0001	<a href="#">LDFF1B (scalar plus scalar) — 16-bit element</a>
0010	<a href="#">LDFF1B (scalar plus scalar) — 32-bit element</a>
0011	<a href="#">LDFF1B (scalar plus scalar) — 64-bit element</a>
0100	<a href="#">LDFF1SW (scalar plus scalar)</a>
0101	<a href="#">LDFF1H (scalar plus scalar) — 16-bit element</a>
0110	<a href="#">LDFF1H (scalar plus scalar) — 32-bit element</a>
0111	<a href="#">LDFF1H (scalar plus scalar) — 64-bit element</a>
1000	<a href="#">LDFF1SH (scalar plus scalar) — 64-bit element</a>
1001	<a href="#">LDFF1SH (scalar plus scalar) — 32-bit element</a>
1010	<a href="#">LDFF1W (scalar plus scalar) — 32-bit element</a>
1011	<a href="#">LDFF1W (scalar plus scalar) — 64-bit element</a>

Decode fields dtype	Instruction Details
1100	<a href="#">LDFF1SB (scalar plus scalar) — 64-bit element</a>
1101	<a href="#">LDFF1SB (scalar plus scalar) — 32-bit element</a>
1110	<a href="#">LDFF1SB (scalar plus scalar) — 16-bit element</a>
1111	<a href="#">LDFF1D (scalar plus scalar)</a>

## SVE Memory - 64-bit Gather

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	1	1																					

Decode fields				Instruction details
op0	op1	op2	op3	
00	01	0xx	1	UNALLOCATED
00	11	1xx	0	<a href="#">SVE 64-bit gather prefetch (scalar plus 64-bit scaled offsets)</a>
00	11		1	UNALLOCATED
00	x1	0xx	0	<a href="#">SVE 64-bit gather prefetch (scalar plus unpacked 32-bit scaled offsets)</a>
!= 00	11	1xx		<a href="#">SVE 64-bit gather load (scalar plus 64-bit scaled offsets)</a>
!= 00	x1	0xx		<a href="#">SVE 64-bit gather load (scalar plus 32-bit unpacked scaled offsets)</a>
	00	101		UNALLOCATED
	00	111	0	<a href="#">SVE 64-bit gather prefetch (vector plus immediate)</a>
	00	111	1	UNALLOCATED
	00	1x0		<a href="#">SVE2 64-bit gather non-temporal load (scalar plus unpacked 32-bit unscaled offsets)</a>
	01	1xx		<a href="#">SVE 64-bit gather load (vector plus immediate)</a>
	10	1xx		<a href="#">SVE 64-bit gather load (scalar plus 64-bit unscaled offsets)</a>
	x0	0xx		<a href="#">SVE 64-bit gather load (scalar plus unpacked 32-bit unscaled offsets)</a>

## SVE 64-bit gather prefetch (scalar plus 64-bit scaled offsets)

These instructions are under [SVE Memory - 64-bit Gather](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	1	1	Zm			1	msz		Pg						Rn			0	prfop				

Decode fields msz	Instruction Details
00	<a href="#">PRFB (scalar plus vector)</a>
01	<a href="#">PRFH (scalar plus vector)</a>
10	<a href="#">PRFW (scalar plus vector)</a>
11	<a href="#">PRFD (scalar plus vector)</a>

## SVE 64-bit gather prefetch (scalar plus unpacked 32-bit scaled offsets)

These instructions are under [SVE Memory - 64-bit Gather](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	0	0	xs	1	Zm			0	msz		Pg					Rn			0	prfop					

Decode fields msz	Instruction Details
00	<a href="#">PRFB (scalar plus vector)</a>
01	<a href="#">PRFH (scalar plus vector)</a>
10	<a href="#">PRFW (scalar plus vector)</a>
11	<a href="#">PRFD (scalar plus vector)</a>

### SVE 64-bit gather load (scalar plus 64-bit scaled offsets)

These instructions are under [SVE Memory - 64-bit Gather](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	!= 00	1	1		Zm		1	U	ff		Pg			Rn							Zt				
opc																															

The following constraints also apply to this encoding: `opc != 00 && opc != 00`

Decode fields opc	U	ff	Instruction Details
01	0	0	<a href="#">LD1SH (scalar plus vector)</a>
01	0	1	<a href="#">LDFF1SH (scalar plus vector)</a>
01	1	0	<a href="#">LD1H (scalar plus vector)</a>
01	1	1	<a href="#">LDFF1H (scalar plus vector)</a>
10	0	0	<a href="#">LD1SW (scalar plus vector)</a>
10	0	1	<a href="#">LDFF1SW (scalar plus vector)</a>
10	1	0	<a href="#">LD1W (scalar plus vector)</a>
10	1	1	<a href="#">LDFF1W (scalar plus vector)</a>
11	0		UNALLOCATED
11	1	0	<a href="#">LD1D (scalar plus vector)</a>
11	1	1	<a href="#">LDFF1D (scalar plus vector)</a>

### SVE 64-bit gather load (scalar plus 32-bit unpacked scaled offsets)

These instructions are under [SVE Memory - 64-bit Gather](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	!= 00	xs	1		Zm		0	U	ff		Pg			Rn							Zt				
opc																															

The following constraints also apply to this encoding: `opc != 00 && opc != 00`

Decode fields opc	U	ff	Instruction Details
01	0	0	<a href="#">LD1SH (scalar plus vector)</a>
01	0	1	<a href="#">LDFF1SH (scalar plus vector)</a>
01	1	0	<a href="#">LD1H (scalar plus vector)</a>
01	1	1	<a href="#">LDFF1H (scalar plus vector)</a>
10	0	0	<a href="#">LD1SW (scalar plus vector)</a>
10	0	1	<a href="#">LDFF1SW (scalar plus vector)</a>
10	1	0	<a href="#">LD1W (scalar plus vector)</a>
10	1	1	<a href="#">LDFF1W (scalar plus vector)</a>
11	0		UNALLOCATED
11	1	0	<a href="#">LD1D (scalar plus vector)</a>

Decode fields			Instruction Details
opc	U	ff	
11	1	1	<a href="#">LDFF1D (scalar plus vector)</a>

### SVE 64-bit gather prefetch (vector plus immediate)

These instructions are under [SVE Memory - 64-bit Gather](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	msz		0	0	imm5				1	1	1	Pg			Zn				0	prfop					

Decode fields		Instruction Details
msz		
00		<a href="#">PRFB (vector plus immediate)</a>
01		<a href="#">PRFH (vector plus immediate)</a>
10		<a href="#">PRFW (vector plus immediate)</a>
11		<a href="#">PRFD (vector plus immediate)</a>

### SVE2 64-bit gather non-temporal load (scalar plus unpacked 32-bit unscaled offsets)

These instructions are under [SVE Memory - 64-bit Gather](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	msz		0	0	Rm				1	U	0	Pg			Zn				Zt						

Decode fields		Instruction Details
msz	U	
00	0	<a href="#">LDNT1SB</a>
00	1	<a href="#">LDNT1B (vector plus scalar)</a>
01	0	<a href="#">LDNT1SH</a>
01	1	<a href="#">LDNT1H (vector plus scalar)</a>
10	0	<a href="#">LDNT1SW</a>
10	1	<a href="#">LDNT1W (vector plus scalar)</a>
11	0	UNALLOCATED
11	1	<a href="#">LDNT1D (vector plus scalar)</a>

### SVE 64-bit gather load (vector plus immediate)

These instructions are under [SVE Memory - 64-bit Gather](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	msz		0	1	imm5				1	U	ff	Pg			Zn				Zt						

Decode fields			Instruction Details
msz	U	ff	
00	0	0	<a href="#">LD1SB (vector plus immediate)</a>
00	0	1	<a href="#">LDFF1SB (vector plus immediate)</a>
00	1	0	<a href="#">LD1B (vector plus immediate)</a>
00	1	1	<a href="#">LDFF1B (vector plus immediate)</a>
01	0	0	<a href="#">LD1SH (vector plus immediate)</a>
01	0	1	<a href="#">LDFF1SH (vector plus immediate)</a>
01	1	0	<a href="#">LD1H (vector plus immediate)</a>
01	1	1	<a href="#">LDFF1H (vector plus immediate)</a>
10	0	0	<a href="#">LD1SW (vector plus immediate)</a>

Decode fields			Instruction Details
msz	U	ff	
10	0	1	<a href="#">LDFF1SW (vector plus immediate)</a>
10	1	0	<a href="#">LD1W (vector plus immediate)</a>
10	1	1	<a href="#">LDFF1W (vector plus immediate)</a>
11	0		UNALLOCATED
11	1	0	<a href="#">LD1D (vector plus immediate)</a>
11	1	1	<a href="#">LDFF1D (vector plus immediate)</a>

### SVE 64-bit gather load (scalar plus 64-bit unscaled offsets)

These instructions are under [SVE Memory - 64-bit Gather](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	msz		1	0	Zm				1	U	ff	Pg			Rn				Zt						

Decode fields			Instruction Details
msz	U	ff	
00	0	0	<a href="#">LD1SB (scalar plus vector)</a>
00	0	1	<a href="#">LDFF1SB (scalar plus vector)</a>
00	1	0	<a href="#">LD1B (scalar plus vector)</a>
00	1	1	<a href="#">LDFF1B (scalar plus vector)</a>
01	0	0	<a href="#">LD1SH (scalar plus vector)</a>
01	0	1	<a href="#">LDFF1SH (scalar plus vector)</a>
01	1	0	<a href="#">LD1H (scalar plus vector)</a>
01	1	1	<a href="#">LDFF1H (scalar plus vector)</a>
10	0	0	<a href="#">LD1SW (scalar plus vector)</a>
10	0	1	<a href="#">LDFF1SW (scalar plus vector)</a>
10	1	0	<a href="#">LD1W (scalar plus vector)</a>
10	1	1	<a href="#">LDFF1W (scalar plus vector)</a>
11	0		UNALLOCATED
11	1	0	<a href="#">LD1D (scalar plus vector)</a>
11	1	1	<a href="#">LDFF1D (scalar plus vector)</a>

### SVE 64-bit gather load (scalar plus unpacked 32-bit unscaled offsets)

These instructions are under [SVE Memory - 64-bit Gather](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	1	0	msz		xs	0	Zm				0	U	ff	Pg			Rn				Zt						

Decode fields			Instruction Details
msz	U	ff	
00	0	0	<a href="#">LD1SB (scalar plus vector)</a>
00	0	1	<a href="#">LDFF1SB (scalar plus vector)</a>
00	1	0	<a href="#">LD1B (scalar plus vector)</a>
00	1	1	<a href="#">LDFF1B (scalar plus vector)</a>
01	0	0	<a href="#">LD1SH (scalar plus vector)</a>
01	0	1	<a href="#">LDFF1SH (scalar plus vector)</a>
01	1	0	<a href="#">LD1H (scalar plus vector)</a>
01	1	1	<a href="#">LDFF1H (scalar plus vector)</a>
10	0	0	<a href="#">LD1SW (scalar plus vector)</a>

Decode fields			Instruction Details
msz	U	ff	
10	0	1	<a href="#">LDFF1SW (scalar plus vector)</a>
10	1	0	<a href="#">LD1W (scalar plus vector)</a>
10	1	1	<a href="#">LDFF1W (scalar plus vector)</a>
11	0		UNALLOCATED
11	1	0	<a href="#">LD1D (scalar plus vector)</a>
11	1	1	<a href="#">LDFF1D (scalar plus vector)</a>

## SVE Memory - Contiguous Store and Unsized Contiguous

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1110010							op0								0	op1	0								op2						

Decode fields			Instruction details
op0	op1	op2	
0xx	0		UNALLOCATED
10x	0		UNALLOCATED
110	0	0	<a href="#">STR (predicate)</a>
110	0	1	UNALLOCATED
110	1		<a href="#">STR (vector)</a>
111	0		UNALLOCATED
!= 110	1		<a href="#">SVE contiguous store (scalar plus scalar)</a>

## SVE contiguous store (scalar plus scalar)

These instructions are under [SVE Memory - Contiguous Store and Unsized Contiguous](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	!= 110		o2	Rm				0	1	0	Pg		Rn				Zt								
opc																															

The following constraints also apply to this encoding: opc != 110 && opc != 110

Decode fields		Instruction Details
opc	o2	
00x		<a href="#">ST1B (scalar plus scalar)</a>
01x		<a href="#">ST1H (scalar plus scalar)</a>
10x		<a href="#">ST1W (scalar plus scalar)</a>
111	0	UNALLOCATED
111	1	<a href="#">ST1D (scalar plus scalar)</a>

## SVE Memory - Non-temporal and Multi-register Store

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1110010											op0					0	op1	1													

Decode fields		Instruction details
op0	op1	
00	0	<a href="#">SVE2 64-bit scatter non-temporal store (vector plus scalar)</a>

00	1	<a href="#">SVE contiguous non-temporal store (scalar plus scalar)</a>
10	0	<a href="#">SVE2 32-bit scatter non-temporal store (vector plus scalar)</a>
!= 00	1	<a href="#">SVE store multiple structures (scalar plus scalar)</a>
x1	0	UNALLOCATED

**SVE2 64-bit scatter non-temporal store (vector plus scalar)**

These instructions are under [SVE Memory - Non-temporal and Multi-register Store](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	msz	0	0		Rm				0	0	1		Pg			Zn				Zt					

Decode fields msz	Instruction Details
00	<a href="#">STNT1B (vector plus scalar)</a>
01	<a href="#">STNT1H (vector plus scalar)</a>
10	<a href="#">STNT1W (vector plus scalar)</a>
11	<a href="#">STNT1D (vector plus scalar)</a>

**SVE contiguous non-temporal store (scalar plus scalar)**

These instructions are under [SVE Memory - Non-temporal and Multi-register Store](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	msz	0	0		Rm				0	1	1		Pg			Rn				Zt					

Decode fields msz	Instruction Details
00	<a href="#">STNT1B (scalar plus scalar)</a>
01	<a href="#">STNT1H (scalar plus scalar)</a>
10	<a href="#">STNT1W (scalar plus scalar)</a>
11	<a href="#">STNT1D (scalar plus scalar)</a>

**SVE2 32-bit scatter non-temporal store (vector plus scalar)**

These instructions are under [SVE Memory - Non-temporal and Multi-register Store](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	msz	1	0	Rm			0	0	1	Pg		Zn			Zt										

Decode fields msz	Instruction Details
00	<a href="#">STNT1B (vector plus scalar)</a>
01	<a href="#">STNT1H (vector plus scalar)</a>
10	<a href="#">STNT1W (vector plus scalar)</a>
11	UNALLOCATED

**SVE store multiple structures (scalar plus scalar)**

These instructions are under [SVE Memory - Non-temporal and Multi-register Store](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1 1 1 0 0 1 0							msz != 00		Rm				0 1 1			Pg			Rn				Zt								
opc																															

The following constraints also apply to this encoding: `opc != 00 && opc != 00`

Decode fields		Instruction Details
msz	opc	
00	01	<a href="#">ST2B (scalar plus scalar)</a>
00	10	<a href="#">ST3B (scalar plus scalar)</a>
00	11	<a href="#">ST4B (scalar plus scalar)</a>
01	01	<a href="#">ST2H (scalar plus scalar)</a>
01	10	<a href="#">ST3H (scalar plus scalar)</a>
01	11	<a href="#">ST4H (scalar plus scalar)</a>
10	01	<a href="#">ST2W (scalar plus scalar)</a>
10	10	<a href="#">ST3W (scalar plus scalar)</a>
10	11	<a href="#">ST4W (scalar plus scalar)</a>
11	01	<a href="#">ST2D (scalar plus scalar)</a>
11	10	<a href="#">ST3D (scalar plus scalar)</a>
11	11	<a href="#">ST4D (scalar plus scalar)</a>

## SVE Memory - Scatter with Optional Sign Extend

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1110010										op0						1			0												

Decode fields		Instruction details
msz	opc	
00		<a href="#">SVE 64-bit scatter store (scalar plus unpacked 32-bit unscaled offsets)</a>
01		<a href="#">SVE 64-bit scatter store (scalar plus unpacked 32-bit scaled offsets)</a>
10		<a href="#">SVE 32-bit scatter store (scalar plus 32-bit unscaled offsets)</a>
11		<a href="#">SVE 32-bit scatter store (scalar plus 32-bit scaled offsets)</a>

## SVE 64-bit scatter store (scalar plus unpacked 32-bit unscaled offsets)

These instructions are under [SVE Memory - Scatter with Optional Sign Extend](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	msz	0	0	Zm				1	xs	0	Pg			Rn				Zt							

Decode fields		Instruction Details
msz	opc	
00		<a href="#">ST1B (scalar plus vector)</a>
01		<a href="#">ST1H (scalar plus vector)</a>
10		<a href="#">ST1W (scalar plus vector)</a>
11		<a href="#">ST1D (scalar plus vector)</a>

## SVE 64-bit scatter store (scalar plus unpacked 32-bit scaled offsets)

These instructions are under [SVE Memory - Scatter with Optional Sign Extend](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	msz		0	1	Zm				1	xs	0	Pg			Rn				Zt						

Decode fields		Instruction Details
msz	opc	
00		UNALLOCATED
01		<a href="#">ST1H (scalar plus vector)</a>



Decode fields msz	Instruction Details
10	<a href="#">ST1W (scalar plus vector)</a>
11	<a href="#">ST1D (scalar plus vector)</a>

### SVE 32-bit scatter store (scalar plus 32-bit unscaled offsets)

These instructions are under [SVE Memory - Scatter with Optional Sign Extend](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	msz	1	0		Zm		1	xs	0		Pg							Rn					Zt		

Decode fields msz	Instruction Details
00	<a href="#">ST1B (scalar plus vector)</a>
01	<a href="#">ST1H (scalar plus vector)</a>
10	<a href="#">ST1W (scalar plus vector)</a>
11	UNALLOCATED

### SVE 32-bit scatter store (scalar plus 32-bit scaled offsets)

These instructions are under [SVE Memory - Scatter with Optional Sign Extend](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	msz	1	1		Zm		1	xs	0		Pg							Rn					Zt		

Decode fields msz	Instruction Details
00	UNALLOCATED
01	<a href="#">ST1H (scalar plus vector)</a>
10	<a href="#">ST1W (scalar plus vector)</a>
11	UNALLOCATED

## SVE Memory - Scatter

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
										op0																					

Decode fields op0	Instruction details
00	<a href="#">SVE 64-bit scatter store (scalar plus 64-bit unscaled offsets)</a>
01	<a href="#">SVE 64-bit scatter store (scalar plus 64-bit scaled offsets)</a>
10	<a href="#">SVE 64-bit scatter store (vector plus immediate)</a>
11	<a href="#">SVE 32-bit scatter store (vector plus immediate)</a>

### SVE 64-bit scatter store (scalar plus 64-bit unscaled offsets)

These instructions are under [SVE Memory - Scatter](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	msz	0	0		Zm		1	0	1		Pg								Rn				Zt		

Decode fields msz	Instruction Details
00	<a href="#">ST1B (scalar plus vector)</a>
01	<a href="#">ST1H (scalar plus vector)</a>
10	<a href="#">ST1W (scalar plus vector)</a>
11	<a href="#">ST1D (scalar plus vector)</a>

### SVE 64-bit scatter store (scalar plus 64-bit scaled offsets)

These instructions are under [SVE Memory - Scatter](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	msz		0	1	Zm				1	0	1	Pg			Rn				Zt						

Decode fields msz	Instruction Details
00	UNALLOCATED
01	<a href="#">ST1H (scalar plus vector)</a>
10	<a href="#">ST1W (scalar plus vector)</a>
11	<a href="#">ST1D (scalar plus vector)</a>

### SVE 64-bit scatter store (vector plus immediate)

These instructions are under [SVE Memory - Scatter](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	msz		1	0	imm5				1	0	1	Pg			Zn				Zt						

Decode fields msz	Instruction Details
00	<a href="#">ST1B (vector plus immediate)</a>
01	<a href="#">ST1H (vector plus immediate)</a>
10	<a href="#">ST1W (vector plus immediate)</a>
11	<a href="#">ST1D (vector plus immediate)</a>

### SVE 32-bit scatter store (vector plus immediate)

These instructions are under [SVE Memory - Scatter](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	msz		1	1	imm5				1	0	1	Pg			Zn				Zt						

Decode fields msz	Instruction Details
00	<a href="#">ST1B (vector plus immediate)</a>
01	<a href="#">ST1H (vector plus immediate)</a>
10	<a href="#">ST1W (vector plus immediate)</a>
11	UNALLOCATED

### SVE Memory - Contiguous Store with Immediate Offset

These instructions are under [SVE encodings](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1110010									op0	op1					111																

Decode fields		Instruction details
op0	op1	
00	1	<a href="#">SVE contiguous non-temporal store (scalar plus immediate)</a>
!= 00	1	<a href="#">SVE store multiple structures (scalar plus immediate)</a>
	0	<a href="#">SVE contiguous store (scalar plus immediate)</a>

### SVE contiguous non-temporal store (scalar plus immediate)

These instructions are under [SVE Memory - Contiguous Store with Immediate Offset](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	msz		0	0	1	imm4				1	1	1	Pg			Rn				Zt					

Decode fields		Instruction Details
msz		
00		<a href="#">STNT1B (scalar plus immediate)</a>
01		<a href="#">STNT1H (scalar plus immediate)</a>
10		<a href="#">STNT1W (scalar plus immediate)</a>
11		<a href="#">STNT1D (scalar plus immediate)</a>

### SVE store multiple structures (scalar plus immediate)

These instructions are under [SVE Memory - Contiguous Store with Immediate Offset](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1 1 1 0 0 1 0							msz		!= 00		1	imm4				1 1 1			Pg			Rn				Zt					
opc																															

The following constraints also apply to this encoding: opc != 00 && opc != 00

Decode fields		Instruction Details
msz	opc	
00	01	<a href="#">ST2B (scalar plus immediate)</a>
00	10	<a href="#">ST3B (scalar plus immediate)</a>
00	11	<a href="#">ST4B (scalar plus immediate)</a>
01	01	<a href="#">ST2H (scalar plus immediate)</a>
01	10	<a href="#">ST3H (scalar plus immediate)</a>
01	11	<a href="#">ST4H (scalar plus immediate)</a>
10	01	<a href="#">ST2W (scalar plus immediate)</a>
10	10	<a href="#">ST3W (scalar plus immediate)</a>
10	11	<a href="#">ST4W (scalar plus immediate)</a>
11	01	<a href="#">ST2D (scalar plus immediate)</a>
11	10	<a href="#">ST3D (scalar plus immediate)</a>
11	11	<a href="#">ST4D (scalar plus immediate)</a>

### SVE contiguous store (scalar plus immediate)

These instructions are under [SVE Memory - Contiguous Store with Immediate Offset](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	msz		size	0	imm4				1	1	1	Pg			Rn				Zt						

Decode fields msz	Instruction Details
00	<a href="#">ST1B (scalar plus immediate)</a>
01	<a href="#">ST1H (scalar plus immediate)</a>
10	<a href="#">ST1W (scalar plus immediate)</a>
11	<a href="#">ST1D (scalar plus immediate)</a>

## Data Processing -- Immediate

These instructions are under the [top-level](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
					100				op0																						

Decode fields op0	Instruction details
00x	<a href="#">PC-rel. addressing</a>
010	<a href="#">Add/subtract (immediate)</a>
011	<a href="#">Add/subtract (immediate, with tags)</a>
100	<a href="#">Logical (immediate)</a>
101	<a href="#">Move wide (immediate)</a>
110	<a href="#">Bitfield</a>
111	<a href="#">Extract</a>

## PC-rel. addressing

These instructions are under [Data Processing -- Immediate](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
op	immlo	1	0	0	0	0																									Rd
																immhi															

Decode fields op	Instruction Details
0	<a href="#">ADR</a>
1	<a href="#">ADRP</a>

## Add/subtract (immediate)

These instructions are under [Data Processing -- Immediate](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	op	S	1	0	0	0	1	0	sh																						Rd
										imm12												Rn									

Decode fields sf op S	Instruction Details
0 0 0	<a href="#">ADD (immediate) — 32-bit</a>
0 0 1	<a href="#">ADDS (immediate) — 32-bit</a>
0 1 0	<a href="#">SUB (immediate) — 32-bit</a>
0 1 1	<a href="#">SUBS (immediate) — 32-bit</a>
1 0 0	<a href="#">ADD (immediate) — 64-bit</a>
1 0 1	<a href="#">ADDS (immediate) — 64-bit</a>
1 1 0	<a href="#">SUB (immediate) — 64-bit</a>
1 1 1	<a href="#">SUBS (immediate) — 64-bit</a>

**Add/subtract (immediate, with tags)**

These instructions are under [Data Processing -- Immediate](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	op	S	1	0	0	0	1	1	o2	uimm6						op3	uimm4				Rn				Rd						

Decode fields				Instruction Details		Architecture Version	
sf	op	S	o2				
			1	UNALLOCATED		-	
0			0	UNALLOCATED		-	
1		1	0	UNALLOCATED		-	
1	0	0	0	<a href="#">ADDG</a>		ARMv8.5-MemTag	
1	1	0	0	<a href="#">SUBG</a>		ARMv8.5-MemTag	

**Logical (immediate)**

These instructions are under [Data Processing -- Immediate](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	opc	1	0	0	1	0	0	N	immr						imms				Rn				Rd								

Decode fields			Instruction Details	
sf	opc	N		
0		1	UNALLOCATED	
0	00	0	<a href="#">AND (immediate) — 32-bit</a>	
0	01	0	<a href="#">ORR (immediate) — 32-bit</a>	
0	10	0	<a href="#">EOR (immediate) — 32-bit</a>	
0	11	0	<a href="#">ANDS (immediate) — 32-bit</a>	
1	00		<a href="#">AND (immediate) — 64-bit</a>	
1	01		<a href="#">ORR (immediate) — 64-bit</a>	
1	10		<a href="#">EOR (immediate) — 64-bit</a>	
1	11		<a href="#">ANDS (immediate) — 64-bit</a>	

**Move wide (immediate)**

These instructions are under [Data Processing -- Immediate](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf		opc		1	0	0	1	0	1	hw		imm16														Rd					

Decode fields			Instruction Details	
sf	opc	hw		
	01		UNALLOCATED	
0		1x	UNALLOCATED	
0	00	0x	<a href="#">MOVN — 32-bit</a>	
0	10	0x	<a href="#">MOVZ — 32-bit</a>	
0	11	0x	<a href="#">MOVK — 32-bit</a>	
1	00		<a href="#">MOVN — 64-bit</a>	
1	10		<a href="#">MOVZ — 64-bit</a>	
1	11		<a href="#">MOVK — 64-bit</a>	

**Bitfield**

These instructions are under [Data Processing -- Immediate](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	opc	1	0	0	1	1	0	N	immr							imms					Rn				Rd						

Decode fields			Instruction Details
sf	opc	N	
	11		UNALLOCATED
0		1	UNALLOCATED
0	00	0	<a href="#">SBFM — 32-bit</a>
0	01	0	<a href="#">BFM — 32-bit</a>
0	10	0	<a href="#">UBFM — 32-bit</a>
1		0	UNALLOCATED
1	00	1	<a href="#">SBFM — 64-bit</a>
1	01	1	<a href="#">BFM — 64-bit</a>
1	10	1	<a href="#">UBFM — 64-bit</a>

## Extract

These instructions are under [Data Processing -- Immediate](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	op21	1	0	0	1	1	1	N	o0	Rm							imms					Rn				Rd					

Decode fields					Instruction Details
sf	op21	N	o0	imms	
	x1				UNALLOCATED
	00		1		UNALLOCATED
	1x				UNALLOCATED
0				1xxxxx	UNALLOCATED
0		1			UNALLOCATED
0	00	0	0	0xxxxx	<a href="#">EXTR — 32-bit</a>
1		0			UNALLOCATED
1	00	1	0		<a href="#">EXTR — 64-bit</a>

## Branches, Exception Generating and System instructions

These instructions are under the [top-level](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
op0			101			op1																		op2							

Decode fields			Instruction details
op0	op1	op2	
010	0xxxxxxxxxxxxxx		<a href="#">Conditional branch (immediate)</a>
110	00xxxxxxxxxxxxxx		<a href="#">Exception generation</a>
110	01000000110010	11111	<a href="#">Hints</a>
110	01000000110011		<a href="#">Barriers</a>
110	0100000xxx0100		<a href="#">PSTATE</a>
110	0100100xxxxxxxxx		<a href="#">System with result</a>
110	0100x01xxxxxxxxx		<a href="#">System instructions</a>
110	0100x1xxxxxxxxxx		<a href="#">System register move</a>
110	1xxxxxxxxxxxxxxx		<a href="#">Unconditional branch (register)</a>
x00			<a href="#">Unconditional branch (immediate)</a>
x01	0xxxxxxxxxxxxxxx		<a href="#">Compare and branch (immediate)</a>
x01	1xxxxxxxxxxxxxxx		<a href="#">Test and branch (immediate)</a>

**Conditional branch (immediate)**

These instructions are under [Branches, Exception Generating and System instructions](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	0	1	0	01	imm19																	00	cond					

Decode fields		Instruction Details
o1	o0	
0	0	<a href="#">B.cond</a>
0	1	UNALLOCATED
1		UNALLOCATED

**Exception generation**

These instructions are under [Branches, Exception Generating and System instructions](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	0	opc		imm16																		op2		LL	

Decode fields			Instruction Details	Architecture Version
opc	op2	LL		
	001		UNALLOCATED	-
	01x		UNALLOCATED	-
	1xx		UNALLOCATED	-
000	000	00	UNALLOCATED	-
000	000	01	<a href="#">SVC</a>	-
000	000	10	<a href="#">HVC</a>	-
000	000	11	<a href="#">SMC</a>	-
001	000	x1	UNALLOCATED	-
001	000	00	<a href="#">BRK</a>	-
001	000	1x	UNALLOCATED	-
010	000	x1	UNALLOCATED	-
010	000	00	<a href="#">HLT</a>	-
010	000	1x	UNALLOCATED	-
011	000	00	<a href="#">TCANCEL</a>	TME
011	000	01	UNALLOCATED	-
011	000	1x	UNALLOCATED	-
100	000		UNALLOCATED	-
101	000	00	UNALLOCATED	-
101	000	01	<a href="#">DCPS1</a>	-
101	000	10	<a href="#">DCPS2</a>	-
101	000	11	<a href="#">DCPS3</a>	-
110	000		UNALLOCATED	-
111	000		UNALLOCATED	-

**Hints**

These instructions are under [Branches, Exception Generating and System instructions](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	CRm		op2		1		1	1	1	1		

Decode fields		Instruction Details	Architecture Version
CRm	op2		
		<a href="#">HINT</a>	-
0000	000	<a href="#">NOP</a>	-
0000	001	<a href="#">YIELD</a>	-
0000	010	<a href="#">WFE</a>	-
0000	011	<a href="#">WFI</a>	-
0000	100	<a href="#">SEV</a>	-
0000	101	<a href="#">SEVL</a>	-
0000	110	<a href="#">DGH</a>	ARMv8.0-DGH
0000	111	<a href="#">XPACD, XPACL, XPACLR</a>	ARMv8.3-PAuth
0001	000	<a href="#">PACIA, PACIA1716, PACIASP, PACIAZ, PACIZA</a> — <a href="#">PACIA1716</a>	ARMv8.3-PAuth
0001	010	<a href="#">PACIB, PACIB1716, PACIBSP, PACIBZ, PACIZB</a> — <a href="#">PACIB1716</a>	ARMv8.3-PAuth
0001	100	<a href="#">AUTIA, AUTIA1716, AUTIASP, AUTIAZ, AUTIZA</a> — <a href="#">AUTIA1716</a>	ARMv8.3-PAuth
0001	110	<a href="#">AUTIB, AUTIB1716, AUTIBSP, AUTIBZ, AUTIZB</a> — <a href="#">AUTIB1716</a>	ARMv8.3-PAuth
0010	000	<a href="#">ESB</a>	RAS
0010	001	<a href="#">PSB CSYNC</a>	SPE
0010	010	<a href="#">TSB CSYNC</a>	ARMv8.4-Trace
0010	100	<a href="#">CSDB</a>	-
0011	000	<a href="#">PACIA, PACIA1716, PACIASP, PACIAZ, PACIZA</a> — <a href="#">PACIAZ</a>	ARMv8.3-PAuth
0011	001	<a href="#">PACIA, PACIA1716, PACIASP, PACIAZ, PACIZA</a> — <a href="#">PACIASP</a>	ARMv8.3-PAuth
0011	010	<a href="#">PACIB, PACIB1716, PACIBSP, PACIBZ, PACIZB</a> — <a href="#">PACIBZ</a>	ARMv8.3-PAuth
0011	011	<a href="#">PACIB, PACIB1716, PACIBSP, PACIBZ, PACIZB</a> — <a href="#">PACIBSP</a>	ARMv8.3-PAuth
0011	100	<a href="#">AUTIA, AUTIA1716, AUTIASP, AUTIAZ, AUTIZA</a> — <a href="#">AUTIAZ</a>	ARMv8.3-PAuth
0011	101	<a href="#">AUTIA, AUTIA1716, AUTIASP, AUTIAZ, AUTIZA</a> — <a href="#">AUTIASP</a>	ARMv8.3-PAuth
0011	110	<a href="#">AUTIB, AUTIB1716, AUTIBSP, AUTIBZ, AUTIZB</a> — <a href="#">AUTIBZ</a>	ARMv8.3-PAuth
0011	111	<a href="#">AUTIB, AUTIB1716, AUTIBSP, AUTIBZ, AUTIZB</a> — <a href="#">AUTIBSP</a>	ARMv8.3-PAuth
0100	xx0	<a href="#">BTI</a>	ARMv8.5-BTI

## Barriers

These instructions are under [Branches, Exception Generating and System instructions](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	1	CRm			op2			Rt					

Decode fields		Rt	Instruction Details	Architecture Version
CRm	op2			
	000		UNALLOCATED	-
	001	<b>!= 11111</b>	UNALLOCATED	-
	010	11111	<a href="#">CLREX</a>	-
	101	11111	<a href="#">DMB</a>	-
	110	11111	<a href="#">ISB</a>	-
	111	<b>!= 11111</b>	UNALLOCATED	-
	111	11111	<a href="#">SB</a>	-
<b>!= 0x00</b>	100	11111	<a href="#">DSB</a>	-
0000	011	11111	<a href="#">TCOMMIT</a>	TME
0000	100	11111	<a href="#">SSBB</a>	-
0001	011		UNALLOCATED	-
001x	011		UNALLOCATED	-
01xx	011		UNALLOCATED	-



Decode fields			Instruction Details	Architecture Version
CRm	op2	Rt		
0100	100	11111	<a href="#">PSSBB</a>	-
1xxx	011		UNALLOCATED	-

## PSTATE

These instructions are under [Branches, Exception Generating and System instructions](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	0	0	0	op1			0			1	0	0	CRm			op2		Rt				

Decode fields			Instruction Details	Architecture Version
op1	op2	Rt		
		!= 11111	UNALLOCATED	-
		11111	<a href="#">MSR (immediate)</a>	-
000	000	11111	<a href="#">CEINV</a>	ARMv8.4-CondM
000	001	11111	<a href="#">XAFLAG</a>	ARMv8.5-CondM
000	010	11111	<a href="#">AXFLAG</a>	ARMv8.5-CondM

## System with result

These instructions are under [Branches, Exception Generating and System instructions](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	1	0	0	op1			CRn			CRm			op2			Rt						

Decode fields				Instruction Details	Architecture Version
op1	CRn	CRm	op2		
!= 011				UNALLOCATED	-
011	!= 0011			UNALLOCATED	-
011	0011		!= 011	UNALLOCATED	-
011	0011	!= 000x	011	UNALLOCATED	-
011	0011	0000	011	<a href="#">TSTART</a>	TME
011	0011	0001	011	<a href="#">TTEST</a>	TME

## System instructions

These instructions are under [Branches, Exception Generating and System instructions](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	L	0	1	op1			CRn			CRm			op2			Rt						

Decode fields		Instruction Details
L		
0		<a href="#">SYS</a>
1		<a href="#">SYSL</a>

## System register move

These instructions are under [Branches, Exception Generating and System instructions](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	0	1	0	0	L	1	o0	op1			CRn			CRm			op2			Rt						

Decode fields L	Instruction Details
0	<a href="#">MSR (register)</a>
1	<a href="#">MRS</a>

**Unconditional branch (register)**

These instructions are under [Branches, Exception Generating and System instructions](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	0	1	1	opc				op2				op3				Rn				op4								

Decode fields					Instruction Details		Architecture Version	
opc	op2	op3	Rn	op4				
	!= 11111				UNALLOCATED		-	
0000	11111	0000000		!= 00000	UNALLOCATED		-	
0000	11111	0000000		00000	<a href="#">BR</a>		-	
0000	11111	0000001			UNALLOCATED		-	
0000	11111	0000010		!= 11111	UNALLOCATED		-	
0000	11111	0000010		11111	<a href="#">BRAA, BRAAZ, BRAB, BRABZ</a> — <a href="#">key A, zero modifier</a>		ARMv8.3-PAuth	
0000	11111	0000011		!= 11111	UNALLOCATED		-	
0000	11111	0000011		11111	<a href="#">BRAA, BRAAZ, BRAB, BRABZ</a> — <a href="#">key B, zero modifier</a>		ARMv8.3-PAuth	
0000	11111	0001xx			UNALLOCATED		-	
0000	11111	001xxx			UNALLOCATED		-	
0000	11111	01xxxx			UNALLOCATED		-	
0000	11111	1xxxxx			UNALLOCATED		-	
0001	11111	0000000		!= 00000	UNALLOCATED		-	
0001	11111	0000000		00000	<a href="#">BLR</a>		-	
0001	11111	0000001			UNALLOCATED		-	
0001	11111	0000010		!= 11111	UNALLOCATED		-	
0001	11111	0000010		11111	<a href="#">BLRAA, BLRAAZ, BLRAB, BLRABZ</a> — <a href="#">key A, zero modifier</a>		ARMv8.3-PAuth	
0001	11111	0000011		!= 11111	UNALLOCATED		-	
0001	11111	0000011		11111	<a href="#">BLRAA, BLRAAZ, BLRAB, BLRABZ</a> — <a href="#">key B, zero modifier</a>		ARMv8.3-PAuth	
0001	11111	0001xx			UNALLOCATED		-	
0001	11111	001xxx			UNALLOCATED		-	
0001	11111	01xxxx			UNALLOCATED		-	
0001	11111	1xxxxx			UNALLOCATED		-	
0010	11111	0000000		!= 00000	UNALLOCATED		-	
0010	11111	0000000		00000	<a href="#">RET</a>		-	
0010	11111	0000001			UNALLOCATED		-	

opc	Decode fields				Instruction Details	Architecture Version
	op2	op3	Rn	op4		
0010	11111	000010	!= 11111	!= 11111	UNALLOCATED	-
0010	11111	000010	11111	11111	<a href="#">RETAA, RETAB</a> — <a href="#">RETAA</a>	ARMv8.3-PAuth
0010	11111	000011	!= 11111	!= 11111	UNALLOCATED	-
0010	11111	000011	11111	11111	<a href="#">RETAA, RETAB</a> — <a href="#">RETAB</a>	ARMv8.3-PAuth
0010	11111	0001xx			UNALLOCATED	-
0010	11111	001xxx			UNALLOCATED	-
0010	11111	01xxxx			UNALLOCATED	-
0010	11111	1xxxxx			UNALLOCATED	-
0011	11111				UNALLOCATED	-
0100	11111	000000	!= 11111	!= 00000	UNALLOCATED	-
0100	11111	000000	!= 11111	00000	UNALLOCATED	-
0100	11111	000000	11111	!= 00000	UNALLOCATED	-
0100	11111	000000	11111	00000	<a href="#">ERET</a>	-
0100	11111	000001			UNALLOCATED	-
0100	11111	000010	!= 11111	!= 11111	UNALLOCATED	-
0100	11111	000010	!= 11111	11111	UNALLOCATED	-
0100	11111	000010	11111	!= 11111	UNALLOCATED	-
0100	11111	000010	11111	11111	<a href="#">ERETAA, ERETAB</a> — <a href="#">ERETAA</a>	ARMv8.3-PAuth
0100	11111	000011	!= 11111	!= 11111	UNALLOCATED	-
0100	11111	000011	!= 11111	11111	UNALLOCATED	-
0100	11111	000011	11111	!= 11111	UNALLOCATED	-
0100	11111	000011	11111	11111	<a href="#">ERETAA, ERETAB</a> — <a href="#">ERETAB</a>	ARMv8.3-PAuth
0100	11111	0001xx			UNALLOCATED	-
0100	11111	001xxx			UNALLOCATED	-
0100	11111	01xxxx			UNALLOCATED	-
0100	11111	1xxxxx			UNALLOCATED	-
0101	11111	!= 000000			UNALLOCATED	-
0101	11111	000000	!= 11111	!= 00000	UNALLOCATED	-
0101	11111	000000	!= 11111	00000	UNALLOCATED	-
0101	11111	000000	11111	!= 00000	UNALLOCATED	-
0101	11111	000000	11111	00000	<a href="#">DRPS</a>	-
011x	11111				UNALLOCATED	-
1000	11111	00000x			UNALLOCATED	-

Decode fields					Instruction Details	Architecture Version
opc	op2	op3	Rn	op4		
1000	11111	000010			<a href="#">BRAA, BRAAZ, BRAB, BRABZ</a> — <a href="#">key A, register modifier</a>	ARMv8.3-PAuth
1000	11111	000011			<a href="#">BRAA, BRAAZ, BRAB, BRABZ</a> — <a href="#">key B, register modifier</a>	ARMv8.3-PAuth
1000	11111	0001xx			UNALLOCATED	-
1000	11111	001xxx			UNALLOCATED	-
1000	11111	01xxxx			UNALLOCATED	-
1000	11111	1xxxxx			UNALLOCATED	-
1001	11111	00000x			UNALLOCATED	-
1001	11111	000010			<a href="#">BLRAA, BLRAAZ, BLRAB, BLRABZ</a> — <a href="#">key A, register modifier</a>	ARMv8.3-PAuth
1001	11111	000011			<a href="#">BLRAA, BLRAAZ, BLRAB, BLRABZ</a> — <a href="#">key B, register modifier</a>	ARMv8.3-PAuth
1001	11111	0001xx			UNALLOCATED	-
1001	11111	001xxx			UNALLOCATED	-
1001	11111	01xxxx			UNALLOCATED	-
1001	11111	1xxxxx			UNALLOCATED	-
101x	11111				UNALLOCATED	-
11xx	11111				UNALLOCATED	-

### Unconditional branch (immediate)

These instructions are under [Branches, Exception Generating and System instructions](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
op	0	0	1	0	1	imm26																										

Decode fields		Instruction Details
op		
0		<a href="#">B</a>
1		<a href="#">BL</a>

### Compare and branch (immediate)

These instructions are under [Branches, Exception Generating and System instructions](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	1	1	0	1	0	op	imm19																						Rt	

Decode fields		Instruction Details
sf	op	
0	0	<a href="#">CBZ</a> — <a href="#">32-bit</a>
0	1	<a href="#">CBNZ</a> — <a href="#">32-bit</a>
1	0	<a href="#">CBZ</a> — <a href="#">64-bit</a>
1	1	<a href="#">CBNZ</a> — <a href="#">64-bit</a>

### Test and branch (immediate)

These instructions are under [Branches, Exception Generating and System instructions](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
b5	0	1	1	0	1	1	op	b40					imm14										Rt								

Decode fields	Instruction Details
<b>op</b>	
0	<a href="#">TBZ</a>
1	<a href="#">TBNZ</a>

## Loads and Stores

These instructions are under the [top-level](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
op0				1	op1	0	op2		op3								op4														

Decode fields					Instruction details	
op0	op1	op2	op3	op4		
0x00	1	00	000000		<a href="#">Advanced SIMD load/store multiple structures</a>	
0x00	1	01	0xxxxx		<a href="#">Advanced SIMD load/store multiple structures (post-indexed)</a>	
0x00	1	0x	1xxxxx		UNALLOCATED	
0x00	1	10	x00000		<a href="#">Advanced SIMD load/store single structure</a>	
0x00	1	11			<a href="#">Advanced SIMD load/store single structure (post-indexed)</a>	
0x00	1	x0	x1xxxx		UNALLOCATED	
0x00	1	x0	xx1xxx		UNALLOCATED	
0x00	1	x0	xxx1xx		UNALLOCATED	
0x00	1	x0	xxxx1x		UNALLOCATED	
0x00	1	x0	xxxxx1		UNALLOCATED	
1101	0	1x	1xxxxx		<a href="#">Load/store memory tags</a>	
1x00	1				UNALLOCATED	
xx00	0	0x			<a href="#">Load/store exclusive</a>	
xx01	0	1x	0xxxxx	00	<a href="#">LDAPR/STLR (unscaled immediate)</a>	
xx01		0x			<a href="#">Load register (literal)</a>	
xx10		00			<a href="#">Load/store no-allocate pair (offset)</a>	
xx10		01			<a href="#">Load/store register pair (post-indexed)</a>	
xx10		10			<a href="#">Load/store register pair (offset)</a>	
xx10		11			<a href="#">Load/store register pair (pre-indexed)</a>	
xx11		0x	0xxxxx	00	<a href="#">Load/store register (unscaled immediate)</a>	
xx11		0x	0xxxxx	01	<a href="#">Load/store register (immediate post-indexed)</a>	
xx11		0x	0xxxxx	10	<a href="#">Load/store register (unprivileged)</a>	
xx11		0x	0xxxxx	11	<a href="#">Load/store register (immediate pre-indexed)</a>	
xx11		0x	1xxxxx	00	<a href="#">Atomic memory operations</a>	
xx11		0x	1xxxxx	10	<a href="#">Load/store register (register offset)</a>	
xx11		0x	1xxxxx	x1	<a href="#">Load/store register (pac)</a>	
xx11		1x			<a href="#">Load/store register (unsigned immediate)</a>	

## Advanced SIMD load/store multiple structures

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	0	0	L	0	0	0	0	0	0	opcode		size		Rn				Rt							

Decode fields	Instruction Details	
<b>L</b>	<b>opcode</b>	
0	0000	<a href="#">ST4 (multiple structures)</a>

Decode fields		Instruction Details
L	opcode	
0	0001	UNALLOCATED
0	0010	<a href="#">ST1 (multiple structures) — four registers</a>
0	0011	UNALLOCATED
0	0100	<a href="#">ST3 (multiple structures)</a>
0	0101	UNALLOCATED
0	0110	<a href="#">ST1 (multiple structures) — three registers</a>
0	0111	<a href="#">ST1 (multiple structures) — one register</a>
0	1000	<a href="#">ST2 (multiple structures)</a>
0	1001	UNALLOCATED
0	1010	<a href="#">ST1 (multiple structures) — two registers</a>
0	1011	UNALLOCATED
0	11xx	UNALLOCATED
1	0000	<a href="#">LD4 (multiple structures)</a>
1	0001	UNALLOCATED
1	0010	<a href="#">LD1 (multiple structures) — four registers</a>
1	0011	UNALLOCATED
1	0100	<a href="#">LD3 (multiple structures)</a>
1	0101	UNALLOCATED
1	0110	<a href="#">LD1 (multiple structures) — three registers</a>
1	0111	<a href="#">LD1 (multiple structures) — one register</a>
1	1000	<a href="#">LD2 (multiple structures)</a>
1	1001	UNALLOCATED
1	1010	<a href="#">LD1 (multiple structures) — two registers</a>
1	1011	UNALLOCATED
1	11xx	UNALLOCATED

### Advanced SIMD load/store multiple structures (post-indexed)

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	0	1	L	0	Rm				opcode				size				Rn				Rt				

Decode fields		opcode	Instruction Details
L	Rm		
0		0001	UNALLOCATED
0		0011	UNALLOCATED
0		0101	UNALLOCATED
0		1001	UNALLOCATED
0		1011	UNALLOCATED
0		11xx	UNALLOCATED
0	!= 11111	0000	<a href="#">ST4 (multiple structures) — register offset</a>
0	!= 11111	0010	<a href="#">ST1 (multiple structures) — four registers, register offset</a>
0	!= 11111	0100	<a href="#">ST3 (multiple structures) — register offset</a>
0	!= 11111	0110	<a href="#">ST1 (multiple structures) — three registers, register offset</a>
0	!= 11111	0111	<a href="#">ST1 (multiple structures) — one register, register offset</a>
0	!= 11111	1000	<a href="#">ST2 (multiple structures) — register offset</a>
0	!= 11111	1010	<a href="#">ST1 (multiple structures) — two registers, register offset</a>
0	11111	0000	<a href="#">ST4 (multiple structures) — immediate offset</a>

Decode fields			Instruction Details
L	Rm	opcode	
0	11111	0010	<a href="#">ST1 (multiple structures)</a> — <a href="#">four registers, immediate offset</a>
0	11111	0100	<a href="#">ST3 (multiple structures)</a> — <a href="#">immediate offset</a>
0	11111	0110	<a href="#">ST1 (multiple structures)</a> — <a href="#">three registers, immediate offset</a>
0	11111	0111	<a href="#">ST1 (multiple structures)</a> — <a href="#">one register, immediate offset</a>
0	11111	1000	<a href="#">ST2 (multiple structures)</a> — <a href="#">immediate offset</a>
0	11111	1010	<a href="#">ST1 (multiple structures)</a> — <a href="#">two registers, immediate offset</a>
1		0001	UNALLOCATED
1		0011	UNALLOCATED
1		0101	UNALLOCATED
1		1001	UNALLOCATED
1		1011	UNALLOCATED
1		11xx	UNALLOCATED
1	!= 11111	0000	<a href="#">LD4 (multiple structures)</a> — <a href="#">register offset</a>
1	!= 11111	0010	<a href="#">LD1 (multiple structures)</a> — <a href="#">four registers, register offset</a>
1	!= 11111	0100	<a href="#">LD3 (multiple structures)</a> — <a href="#">register offset</a>
1	!= 11111	0110	<a href="#">LD1 (multiple structures)</a> — <a href="#">three registers, register offset</a>
1	!= 11111	0111	<a href="#">LD1 (multiple structures)</a> — <a href="#">one register, register offset</a>
1	!= 11111	1000	<a href="#">LD2 (multiple structures)</a> — <a href="#">register offset</a>
1	!= 11111	1010	<a href="#">LD1 (multiple structures)</a> — <a href="#">two registers, register offset</a>
1	11111	0000	<a href="#">LD4 (multiple structures)</a> — <a href="#">immediate offset</a>
1	11111	0010	<a href="#">LD1 (multiple structures)</a> — <a href="#">four registers, immediate offset</a>
1	11111	0100	<a href="#">LD3 (multiple structures)</a> — <a href="#">immediate offset</a>
1	11111	0110	<a href="#">LD1 (multiple structures)</a> — <a href="#">three registers, immediate offset</a>
1	11111	0111	<a href="#">LD1 (multiple structures)</a> — <a href="#">one register, immediate offset</a>
1	11111	1000	<a href="#">LD2 (multiple structures)</a> — <a href="#">immediate offset</a>
1	11111	1010	<a href="#">LD1 (multiple structures)</a> — <a href="#">two registers, immediate offset</a>

### Advanced SIMD load/store single structure

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	0	L	R	0	0	0	0	0	opcode	S	size							Rn					Rt	

Decode fields					Instruction Details
L	R	opcode	S	size	
0		11x			UNALLOCATED
0	0	000			<a href="#">ST1 (single structure)</a> — <a href="#">8-bit</a>
0	0	001			<a href="#">ST3 (single structure)</a> — <a href="#">8-bit</a>
0	0	010		x0	<a href="#">ST1 (single structure)</a> — <a href="#">16-bit</a>
0	0	010		x1	UNALLOCATED
0	0	011		x0	<a href="#">ST3 (single structure)</a> — <a href="#">16-bit</a>
0	0	011		x1	UNALLOCATED
0	0	100		00	<a href="#">ST1 (single structure)</a> — <a href="#">32-bit</a>
0	0	100		1x	UNALLOCATED
0	0	100	0	01	<a href="#">ST1 (single structure)</a> — <a href="#">64-bit</a>
0	0	100	1	01	UNALLOCATED
0	0	101		00	<a href="#">ST3 (single structure)</a> — <a href="#">32-bit</a>
0	0	101		10	UNALLOCATED

Decode fields					Instruction Details
L	R	opcode	S	size	
0	0	101	0	01	<a href="#">ST3 (single structure) — 64-bit</a>
0	0	101	0	11	UNALLOCATED
0	0	101	1	x1	UNALLOCATED
0	1	000			<a href="#">ST2 (single structure) — 8-bit</a>
0	1	001			<a href="#">ST4 (single structure) — 8-bit</a>
0	1	010		x0	<a href="#">ST2 (single structure) — 16-bit</a>
0	1	010		x1	UNALLOCATED
0	1	011		x0	<a href="#">ST4 (single structure) — 16-bit</a>
0	1	011		x1	UNALLOCATED
0	1	100		00	<a href="#">ST2 (single structure) — 32-bit</a>
0	1	100		10	UNALLOCATED
0	1	100	0	01	<a href="#">ST2 (single structure) — 64-bit</a>
0	1	100	0	11	UNALLOCATED
0	1	100	1	x1	UNALLOCATED
0	1	101		00	<a href="#">ST4 (single structure) — 32-bit</a>
0	1	101		10	UNALLOCATED
0	1	101	0	01	<a href="#">ST4 (single structure) — 64-bit</a>
0	1	101	0	11	UNALLOCATED
0	1	101	1	x1	UNALLOCATED
1	0	000			<a href="#">LD1 (single structure) — 8-bit</a>
1	0	001			<a href="#">LD3 (single structure) — 8-bit</a>
1	0	010		x0	<a href="#">LD1 (single structure) — 16-bit</a>
1	0	010		x1	UNALLOCATED
1	0	011		x0	<a href="#">LD3 (single structure) — 16-bit</a>
1	0	011		x1	UNALLOCATED
1	0	100		00	<a href="#">LD1 (single structure) — 32-bit</a>
1	0	100		1x	UNALLOCATED
1	0	100	0	01	<a href="#">LD1 (single structure) — 64-bit</a>
1	0	100	1	01	UNALLOCATED
1	0	101		00	<a href="#">LD3 (single structure) — 32-bit</a>
1	0	101		10	UNALLOCATED
1	0	101	0	01	<a href="#">LD3 (single structure) — 64-bit</a>
1	0	101	0	11	UNALLOCATED
1	0	101	1	x1	UNALLOCATED
1	0	110	0		<a href="#">LD1R</a>
1	0	110	1		UNALLOCATED
1	0	111	0		<a href="#">LD3R</a>
1	0	111	1		UNALLOCATED
1	1	000			<a href="#">LD2 (single structure) — 8-bit</a>
1	1	001			<a href="#">LD4 (single structure) — 8-bit</a>
1	1	010		x0	<a href="#">LD2 (single structure) — 16-bit</a>
1	1	010		x1	UNALLOCATED
1	1	011		x0	<a href="#">LD4 (single structure) — 16-bit</a>
1	1	011		x1	UNALLOCATED
1	1	100		00	<a href="#">LD2 (single structure) — 32-bit</a>
1	1	100		10	UNALLOCATED
1	1	100	0	01	<a href="#">LD2 (single structure) — 64-bit</a>



Decode fields					Instruction Details
L	R	opcode	S	size	
1	1	100	0	11	UNALLOCATED
1	1	100	1	x1	UNALLOCATED
1	1	101		00	<a href="#">LD4 (single structure) — 32-bit</a>
1	1	101		10	UNALLOCATED
1	1	101	0	01	<a href="#">LD4 (single structure) — 64-bit</a>
1	1	101	0	11	UNALLOCATED
1	1	101	1	x1	UNALLOCATED
1	1	110	0		<a href="#">LD2R</a>
1	1	110	1		UNALLOCATED
1	1	111	0		<a href="#">LD4R</a>
1	1	111	1		UNALLOCATED

**Advanced SIMD load/store single structure (post-indexed)**

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	0	1	1	L	R	Rm				opcode				S	size		Rn				Rt					

Decode fields						Instruction Details
L	R	Rm	opcode	S	size	
0			11x			UNALLOCATED
0	0		010		x1	UNALLOCATED
0	0		011		x1	UNALLOCATED
0	0		100		1x	UNALLOCATED
0	0		100	1	01	UNALLOCATED
0	0		101		10	UNALLOCATED
0	0		101	0	11	UNALLOCATED
0	0		101	1	x1	UNALLOCATED
0	0	!= 11111	000			<a href="#">ST1 (single structure) — 8-bit, register offset</a>
0	0	!= 11111	001			<a href="#">ST3 (single structure) — 8-bit, register offset</a>
0	0	!= 11111	010		x0	<a href="#">ST1 (single structure) — 16-bit, register offset</a>
0	0	!= 11111	011		x0	<a href="#">ST3 (single structure) — 16-bit, register offset</a>
0	0	!= 11111	100		00	<a href="#">ST1 (single structure) — 32-bit, register offset</a>
0	0	!= 11111	100	0	01	<a href="#">ST1 (single structure) — 64-bit, register offset</a>
0	0	!= 11111	101		00	<a href="#">ST3 (single structure) — 32-bit, register offset</a>
0	0	!= 11111	101	0	01	<a href="#">ST3 (single structure) — 64-bit, register offset</a>
0	0	11111	000			<a href="#">ST1 (single structure) — 8-bit, immediate offset</a>
0	0	11111	001			<a href="#">ST3 (single structure) — 8-bit, immediate offset</a>
0	0	11111	010		x0	<a href="#">ST1 (single structure) — 16-bit, immediate offset</a>
0	0	11111	011		x0	<a href="#">ST3 (single structure) — 16-bit, immediate offset</a>
0	0	11111	100		00	<a href="#">ST1 (single structure) — 32-bit, immediate offset</a>
0	0	11111	100	0	01	<a href="#">ST1 (single structure) — 64-bit, immediate offset</a>
0	0	11111	101		00	<a href="#">ST3 (single structure) — 32-bit, immediate offset</a>
0	0	11111	101	0	01	<a href="#">ST3 (single structure) — 64-bit, immediate offset</a>
0	1		010		x1	UNALLOCATED
0	1		011		x1	UNALLOCATED
0	1		100		10	UNALLOCATED
0	1		100	0	11	UNALLOCATED

L	R	Decode fields		S	size	Instruction Details
		Rm	opcode			
0	1		100	1	x1	UNALLOCATED
0	1		101		10	UNALLOCATED
0	1		101	0	11	UNALLOCATED
0	1		101	1	x1	UNALLOCATED
0	1	!= 11111	000			<a href="#">ST2 (single structure) — 8-bit, register offset</a>
0	1	!= 11111	001			<a href="#">ST4 (single structure) — 8-bit, register offset</a>
0	1	!= 11111	010		x0	<a href="#">ST2 (single structure) — 16-bit, register offset</a>
0	1	!= 11111	011		x0	<a href="#">ST4 (single structure) — 16-bit, register offset</a>
0	1	!= 11111	100		00	<a href="#">ST2 (single structure) — 32-bit, register offset</a>
0	1	!= 11111	100	0	01	<a href="#">ST2 (single structure) — 64-bit, register offset</a>
0	1	!= 11111	101		00	<a href="#">ST4 (single structure) — 32-bit, register offset</a>
0	1	!= 11111	101	0	01	<a href="#">ST4 (single structure) — 64-bit, register offset</a>
0	1	11111	000			<a href="#">ST2 (single structure) — 8-bit, immediate offset</a>
0	1	11111	001			<a href="#">ST4 (single structure) — 8-bit, immediate offset</a>
0	1	11111	010		x0	<a href="#">ST2 (single structure) — 16-bit, immediate offset</a>
0	1	11111	011		x0	<a href="#">ST4 (single structure) — 16-bit, immediate offset</a>
0	1	11111	100		00	<a href="#">ST2 (single structure) — 32-bit, immediate offset</a>
0	1	11111	100	0	01	<a href="#">ST2 (single structure) — 64-bit, immediate offset</a>
0	1	11111	101		00	<a href="#">ST4 (single structure) — 32-bit, immediate offset</a>
0	1	11111	101	0	01	<a href="#">ST4 (single structure) — 64-bit, immediate offset</a>
1	0		010		x1	UNALLOCATED
1	0		011		x1	UNALLOCATED
1	0		100		1x	UNALLOCATED
1	0		100	1	01	UNALLOCATED
1	0		101		10	UNALLOCATED
1	0		101	0	11	UNALLOCATED
1	0		101	1	x1	UNALLOCATED
1	0		110	1		UNALLOCATED
1	0		111	1		UNALLOCATED
1	0	!= 11111	000			<a href="#">LD1 (single structure) — 8-bit, register offset</a>
1	0	!= 11111	001			<a href="#">LD3 (single structure) — 8-bit, register offset</a>
1	0	!= 11111	010		x0	<a href="#">LD1 (single structure) — 16-bit, register offset</a>
1	0	!= 11111	011		x0	<a href="#">LD3 (single structure) — 16-bit, register offset</a>
1	0	!= 11111	100		00	<a href="#">LD1 (single structure) — 32-bit, register offset</a>
1	0	!= 11111	100	0	01	<a href="#">LD1 (single structure) — 64-bit, register offset</a>
1	0	!= 11111	101		00	<a href="#">LD3 (single structure) — 32-bit, register offset</a>
1	0	!= 11111	101	0	01	<a href="#">LD3 (single structure) — 64-bit, register offset</a>
1	0	!= 11111	110	0		<a href="#">LD1R — register offset</a>
1	0	!= 11111	111	0		<a href="#">LD3R — register offset</a>
1	0	11111	000			<a href="#">LD1 (single structure) — 8-bit, immediate offset</a>
1	0	11111	001			<a href="#">LD3 (single structure) — 8-bit, immediate offset</a>
1	0	11111	010		x0	<a href="#">LD1 (single structure) — 16-bit, immediate offset</a>
1	0	11111	011		x0	<a href="#">LD3 (single structure) — 16-bit, immediate offset</a>
1	0	11111	100		00	<a href="#">LD1 (single structure) — 32-bit, immediate offset</a>
1	0	11111	100	0	01	<a href="#">LD1 (single structure) — 64-bit, immediate offset</a>
1	0	11111	101		00	<a href="#">LD3 (single structure) — 32-bit, immediate offset</a>
1	0	11111	101	0	01	<a href="#">LD3 (single structure) — 64-bit, immediate offset</a>

Decode fields						Instruction Details
L	R	Rm	opcode	S	size	
1	0	11111	110	0		<a href="#">LD1R — immediate offset</a>
1	0	11111	111	0		<a href="#">LD3R — immediate offset</a>
1	1		010		x1	UNALLOCATED
1	1		011		x1	UNALLOCATED
1	1		100		10	UNALLOCATED
1	1		100	0	11	UNALLOCATED
1	1		100	1	x1	UNALLOCATED
1	1		101		10	UNALLOCATED
1	1		101	0	11	UNALLOCATED
1	1		101	1	x1	UNALLOCATED
1	1		110	1		UNALLOCATED
1	1		111	1		UNALLOCATED
1	1	!= 11111	000			<a href="#">LD2 (single structure) — 8-bit, register offset</a>
1	1	!= 11111	001			<a href="#">LD4 (single structure) — 8-bit, register offset</a>
1	1	!= 11111	010		x0	<a href="#">LD2 (single structure) — 16-bit, register offset</a>
1	1	!= 11111	011		x0	<a href="#">LD4 (single structure) — 16-bit, register offset</a>
1	1	!= 11111	100		00	<a href="#">LD2 (single structure) — 32-bit, register offset</a>
1	1	!= 11111	100	0	01	<a href="#">LD2 (single structure) — 64-bit, register offset</a>
1	1	!= 11111	101		00	<a href="#">LD4 (single structure) — 32-bit, register offset</a>
1	1	!= 11111	101	0	01	<a href="#">LD4 (single structure) — 64-bit, register offset</a>
1	1	!= 11111	110	0		<a href="#">LD2R — register offset</a>
1	1	!= 11111	111	0		<a href="#">LD4R — register offset</a>
1	1	11111	000			<a href="#">LD2 (single structure) — 8-bit, immediate offset</a>
1	1	11111	001			<a href="#">LD4 (single structure) — 8-bit, immediate offset</a>
1	1	11111	010		x0	<a href="#">LD2 (single structure) — 16-bit, immediate offset</a>
1	1	11111	011		x0	<a href="#">LD4 (single structure) — 16-bit, immediate offset</a>
1	1	11111	100		00	<a href="#">LD2 (single structure) — 32-bit, immediate offset</a>
1	1	11111	100	0	01	<a href="#">LD2 (single structure) — 64-bit, immediate offset</a>
1	1	11111	101		00	<a href="#">LD4 (single structure) — 32-bit, immediate offset</a>
1	1	11111	101	0	01	<a href="#">LD4 (single structure) — 64-bit, immediate offset</a>
1	1	11111	110	0		<a href="#">LD2R — immediate offset</a>
1	1	11111	111	0		<a href="#">LD4R — immediate offset</a>

## Load/store memory tags

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	opc	1	imm9										op2	Rn				Rt						

Decode fields			Instruction Details	Architecture Version
opc	imm9	op2		
00		01	<a href="#">STG — post-index</a>	ARMv8.5-MemTag
00		10	<a href="#">STG — signed offset</a>	ARMv8.5-MemTag
00		11	<a href="#">STG — pre-index</a>	ARMv8.5-MemTag
00	000000000	00	<a href="#">STZGM</a>	ARMv8.5-MemTag
01		00	<a href="#">LDG</a>	ARMv8.5-MemTag
01		01	<a href="#">STZG — post-index</a>	ARMv8.5-MemTag
01		10	<a href="#">STZG — signed offset</a>	ARMv8.5-MemTag

opc	Decode fields imm9	op2	Instruction Details	Architecture Version
01		11	<a href="#">STZG — pre-index</a>	ARMv8.5-MemTag
10		01	<a href="#">ST2G — post-index</a>	ARMv8.5-MemTag
10		10	<a href="#">ST2G — signed offset</a>	ARMv8.5-MemTag
10		11	<a href="#">ST2G — pre-index</a>	ARMv8.5-MemTag
10	!= 000000000	00	UNALLOCATED	-
10	000000000	00	<a href="#">STGM</a>	ARMv8.5-MemTag
11		01	<a href="#">STZ2G — post-index</a>	ARMv8.5-MemTag
11		10	<a href="#">STZ2G — signed offset</a>	ARMv8.5-MemTag
11		11	<a href="#">STZ2G — pre-index</a>	ARMv8.5-MemTag
11	!= 000000000	00	UNALLOCATED	-
11	000000000	00	<a href="#">LDGM</a>	ARMv8.5-MemTag

### Load/store exclusive

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size	0	0	1	0	0	0	o2	L	o1	Rs			o0			Rt2			Rn			Rt									

size	o2	Decode fields L	o1	o0	Rt2	Instruction Details	Architecture Version
	1		1		!= 11111	UNALLOCATED	-
0x	0		1		!= 11111	UNALLOCATED	-
00	0	0	0	0		<a href="#">STXRB</a>	-
00	0	0	0	1		<a href="#">STLXRB</a>	-
00	0	0	1	0	11111	<a href="#">CASP, CASPA, CASPAL, CASPL — 32-bit CASP</a>	ARMv8.1-LSE
00	0	0	1	1	11111	<a href="#">CASP, CASPA, CASPAL, CASPL — 32-bit CASPL</a>	ARMv8.1-LSE
00	0	1	0	0		<a href="#">LDXRB</a>	-
00	0	1	0	1		<a href="#">LDAXRB</a>	-
00	0	1	1	0	11111	<a href="#">CASB, CASAB, CASALB, CASLB — 32-bit CASPA</a>	ARMv8.1-LSE
00	0	1	1	1	11111	<a href="#">CASB, CASAB, CASALB, CASLB — 32-bit CASPAL</a>	ARMv8.1-LSE
00	1	0	0	0		<a href="#">STLLRB</a>	ARMv8.1-LOR
00	1	0	0	1		<a href="#">STLRB</a>	-
00	1	0	1	0	11111	<a href="#">CASB, CASAB, CASALB, CASLB — CASB</a>	ARMv8.1-LSE
00	1	0	1	1	11111	<a href="#">CASB, CASAB, CASALB, CASLB — CASLB</a>	ARMv8.1-LSE
00	1	1	0	0		<a href="#">LDLARB</a>	ARMv8.1-LOR
00	1	1	0	1		<a href="#">LDARB</a>	-
00	1	1	1	0	11111	<a href="#">CASB, CASAB, CASALB, CASLB — CASAB</a>	ARMv8.1-LSE
00	1	1	1	1	11111	<a href="#">CASB, CASAB, CASALB, CASLB — CASALB</a>	ARMv8.1-LSE
01	0	0	0	0		<a href="#">STXRH</a>	-
01	0	0	0	1		<a href="#">STLXRH</a>	-
01	0	0	1	0	11111	<a href="#">CASP, CASPA, CASPAL, CASPL — 64-bit CASP</a>	ARMv8.1-LSE

size	o2	Decode fields			Rt2	Instruction Details	Architecture Version
		L	o1	o0			
01	0	0	1	1	11111	<a href="#">CASP, CASPA, CASPAL, CASPL — 64-bit CASPL</a>	ARMv8.1-LSE
01	0	1	0	0		<a href="#">LDXRH</a>	-
01	0	1	0	1		<a href="#">LDAXRH</a>	-
01	0	1	1	0	11111	<a href="#">CASP, CASPA, CASPAL, CASPL — 64-bit CASPA</a>	ARMv8.1-LSE
01	0	1	1	1	11111	<a href="#">CASP, CASPA, CASPAL, CASPL — 64-bit CASPAL</a>	ARMv8.1-LSE
01	1	0	0	0		<a href="#">STLLRH</a>	ARMv8.1-LOR
01	1	0	0	1		<a href="#">STLRH</a>	-
01	1	0	1	0	11111	<a href="#">CASH, CASAH, CASALH, CASLH — CASH</a>	ARMv8.1-LSE
01	1	0	1	1	11111	<a href="#">CASH, CASAH, CASALH, CASLH — CASLH</a>	ARMv8.1-LSE
01	1	1	0	0		<a href="#">LDLARH</a>	ARMv8.1-LOR
01	1	1	0	1		<a href="#">LDARH</a>	-
01	1	1	1	0	11111	<a href="#">CASH, CASAH, CASALH, CASLH — CASAH</a>	ARMv8.1-LSE
01	1	1	1	1	11111	<a href="#">CASH, CASAH, CASALH, CASLH — CASALH</a>	ARMv8.1-LSE
10	0	0	0	0		<a href="#">STXR — 32-bit</a>	-
10	0	0	0	1		<a href="#">STLXR — 32-bit</a>	-
10	0	0	1	0		<a href="#">STXP — 32-bit</a>	-
10	0	0	1	1		<a href="#">STLXP — 32-bit</a>	-
10	0	1	0	0		<a href="#">LDXR — 32-bit</a>	-
10	0	1	0	1		<a href="#">LDAXR — 32-bit</a>	-
10	0	1	1	0		<a href="#">LDXP — 32-bit</a>	-
10	0	1	1	1		<a href="#">LDAXP — 32-bit</a>	-
10	1	0	0	0		<a href="#">STLLR — 32-bit</a>	ARMv8.1-LOR
10	1	0	0	1		<a href="#">STLR — 32-bit</a>	-
10	1	0	1	0	11111	<a href="#">CAS, CASA, CASAL, CASL — 32-bit CAS</a>	ARMv8.1-LSE
10	1	0	1	1	11111	<a href="#">CAS, CASA, CASAL, CASL — 32-bit CASL</a>	ARMv8.1-LSE
10	1	1	0	0		<a href="#">LDLAR — 32-bit</a>	ARMv8.1-LOR
10	1	1	0	1		<a href="#">LDAR — 32-bit</a>	-
10	1	1	1	0	11111	<a href="#">CAS, CASA, CASAL, CASL — 32-bit CASA</a>	ARMv8.1-LSE
10	1	1	1	1	11111	<a href="#">CAS, CASA, CASAL, CASL — 32-bit CASAL</a>	ARMv8.1-LSE
11	0	0	0	0		<a href="#">STXR — 64-bit</a>	-
11	0	0	0	1		<a href="#">STLXR — 64-bit</a>	-
11	0	0	1	0		<a href="#">STXP — 64-bit</a>	-
11	0	0	1	1		<a href="#">STLXP — 64-bit</a>	-
11	0	1	0	0		<a href="#">LDXR — 64-bit</a>	-
11	0	1	0	1		<a href="#">LDAXR — 64-bit</a>	-
11	0	1	1	0		<a href="#">LDXP — 64-bit</a>	-
11	0	1	1	1		<a href="#">LDAXP — 64-bit</a>	-
11	1	0	0	0		<a href="#">STLLR — 64-bit</a>	ARMv8.1-LOR
11	1	0	0	1		<a href="#">STLR — 64-bit</a>	-
11	1	0	1	0	11111	<a href="#">CAS, CASA, CASAL, CASL — 64-bit CAS</a>	ARMv8.1-LSE
11	1	0	1	1	11111	<a href="#">CAS, CASA, CASAL, CASL — 64-bit CASL</a>	ARMv8.1-LSE
11	1	1	0	0		<a href="#">LDLAR — 64-bit</a>	ARMv8.1-LOR
11	1	1	0	1		<a href="#">LDAR — 64-bit</a>	-
11	1	1	1	0	11111	<a href="#">CAS, CASA, CASAL, CASL — 64-bit CASA</a>	ARMv8.1-LSE

Decode fields					Rt2	Instruction Details	Architecture Version
size	o2	L	o1	o0			
11	1	1	1	1	11111	<a href="#">CAS, CASA, CASAL, CASL</a> — <a href="#">64-bit CASAL</a>	ARMv8.1-LSE

**LDAPR/STLR (unscaled immediate)**

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size	0	1	1	0	0	1		opc	0												0	0									Rt

Decode fields		Instruction Details	Architecture Version
size	opc		
00	00	<a href="#">STLURB</a>	ARMv8.4-RCPC
00	01	<a href="#">LDAPURB</a>	ARMv8.4-RCPC
00	10	<a href="#">LDAPURSB</a> — <a href="#">64-bit</a>	ARMv8.4-RCPC
00	11	<a href="#">LDAPURSB</a> — <a href="#">32-bit</a>	ARMv8.4-RCPC
01	00	<a href="#">STLURH</a>	ARMv8.4-RCPC
01	01	<a href="#">LDAPURH</a>	ARMv8.4-RCPC
01	10	<a href="#">LDAPURSH</a> — <a href="#">64-bit</a>	ARMv8.4-RCPC
01	11	<a href="#">LDAPURSH</a> — <a href="#">32-bit</a>	ARMv8.4-RCPC
10	00	<a href="#">STLUR</a> — <a href="#">32-bit</a>	ARMv8.4-RCPC
10	01	<a href="#">LDAPUR</a> — <a href="#">32-bit</a>	ARMv8.4-RCPC
10	10	<a href="#">LDAPURSW</a>	ARMv8.4-RCPC
10	11	UNALLOCATED	-
11	00	<a href="#">STLUR</a> — <a href="#">64-bit</a>	ARMv8.4-RCPC
11	01	<a href="#">LDAPUR</a> — <a href="#">64-bit</a>	ARMv8.4-RCPC
11	10	UNALLOCATED	-
11	11	UNALLOCATED	-

**Load register (literal)**

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
opc	0	1	1	V	0	0																									Rt

Decode fields		Instruction Details
opc	V	
00	0	<a href="#">LDR (literal)</a> — <a href="#">32-bit</a>
00	1	<a href="#">LDR (literal, SIMD&amp;FP)</a> — <a href="#">32-bit</a>
01	0	<a href="#">LDR (literal)</a> — <a href="#">64-bit</a>
01	1	<a href="#">LDR (literal, SIMD&amp;FP)</a> — <a href="#">64-bit</a>
10	0	<a href="#">LDRSW (literal)</a>
10	1	<a href="#">LDR (literal, SIMD&amp;FP)</a> — <a href="#">128-bit</a>
11	0	<a href="#">PRFM (literal)</a>
11	1	UNALLOCATED

**Load/store no-allocate pair (offset)**

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
opc	1	0	1	V	0	0	0	L																							Rt

Decode fields			Instruction Details
opc	V	L	
00	0	0	<a href="#">STNP — 32-bit</a>
00	0	1	<a href="#">LDNP — 32-bit</a>
00	1	0	<a href="#">STNP (SIMD&amp;FP) — 32-bit</a>
00	1	1	<a href="#">LDNP (SIMD&amp;FP) — 32-bit</a>
01	0		UNALLOCATED
01	1	0	<a href="#">STNP (SIMD&amp;FP) — 64-bit</a>
01	1	1	<a href="#">LDNP (SIMD&amp;FP) — 64-bit</a>
10	0	0	<a href="#">STNP — 64-bit</a>
10	0	1	<a href="#">LDNP — 64-bit</a>
10	1	0	<a href="#">STNP (SIMD&amp;FP) — 128-bit</a>
10	1	1	<a href="#">LDNP (SIMD&amp;FP) — 128-bit</a>
11			UNALLOCATED

### Load/store register pair (post-indexed)

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
opc		1	0	1	V	0	0	1	L	imm7						Rt2				Rn				Rt							

Decode fields			Instruction Details	Architecture Version
opc	V	L		
00	0	0	<a href="#">STP — 32-bit</a>	-
00	0	1	<a href="#">LDP — 32-bit</a>	-
00	1	0	<a href="#">STP (SIMD&amp;FP) — 32-bit</a>	-
00	1	1	<a href="#">LDP (SIMD&amp;FP) — 32-bit</a>	-
01	0	0	<a href="#">STGP</a>	ARMv8.5-MemTag
01	0	1	<a href="#">LDPSW</a>	-
01	1	0	<a href="#">STP (SIMD&amp;FP) — 64-bit</a>	-
01	1	1	<a href="#">LDP (SIMD&amp;FP) — 64-bit</a>	-
10	0	0	<a href="#">STP — 64-bit</a>	-
10	0	1	<a href="#">LDP — 64-bit</a>	-
10	1	0	<a href="#">STP (SIMD&amp;FP) — 128-bit</a>	-
10	1	1	<a href="#">LDP (SIMD&amp;FP) — 128-bit</a>	-
11			UNALLOCATED	-

### Load/store register pair (offset)

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
opc		1	0	1	V	0	1	0	L	imm7						Rt2				Rn				Rt							

Decode fields			Instruction Details	Architecture Version
opc	V	L		
00	0	0	<a href="#">STP — 32-bit</a>	-
00	0	1	<a href="#">LDP — 32-bit</a>	-
00	1	0	<a href="#">STP (SIMD&amp;FP) — 32-bit</a>	-
00	1	1	<a href="#">LDP (SIMD&amp;FP) — 32-bit</a>	-
01	0	0	<a href="#">STGP</a>	ARMv8.5-MemTag

Decode fields			Instruction Details	Architecture Version
opc	V	L		
01	0	1	<a href="#">LDPSW</a>	-
01	1	0	<a href="#">STP (SIMD&amp;FP) — 64-bit</a>	-
01	1	1	<a href="#">LDP (SIMD&amp;FP) — 64-bit</a>	-
10	0	0	<a href="#">STP — 64-bit</a>	-
10	0	1	<a href="#">LDP — 64-bit</a>	-
10	1	0	<a href="#">STP (SIMD&amp;FP) — 128-bit</a>	-
10	1	1	<a href="#">LDP (SIMD&amp;FP) — 128-bit</a>	-
11			UNALLOCATED	-

### Load/store register pair (pre-indexed)

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
opc		1	0	1	V	0	1	1	L	imm7						Rt2				Rn				Rt							

Decode fields			Instruction Details	Architecture Version
opc	V	L		
00	0	0	<a href="#">STP — 32-bit</a>	-
00	0	1	<a href="#">LDP — 32-bit</a>	-
00	1	0	<a href="#">STP (SIMD&amp;FP) — 32-bit</a>	-
00	1	1	<a href="#">LDP (SIMD&amp;FP) — 32-bit</a>	-
01	0	0	<a href="#">STGP</a>	ARMv8.5-MemTag
01	0	1	<a href="#">LDPSW</a>	-
01	1	0	<a href="#">STP (SIMD&amp;FP) — 64-bit</a>	-
01	1	1	<a href="#">LDP (SIMD&amp;FP) — 64-bit</a>	-
10	0	0	<a href="#">STP — 64-bit</a>	-
10	0	1	<a href="#">LDP — 64-bit</a>	-
10	1	0	<a href="#">STP (SIMD&amp;FP) — 128-bit</a>	-
10	1	1	<a href="#">LDP (SIMD&amp;FP) — 128-bit</a>	-
11			UNALLOCATED	-

### Load/store register (unscaled immediate)

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size		1	1	1	V	0	0	opc		0	imm9										0	0	Rn				Rt				

Decode fields			Instruction Details
size	V	opc	
x1	1	1x	UNALLOCATED
00	0	00	<a href="#">STURB</a>
00	0	01	<a href="#">LDURB</a>
00	0	10	<a href="#">LDURSB — 64-bit</a>
00	0	11	<a href="#">LDURSB — 32-bit</a>
00	1	00	<a href="#">STUR (SIMD&amp;FP) — 8-bit</a>
00	1	01	<a href="#">LDUR (SIMD&amp;FP) — 8-bit</a>
00	1	10	<a href="#">STUR (SIMD&amp;FP) — 128-bit</a>
00	1	11	<a href="#">LDUR (SIMD&amp;FP) — 128-bit</a>



Decode fields size	V	opc	Instruction Details
01	0	00	<a href="#">STURH</a>
01	0	01	<a href="#">LDURH</a>
01	0	10	<a href="#">LDURSH</a> — 64-bit
01	0	11	<a href="#">LDURSH</a> — 32-bit
01	1	00	<a href="#">STUR (SIMD&amp;FP)</a> — 16-bit
01	1	01	<a href="#">LDUR (SIMD&amp;FP)</a> — 16-bit
1x	0	11	UNALLOCATED
1x	1	1x	UNALLOCATED
10	0	00	<a href="#">STUR</a> — 32-bit
10	0	01	<a href="#">LDUR</a> — 32-bit
10	0	10	<a href="#">LDURSW</a>
10	1	00	<a href="#">STUR (SIMD&amp;FP)</a> — 32-bit
10	1	01	<a href="#">LDUR (SIMD&amp;FP)</a> — 32-bit
11	0	00	<a href="#">STUR</a> — 64-bit
11	0	01	<a href="#">LDUR</a> — 64-bit
11	0	10	<a href="#">PRFUM</a>
11	1	00	<a href="#">STUR (SIMD&amp;FP)</a> — 64-bit
11	1	01	<a href="#">LDUR (SIMD&amp;FP)</a> — 64-bit

**Load/store register (immediate post-indexed)**

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size		1	1	1	V	0	0	opc		0	imm9										0	1	Rn				Rt				

Decode fields size	V	opc	Instruction Details
x1	1	1x	UNALLOCATED
00	0	00	<a href="#">STRB (immediate)</a>
00	0	01	<a href="#">LDRB (immediate)</a>
00	0	10	<a href="#">LDRSB (immediate)</a> — 64-bit
00	0	11	<a href="#">LDRSB (immediate)</a> — 32-bit
00	1	00	<a href="#">STR (immediate, SIMD&amp;FP)</a> — 8-bit
00	1	01	<a href="#">LDR (immediate, SIMD&amp;FP)</a> — 8-bit
00	1	10	<a href="#">STR (immediate, SIMD&amp;FP)</a> — 128-bit
00	1	11	<a href="#">LDR (immediate, SIMD&amp;FP)</a> — 128-bit
01	0	00	<a href="#">STRH (immediate)</a>
01	0	01	<a href="#">LDRH (immediate)</a>
01	0	10	<a href="#">LDRSH (immediate)</a> — 64-bit
01	0	11	<a href="#">LDRSH (immediate)</a> — 32-bit
01	1	00	<a href="#">STR (immediate, SIMD&amp;FP)</a> — 16-bit
01	1	01	<a href="#">LDR (immediate, SIMD&amp;FP)</a> — 16-bit
1x	0	11	UNALLOCATED
1x	1	1x	UNALLOCATED
10	0	00	<a href="#">STR (immediate)</a> — 32-bit
10	0	01	<a href="#">LDR (immediate)</a> — 32-bit
10	0	10	<a href="#">LDRSW (immediate)</a>
10	1	00	<a href="#">STR (immediate, SIMD&amp;FP)</a> — 32-bit

Decode fields size	V	opc	Instruction Details
10	1	01	<a href="#">LDR (immediate, SIMD&amp;FP) — 32-bit</a>
11	0	00	<a href="#">STR (immediate) — 64-bit</a>
11	0	01	<a href="#">LDR (immediate) — 64-bit</a>
11	0	10	UNALLOCATED
11	1	00	<a href="#">STR (immediate, SIMD&amp;FP) — 64-bit</a>
11	1	01	<a href="#">LDR (immediate, SIMD&amp;FP) — 64-bit</a>

### Load/store register (unprivileged)

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size		1	1	1	V	0	0	opc		0	imm9										1	0	Rn				Rt				

Decode fields size	V	opc	Instruction Details
	1		UNALLOCATED
00	0	00	<a href="#">STTRB</a>
00	0	01	<a href="#">LDTRB</a>
00	0	10	<a href="#">LDTRSB — 64-bit</a>
00	0	11	<a href="#">LDTRSB — 32-bit</a>
01	0	00	<a href="#">STTRH</a>
01	0	01	<a href="#">LDTRH</a>
01	0	10	<a href="#">LDTRSH — 64-bit</a>
01	0	11	<a href="#">LDTRSH — 32-bit</a>
1x	0	11	UNALLOCATED
10	0	00	<a href="#">STTR — 32-bit</a>
10	0	01	<a href="#">LDTR — 32-bit</a>
10	0	10	<a href="#">LDTRSW</a>
11	0	00	<a href="#">STTR — 64-bit</a>
11	0	01	<a href="#">LDTR — 64-bit</a>
11	0	10	UNALLOCATED

### Load/store register (immediate pre-indexed)

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size		1	1	1	V	0	0	opc		0	imm9										1	1	Rn				Rt				

Decode fields size	V	opc	Instruction Details
x1	1	1x	UNALLOCATED
00	0	00	<a href="#">STRB (immediate)</a>
00	0	01	<a href="#">LDRB (immediate)</a>
00	0	10	<a href="#">LDRSB (immediate) — 64-bit</a>
00	0	11	<a href="#">LDRSB (immediate) — 32-bit</a>
00	1	00	<a href="#">STR (immediate, SIMD&amp;FP) — 8-bit</a>
00	1	01	<a href="#">LDR (immediate, SIMD&amp;FP) — 8-bit</a>
00	1	10	<a href="#">STR (immediate, SIMD&amp;FP) — 128-bit</a>

Decode fields			Instruction Details
size	V	opc	
00	1	11	<a href="#">LDR (immediate, SIMD&amp;FP) — 128-bit</a>
01	0	00	<a href="#">STRH (immediate)</a>
01	0	01	<a href="#">LDRH (immediate)</a>
01	0	10	<a href="#">LDRSH (immediate) — 64-bit</a>
01	0	11	<a href="#">LDRSH (immediate) — 32-bit</a>
01	1	00	<a href="#">STR (immediate, SIMD&amp;FP) — 16-bit</a>
01	1	01	<a href="#">LDR (immediate, SIMD&amp;FP) — 16-bit</a>
1x	0	11	UNALLOCATED
1x	1	1x	UNALLOCATED
10	0	00	<a href="#">STR (immediate) — 32-bit</a>
10	0	01	<a href="#">LDR (immediate) — 32-bit</a>
10	0	10	<a href="#">LDRSW (immediate)</a>
10	1	00	<a href="#">STR (immediate, SIMD&amp;FP) — 32-bit</a>
10	1	01	<a href="#">LDR (immediate, SIMD&amp;FP) — 32-bit</a>
11	0	00	<a href="#">STR (immediate) — 64-bit</a>
11	0	01	<a href="#">LDR (immediate) — 64-bit</a>
11	0	10	UNALLOCATED
11	1	00	<a href="#">STR (immediate, SIMD&amp;FP) — 64-bit</a>
11	1	01	<a href="#">LDR (immediate, SIMD&amp;FP) — 64-bit</a>

## Atomic memory operations

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size	1	1	1	V	0	0	A	R	1	Rs					o3	opc			0	0	Rn					Rt					

Decode fields						Instruction Details	Architecture Version
size	V	A	R	o3	opc		
	0			1	11x	UNALLOCATED	-
	0	0		1	100	UNALLOCATED	-
	0	0	1	1	001	UNALLOCATED	-
	0	0	1	1	010	UNALLOCATED	-
	0	0	1	1	011	UNALLOCATED	-
	0	0	1	1	101	UNALLOCATED	-
	0	1	0	1	001	UNALLOCATED	-
	0	1	0	1	010	UNALLOCATED	-
	0	1	0	1	011	UNALLOCATED	-
	0	1	0	1	101	UNALLOCATED	-
	0	1	1	1	001	UNALLOCATED	-
	0	1	1	1	010	UNALLOCATED	-
	0	1	1	1	011	UNALLOCATED	-
	0	1	1	1	100	UNALLOCATED	-
	0	1	1	1	101	UNALLOCATED	-
	1					UNALLOCATED	-
00	0	0	0	0	000	<a href="#">LDADDB, LDADDAB, LDADDALB, LDADDLB — LDADDB</a>	ARMv8.1-LSE
00	0	0	0	0	001	<a href="#">LDCLRB, LDCLRAB, LDCLRALB, LDCLRLB — LDCLRB</a>	ARMv8.1-LSE

size	Decode fields					Instruction Details	Architecture Version
	V	A	R	o3	opc		
00	0	0	0	0	010	<a href="#">LDEORB, LDEORAB, LDEORALB, LDEORLB</a> — <a href="#">LDEORB</a>	ARMv8.1-LSE
00	0	0	0	0	011	<a href="#">LDSETB, LDSETAB, LDSETALB, LDSETLB</a> — <a href="#">LDSETB</a>	ARMv8.1-LSE
00	0	0	0	0	100	<a href="#">LDSMAXB, LDSMAXAB, LDSMAXALB, LDSMAXLB</a> — <a href="#">LDSMAXB</a>	ARMv8.1-LSE
00	0	0	0	0	101	<a href="#">LDSMINB, LDSMINAB, LDSMINALB, LDSMINLB</a> — <a href="#">LDSMINB</a>	ARMv8.1-LSE
00	0	0	0	0	110	<a href="#">LDUMAXB, LDUMAXAB, LDUMAXALB, LDUMAXLB</a> — <a href="#">LDUMAXB</a>	ARMv8.1-LSE
00	0	0	0	0	111	<a href="#">LDUMINB, LDUMINAB, LDUMINALB, LDUMINLB</a> — <a href="#">LDUMINB</a>	ARMv8.1-LSE
00	0	0	0	1	000	<a href="#">SWPB, SWPAB, SWPALB, SWPLB</a> — <a href="#">SWPB</a>	ARMv8.1-LSE
00	0	0	0	1	001	UNALLOCATED	-
00	0	0	0	1	010	UNALLOCATED	-
00	0	0	0	1	011	UNALLOCATED	-
00	0	0	0	1	101	UNALLOCATED	-
00	0	0	1	0	000	<a href="#">LDADDB, LDADDAB, LDADDALB, LDADDLB</a> — <a href="#">LDADDLB</a>	ARMv8.1-LSE
00	0	0	1	0	001	<a href="#">LDCLRB, LDCLRAB, LDCLRALB, LDCLRLB</a> — <a href="#">LDCLRLB</a>	ARMv8.1-LSE
00	0	0	1	0	010	<a href="#">LDEORB, LDEORAB, LDEORALB, LDEORLB</a> — <a href="#">LDEORLB</a>	ARMv8.1-LSE
00	0	0	1	0	011	<a href="#">LDSETB, LDSETAB, LDSETALB, LDSETLB</a> — <a href="#">LDSETLB</a>	ARMv8.1-LSE
00	0	0	1	0	100	<a href="#">LDSMAXB, LDSMAXAB, LDSMAXALB, LDSMAXLB</a> — <a href="#">LDSMAXLB</a>	ARMv8.1-LSE
00	0	0	1	0	101	<a href="#">LDSMINB, LDSMINAB, LDSMINALB, LDSMINLB</a> — <a href="#">LDSMINLB</a>	ARMv8.1-LSE
00	0	0	1	0	110	<a href="#">LDUMAXB, LDUMAXAB, LDUMAXALB, LDUMAXLB</a> — <a href="#">LDUMAXLB</a>	ARMv8.1-LSE
00	0	0	1	0	111	<a href="#">LDUMINB, LDUMINAB, LDUMINALB, LDUMINLB</a> — <a href="#">LDUMINLB</a>	ARMv8.1-LSE
00	0	0	1	1	000	<a href="#">SWPB, SWPAB, SWPALB, SWPLB</a> — <a href="#">SWPLB</a>	ARMv8.1-LSE
00	0	1	0	0	000	<a href="#">LDADDB, LDADDAB, LDADDALB, LDADDLB</a> — <a href="#">LDADDAB</a>	ARMv8.1-LSE
00	0	1	0	0	001	<a href="#">LDCLRB, LDCLRAB, LDCLRALB, LDCLRLB</a> — <a href="#">LDCLRAB</a>	ARMv8.1-LSE
00	0	1	0	0	010	<a href="#">LDEORB, LDEORAB, LDEORALB, LDEORLB</a> — <a href="#">LDEORAB</a>	ARMv8.1-LSE
00	0	1	0	0	011	<a href="#">LDSETB, LDSETAB, LDSETALB, LDSETLB</a> — <a href="#">LDSETAB</a>	ARMv8.1-LSE
00	0	1	0	0	100	<a href="#">LDSMAXB, LDSMAXAB, LDSMAXALB, LDSMAXLB</a> — <a href="#">LDSMAXAB</a>	ARMv8.1-LSE
00	0	1	0	0	101	<a href="#">LDSMINB, LDSMINAB, LDSMINALB, LDSMINLB</a> — <a href="#">LDSMINAB</a>	ARMv8.1-LSE
00	0	1	0	0	110	<a href="#">LDUMAXB, LDUMAXAB, LDUMAXALB, LDUMAXLB</a> — <a href="#">LDUMAXAB</a>	ARMv8.1-LSE
00	0	1	0	0	111	<a href="#">LDUMINB, LDUMINAB, LDUMINALB, LDUMINLB</a> — <a href="#">LDUMINAB</a>	ARMv8.1-LSE
00	0	1	0	1	000	<a href="#">SWPB, SWPAB, SWPALB, SWPLB</a> — <a href="#">SWPAB</a>	ARMv8.1-LSE
00	0	1	0	1	100	<a href="#">LDAPRB</a>	ARMv8.3-RCPC
00	0	1	1	0	000	<a href="#">LDADDB, LDADDAB, LDADDALB, LDADDLB</a> — <a href="#">LDADDALB</a>	ARMv8.1-LSE
00	0	1	1	0	001	<a href="#">LDCLRB, LDCLRAB, LDCLRALB, LDCLRLB</a> — <a href="#">LDCLRALB</a>	ARMv8.1-LSE

size	Decode fields					Instruction Details	Architecture Version
	V	A	R	o3	opc		
00	0	1	1	0	010	<a href="#">LDEORB, LDEORAB, LDEORALB, LDEORLB</a> — <a href="#">LDEORALB</a>	ARMv8.1-LSE
00	0	1	1	0	011	<a href="#">LDSETB, LDSETAB, LDSETALB, LDSETLB</a> — <a href="#">LDSETALB</a>	ARMv8.1-LSE
00	0	1	1	0	100	<a href="#">LDSMAXB, LDSMAXAB, LDSMAXALB, LDSMAXLB</a> — <a href="#">LDSMAXALB</a>	ARMv8.1-LSE
00	0	1	1	0	101	<a href="#">LDSMINB, LDSMINAB, LDSMINALB, LDSMINLB</a> — <a href="#">LDSMINALB</a>	ARMv8.1-LSE
00	0	1	1	0	110	<a href="#">LDUMAXB, LDUMAXAB, LDUMAXALB, LDUMAXLB</a> — <a href="#">LDUMAXALB</a>	ARMv8.1-LSE
00	0	1	1	0	111	<a href="#">LDUMINB, LDUMINAB, LDUMINALB, LDUMINLB</a> — <a href="#">LDUMINALB</a>	ARMv8.1-LSE
00	0	1	1	1	000	<a href="#">SWPB, SWPAB, SWPALB, SWPLB</a> — <a href="#">SWPALB</a>	ARMv8.1-LSE
01	0	0	0	0	000	<a href="#">LDADDH, LDADDAH, LDADDALH, LDADDLH</a> — <a href="#">LDADDH</a>	ARMv8.1-LSE
01	0	0	0	0	001	<a href="#">LDCLR H, LDCLRAH, LDCLRALH, LDCLRLH</a> — <a href="#">LDCLR H</a>	ARMv8.1-LSE
01	0	0	0	0	010	<a href="#">LDEORH, LDEORAH, LDEORALH, LDEORLH</a> — <a href="#">LDEORH</a>	ARMv8.1-LSE
01	0	0	0	0	011	<a href="#">LDSETH, LDSETAH, LDSETALH, LDSETLH</a> — <a href="#">LDSETH</a>	ARMv8.1-LSE
01	0	0	0	0	100	<a href="#">LDSMAXH, LDSMAXAH, LDSMAXALH, LDSMAXLH</a> — <a href="#">LDSMAXH</a>	ARMv8.1-LSE
01	0	0	0	0	101	<a href="#">LDSMINH, LDSMINAH, LDSMINALH, LDSMINLH</a> — <a href="#">LDSMINH</a>	ARMv8.1-LSE
01	0	0	0	0	110	<a href="#">LDUMAXH, LDUMAXAH, LDUMAXALH, LDUMAXLH</a> — <a href="#">LDUMAXH</a>	ARMv8.1-LSE
01	0	0	0	0	111	<a href="#">LDUMINH, LDUMINAH, LDUMINALH, LDUMINLH</a> — <a href="#">LDUMINH</a>	ARMv8.1-LSE
01	0	0	0	1	000	<a href="#">SWPH, SWPAH, SWPALH, SWPLH</a> — <a href="#">SWPH</a>	ARMv8.1-LSE
01	0	0	0	1	001	UNALLOCATED	-
01	0	0	0	1	010	UNALLOCATED	-
01	0	0	0	1	011	UNALLOCATED	-
01	0	0	0	1	101	UNALLOCATED	-
01	0	0	1	0	000	<a href="#">LDADDH, LDADDAH, LDADDALH, LDADDLH</a> — <a href="#">LDADDLH</a>	ARMv8.1-LSE
01	0	0	1	0	001	<a href="#">LDCLR H, LDCLRAH, LDCLRALH, LDCLRLH</a> — <a href="#">LDCLRLH</a>	ARMv8.1-LSE
01	0	0	1	0	010	<a href="#">LDEORH, LDEORAH, LDEORALH, LDEORLH</a> — <a href="#">LDEORLH</a>	ARMv8.1-LSE
01	0	0	1	0	011	<a href="#">LDSETH, LDSETAH, LDSETALH, LDSETLH</a> — <a href="#">LDSETLH</a>	ARMv8.1-LSE
01	0	0	1	0	100	<a href="#">LDSMAXH, LDSMAXAH, LDSMAXALH, LDSMAXLH</a> — <a href="#">LDSMAXLH</a>	ARMv8.1-LSE
01	0	0	1	0	101	<a href="#">LDSMINH, LDSMINAH, LDSMINALH, LDSMINLH</a> — <a href="#">LDSMINLH</a>	ARMv8.1-LSE
01	0	0	1	0	110	<a href="#">LDUMAXH, LDUMAXAH, LDUMAXALH, LDUMAXLH</a> — <a href="#">LDUMAXLH</a>	ARMv8.1-LSE
01	0	0	1	0	111	<a href="#">LDUMINH, LDUMINAH, LDUMINALH, LDUMINLH</a> — <a href="#">LDUMINLH</a>	ARMv8.1-LSE
01	0	0	1	1	000	<a href="#">SWPH, SWPAH, SWPALH, SWPLH</a> — <a href="#">SWPLH</a>	ARMv8.1-LSE
01	0	1	0	0	000	<a href="#">LDADDH, LDADDAH, LDADDALH, LDADDLH</a> — <a href="#">LDADDAH</a>	ARMv8.1-LSE
01	0	1	0	0	001	<a href="#">LDCLR H, LDCLRAH, LDCLRALH, LDCLRLH</a> — <a href="#">LDCLRAH</a>	ARMv8.1-LSE

size	Decode fields					Instruction Details	Architecture Version
	V	A	R	o3	opc		
01	0	1	0	0	010	<a href="#">LDEORH, LDEORAH, LDEORALH, LDEORLH</a> — <a href="#">LDEORAH</a>	ARMv8.1-LSE
01	0	1	0	0	011	<a href="#">LDSETH, LDSETAH, LDSETALH, LDSETLH</a> — <a href="#">LDSETAH</a>	ARMv8.1-LSE
01	0	1	0	0	100	<a href="#">LDSMAXH, LDSMAXAH, LDSMAXALH, LDSMAXLH</a> — <a href="#">LDSMAXAH</a>	ARMv8.1-LSE
01	0	1	0	0	101	<a href="#">LDSMINH, LDSMINAH, LDSMINALH, LDSMINLH</a> — <a href="#">LDSMINAH</a>	ARMv8.1-LSE
01	0	1	0	0	110	<a href="#">LDUMAXH, LDUMAXAH, LDUMAXALH, LDUMAXLH</a> — <a href="#">LDUMAXAH</a>	ARMv8.1-LSE
01	0	1	0	0	111	<a href="#">LDUMINH, LDUMINAH, LDUMINALH, LDUMINLH</a> — <a href="#">LDUMINAH</a>	ARMv8.1-LSE
01	0	1	0	1	000	<a href="#">SWPH, SWPAH, SWPALH, SWPLH</a> — <a href="#">SWPAH</a>	ARMv8.1-LSE
01	0	1	0	1	100	<a href="#">LDAPRH</a>	ARMv8.3-RCPC
01	0	1	1	0	000	<a href="#">LDADDH, LDADDAH, LDADDALH, LDADDLH</a> — <a href="#">LDADDALH</a>	ARMv8.1-LSE
01	0	1	1	0	001	<a href="#">LDCLR, LDCLRA, LDCLRAL, LDCLRL</a> — <a href="#">LDCLRALH</a>	ARMv8.1-LSE
01	0	1	1	0	010	<a href="#">LDEORH, LDEORAH, LDEORALH, LDEORLH</a> — <a href="#">LDEORALH</a>	ARMv8.1-LSE
01	0	1	1	0	011	<a href="#">LDSETH, LDSETAH, LDSETALH, LDSETLH</a> — <a href="#">LDSETALH</a>	ARMv8.1-LSE
01	0	1	1	0	100	<a href="#">LDSMAXH, LDSMAXAH, LDSMAXALH, LDSMAXLH</a> — <a href="#">LDSMAXALH</a>	ARMv8.1-LSE
01	0	1	1	0	101	<a href="#">LDSMINH, LDSMINAH, LDSMINALH, LDSMINLH</a> — <a href="#">LDSMINALH</a>	ARMv8.1-LSE
01	0	1	1	0	110	<a href="#">LDUMAXH, LDUMAXAH, LDUMAXALH, LDUMAXLH</a> — <a href="#">LDUMAXALH</a>	ARMv8.1-LSE
01	0	1	1	0	111	<a href="#">LDUMINH, LDUMINAH, LDUMINALH, LDUMINLH</a> — <a href="#">LDUMINALH</a>	ARMv8.1-LSE
01	0	1	1	1	000	<a href="#">SWPH, SWPAH, SWPALH, SWPLH</a> — <a href="#">SWPALH</a>	ARMv8.1-LSE
10	0	0	0	0	000	<a href="#">LDADD, LDADDA, LDADDAL, LDADDL</a> — 32-bit <a href="#">LDADD</a>	ARMv8.1-LSE
10	0	0	0	0	001	<a href="#">LDCLR, LDCLRA, LDCLRAL, LDCLRL</a> — 32-bit <a href="#">LDCLR</a>	ARMv8.1-LSE
10	0	0	0	0	010	<a href="#">LDEOR, LDEORA, LDEORAL, LDEORL</a> — 32-bit <a href="#">LDEOR</a>	ARMv8.1-LSE
10	0	0	0	0	011	<a href="#">LDSET, LDSETA, LDSETAL, LDSETL</a> — 32-bit <a href="#">LDSET</a>	ARMv8.1-LSE
10	0	0	0	0	100	<a href="#">LDSMAX, LDSMAXA, LDSMAXAL, LDSMAXL</a> — 32-bit <a href="#">LDSMAX</a>	ARMv8.1-LSE
10	0	0	0	0	101	<a href="#">LDSMIN, LDSMINA, LDSMINAL, LDSMINL</a> — 32-bit <a href="#">LDSMIN</a>	ARMv8.1-LSE
10	0	0	0	0	110	<a href="#">LDUMAX, LDUMAXA, LDUMAXAL, LDUMAXL</a> — 32-bit <a href="#">LDUMAX</a>	ARMv8.1-LSE
10	0	0	0	0	111	<a href="#">LDUMIN, LDUMINA, LDUMINAL, LDUMINL</a> — 32-bit <a href="#">LDUMIN</a>	ARMv8.1-LSE
10	0	0	0	1	000	<a href="#">SWP, SWPA, SWPAL, SWPL</a> — 32-bit <a href="#">SWP</a>	ARMv8.1-LSE
10	0	0	0	1	001	UNALLOCATED	-
10	0	0	0	1	010	UNALLOCATED	-
10	0	0	0	1	011	UNALLOCATED	-
10	0	0	0	1	101	UNALLOCATED	-
10	0	0	1	0	000	<a href="#">LDADD, LDADDA, LDADDAL, LDADDL</a> — 32-bit <a href="#">LDADDL</a>	ARMv8.1-LSE
10	0	0	1	0	001	<a href="#">LDCLR, LDCLRA, LDCLRAL, LDCLRL</a> — 32-bit <a href="#">LDCLRL</a>	ARMv8.1-LSE

size	Decode fields					Instruction Details	Architecture Version
	V	A	R	o3	opc		
10	0	0	1	0	010	<a href="#">LDEOR, LDEORA, LDEORAL, LDEORL</a> — 32-bit LDEORL	ARMv8.1-LSE
10	0	0	1	0	011	<a href="#">LDSET, LDSETA, LDSETAL, LDSETL</a> — 32-bit LDSETL	ARMv8.1-LSE
10	0	0	1	0	100	<a href="#">LDSMAX, LDSMAXA, LDSMAXAL, LDSMAXL</a> — 32-bit LDSMAXL	ARMv8.1-LSE
10	0	0	1	0	101	<a href="#">LDSMIN, LDSMINA, LDSMINAL, LDSMINL</a> — 32-bit LDSMINL	ARMv8.1-LSE
10	0	0	1	0	110	<a href="#">LDUMAX, LDUMAXA, LDUMAXAL, LDUMAXL</a> — 32-bit LDUMAXL	ARMv8.1-LSE
10	0	0	1	0	111	<a href="#">LDUMIN, LDUMINA, LDUMINAL, LDUMINL</a> — 32-bit LDUMINL	ARMv8.1-LSE
10	0	0	1	1	000	<a href="#">SWP, SWPA, SWPAL, SWPL</a> — 32-bit SWPL	ARMv8.1-LSE
10	0	1	0	0	000	<a href="#">LDADD, LDADDA, LDADDAL, LDADDL</a> — 32-bit LDADDA	ARMv8.1-LSE
10	0	1	0	0	001	<a href="#">LDCLR, LDCLRA, LDCLRAL, LDCLRL</a> — 32-bit LDCLRA	ARMv8.1-LSE
10	0	1	0	0	010	<a href="#">LDEOR, LDEORA, LDEORAL, LDEORL</a> — 32-bit LDEORA	ARMv8.1-LSE
10	0	1	0	0	011	<a href="#">LDSET, LDSETA, LDSETAL, LDSETL</a> — 32-bit LDSETA	ARMv8.1-LSE
10	0	1	0	0	100	<a href="#">LDSMAX, LDSMAXA, LDSMAXAL, LDSMAXL</a> — 32-bit LDSMAXA	ARMv8.1-LSE
10	0	1	0	0	101	<a href="#">LDSMIN, LDSMINA, LDSMINAL, LDSMINL</a> — 32-bit LDSMINA	ARMv8.1-LSE
10	0	1	0	0	110	<a href="#">LDUMAX, LDUMAXA, LDUMAXAL, LDUMAXL</a> — 32-bit LDUMAXA	ARMv8.1-LSE
10	0	1	0	0	111	<a href="#">LDUMIN, LDUMINA, LDUMINAL, LDUMINL</a> — 32-bit LDUMINA	ARMv8.1-LSE
10	0	1	0	1	000	<a href="#">SWP, SWPA, SWPAL, SWPL</a> — 32-bit SWPA	ARMv8.1-LSE
10	0	1	0	1	100	<a href="#">LDAPR</a> — 32-bit	ARMv8.3-RCPC
10	0	1	1	0	000	<a href="#">LDADD, LDADDA, LDADDAL, LDADDL</a> — 32-bit LDADDAL	ARMv8.1-LSE
10	0	1	1	0	001	<a href="#">LDCLR, LDCLRA, LDCLRAL, LDCLRL</a> — 32-bit LDCLRAL	ARMv8.1-LSE
10	0	1	1	0	010	<a href="#">LDEOR, LDEORA, LDEORAL, LDEORL</a> — 32-bit LDEORAL	ARMv8.1-LSE
10	0	1	1	0	011	<a href="#">LDSET, LDSETA, LDSETAL, LDSETL</a> — 32-bit LDSETAL	ARMv8.1-LSE
10	0	1	1	0	100	<a href="#">LDSMAX, LDSMAXA, LDSMAXAL, LDSMAXL</a> — 32-bit LDSMAXAL	ARMv8.1-LSE
10	0	1	1	0	101	<a href="#">LDSMIN, LDSMINA, LDSMINAL, LDSMINL</a> — 32-bit LDSMINAL	ARMv8.1-LSE
10	0	1	1	0	110	<a href="#">LDUMAX, LDUMAXA, LDUMAXAL, LDUMAXL</a> — 32-bit LDUMAXAL	ARMv8.1-LSE
10	0	1	1	0	111	<a href="#">LDUMIN, LDUMINA, LDUMINAL, LDUMINL</a> — 32-bit LDUMINAL	ARMv8.1-LSE
10	0	1	1	1	000	<a href="#">SWP, SWPA, SWPAL, SWPL</a> — 32-bit SWPAL	ARMv8.1-LSE
11	0	0	0	0	000	<a href="#">LDADD, LDADDA, LDADDAL, LDADDL</a> — 64-bit LDADD	ARMv8.1-LSE
11	0	0	0	0	001	<a href="#">LDCLR, LDCLRA, LDCLRAL, LDCLRL</a> — 64-bit LDCLR	ARMv8.1-LSE
11	0	0	0	0	010	<a href="#">LDEOR, LDEORA, LDEORAL, LDEORL</a> — 64-bit LDEOR	ARMv8.1-LSE
11	0	0	0	0	011	<a href="#">LDSET, LDSETA, LDSETAL, LDSETL</a> — 64-bit LDSET	ARMv8.1-LSE
11	0	0	0	0	100	<a href="#">LDSMAX, LDSMAXA, LDSMAXAL, LDSMAXL</a> — 64-bit LDSMAX	ARMv8.1-LSE

size	Decode fields					Instruction Details	Architecture Version
	V	A	R	o3	opc		
11	0	0	0	0	101	<a href="#">LDSMIN, LDSMINA, LDSMINAL, LDSMINL — 64-bit LD</a> <a href="#">LDSMIN</a>	ARMv8.1-LSE
11	0	0	0	0	110	<a href="#">LDUMAX, LDUMAXA, LDUMAXAL, LDUMAXL — 64-bit LD</a> <a href="#">LDUMAX</a>	ARMv8.1-LSE
11	0	0	0	0	111	<a href="#">LDUMIN, LDUMINA, LDUMINAL, LDUMINL — 64-bit LD</a> <a href="#">LDUMIN</a>	ARMv8.1-LSE
11	0	0	0	1	000	<a href="#">SWP, SWPA, SWPAL, SWPL — 64-bit SWP</a>	ARMv8.1-LSE
11	0	0	1	0	000	<a href="#">LDADD, LDADDA, LDADDAL, LDADDL — 64-bit LD</a> <a href="#">LDADDL</a>	ARMv8.1-LSE
11	0	0	1	0	001	<a href="#">LDCLR, LDCLRA, LDCLRAL, LDCLRL — 64-bit LD</a> <a href="#">LDCLRL</a>	ARMv8.1-LSE
11	0	0	1	0	010	<a href="#">LDEOR, LDEORA, LDEORAL, LDEORL — 64-bit LD</a> <a href="#">LDEORL</a>	ARMv8.1-LSE
11	0	0	1	0	011	<a href="#">LDSET, LDSETA, LDSETAL, LDSETL — 64-bit LD</a> <a href="#">LDSETL</a>	ARMv8.1-LSE
11	0	0	1	0	100	<a href="#">LDSMAX, LDSMAXA, LDSMAXAL, LDSMAXL — 64-bit LD</a> <a href="#">LDSMAXL</a>	ARMv8.1-LSE
11	0	0	1	0	101	<a href="#">LDSMIN, LDSMINA, LDSMINAL, LDSMINL — 64-bit LD</a> <a href="#">LDSMINL</a>	ARMv8.1-LSE
11	0	0	1	0	110	<a href="#">LDUMAX, LDUMAXA, LDUMAXAL, LDUMAXL — 64-bit LD</a> <a href="#">LDUMAXL</a>	ARMv8.1-LSE
11	0	0	1	0	111	<a href="#">LDUMIN, LDUMINA, LDUMINAL, LDUMINL — 64-bit LD</a> <a href="#">LDUMINL</a>	ARMv8.1-LSE
11	0	0	1	1	000	<a href="#">SWP, SWPA, SWPAL, SWPL — 64-bit SWPL</a>	ARMv8.1-LSE
11	0	1	0	0	000	<a href="#">LDADD, LDADDA, LDADDAL, LDADDL — 64-bit LD</a> <a href="#">LDADDA</a>	ARMv8.1-LSE
11	0	1	0	0	001	<a href="#">LDCLR, LDCLRA, LDCLRAL, LDCLRL — 64-bit LD</a> <a href="#">LDCLRA</a>	ARMv8.1-LSE
11	0	1	0	0	010	<a href="#">LDEOR, LDEORA, LDEORAL, LDEORL — 64-bit LD</a> <a href="#">LDEORA</a>	ARMv8.1-LSE
11	0	1	0	0	011	<a href="#">LDSET, LDSETA, LDSETAL, LDSETL — 64-bit LD</a> <a href="#">LDSETA</a>	ARMv8.1-LSE
11	0	1	0	0	100	<a href="#">LDSMAX, LDSMAXA, LDSMAXAL, LDSMAXL — 64-bit LD</a> <a href="#">LDSMAXA</a>	ARMv8.1-LSE
11	0	1	0	0	101	<a href="#">LDSMIN, LDSMINA, LDSMINAL, LDSMINL — 64-bit LD</a> <a href="#">LDSMINA</a>	ARMv8.1-LSE
11	0	1	0	0	110	<a href="#">LDUMAX, LDUMAXA, LDUMAXAL, LDUMAXL — 64-bit LD</a> <a href="#">LDUMAXA</a>	ARMv8.1-LSE
11	0	1	0	0	111	<a href="#">LDUMIN, LDUMINA, LDUMINAL, LDUMINL — 64-bit LD</a> <a href="#">LDUMINA</a>	ARMv8.1-LSE
11	0	1	0	1	000	<a href="#">SWP, SWPA, SWPAL, SWPL — 64-bit SWPA</a>	ARMv8.1-LSE
11	0	1	0	1	100	<a href="#">LDAPR — 64-bit</a>	ARMv8.3-RCPC
11	0	1	1	0	000	<a href="#">LDADD, LDADDA, LDADDAL, LDADDL — 64-bit LD</a> <a href="#">LDADDAL</a>	ARMv8.1-LSE
11	0	1	1	0	001	<a href="#">LDCLR, LDCLRA, LDCLRAL, LDCLRL — 64-bit LD</a> <a href="#">LDCLRAL</a>	ARMv8.1-LSE
11	0	1	1	0	010	<a href="#">LDEOR, LDEORA, LDEORAL, LDEORL — 64-bit LD</a> <a href="#">LDEORAL</a>	ARMv8.1-LSE
11	0	1	1	0	011	<a href="#">LDSET, LDSETA, LDSETAL, LDSETL — 64-bit LD</a> <a href="#">LDSETAL</a>	ARMv8.1-LSE
11	0	1	1	0	100	<a href="#">LDSMAX, LDSMAXA, LDSMAXAL, LDSMAXL — 64-bit LD</a> <a href="#">LDSMAXAL</a>	ARMv8.1-LSE
11	0	1	1	0	101	<a href="#">LDSMIN, LDSMINA, LDSMINAL, LDSMINL — 64-bit LD</a> <a href="#">LDSMINAL</a>	ARMv8.1-LSE
11	0	1	1	0	110	<a href="#">LDUMAX, LDUMAXA, LDUMAXAL, LDUMAXL — 64-bit LD</a> <a href="#">LDUMAXAL</a>	ARMv8.1-LSE
11	0	1	1	0	111	<a href="#">LDUMIN, LDUMINA, LDUMINAL, LDUMINL — 64-bit LD</a> <a href="#">LDUMINAL</a>	ARMv8.1-LSE



Decode fields						Instruction Details	Architecture Version
size	V	A	R	o3	opc		
11	0	1	1	1	000	<a href="#">SWP, SWPA, SWPAL, SWPL — 64-bit SWPAL</a>	ARMv8.1-LSE

**Load/store register (register offset)**

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size	1	1	1	V	0	0	opc	1	Rm				option			S	1	0	Rn				Rt								

Decode fields				Instruction Details
size	V	opc	option	
x1	1	1x		UNALLOCATED
00	0	00	!= 011	<a href="#">STRB (register) — extended register</a>
00	0	00	011	<a href="#">STRB (register) — shifted register</a>
00	0	01	!= 011	<a href="#">LDRB (register) — extended register</a>
00	0	01	011	<a href="#">LDRB (register) — shifted register</a>
00	0	10	!= 011	<a href="#">LDRSB (register) — 64-bit with extended register offset</a>
00	0	10	011	<a href="#">LDRSB (register) — 64-bit with shifted register offset</a>
00	0	11	!= 011	<a href="#">LDRSB (register) — 32-bit with extended register offset</a>
00	0	11	011	<a href="#">LDRSB (register) — 32-bit with shifted register offset</a>
00	1	00	!= 011	<a href="#">STR (register, SIMD&amp;FP)</a>
00	1	00	011	<a href="#">STR (register, SIMD&amp;FP)</a>
00	1	01	!= 011	<a href="#">LDR (register, SIMD&amp;FP)</a>
00	1	01	011	<a href="#">LDR (register, SIMD&amp;FP)</a>
00	1	10		<a href="#">STR (register, SIMD&amp;FP)</a>
00	1	11		<a href="#">LDR (register, SIMD&amp;FP)</a>
01	0	00		<a href="#">STRH (register)</a>
01	0	01		<a href="#">LDRH (register)</a>
01	0	10		<a href="#">LDRSH (register) — 64-bit</a>
01	0	11		<a href="#">LDRSH (register) — 32-bit</a>
01	1	00		<a href="#">STR (register, SIMD&amp;FP)</a>
01	1	01		<a href="#">LDR (register, SIMD&amp;FP)</a>
1x	0	11		UNALLOCATED
1x	1	1x		UNALLOCATED
10	0	00		<a href="#">STR (register) — 32-bit</a>
10	0	01		<a href="#">LDR (register) — 32-bit</a>
10	0	10		<a href="#">LDRSW (register)</a>
10	1	00		<a href="#">STR (register, SIMD&amp;FP)</a>
10	1	01		<a href="#">LDR (register, SIMD&amp;FP)</a>
11	0	00		<a href="#">STR (register) — 64-bit</a>
11	0	01		<a href="#">LDR (register) — 64-bit</a>
11	0	10		<a href="#">PRFM (register)</a>
11	1	00		<a href="#">STR (register, SIMD&amp;FP)</a>
11	1	01		<a href="#">LDR (register, SIMD&amp;FP)</a>

**Load/store register (pac)**

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size	1	1	1	V	0	0	M	S	1	imm9											W	1	Rn					Rt			

Decode fields				Instruction Details		Architecture Version
size	V	M	W			
!= 11				UNALLOCATED		-
11	0	0	0	<a href="#">LDRAA, LDRAB</a> — <a href="#">key A, offset</a>		ARMv8.3-PAuth
11	0	0	1	<a href="#">LDRAA, LDRAB</a> — <a href="#">key A, pre-indexed</a>		ARMv8.3-PAuth
11	0	1	0	<a href="#">LDRAA, LDRAB</a> — <a href="#">key B, offset</a>		ARMv8.3-PAuth
11	0	1	1	<a href="#">LDRAA, LDRAB</a> — <a href="#">key B, pre-indexed</a>		ARMv8.3-PAuth
11	1			UNALLOCATED		-

## Load/store register (unsigned immediate)

These instructions are under [Loads and Stores](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
size		1	1	1	V	0	1	opc		imm12												Rn					Rt				

Decode fields			Instruction Details	
size	V	opc		
x1	1	1x	UNALLOCATED	
00	0	00	<a href="#">STRB (immediate)</a>	
00	0	01	<a href="#">LDRB (immediate)</a>	
00	0	10	<a href="#">LDRSB (immediate)</a> — <a href="#">64-bit</a>	
00	0	11	<a href="#">LDRSB (immediate)</a> — <a href="#">32-bit</a>	
00	1	00	<a href="#">STR (immediate, SIMD&amp;FP)</a> — <a href="#">8-bit</a>	
00	1	01	<a href="#">LDR (immediate, SIMD&amp;FP)</a> — <a href="#">8-bit</a>	
00	1	10	<a href="#">STR (immediate, SIMD&amp;FP)</a> — <a href="#">128-bit</a>	
00	1	11	<a href="#">LDR (immediate, SIMD&amp;FP)</a> — <a href="#">128-bit</a>	
01	0	00	<a href="#">STRH (immediate)</a>	
01	0	01	<a href="#">LDRH (immediate)</a>	
01	0	10	<a href="#">LDRSH (immediate)</a> — <a href="#">64-bit</a>	
01	0	11	<a href="#">LDRSH (immediate)</a> — <a href="#">32-bit</a>	
01	1	00	<a href="#">STR (immediate, SIMD&amp;FP)</a> — <a href="#">16-bit</a>	
01	1	01	<a href="#">LDR (immediate, SIMD&amp;FP)</a> — <a href="#">16-bit</a>	
1x	0	11	UNALLOCATED	
1x	1	1x	UNALLOCATED	
10	0	00	<a href="#">STR (immediate)</a> — <a href="#">32-bit</a>	
10	0	01	<a href="#">LDR (immediate)</a> — <a href="#">32-bit</a>	
10	0	10	<a href="#">LDRSW (immediate)</a>	
10	1	00	<a href="#">STR (immediate, SIMD&amp;FP)</a> — <a href="#">32-bit</a>	
10	1	01	<a href="#">LDR (immediate, SIMD&amp;FP)</a> — <a href="#">32-bit</a>	
11	0	00	<a href="#">STR (immediate)</a> — <a href="#">64-bit</a>	
11	0	01	<a href="#">LDR (immediate)</a> — <a href="#">64-bit</a>	
11	0	10	<a href="#">PRFM (immediate)</a>	
11	1	00	<a href="#">STR (immediate, SIMD&amp;FP)</a> — <a href="#">64-bit</a>	
11	1	01	<a href="#">LDR (immediate, SIMD&amp;FP)</a> — <a href="#">64-bit</a>	

## Data Processing -- Register

These instructions are under the [top-level](#).



Decode fields			Instruction Details	Architecture Version
sf	S	opcode		
0	0	010110	<a href="#">CRC32CB, CRC32CH, CRC32CW, CRC32CX — CRC32CW</a>	-
1	0	000000	<a href="#">SUBP</a>	ARMv8.5-MemTag
1	0	000010	<a href="#">UDIV — 64-bit</a>	-
1	0	000011	<a href="#">SDIV — 64-bit</a>	-
1	0	000100	<a href="#">IRG</a>	ARMv8.5-MemTag
1	0	000101	<a href="#">GMI</a>	ARMv8.5-MemTag
1	0	001000	<a href="#">LSLV — 64-bit</a>	-
1	0	001001	<a href="#">LSRV — 64-bit</a>	-
1	0	001010	<a href="#">ASRV — 64-bit</a>	-
1	0	001011	<a href="#">RORV — 64-bit</a>	-
1	0	001100	<a href="#">PACGA</a>	ARMv8.3-PAAuth
1	0	010xx0	UNALLOCATED	-
1	0	010x0x	UNALLOCATED	-
1	0	010011	<a href="#">CRC32B, CRC32H, CRC32W, CRC32X — CRC32X</a>	-
1	0	010111	<a href="#">CRC32CB, CRC32CH, CRC32CW, CRC32CX — CRC32CX</a>	-
1	1	000000	<a href="#">SUBPS</a>	ARMv8.5-MemTag

**Data-processing (1 source)**

These instructions are under [Data Processing -- Register](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	1	S	1	1	0	1	0	1	1	0	opcode2				opcode				Rn				Rd								

Decode fields				Rn	Instruction Details	Architecture Version
sf	S	opcode2	opcode			
			1xxxxx		UNALLOCATED	-
		xxx1x			UNALLOCATED	-
		xx1xx			UNALLOCATED	-
		x1xxx			UNALLOCATED	-
		1xxxx			UNALLOCATED	-
	0	00000	00011x		UNALLOCATED	-
	0	00000	001xxx		UNALLOCATED	-
	0	00000	01xxxx		UNALLOCATED	-
	1				UNALLOCATED	-
0		00001			UNALLOCATED	-
0	0	00000	000000		<a href="#">RBIT — 32-bit</a>	-
0	0	00000	000001		<a href="#">REV16 — 32-bit</a>	-
0	0	00000	000010		<a href="#">REV — 32-bit</a>	-
0	0	00000	000011		UNALLOCATED	-
0	0	00000	000100		<a href="#">CLZ — 32-bit</a>	-
0	0	00000	000101		<a href="#">CLS — 32-bit</a>	-
1	0	00000	000000		<a href="#">RBIT — 64-bit</a>	-
1	0	00000	000001		<a href="#">REV16 — 64-bit</a>	-
1	0	00000	000010		<a href="#">REV32</a>	-
1	0	00000	000011		<a href="#">REV — 64-bit</a>	-
1	0	00000	000100		<a href="#">CLZ — 64-bit</a>	-
1	0	00000	000101		<a href="#">CLS — 64-bit</a>	-

sf	S	Decode fields		Rn	Instruction Details	Architecture Version
		opcode2	opcode			
1	0	00001	000000		<a href="#">PACIA, PACIA1716, PACIASP, PACIAZ, PACIZA</a> — <a href="#">PACIA</a>	ARMv8.3-PAAuth
1	0	00001	000001		<a href="#">PACIB, PACIB1716, PACIBSP, PACIBZ, PACIZB</a> — <a href="#">PACIB</a>	ARMv8.3-PAAuth
1	0	00001	000010		<a href="#">PACDA, PACDZA</a> — <a href="#">PACDA</a>	ARMv8.3-PAAuth
1	0	00001	000011		<a href="#">PACDB, PACDZB</a> — <a href="#">PACDB</a>	ARMv8.3-PAAuth
1	0	00001	000100		<a href="#">AUTIA, AUTIA1716, AUTIASP, AUTIAZ, AUTIZA</a> — <a href="#">AUTIA</a>	ARMv8.3-PAAuth
1	0	00001	000101		<a href="#">AUTIB, AUTIB1716, AUTIBSP, AUTIBZ, AUTIZB</a> — <a href="#">AUTIB</a>	ARMv8.3-PAAuth
1	0	00001	000110		<a href="#">AUTDA, AUTDZA</a> — <a href="#">AUTDA</a>	ARMv8.3-PAAuth
1	0	00001	000111		<a href="#">AUTDB, AUTDZB</a> — <a href="#">AUTDB</a>	ARMv8.3-PAAuth
1	0	00001	001000	11111	<a href="#">PACIA, PACIA1716, PACIASP, PACIAZ, PACIZA</a> — <a href="#">PACIZA</a>	ARMv8.3-PAAuth
1	0	00001	001001	11111	<a href="#">PACIB, PACIB1716, PACIBSP, PACIBZ, PACIZB</a> — <a href="#">PACIZB</a>	ARMv8.3-PAAuth
1	0	00001	001010	11111	<a href="#">PACDA, PACDZA</a> — <a href="#">PACDZA</a>	ARMv8.3-PAAuth
1	0	00001	001011	11111	<a href="#">PACDB, PACDZB</a> — <a href="#">PACDZB</a>	ARMv8.3-PAAuth
1	0	00001	001100	11111	<a href="#">AUTIA, AUTIA1716, AUTIASP, AUTIAZ, AUTIZA</a> — <a href="#">AUTIZA</a>	ARMv8.3-PAAuth
1	0	00001	001101	11111	<a href="#">AUTIB, AUTIB1716, AUTIBSP, AUTIBZ, AUTIZB</a> — <a href="#">AUTIZB</a>	ARMv8.3-PAAuth
1	0	00001	001110	11111	<a href="#">AUTDA, AUTDZA</a> — <a href="#">AUTDZA</a>	ARMv8.3-PAAuth
1	0	00001	001111	11111	<a href="#">AUTDB, AUTDZB</a> — <a href="#">AUTDZB</a>	ARMv8.3-PAAuth
1	0	00001	010000	11111	<a href="#">XPACD, XPACL, XPACLRI</a> — <a href="#">XPACI</a>	ARMv8.3-PAAuth
1	0	00001	010001	11111	<a href="#">XPACD, XPACL, XPACLRI</a> — <a href="#">XPACD</a>	ARMv8.3-PAAuth
1	0	00001	01001x		UNALLOCATED	-
1	0	00001	0101xx		UNALLOCATED	-
1	0	00001	011xxx		UNALLOCATED	-

**Logical (shifted register)**

These instructions are under [Data Processing -- Register](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	opc	0	1	0	1	0		shift	N																						

sf	Decode fields			Instruction Details
	opc	N	imm6	
0			1xxxxx	UNALLOCATED
0	00	0		<a href="#">AND (shifted register)</a> — 32-bit
0	00	1		<a href="#">BIC (shifted register)</a> — 32-bit
0	01	0		<a href="#">ORR (shifted register)</a> — 32-bit
0	01	1		<a href="#">ORN (shifted register)</a> — 32-bit
0	10	0		<a href="#">EOR (shifted register)</a> — 32-bit
0	10	1		<a href="#">EON (shifted register)</a> — 32-bit
0	11	0		<a href="#">ANDS (shifted register)</a> — 32-bit
0	11	1		<a href="#">BICS (shifted register)</a> — 32-bit
1	00	0		<a href="#">AND (shifted register)</a> — 64-bit
1	00	1		<a href="#">BIC (shifted register)</a> — 64-bit
1	01	0		<a href="#">ORR (shifted register)</a> — 64-bit

Decode fields				Instruction Details
sf	opc	N	imm6	
1	01	1		<a href="#">ORN (shifted register) — 64-bit</a>
1	10	0		<a href="#">EOR (shifted register) — 64-bit</a>
1	10	1		<a href="#">EON (shifted register) — 64-bit</a>
1	11	0		<a href="#">ANDS (shifted register) — 64-bit</a>
1	11	1		<a href="#">BICS (shifted register) — 64-bit</a>

### Add/subtract (shifted register)

These instructions are under [Data Processing -- Register](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	op	S	0	1	0	1	1	shift	0			Rm				imm6				Rn				Rd							

Decode fields				Instruction Details
sf	op	S	shift	
			11	UNALLOCATED
0				1xxxxx UNALLOCATED
0	0	0		<a href="#">ADD (shifted register) — 32-bit</a>
0	0	1		<a href="#">ADDS (shifted register) — 32-bit</a>
0	1	0		<a href="#">SUB (shifted register) — 32-bit</a>
0	1	1		<a href="#">SUBS (shifted register) — 32-bit</a>
1	0	0		<a href="#">ADD (shifted register) — 64-bit</a>
1	0	1		<a href="#">ADDS (shifted register) — 64-bit</a>
1	1	0		<a href="#">SUB (shifted register) — 64-bit</a>
1	1	1		<a href="#">SUBS (shifted register) — 64-bit</a>

### Add/subtract (extended register)

These instructions are under [Data Processing -- Register](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	op	S	0	1	0	1	1	opt	1			Rm				option		imm3		Rn				Rd							

Decode fields				Instruction Details
sf	op	S	opt	
				1x1 UNALLOCATED
				11x UNALLOCATED
			x1	UNALLOCATED
			1x	UNALLOCATED
0	0	0	00	<a href="#">ADD (extended register) — 32-bit</a>
0	0	1	00	<a href="#">ADDS (extended register) — 32-bit</a>
0	1	0	00	<a href="#">SUB (extended register) — 32-bit</a>
0	1	1	00	<a href="#">SUBS (extended register) — 32-bit</a>
1	0	0	00	<a href="#">ADD (extended register) — 64-bit</a>
1	0	1	00	<a href="#">ADDS (extended register) — 64-bit</a>
1	1	0	00	<a href="#">SUB (extended register) — 64-bit</a>
1	1	1	00	<a href="#">SUBS (extended register) — 64-bit</a>

### Add/subtract (with carry)

These instructions are under [Data Processing -- Register](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	op	S	1	1	0	1	0	0	0	0	Rm					0	0	0	0	0	0	Rn					Rd				

Decode fields			Instruction Details
sf	op	S	
0	0	0	<a href="#">ADC — 32-bit</a>
0	0	1	<a href="#">ADCS — 32-bit</a>
0	1	0	<a href="#">SBC — 32-bit</a>
0	1	1	<a href="#">SBCS — 32-bit</a>
1	0	0	<a href="#">ADC — 64-bit</a>
1	0	1	<a href="#">ADCS — 64-bit</a>
1	1	0	<a href="#">SBC — 64-bit</a>
1	1	1	<a href="#">SBCS — 64-bit</a>

## Rotate right into flags

These instructions are under [Data Processing -- Register](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	op	S	1	1	0	1	0	0	0	0	imm6					0	0	0	0	1	Rn					o2	mask				

Decode fields				Instruction Details	Architecture Version
sf	op	S	o2		
0				UNALLOCATED	-
1	0	0		UNALLOCATED	-
1	0	1	0	<a href="#">RMIF</a>	ARMv8.4-CondM
1	0	1	1	UNALLOCATED	-
1	1			UNALLOCATED	-

## Evaluate into flags

These instructions are under [Data Processing -- Register](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	op	S	1	1	0	1	0	0	0	0	opcode2					sz	0	0	1	0	Rn					o3	mask				

Decode fields							Instruction Details	Architecture Version
sf	op	S	opcode2	sz	o3	mask		
0	0	0					UNALLOCATED	-
0	0	1	!= 000000				UNALLOCATED	-
0	0	1	000000		0	!= 1101	UNALLOCATED	-
0	0	1	000000		1		UNALLOCATED	-
0	0	1	000000	0	0	1101	<a href="#">SETF8, SETF16</a> — <a href="#">SETF8</a>	ARMv8.4-CondM
0	0	1	000000	1	0	1101	<a href="#">SETF8, SETF16</a> — <a href="#">SETF16</a>	ARMv8.4-CondM
0	1						UNALLOCATED	-
1							UNALLOCATED	-

## Conditional compare (register)

These instructions are under [Data Processing -- Register](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	op	S	1	1	0	1	0	0	1	0	Rm					cond			0	o2	Rn					o3	nzcw				

Decode fields					Instruction Details
sf	op	S	o2	o3	
				1	UNALLOCATED
			1		UNALLOCATED
		0			UNALLOCATED
0	0	1	0	0	<a href="#">CCMN (register) — 32-bit</a>
0	1	1	0	0	<a href="#">CCMP (register) — 32-bit</a>
1	0	1	0	0	<a href="#">CCMN (register) — 64-bit</a>
1	1	1	0	0	<a href="#">CCMP (register) — 64-bit</a>

### Conditional compare (immediate)

These instructions are under [Data Processing -- Register](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
sf	op	S	1	1	0	1	0	0	1	0	imm5					cond					1	o2	Rn					o3	nzcvc				

Decode fields					Instruction Details
sf	op	S	o2	o3	
				1	UNALLOCATED
			1		UNALLOCATED
		0			UNALLOCATED
0	0	1	0	0	<a href="#">CCMN (immediate) — 32-bit</a>
0	1	1	0	0	<a href="#">CCMP (immediate) — 32-bit</a>
1	0	1	0	0	<a href="#">CCMN (immediate) — 64-bit</a>
1	1	1	0	0	<a href="#">CCMP (immediate) — 64-bit</a>

### Conditional select

These instructions are under [Data Processing -- Register](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	op	S	1	1	0	1	0	1	0	0	Rm					cond					op2	Rn					Rd				

Decode fields				Instruction Details
sf	op	S	op2	
			1x	UNALLOCATED
		1		UNALLOCATED
0	0	0	00	<a href="#">CSEL — 32-bit</a>
0	0	0	01	<a href="#">CSINC — 32-bit</a>
0	1	0	00	<a href="#">CSINV — 32-bit</a>
0	1	0	01	<a href="#">CSNEG — 32-bit</a>
1	0	0	00	<a href="#">CSEL — 64-bit</a>
1	0	0	01	<a href="#">CSINC — 64-bit</a>
1	1	0	00	<a href="#">CSINV — 64-bit</a>
1	1	0	01	<a href="#">CSNEG — 64-bit</a>

### Data-processing (3 source)

These instructions are under [Data Processing -- Register](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
sf	op54	1	1	0	1	1	op31					Rm					o0	Ra					Rn					Rd				



sf	Decode fields		o0	Instruction Details
	op54	op31		
	00	010	1	UNALLOCATED
	00	011		UNALLOCATED
	00	100		UNALLOCATED
	00	110	1	UNALLOCATED
	00	111		UNALLOCATED
	01			UNALLOCATED
	1x			UNALLOCATED
0	00	000	0	<a href="#">MADD — 32-bit</a>
0	00	000	1	<a href="#">MSUB — 32-bit</a>
0	00	001	0	UNALLOCATED
0	00	001	1	UNALLOCATED
0	00	010	0	UNALLOCATED
0	00	101	0	UNALLOCATED
0	00	101	1	UNALLOCATED
0	00	110	0	UNALLOCATED
1	00	000	0	<a href="#">MADD — 64-bit</a>
1	00	000	1	<a href="#">MSUB — 64-bit</a>
1	00	001	0	<a href="#">SMADDL</a>
1	00	001	1	<a href="#">SMSUBL</a>
1	00	010	0	<a href="#">SMULH</a>
1	00	101	0	<a href="#">UMADDL</a>
1	00	101	1	<a href="#">UMSUBL</a>
1	00	110	0	<a href="#">UMULH</a>

## Data Processing -- Scalar Floating-Point and Advanced SIMD

These instructions are under the [top-level](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
op0				111		op1		op2				op3																			

Decode fields				Instruction details	Architecture version
op0	op1	op2	op3		
0000	0x	x101	00xxxxx10	UNALLOCATED	-
0010	0x	x101	00xxxxx10	UNALLOCATED	-
0100	0x	x101	00xxxxx10	<a href="#">Cryptographic AES</a>	-
0101	0x	x0xx	xxx0xxx00	<a href="#">Cryptographic three-register SHA</a>	-
0101	0x	x0xx	xxx0xxx10	UNALLOCATED	-
0101	0x	x101	00xxxxx10	<a href="#">Cryptographic two-register SHA</a>	-
0110	0x	x101	00xxxxx10	UNALLOCATED	-
0111	0x	x0xx	xxx0xxx00	UNALLOCATED	-
0111	0x	x101	00xxxxx10	UNALLOCATED	-
01x1	00	00xx	xxx0xxx1	<a href="#">Advanced SIMD scalar copy</a>	-
01x1	01	00xx	xxx0xxx1	UNALLOCATED	-
01x1	0x	0111	00xxxxx10	UNALLOCATED	-
01x1	0x	10xx	xxx00xxx1	<a href="#">Advanced SIMD scalar three same FP16</a>	ARMv8.2-FP16
01x1	0x	10xx	xxx01xxx1	UNALLOCATED	-
01x1	0x	1111	00xxxxx10	<a href="#">Advanced SIMD scalar two-register miscellaneous FP16</a>	ARMv8.2-FP16

01x1	0x	x0xx	xxx1xxxx0	UNALLOCATED	-
01x1	0x	x0xx	xxx1xxxx1	<a href="#">Advanced SIMD scalar three same extra</a>	ARMv8.1-RDMA
01x1	0x	x100	00xxxxx10	<a href="#">Advanced SIMD scalar two-register miscellaneous</a>	-
01x1	0x	x110	00xxxxx10	<a href="#">Advanced SIMD scalar pairwise</a>	ARMv8.2-FP16
01x1	0x	x1xx	1xxxxxx10	UNALLOCATED	-
01x1	0x	x1xx	x1xxxxx10	UNALLOCATED	-
01x1	0x	x1xx	xxxxxxx00	<a href="#">Advanced SIMD scalar three different</a>	-
01x1	0x	x1xx	xxxxxxx1	<a href="#">Advanced SIMD scalar three same</a>	-
01x1	10		xxxxxxx1	<a href="#">Advanced SIMD scalar shift by immediate</a>	-
01x1	11		xxxxxxx1	UNALLOCATED	-
01x1	1x		xxxxxxx0	<a href="#">Advanced SIMD scalar x indexed element</a>	ARMv8.2-FP16
0x00	0x	x0xx	xxx0xxx00	<a href="#">Advanced SIMD table lookup</a>	-
0x00	0x	x0xx	xxx0xxx10	<a href="#">Advanced SIMD permute</a>	-
0x10	0x	x0xx	xxx0xxx0	<a href="#">Advanced SIMD extract</a>	-
0xx0	00	00xx	xxx0xxx1	<a href="#">Advanced SIMD copy</a>	-
0xx0	01	00xx	xxx0xxx1	UNALLOCATED	-
0xx0	0x	0111	00xxxxx10	UNALLOCATED	-
0xx0	0x	10xx	xxx00xxx1	<a href="#">Advanced SIMD three same (FP16)</a>	ARMv8.2-FP16
0xx0	0x	10xx	xxx01xxx1	UNALLOCATED	-
0xx0	0x	1111	00xxxxx10	<a href="#">Advanced SIMD two-register miscellaneous (FP16)</a>	ARMv8.2-FP16
0xx0	0x	x0xx	xxx1xxxx0	UNALLOCATED	-
0xx0	0x	x0xx	xxx1xxxx1	<a href="#">Advanced SIMD three-register extension</a>	ARMv8.2-DotProd
0xx0	0x	x100	00xxxxx10	<a href="#">Advanced SIMD two-register miscellaneous</a>	ARMv8.5-FRINT
0xx0	0x	x110	00xxxxx10	<a href="#">Advanced SIMD across lanes</a>	ARMv8.2-FP16
0xx0	0x	x1xx	1xxxxxx10	UNALLOCATED	-
0xx0	0x	x1xx	x1xxxxx10	UNALLOCATED	-
0xx0	0x	x1xx	xxxxxxx00	<a href="#">Advanced SIMD three different</a>	-
0xx0	0x	x1xx	xxxxxxx1	<a href="#">Advanced SIMD three same</a>	ARMv8.2-FHM
0xx0	10	0000	xxxxxxx1	<a href="#">Advanced SIMD modified immediate</a>	ARMv8.2-FP16
0xx0	10	!= 0000	xxxxxxx1	<a href="#">Advanced SIMD shift by immediate</a>	-
0xx0	11		xxxxxxx1	UNALLOCATED	-
0xx0	1x		xxxxxxx0	<a href="#">Advanced SIMD vector x indexed element</a>	ARMv8.2-DotProd
1100	00	10xx	xxx10xxxx	<a href="#">Cryptographic three-register, imm2</a>	ARMv8.2-SM3
1100	00	11xx	xxx1x00xx	<a href="#">Cryptographic three-register SHA 512</a>	ARMv8.2-SHA2
1100	00		xxx0xxxxx	<a href="#">Cryptographic four-register</a>	ARMv8.2-SHA3
1100	01	00xx		<a href="#">XAR</a>	ARMv8.2-SHA3
1100	01	1000	0001000xx	<a href="#">Cryptographic two-register SHA 512</a>	ARMv8.2-SHA2
1xx0	1x			UNALLOCATED	-
x0x1	0x	x0xx		<a href="#">Conversion between floating-point and fixed-point</a>	ARMv8.2-FP16
x0x1	0x	x1xx	xxx000000	<a href="#">Conversion between floating-point and integer</a>	ARMv8.3-JConv
x0x1	0x	x1xx	xxx10000	<a href="#">Floating-point data-processing (1 source)</a>	ARMv8.5-FRINT
x0x1	0x	x1xx	xxxxx1000	<a href="#">Floating-point compare</a>	ARMv8.2-FP16
x0x1	0x	x1xx	xxxxxx100	<a href="#">Floating-point immediate</a>	ARMv8.2-FP16
x0x1	0x	x1xx	xxxxxxx01	<a href="#">Floating-point conditional compare</a>	ARMv8.2-FP16
x0x1	0x	x1xx	xxxxxxx10	<a href="#">Floating-point data-processing (2 source)</a>	ARMv8.2-FP16
x0x1	0x	x1xx	xxxxxxx11	<a href="#">Floating-point conditional select</a>	ARMv8.2-FP16

x0x1	1x			<a href="#">Floating-point data-processing (3 source)</a>	ARMv8.2-FP16
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## Cryptographic AES

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	1	1	1	0	size	1	0	1	0	0	opcode				1	0	Rn				Rd							

Decode fields size	opcode	Instruction Details
	x1xxx	UNALLOCATED
	000xx	UNALLOCATED
	1xxxx	UNALLOCATED
x1		UNALLOCATED
00	00100	<a href="#">AESE</a>
00	00101	<a href="#">AESD</a>
00	00110	<a href="#">AESMC</a>
00	00111	<a href="#">AESIMC</a>
1x		UNALLOCATED

## Cryptographic three-register SHA

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	size	0	Rm				0	opcode				0	0	Rn				Rd						

Decode fields size	opcode	Instruction Details
	111	UNALLOCATED
x1		UNALLOCATED
00	000	<a href="#">SHA1C</a>
00	001	<a href="#">SHA1P</a>
00	010	<a href="#">SHA1M</a>
00	011	<a href="#">SHA1SU0</a>
00	100	<a href="#">SHA256H</a>
00	101	<a href="#">SHA256H2</a>
00	110	<a href="#">SHA256SU1</a>
1x		UNALLOCATED

## Cryptographic two-register SHA

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	1	0	size	1	0	1	0	0	opcode				1	0	Rn				Rd							

Decode fields size	opcode	Instruction Details
	xx1xx	UNALLOCATED
	x1xxx	UNALLOCATED
	1xxxx	UNALLOCATED

Decode fields size	opcode	Instruction Details
x1		UNALLOCATED
00	00000	<a href="#">SHA1H</a>
00	00001	<a href="#">SHA1SU1</a>
00	00010	<a href="#">SHA256SU0</a>
00	00011	UNALLOCATED
1x		UNALLOCATED

### Advanced SIMD scalar copy

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	op	1	1	1	1	0	0	0	0	imm5				0	imm4				1	Rn				Rd						

Decode fields op	imm5	imm4	Instruction Details
0		xxx1	UNALLOCATED
0		xx1x	UNALLOCATED
0		x1xx	UNALLOCATED
0		0000	<a href="#">DUP (element)</a>
0		1xxx	UNALLOCATED
0	x0000	0000	UNALLOCATED
1			UNALLOCATED

### Advanced SIMD scalar three same FP16

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	U	1	1	1	1	0	a	1	0	Rm				0	0	opcode				1	Rn				Rd					

Decode fields U	a	opcode	Instruction Details	Architecture Version
		110	UNALLOCATED	-
	1	011	UNALLOCATED	-
0	0	011	<a href="#">FMULX</a>	ARMv8.2-FP16
0	0	100	<a href="#">FCMEQ (register)</a>	ARMv8.2-FP16
0	0	101	UNALLOCATED	-
0	0	111	<a href="#">FRECPS</a>	ARMv8.2-FP16
0	1	100	UNALLOCATED	-
0	1	101	UNALLOCATED	-
0	1	111	<a href="#">FRSQRTS</a>	ARMv8.2-FP16
1	0	011	UNALLOCATED	-
1	0	100	<a href="#">FCMGE (register)</a>	ARMv8.2-FP16
1	0	101	<a href="#">FACGE</a>	ARMv8.2-FP16
1	0	111	UNALLOCATED	-
1	1	010	<a href="#">FABD</a>	ARMv8.2-FP16
1	1	100	<a href="#">FCMGT (register)</a>	ARMv8.2-FP16
1	1	101	<a href="#">FACGT</a>	ARMv8.2-FP16
1	1	111	UNALLOCATED	-

**Advanced SIMD scalar two-register miscellaneous FP16**

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	U	1	1	1	1	0	a	1	1	1	1	0	0	opcode				1	0	Rn				Rd						

Decode fields			Instruction Details	Architecture Version
U	a	opcode		
		00xxx	UNALLOCATED	-
		010xx	UNALLOCATED	-
		10xxx	UNALLOCATED	-
		1100x	UNALLOCATED	-
		11110	UNALLOCATED	-
	0	011xx	UNALLOCATED	-
	0	11111	UNALLOCATED	-
	1	01111	UNALLOCATED	-
	1	11100	UNALLOCATED	-
0	0	11010	<a href="#">FCVTNS (vector)</a>	ARMv8.2-FP16
0	0	11011	<a href="#">FCVTMS (vector)</a>	ARMv8.2-FP16
0	0	11100	<a href="#">FCVTAS (vector)</a>	ARMv8.2-FP16
0	0	11101	<a href="#">SCVTF (vector, integer)</a>	ARMv8.2-FP16
0	1	01100	<a href="#">FCMGT (zero)</a>	ARMv8.2-FP16
0	1	01101	<a href="#">FCMEQ (zero)</a>	ARMv8.2-FP16
0	1	01110	<a href="#">FCMLT (zero)</a>	ARMv8.2-FP16
0	1	11010	<a href="#">FCVTPS (vector)</a>	ARMv8.2-FP16
0	1	11011	<a href="#">FCVTZS (vector, integer)</a>	ARMv8.2-FP16
0	1	11101	<a href="#">FRECPE</a>	ARMv8.2-FP16
0	1	11111	<a href="#">FRECPX</a>	ARMv8.2-FP16
1	0	11010	<a href="#">FCVTNU (vector)</a>	ARMv8.2-FP16
1	0	11011	<a href="#">FCVTMU (vector)</a>	ARMv8.2-FP16
1	0	11100	<a href="#">FCVTAU (vector)</a>	ARMv8.2-FP16
1	0	11101	<a href="#">UCVTF (vector, integer)</a>	ARMv8.2-FP16
1	1	01100	<a href="#">FCMGE (zero)</a>	ARMv8.2-FP16
1	1	01101	<a href="#">FCMLE (zero)</a>	ARMv8.2-FP16
1	1	01110	UNALLOCATED	-
1	1	11010	<a href="#">FCVTPU (vector)</a>	ARMv8.2-FP16
1	1	11011	<a href="#">FCVTZU (vector, integer)</a>	ARMv8.2-FP16
1	1	11101	<a href="#">FRSQRT</a>	ARMv8.2-FP16
1	1	11111	UNALLOCATED	-

**Advanced SIMD scalar three same extra**

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	U	1	1	1	1	0	size	0	Rm				1	opcode				1	Rn				Rd							

Decode fields		Instruction Details	Architecture Version
U	opcode		
	001x	UNALLOCATED	-
	01xx	UNALLOCATED	-
	1xxx	UNALLOCATED	-

Decode fields		Instruction Details	Architecture Version
U	opcode		
0	0000	UNALLOCATED	-
0	0001	UNALLOCATED	-
1	0000	<a href="#">SQRDMLAH (vector)</a>	ARMv8.1-RDMA
1	0001	<a href="#">SQRDMLSH (vector)</a>	ARMv8.1-RDMA

### Advanced SIMD scalar two-register miscellaneous

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	U	1	1	1	1	0	size	1	0	0	0	0	0	opcode					1	0	Rn					Rd				

Decode fields		Instruction Details
U	size opcode	
	0000x	UNALLOCATED
	00010	UNALLOCATED
	0010x	UNALLOCATED
	00110	UNALLOCATED
	01111	UNALLOCATED
	1000x	UNALLOCATED
	10011	UNALLOCATED
	10101	UNALLOCATED
	10111	UNALLOCATED
	1100x	UNALLOCATED
	11110	UNALLOCATED
	0x 011xx	UNALLOCATED
	0x 11111	UNALLOCATED
	1x 10110	UNALLOCATED
	1x 11100	UNALLOCATED
0		00011 <a href="#">SUQADD</a>
0		00111 <a href="#">SQABS</a>
0		01000 <a href="#">CMGT (zero)</a>
0		01001 <a href="#">CMEQ (zero)</a>
0		01010 <a href="#">CMLT (zero)</a>
0		01011 <a href="#">ABS</a>
0		10010 UNALLOCATED
0		10100 <a href="#">SQXTN, SQXTN2</a>
0	0x	10110 UNALLOCATED
0	0x	11010 <a href="#">FCVTNS (vector)</a>
0	0x	11011 <a href="#">FCVTMS (vector)</a>
0	0x	11100 <a href="#">FCVTAS (vector)</a>
0	0x	11101 <a href="#">SCVTF (vector, integer)</a>
0	1x	01100 <a href="#">FCMGT (zero)</a>
0	1x	01101 <a href="#">FCMEQ (zero)</a>
0	1x	01110 <a href="#">FCMLT (zero)</a>
0	1x	11010 <a href="#">FCVTPS (vector)</a>
0	1x	11011 <a href="#">FCVTZS (vector, integer)</a>
0	1x	11101 <a href="#">FRECPE</a>
0	1x	11111 <a href="#">FRECPS</a>

Decode fields			Instruction Details
U	size	opcode	
1		00011	<a href="#">USQADD</a>
1		00111	<a href="#">SONEG</a>
1		01000	<a href="#">CMGE (zero)</a>
1		01001	<a href="#">CMLE (zero)</a>
1		01010	UNALLOCATED
1		01011	<a href="#">NEG (vector)</a>
1		10010	<a href="#">SQXTUN, SQXTUN2</a>
1		10100	<a href="#">UQXTN, UQXTN2</a>
1	0x	10110	<a href="#">FCVTXN, FCVTXN2</a>
1	0x	11010	<a href="#">FCVTNU (vector)</a>
1	0x	11011	<a href="#">FCVTMU (vector)</a>
1	0x	11100	<a href="#">FCVTAU (vector)</a>
1	0x	11101	<a href="#">UCVTF (vector, integer)</a>
1	1x	01100	<a href="#">FCMGE (zero)</a>
1	1x	01101	<a href="#">FCMLE (zero)</a>
1	1x	01110	UNALLOCATED
1	1x	11010	<a href="#">FCVTPU (vector)</a>
1	1x	11011	<a href="#">FCVTZU (vector, integer)</a>
1	1x	11101	<a href="#">FRSQRT</a>
1	1x	11111	UNALLOCATED

Advanced SIMD scalar pairwise

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	U	1	1	1	1	0	size	1	1	0	0	0		opcode	1	0														

Decode fields			Instruction Details	Architecture Version
U	size	opcode		
		00xxx	UNALLOCATED	-
		010xx	UNALLOCATED	-
		01110	UNALLOCATED	-
		10xxx	UNALLOCATED	-
		1100x	UNALLOCATED	-
		11010	UNALLOCATED	-
		111xx	UNALLOCATED	-
	1x	01101	UNALLOCATED	-
0		11011	<a href="#">ADDP (scalar)</a>	-
0	00	01100	<a href="#">FMAXNMP (scalar) — half-precision</a>	ARMv8.2-FP16
0	00	01101	<a href="#">FADDP (scalar) — half-precision</a>	ARMv8.2-FP16
0	00	01111	<a href="#">FMAXP (scalar) — half-precision</a>	ARMv8.2-FP16
0	01	01100	UNALLOCATED	-
0	01	01101	UNALLOCATED	-
0	01	01111	UNALLOCATED	-
0	10	01100	<a href="#">FMINNMP (scalar) — half-precision</a>	ARMv8.2-FP16
0	10	01111	<a href="#">FMINP (scalar) — half-precision</a>	ARMv8.2-FP16
0	11	01100	UNALLOCATED	-
0	11	01111	UNALLOCATED	-

Decode fields			Instruction Details	Architecture Version
U	size	opcode		
1		11011	UNALLOCATED	-
1	0x	01100	<a href="#">FMAXNMP (scalar)</a> — <a href="#">single-precision and double-precision</a>	-
1	0x	01101	<a href="#">FADDP (scalar)</a> — <a href="#">single-precision and double-precision</a>	-
1	0x	01111	<a href="#">FMAXP (scalar)</a> — <a href="#">single-precision and double-precision</a>	-
1	1x	01100	<a href="#">FMINNMP (scalar)</a> — <a href="#">single-precision and double-precision</a>	-
1	1x	01111	<a href="#">FMINP (scalar)</a> — <a href="#">single-precision and double-precision</a>	-

### Advanced SIMD scalar three different

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	U	1	1	1	1	0	size	1		Rm									opcode	0	0									Rd

Decode fields			Instruction Details
U	size	opcode	
		00xx	UNALLOCATED
		01xx	UNALLOCATED
		1000	UNALLOCATED
		1010	UNALLOCATED
		1100	UNALLOCATED
		111x	UNALLOCATED
0		1001	<a href="#">SQDMLAL, SQDMLAL2 (vector)</a>
0		1011	<a href="#">SQDMLSL, SQDMLSL2 (vector)</a>
0		1101	<a href="#">SQDMULL, SQDMULL2 (vector)</a>
1		1001	UNALLOCATED
1		1011	UNALLOCATED
1		1101	UNALLOCATED

### Advanced SIMD scalar three same

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	U	1	1	1	1	0	size	1		Rm										opcode	1									Rd

Decode fields			Instruction Details
U	size	opcode	
		00000	UNALLOCATED
		0001x	UNALLOCATED
		00100	UNALLOCATED
		011xx	UNALLOCATED
		1001x	UNALLOCATED
	1x	11011	UNALLOCATED
0		00001	<a href="#">SQADD</a>
0		00101	<a href="#">SQSUB</a>
0		00110	<a href="#">CMGT (register)</a>
0		00111	<a href="#">CMGE (register)</a>
0		01000	<a href="#">SSHL</a>
0		01001	<a href="#">SQSHL (register)</a>



U	Decode fields		Instruction Details
	size	opcode	
0		01010	<a href="#">SRSHL</a>
0		01011	<a href="#">SQRSHL</a>
0		10000	<a href="#">ADD (vector)</a>
0		10001	<a href="#">CMTST</a>
0		10100	UNALLOCATED
0		10101	UNALLOCATED
0		10110	<a href="#">SQDMULH (vector)</a>
0		10111	UNALLOCATED
0	0x	11000	UNALLOCATED
0	0x	11001	UNALLOCATED
0	0x	11010	UNALLOCATED
0	0x	11011	<a href="#">FMULX</a>
0	0x	11100	<a href="#">FCMEQ (register)</a>
0	0x	11101	UNALLOCATED
0	0x	11110	UNALLOCATED
0	0x	11111	<a href="#">FRECPS</a>
0	1x	11000	UNALLOCATED
0	1x	11001	UNALLOCATED
0	1x	11010	UNALLOCATED
0	1x	11100	UNALLOCATED
0	1x	11101	UNALLOCATED
0	1x	11110	UNALLOCATED
0	1x	11111	<a href="#">FRSQRTS</a>
1		00001	<a href="#">UQADD</a>
1		00101	<a href="#">UQSUB</a>
1		00110	<a href="#">CMHI (register)</a>
1		00111	<a href="#">CMHS (register)</a>
1		01000	<a href="#">USHL</a>
1		01001	<a href="#">UQSHL (register)</a>
1		01010	<a href="#">URSHL</a>
1		01011	<a href="#">UQRSHL</a>
1		10000	<a href="#">SUB (vector)</a>
1		10001	<a href="#">CMEQ (register)</a>
1		10100	UNALLOCATED
1		10101	UNALLOCATED
1		10110	<a href="#">SQRDMULH (vector)</a>
1		10111	UNALLOCATED
1	0x	11000	UNALLOCATED
1	0x	11001	UNALLOCATED
1	0x	11010	UNALLOCATED
1	0x	11011	UNALLOCATED
1	0x	11100	<a href="#">FCMGE (register)</a>
1	0x	11101	<a href="#">FACGE</a>
1	0x	11110	UNALLOCATED
1	0x	11111	UNALLOCATED
1	1x	11000	UNALLOCATED
1	1x	11001	UNALLOCATED

Decode fields			Instruction Details
U	size	opcode	
1	1x	11010	<a href="#">FABD</a>
1	1x	11100	<a href="#">FCMGT (register)</a>
1	1x	11101	<a href="#">FACGT</a>
1	1x	11110	UNALLOCATED
1	1x	11111	UNALLOCATED

### Advanced SIMD scalar shift by immediate

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	U	1	1	1	1	1	0	immh			immb			opcode				1	Rn					Rd						

Decode fields			Instruction Details
U	immh	opcode	
	!= 0000	00001	UNALLOCATED
	!= 0000	00011	UNALLOCATED
	!= 0000	00101	UNALLOCATED
	!= 0000	00111	UNALLOCATED
	!= 0000	01001	UNALLOCATED
	!= 0000	01011	UNALLOCATED
	!= 0000	01101	UNALLOCATED
	!= 0000	01111	UNALLOCATED
	!= 0000	101xx	UNALLOCATED
	!= 0000	110xx	UNALLOCATED
	!= 0000	11101	UNALLOCATED
	!= 0000	11110	UNALLOCATED
	0000		UNALLOCATED
0	!= 0000	00000	<a href="#">SSHR</a>
0	!= 0000	00010	<a href="#">SSRA</a>
0	!= 0000	00100	<a href="#">SRSHR</a>
0	!= 0000	00110	<a href="#">SRSRA</a>
0	!= 0000	01000	UNALLOCATED
0	!= 0000	01010	<a href="#">SHL</a>
0	!= 0000	01100	UNALLOCATED
0	!= 0000	01110	<a href="#">SQSHL (immediate)</a>
0	!= 0000	10000	UNALLOCATED
0	!= 0000	10001	UNALLOCATED
0	!= 0000	10010	<a href="#">SQSHRN, SQSHRN2</a>
0	!= 0000	10011	<a href="#">SQRSHRN, SQRSHRN2</a>
0	!= 0000	11100	<a href="#">SCVTF (vector, fixed-point)</a>
0	!= 0000	11111	<a href="#">FCVTZS (vector, fixed-point)</a>
1	!= 0000	00000	<a href="#">USHR</a>
1	!= 0000	00010	<a href="#">USRA</a>
1	!= 0000	00100	<a href="#">URSHR</a>
1	!= 0000	00110	<a href="#">URSRA</a>
1	!= 0000	01000	<a href="#">SRI</a>
1	!= 0000	01010	<a href="#">SLI</a>
1	!= 0000	01100	<a href="#">SQSHLU</a>

Decode fields			Instruction Details
U	immh	opcode	
1	!= 0000	01110	<a href="#">UQSHL (immediate)</a>
1	!= 0000	10000	<a href="#">SQSHRUN, SQSHRUN2</a>
1	!= 0000	10001	<a href="#">SQRSHRUN, SQRSHRUN2</a>
1	!= 0000	10010	<a href="#">UQSHRN, UQSHRN2</a>
1	!= 0000	10011	<a href="#">UQRSHRN, UQRSHRN2</a>
1	!= 0000	11100	<a href="#">UCVTF (vector, fixed-point)</a>
1	!= 0000	11111	<a href="#">FCVTZU (vector, fixed-point)</a>

### Advanced SIMD scalar x indexed element

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	U	1	1	1	1	1	size	L	M			Rm																		

Decode fields			Instruction Details	Architecture Version
U	size	opcode		
		0000	UNALLOCATED	-
		0010	UNALLOCATED	-
		0100	UNALLOCATED	-
		0110	UNALLOCATED	-
		1000	UNALLOCATED	-
		1010	UNALLOCATED	-
		1110	UNALLOCATED	-
	01	0001	UNALLOCATED	-
	01	0101	UNALLOCATED	-
	01	1001	UNALLOCATED	-
0		0011	<a href="#">SQDMLAL, SQDMLAL2 (by element)</a>	-
0		0111	<a href="#">SQDMLSL, SQDMLSL2 (by element)</a>	-
0		1011	<a href="#">SQDMULL, SQDMULL2 (by element)</a>	-
0		1100	<a href="#">SQDMULH (by element)</a>	-
0		1101	<a href="#">SQRDMULH (by element)</a>	-
0		1111	UNALLOCATED	-
0	00	0001	<a href="#">FMLA (by element) — half-precision</a>	ARMv8.2-FP16
0	00	0101	<a href="#">FMLS (by element) — half-precision</a>	ARMv8.2-FP16
0	00	1001	<a href="#">FMUL (by element) — half-precision</a>	ARMv8.2-FP16
0	1x	0001	<a href="#">FMLA (by element) — single-precision and double-precision</a>	-
0	1x	0101	<a href="#">FMLS (by element) — single-precision and double-precision</a>	-
0	1x	1001	<a href="#">FMUL (by element) — single-precision and double-precision</a>	-
1		0011	UNALLOCATED	-
1		0111	UNALLOCATED	-
1		1011	UNALLOCATED	-
1		1100	UNALLOCATED	-
1		1101	<a href="#">SQRDMLAH (by element)</a>	ARMv8.1-RDMA
1		1111	<a href="#">SQRDMLSH (by element)</a>	ARMv8.1-RDMA
1	00	0001	UNALLOCATED	-
1	00	0101	UNALLOCATED	-
1	00	1001	<a href="#">FMULX (by element) — half-precision</a>	ARMv8.2-FP16
1	1x	0001	UNALLOCATED	-

Decode fields			Instruction Details	Architecture Version
U	size	opcode		
1	1x	0101	UNALLOCATED	-
1	1x	1001	<a href="#">FMULX (by element) — single-precision and double-precision</a>	-

### Advanced SIMD table lookup

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	op2	0	Rm				0	len	op	0	0	Rn				Rd								

Decode fields			Instruction Details
op2	len	op	
x1			UNALLOCATED
00	00	0	<a href="#">TBL — single register table</a>
00	00	1	<a href="#">TBX — single register table</a>
00	01	0	<a href="#">TBL — two register table</a>
00	01	1	<a href="#">TBX — two register table</a>
00	10	0	<a href="#">TBL — three register table</a>
00	10	1	<a href="#">TBX — three register table</a>
00	11	0	<a href="#">TBL — four register table</a>
00	11	1	<a href="#">TBX — four register table</a>
1x			UNALLOCATED

### Advanced SIMD permute

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	0	0	1	1	1	0	size	0	Rm				0	opcode	1	0	Rn				Rd									

Decode fields	Instruction Details
opcode	
000	UNALLOCATED
001	<a href="#">UZP1</a>
010	<a href="#">TRN1</a>
011	<a href="#">ZIP1</a>
100	UNALLOCATED
101	<a href="#">UZP2</a>
110	<a href="#">TRN2</a>
111	<a href="#">ZIP2</a>

### Advanced SIMD extract

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	1	0	1	1	1	0	op2	0	Rm				0	imm4				0	Rn				Rd							

Decode fields	Instruction Details
op2	
x1	UNALLOCATED
00	<a href="#">EXT</a>

Decode fields	Instruction Details
op2	
1x	UNALLOCATED

### Advanced SIMD copy

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	op	0	1	1	1	0	0	0	0					imm5	0					imm4	1									Rd

Q	op	imm5	imm4	Instruction Details
		x0000		UNALLOCATED
	0		0000	<a href="#">DUP (element)</a>
	0		0001	<a href="#">DUP (general)</a>
	0		0010	UNALLOCATED
	0		0100	UNALLOCATED
	0		0110	UNALLOCATED
	0		1xxx	UNALLOCATED
0	0		0011	UNALLOCATED
0	0		0101	<a href="#">SMOV</a>
0	0		0111	<a href="#">UMOV</a>
0	1			UNALLOCATED
1	0		0011	<a href="#">INS (general)</a>
1	0		0101	<a href="#">SMOV</a>
1	0	x1000	0111	<a href="#">UMOV</a>
1	1			<a href="#">INS (element)</a>

### Advanced SIMD three same (FP16)

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	U	0	1	1	1	0	a	1	0					Rm	0	0				opcode	1									Rd

U	a	Decode fields opcode	Instruction Details	Architecture Version
0	0	000	<a href="#">FMAXNM (vector)</a>	ARMv8.2-FP16
0	0	001	<a href="#">FMLA (vector)</a>	ARMv8.2-FP16
0	0	010	<a href="#">FADD (vector)</a>	ARMv8.2-FP16
0	0	011	<a href="#">FMULX</a>	ARMv8.2-FP16
0	0	100	<a href="#">FCMEQ (register)</a>	ARMv8.2-FP16
0	0	101	UNALLOCATED	-
0	0	110	<a href="#">FMAX (vector)</a>	ARMv8.2-FP16
0	0	111	<a href="#">FRECPS</a>	ARMv8.2-FP16
0	1	000	<a href="#">FMINNM (vector)</a>	ARMv8.2-FP16
0	1	001	<a href="#">FMLS (vector)</a>	ARMv8.2-FP16
0	1	010	<a href="#">FSUB (vector)</a>	ARMv8.2-FP16
0	1	011	UNALLOCATED	-
0	1	100	UNALLOCATED	-
0	1	101	UNALLOCATED	-

Decode fields			Instruction Details	Architecture Version
U	a	opcode		
0	1	110	<a href="#">FMIN (vector)</a>	ARMv8.2-FP16
0	1	111	<a href="#">FRSQRTS</a>	ARMv8.2-FP16
1	0	000	<a href="#">FMAXNMP (vector)</a>	ARMv8.2-FP16
1	0	001	UNALLOCATED	-
1	0	010	<a href="#">FADDP (vector)</a>	ARMv8.2-FP16
1	0	011	<a href="#">FMUL (vector)</a>	ARMv8.2-FP16
1	0	100	<a href="#">FCMGE (register)</a>	ARMv8.2-FP16
1	0	101	<a href="#">FACGE</a>	ARMv8.2-FP16
1	0	110	<a href="#">FMAXP (vector)</a>	ARMv8.2-FP16
1	0	111	<a href="#">FDIV (vector)</a>	ARMv8.2-FP16
1	1	000	<a href="#">FMINNMP (vector)</a>	ARMv8.2-FP16
1	1	001	UNALLOCATED	-
1	1	010	<a href="#">FABD</a>	ARMv8.2-FP16
1	1	011	UNALLOCATED	-
1	1	100	<a href="#">FCMGT (register)</a>	ARMv8.2-FP16
1	1	101	<a href="#">FACGT</a>	ARMv8.2-FP16
1	1	110	<a href="#">FMINP (vector)</a>	ARMv8.2-FP16
1	1	111	UNALLOCATED	-

### Advanced SIMD two-register miscellaneous (FP16)

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	U	0	1	1	1	0	a	1	1	1	1	0	0	opcode				1	0	Rn				Rd						

Decode fields			Instruction Details	Architecture Version
U	a	opcode		
		00xxx	UNALLOCATED	-
		010xx	UNALLOCATED	-
		10xxx	UNALLOCATED	-
		11110	UNALLOCATED	-
	0	011xx	UNALLOCATED	-
	0	11111	UNALLOCATED	-
	1	11100	UNALLOCATED	-
0	0	11000	<a href="#">FRINTN (vector)</a>	ARMv8.2-FP16
0	0	11001	<a href="#">FRINTM (vector)</a>	ARMv8.2-FP16
0	0	11010	<a href="#">FCVTNS (vector)</a>	ARMv8.2-FP16
0	0	11011	<a href="#">FCVTMS (vector)</a>	ARMv8.2-FP16
0	0	11100	<a href="#">FCVTAS (vector)</a>	ARMv8.2-FP16
0	0	11101	<a href="#">SCVTF (vector, integer)</a>	ARMv8.2-FP16
0	1	01100	<a href="#">FCMGT (zero)</a>	ARMv8.2-FP16
0	1	01101	<a href="#">FCMEQ (zero)</a>	ARMv8.2-FP16
0	1	01110	<a href="#">FCMLT (zero)</a>	ARMv8.2-FP16
0	1	01111	<a href="#">FABS (vector)</a>	ARMv8.2-FP16
0	1	11000	<a href="#">FRINTP (vector)</a>	ARMv8.2-FP16
0	1	11001	<a href="#">FRINTZ (vector)</a>	ARMv8.2-FP16
0	1	11010	<a href="#">FCVTPS (vector)</a>	ARMv8.2-FP16
0	1	11011	<a href="#">FCVTZS (vector, integer)</a>	ARMv8.2-FP16

Decode fields			Instruction Details	Architecture Version
U	a	opcode		
0	1	11101	<a href="#">FRECPE</a>	ARMv8.2-FP16
0	1	11111	UNALLOCATED	-
1	0	11000	<a href="#">FRINTA (vector)</a>	ARMv8.2-FP16
1	0	11001	<a href="#">FRINTX (vector)</a>	ARMv8.2-FP16
1	0	11010	<a href="#">FCVTNU (vector)</a>	ARMv8.2-FP16
1	0	11011	<a href="#">FCVTMU (vector)</a>	ARMv8.2-FP16
1	0	11100	<a href="#">FCVTAU (vector)</a>	ARMv8.2-FP16
1	0	11101	<a href="#">UCVTF (vector, integer)</a>	ARMv8.2-FP16
1	1	01100	<a href="#">FCMGE (zero)</a>	ARMv8.2-FP16
1	1	01101	<a href="#">FCMLE (zero)</a>	ARMv8.2-FP16
1	1	01110	UNALLOCATED	-
1	1	01111	<a href="#">FNEG (vector)</a>	ARMv8.2-FP16
1	1	11000	UNALLOCATED	-
1	1	11001	<a href="#">FRINTI (vector)</a>	ARMv8.2-FP16
1	1	11010	<a href="#">FCVTPU (vector)</a>	ARMv8.2-FP16
1	1	11011	<a href="#">FCVTZU (vector, integer)</a>	ARMv8.2-FP16
1	1	11101	<a href="#">FRSQRT</a>	ARMv8.2-FP16
1	1	11111	<a href="#">FSQRT (vector)</a>	ARMv8.2-FP16

### Advanced SIMD three-register extension

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	U	0	1	1	1	0	size	0		Rm				1		opcode		1			Rn							Rd		

Decode fields				Instruction Details	Architecture Version
Q	U	size	opcode		
		0x	0011	UNALLOCATED	-
		11	0011	UNALLOCATED	-
	0		0000	UNALLOCATED	-
	0		0001	UNALLOCATED	-
	0		0010	<a href="#">SDOT (vector)</a>	ARMv8.2-DotProd
	0		1xxx	UNALLOCATED	-
	0	10	0011	<a href="#">USDOT (vector)</a>	ARMv8.2-I8MM
	1		0000	<a href="#">SQRDMLAH (vector)</a>	ARMv8.1-RDMA
	1		0001	<a href="#">SQRDMLSH (vector)</a>	ARMv8.1-RDMA
	1		0010	<a href="#">UDOT (vector)</a>	ARMv8.2-DotProd
	1		10xx	<a href="#">FCMLA</a>	ARMv8.3-CompNum
	1		11x0	<a href="#">FCADD</a>	ARMv8.3-CompNum
	1	00	1101	UNALLOCATED	-
	1	00	1111	UNALLOCATED	-
	1	01	1111	<a href="#">BFDOT (vector)</a>	ARMv8.2-BF16
	1	1x	1101	UNALLOCATED	-
	1	10	0011	UNALLOCATED	-
	1	10	1111	UNALLOCATED	-
	1	11	1111	<a href="#">BFMLALB, BFMLALT (vector)</a>	ARMv8.2-BF16
0			01xx	UNALLOCATED	-
0	1	01	1101	UNALLOCATED	-

Decode fields				Instruction Details	Architecture Version
Q	U	size	opcode		
1		0x	01xx	UNALLOCATED	-
1		1x	011x	UNALLOCATED	-
1	0	10	0100	<a href="#">SMMLA (vector)</a>	ARMv8.2-I8MM
1	0	10	0101	<a href="#">USMMLA (vector)</a>	ARMv8.2-I8MM
1	1	01	1101	<a href="#">BFMMLA</a>	ARMv8.2-BF16
1	1	10	0100	<a href="#">UMMLA (vector)</a>	ARMv8.2-I8MM
1	1	10	0101	UNALLOCATED	-

### Advanced SIMD two-register miscellaneous

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	U	0	1	1	1	0	size		1	0	0	0	0	opcode				1		0	Rn				Rd					

Decode fields			Instruction Details	Architecture Version
U	size	opcode		
		1000x	UNALLOCATED	-
		10101	UNALLOCATED	-
	0x	011xx	UNALLOCATED	-
	1x	10111	UNALLOCATED	-
	1x	11110	UNALLOCATED	-
	11	10110	UNALLOCATED	-
0		00000	<a href="#">REV64</a>	-
0		00001	<a href="#">REV16 (vector)</a>	-
0		00010	<a href="#">SADDLP</a>	-
0		00011	<a href="#">SUQADD</a>	-
0		00100	<a href="#">CLS (vector)</a>	-
0		00101	<a href="#">CNT</a>	-
0		00110	<a href="#">SADALP</a>	-
0		00111	<a href="#">SQABS</a>	-
0		01000	<a href="#">CMGT (zero)</a>	-
0		01001	<a href="#">CMEQ (zero)</a>	-
0		01010	<a href="#">CMLT (zero)</a>	-
0		01011	<a href="#">ABS</a>	-
0		10010	<a href="#">XTN, XTN2</a>	-
0		10011	UNALLOCATED	-
0		10100	<a href="#">SQXTN, SQXTN2</a>	-
0	0x	10110	<a href="#">FCVTN, FCVTN2</a>	-
0	0x	10111	<a href="#">FCVTL, FCVTL2</a>	-
0	0x	11000	<a href="#">FRINTN (vector)</a>	-
0	0x	11001	<a href="#">FRINTM (vector)</a>	-
0	0x	11010	<a href="#">FCVTNS (vector)</a>	-
0	0x	11011	<a href="#">FCVTMS (vector)</a>	-
0	0x	11100	<a href="#">FCVTAS (vector)</a>	-
0	0x	11101	<a href="#">SCVTF (vector, integer)</a>	-
0	0x	11110	<a href="#">FRINT32Z (vector)</a>	ARMv8.5-FRINT
0	0x	11111	<a href="#">FRINT64Z (vector)</a>	ARMv8.5-FRINT
0	1x	01100	<a href="#">ECMGT (zero)</a>	-



U	Decode fields		Instruction Details	Architecture Version
	size	opcode		
0	1x	01101	<a href="#">FCMEQ (zero)</a>	-
0	1x	01110	<a href="#">FCMLT (zero)</a>	-
0	1x	01111	<a href="#">FABS (vector)</a>	-
0	1x	11000	<a href="#">FRINTP (vector)</a>	-
0	1x	11001	<a href="#">FRINTZ (vector)</a>	-
0	1x	11010	<a href="#">FCVTPS (vector)</a>	-
0	1x	11011	<a href="#">FCVTZS (vector, integer)</a>	-
0	1x	11100	<a href="#">URECPE</a>	-
0	1x	11101	<a href="#">FRECPE</a>	-
0	1x	11111	UNALLOCATED	-
0	10	10110	<a href="#">BFCVTN, BFCVTN2</a>	ARMv8.2-BF16
1		00000	<a href="#">REV32 (vector)</a>	-
1		00001	UNALLOCATED	-
1		00010	<a href="#">UADDLP</a>	-
1		00011	<a href="#">USQADD</a>	-
1		00100	<a href="#">CLZ (vector)</a>	-
1		00110	<a href="#">UADALP</a>	-
1		00111	<a href="#">SQNEG</a>	-
1		01000	<a href="#">CMGE (zero)</a>	-
1		01001	<a href="#">CMLE (zero)</a>	-
1		01010	UNALLOCATED	-
1		01011	<a href="#">NEG (vector)</a>	-
1		10010	<a href="#">SQXTUN, SQXTUN2</a>	-
1		10011	<a href="#">SHLL, SHLL2</a>	-
1		10100	<a href="#">UQXTN, UQXTN2</a>	-
1	0x	10110	<a href="#">FCVTXN, FCVTXN2</a>	-
1	0x	10111	UNALLOCATED	-
1	0x	11000	<a href="#">FRINTA (vector)</a>	-
1	0x	11001	<a href="#">FRINTX (vector)</a>	-
1	0x	11010	<a href="#">FCVTNU (vector)</a>	-
1	0x	11011	<a href="#">FCVTMU (vector)</a>	-
1	0x	11100	<a href="#">FCVTAU (vector)</a>	-
1	0x	11101	<a href="#">UCVTF (vector, integer)</a>	-
1	0x	11110	<a href="#">FRINT32X (vector)</a>	ARMv8.5-FRINT
1	0x	11111	<a href="#">FRINT64X (vector)</a>	ARMv8.5-FRINT
1	00	00101	<a href="#">NOT</a>	-
1	01	00101	<a href="#">RBIT (vector)</a>	-
1	1x	00101	UNALLOCATED	-
1	1x	01100	<a href="#">FCMGE (zero)</a>	-
1	1x	01101	<a href="#">FCMLE (zero)</a>	-
1	1x	01110	UNALLOCATED	-
1	1x	01111	<a href="#">FNEG (vector)</a>	-
1	1x	11000	UNALLOCATED	-
1	1x	11001	<a href="#">FRINTI (vector)</a>	-
1	1x	11010	<a href="#">FCVTPU (vector)</a>	-
1	1x	11011	<a href="#">FCVTZU (vector, integer)</a>	-
1	1x	11100	<a href="#">URSQRTE</a>	-

U	Decode fields size	opcode	Instruction Details	Architecture Version
1	1x	11101	<a href="#">FRSQRT</a>	-
1	1x	11111	<a href="#">FSQRT (vector)</a>	-
1	10	10110	UNALLOCATED	-

### Advanced SIMD across lanes

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	U	0	1	1	1	0	size	1	1	0	0	0	opcode			1		0	Rn				Rd							

U	Decode fields size	opcode	Instruction Details	Architecture Version
		0000x	UNALLOCATED	-
		00010	UNALLOCATED	-
		001xx	UNALLOCATED	-
		0100x	UNALLOCATED	-
		01011	UNALLOCATED	-
		01101	UNALLOCATED	-
		01110	UNALLOCATED	-
		10xxx	UNALLOCATED	-
		1100x	UNALLOCATED	-
		111xx	UNALLOCATED	-
0		00011	<a href="#">SADDLV</a>	-
0		01010	<a href="#">SMAXV</a>	-
0		11010	<a href="#">SMINV</a>	-
0		11011	<a href="#">ADDV</a>	-
0	00	01100	<a href="#">FMAXNMV</a> — <a href="#">half-precision</a>	ARMv8.2-FP16
0	00	01111	<a href="#">FMAXV</a> — <a href="#">half-precision</a>	ARMv8.2-FP16
0	01	01100	UNALLOCATED	-
0	01	01111	UNALLOCATED	-
0	10	01100	<a href="#">FMINNMV</a> — <a href="#">half-precision</a>	ARMv8.2-FP16
0	10	01111	<a href="#">FMINV</a> — <a href="#">half-precision</a>	ARMv8.2-FP16
0	11	01100	UNALLOCATED	-
0	11	01111	UNALLOCATED	-
1		00011	<a href="#">UADDLV</a>	-
1		01010	<a href="#">UMAXV</a>	-
1		11010	<a href="#">UMINV</a>	-
1		11011	UNALLOCATED	-
1	0x	01100	<a href="#">FMAXNMV</a> — <a href="#">single-precision and double-precision</a>	-
1	0x	01111	<a href="#">FMAXV</a> — <a href="#">single-precision and double-precision</a>	-
1	1x	01100	<a href="#">FMINNMV</a> — <a href="#">single-precision and double-precision</a>	-
1	1x	01111	<a href="#">FMINV</a> — <a href="#">single-precision and double-precision</a>	-

### Advanced SIMD three different

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	U	0	1	1	1	0	size	1	Rm	opcode	0	0	Rn																	Rd

Decode fields		Instruction Details
U	opcode	
	1111	UNALLOCATED
0	0000	<a href="#">SADDL, SADDL2</a>
0	0001	<a href="#">SADDW, SADDW2</a>
0	0010	<a href="#">SSUBL, SSUBL2</a>
0	0011	<a href="#">SSUBW, SSUBW2</a>
0	0100	<a href="#">ADDHN, ADDHN2</a>
0	0101	<a href="#">SABAL, SABAL2</a>
0	0110	<a href="#">SUBHN, SUBHN2</a>
0	0111	<a href="#">SABDL, SABDL2</a>
0	1000	<a href="#">SMLAL, SMLAL2 (vector)</a>
0	1001	<a href="#">SQDMLAL, SQDMLAL2 (vector)</a>
0	1010	<a href="#">SMLSL, SMLSL2 (vector)</a>
0	1011	<a href="#">SQDMLSL, SQDMLSL2 (vector)</a>
0	1100	<a href="#">SMULL, SMULL2 (vector)</a>
0	1101	<a href="#">SQDMULL, SQDMULL2 (vector)</a>
0	1110	<a href="#">PMULL, PMULL2</a>
1	0000	<a href="#">UADDL, UADDL2</a>
1	0001	<a href="#">UADDW, UADDW2</a>
1	0010	<a href="#">USUBL, USUBL2</a>
1	0011	<a href="#">USUBW, USUBW2</a>
1	0100	<a href="#">RADDHN, RADDHN2</a>
1	0101	<a href="#">UABAL, UABAL2</a>
1	0110	<a href="#">RSUBHN, RSUBHN2</a>
1	0111	<a href="#">UABDL, UABDL2</a>
1	1000	<a href="#">UMLAL, UMLAL2 (vector)</a>
1	1001	UNALLOCATED
1	1010	<a href="#">UMLSL, UMLSL2 (vector)</a>
1	1011	UNALLOCATED
1	1100	<a href="#">UMULL, UMULL2 (vector)</a>
1	1101	UNALLOCATED
1	1110	UNALLOCATED

### Advanced SIMD three same

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	U	0	1	1	1	0	size	1	Rm			opcode			1	Rn			Rd											

Decode fields		Instruction Details	Architecture Version
U	size opcode		
0		00000	<a href="#">SHADD</a>
0		00001	<a href="#">SQADD</a>
0		00010	<a href="#">SRHADD</a>
0		00100	<a href="#">SHSUB</a>
0		00101	<a href="#">SQSUB</a>
0		00110	<a href="#">CMGT (register)</a>
0		00111	<a href="#">CMGE (register)</a>
0		01000	<a href="#">SSHL</a>

Decode fields			Instruction Details	Architecture Version
U	size	opcode		
0		01001	<a href="#">SQSHL (register)</a>	-
0		01010	<a href="#">SRSHL</a>	-
0		01011	<a href="#">SQRSHL</a>	-
0		01100	<a href="#">SMAX</a>	-
0		01101	<a href="#">SMIN</a>	-
0		01110	<a href="#">SABD</a>	-
0		01111	<a href="#">SABA</a>	-
0		10000	<a href="#">ADD (vector)</a>	-
0		10001	<a href="#">CMTST</a>	-
0		10010	<a href="#">MLA (vector)</a>	-
0		10011	<a href="#">MUL (vector)</a>	-
0		10100	<a href="#">SMAXP</a>	-
0		10101	<a href="#">SMINP</a>	-
0		10110	<a href="#">SQDMULH (vector)</a>	-
0		10111	<a href="#">ADDP (vector)</a>	-
0	0x	11000	<a href="#">FMAXNM (vector)</a>	-
0	0x	11001	<a href="#">FMLA (vector)</a>	-
0	0x	11010	<a href="#">FADD (vector)</a>	-
0	0x	11011	<a href="#">FMULX</a>	-
0	0x	11100	<a href="#">FCMEQ (register)</a>	-
0	0x	11110	<a href="#">FMAX (vector)</a>	-
0	0x	11111	<a href="#">FRECPS</a>	-
0	00	00011	<a href="#">AND (vector)</a>	-
0	00	11101	<a href="#">FMLAL, FMLAL2 (vector) — FMLAL</a>	ARMv8.2-FHM
0	01	00011	<a href="#">BIC (vector, register)</a>	-
0	01	11101	UNALLOCATED	-
0	1x	11000	<a href="#">FMINNM (vector)</a>	-
0	1x	11001	<a href="#">FMLS (vector)</a>	-
0	1x	11010	<a href="#">FSUB (vector)</a>	-
0	1x	11011	UNALLOCATED	-
0	1x	11100	UNALLOCATED	-
0	1x	11110	<a href="#">FMIN (vector)</a>	-
0	1x	11111	<a href="#">FRSQRTS</a>	-
0	10	00011	<a href="#">ORR (vector, register)</a>	-
0	10	11101	<a href="#">FMLSL, FMLSL2 (vector) — FMLSL</a>	ARMv8.2-FHM
0	11	00011	<a href="#">ORN (vector)</a>	-
0	11	11101	UNALLOCATED	-
1		00000	<a href="#">UHADD</a>	-
1		00001	<a href="#">UQADD</a>	-
1		00010	<a href="#">URHADD</a>	-
1		00100	<a href="#">UHSUB</a>	-
1		00101	<a href="#">UQSUB</a>	-
1		00110	<a href="#">CMHI (register)</a>	-
1		00111	<a href="#">CMHS (register)</a>	-
1		01000	<a href="#">USHL</a>	-
1		01001	<a href="#">UQSHL (register)</a>	-
1		01010	<a href="#">URSHL</a>	-

Decode fields			Instruction Details	Architecture Version
U	size	opcode		
1		01011	<a href="#">UQRSHL</a>	-
1		01100	<a href="#">UMAX</a>	-
1		01101	<a href="#">UMIN</a>	-
1		01110	<a href="#">UABD</a>	-
1		01111	<a href="#">UABA</a>	-
1		10000	<a href="#">SUB (vector)</a>	-
1		10001	<a href="#">CMEQ (register)</a>	-
1		10010	<a href="#">MLS (vector)</a>	-
1		10011	<a href="#">PMUL</a>	-
1		10100	<a href="#">UMAXP</a>	-
1		10101	<a href="#">UMINP</a>	-
1		10110	<a href="#">SQRDMULH (vector)</a>	-
1		10111	UNALLOCATED	-
1	0x	11000	<a href="#">FMAXNMP (vector)</a>	-
1	0x	11010	<a href="#">FADDP (vector)</a>	-
1	0x	11011	<a href="#">FMUL (vector)</a>	-
1	0x	11100	<a href="#">FCMGE (register)</a>	-
1	0x	11101	<a href="#">FACGE</a>	-
1	0x	11110	<a href="#">FMAXP (vector)</a>	-
1	0x	11111	<a href="#">FDIV (vector)</a>	-
1	00	00011	<a href="#">EOR (vector)</a>	-
1	00	11001	<a href="#">FMLAL, FMLAL2 (vector)</a> — <a href="#">FMLAL2</a>	ARMv8.2-FHM
1	01	00011	<a href="#">BSL</a>	-
1	01	11001	UNALLOCATED	-
1	1x	11000	<a href="#">FMINNMP (vector)</a>	-
1	1x	11010	<a href="#">FABD</a>	-
1	1x	11011	UNALLOCATED	-
1	1x	11100	<a href="#">FCMGT (register)</a>	-
1	1x	11101	<a href="#">FACGT</a>	-
1	1x	11110	<a href="#">FMINP (vector)</a>	-
1	1x	11111	UNALLOCATED	-
1	10	00011	<a href="#">BIT</a>	-
1	10	11001	<a href="#">FMLS, FMLSL2 (vector)</a> — <a href="#">FMLS2</a>	ARMv8.2-FHM
1	11	00011	<a href="#">BIF</a>	-
1	11	11001	UNALLOCATED	-

### Advanced SIMD modified immediate

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	op	0	1	1	1	1	0	0	0	0	0	a	b	c	cmode				o2	1	d	e	f	g	h	Rd				

Decode fields				Instruction Details	Architecture Version
Q	op	cmode	o2		
	0	0xxx	1	UNALLOCATED	-
	0	0xx0	0	<a href="#">MOVI — 32-bit shifted immediate</a>	-
	0	0xx1	0	<a href="#">ORR (vector, immediate) — 32-bit</a>	-
	0	10xx	1	UNALLOCATED	-

Q	Decode fields op	cmode	o2	Instruction Details	Architecture Version
	0	10x0	0	<a href="#">MOVI — 16-bit shifted immediate</a>	-
	0	10x1	0	<a href="#">ORR (vector, immediate) — 16-bit</a>	-
	0	110x	0	<a href="#">MOVI — 32-bit shifting ones</a>	-
	0	110x	1	UNALLOCATED	-
	0	1110	0	<a href="#">MOVI — 8-bit</a>	-
	0	1110	1	UNALLOCATED	-
	0	1111	0	<a href="#">FMOV (vector, immediate) — single-precision</a>	-
	0	1111	1	<a href="#">FMOV (vector, immediate) — half-precision</a>	ARMv8.2-FP16
	1		1	UNALLOCATED	-
	1	0xx0	0	<a href="#">MVNI — 32-bit shifted immediate</a>	-
	1	0xx1	0	<a href="#">BIC (vector, immediate) — 32-bit</a>	-
	1	10x0	0	<a href="#">MVNI — 16-bit shifted immediate</a>	-
	1	10x1	0	<a href="#">BIC (vector, immediate) — 16-bit</a>	-
	1	110x	0	<a href="#">MVNI — 32-bit shifting ones</a>	-
0	1	1110	0	<a href="#">MOVI — 64-bit scalar</a>	-
0	1	1111	0	UNALLOCATED	-
1	1	1110	0	<a href="#">MOVI — 64-bit vector</a>	-
1	1	1111	0	<a href="#">FMOV (vector, immediate) — double-precision</a>	-

### Advanced SIMD shift by immediate

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	U	0	1	1	1	1	0	!= 0000				immb			opcode					1	Rn				Rd					
immh																															

The following constraints also apply to this encoding: immh != 0000 && immh != 0000

Decode fields U	opcode	Instruction Details
	00001	UNALLOCATED
	00011	UNALLOCATED
	00101	UNALLOCATED
	00111	UNALLOCATED
	01001	UNALLOCATED
	01011	UNALLOCATED
	01101	UNALLOCATED
	01111	UNALLOCATED
	10101	UNALLOCATED
	1011x	UNALLOCATED
	110xx	UNALLOCATED
	11101	UNALLOCATED
	11110	UNALLOCATED
0	00000	<a href="#">SSHR</a>
0	00010	<a href="#">SSRA</a>
0	00100	<a href="#">SRSR</a>
0	00110	<a href="#">SRSRA</a>
0	01000	UNALLOCATED

Decode fields		Instruction Details
U	opcode	
0	01010	<a href="#">SHL</a>
0	01100	UNALLOCATED
0	01110	<a href="#">SQSHL (immediate)</a>
0	10000	<a href="#">SHRN, SHRN2</a>
0	10001	<a href="#">RSHRN, RSHRN2</a>
0	10010	<a href="#">SQSHRN, SQSHRN2</a>
0	10011	<a href="#">SQRSHRN, SQRSHRN2</a>
0	10100	<a href="#">SSHLL, SSHLL2</a>
0	11100	<a href="#">SCVTF (vector, fixed-point)</a>
0	11111	<a href="#">FCVTZS (vector, fixed-point)</a>
1	00000	<a href="#">USHR</a>
1	00010	<a href="#">USRA</a>
1	00100	<a href="#">URSHR</a>
1	00110	<a href="#">URSRA</a>
1	01000	<a href="#">SRI</a>
1	01010	<a href="#">SLI</a>
1	01100	<a href="#">SQSHLU</a>
1	01110	<a href="#">UQSHL (immediate)</a>
1	10000	<a href="#">SQSHRUN, SQSHRUN2</a>
1	10001	<a href="#">SQRSHRUN, SQRSHRUN2</a>
1	10010	<a href="#">UQSHRN, UQSHRN2</a>
1	10011	<a href="#">UQRSHRN, UQRSHRN2</a>
1	10100	<a href="#">USHLL, USHLL2</a>
1	11100	<a href="#">UCVTF (vector, fixed-point)</a>
1	11111	<a href="#">FCVTZU (vector, fixed-point)</a>

### Advanced SIMD vector x indexed element

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Q	U	0	1	1	1	1	size	L	M	Rm				opcode				H	0	Rn				Rd						

Decode fields			Instruction Details	Architecture Version
U	size	opcode		
	01	1001	UNALLOCATED	-
0		0010	<a href="#">SMLAL, SMLAL2 (by element)</a>	-
0		0011	<a href="#">SQDMLAL, SQDMLAL2 (by element)</a>	-
0		0110	<a href="#">SMLSL, SMLSL2 (by element)</a>	-
0		0111	<a href="#">SQDMLSL, SQDMLSL2 (by element)</a>	-
0		1000	<a href="#">MUL (by element)</a>	-
0		1010	<a href="#">SMULL, SMULL2 (by element)</a>	-
0		1011	<a href="#">SQDMULL, SQDMULL2 (by element)</a>	-
0		1100	<a href="#">SQDMULH (by element)</a>	-
0		1101	<a href="#">SQRDMULH (by element)</a>	-
0		1110	<a href="#">SDOT (by element)</a>	ARMv8.2-DotProd
0	0x	0000	UNALLOCATED	-
0	0x	0100	UNALLOCATED	-
0	00	0001	<a href="#">FMLA (by element)</a> — <a href="#">half-precision</a>	ARMv8.2-FP16

Decode fields			Instruction Details	Architecture Version
U	size	opcode		
0	00	0101	<a href="#">FMLS (by element) — half-precision</a>	ARMv8.2-FP16
0	00	1001	<a href="#">FMUL (by element) — half-precision</a>	ARMv8.2-FP16
0	00	1111	<a href="#">SUDOT (by element)</a>	ARMv8.2-I8MM
0	01	0001	UNALLOCATED	-
0	01	0101	UNALLOCATED	-
0	01	1111	<a href="#">BFDOT (by element)</a>	ARMv8.2-BF16
0	1x	0001	<a href="#">FMLA (by element) — single-precision and double-precision</a>	-
0	1x	0101	<a href="#">FMLS (by element) — single-precision and double-precision</a>	-
0	1x	1001	<a href="#">FMUL (by element) — single-precision and double-precision</a>	-
0	10	0000	<a href="#">FMLAL, FMLAL2 (by element) — FMLAL</a>	ARMv8.2-FHM
0	10	0100	<a href="#">FMLS, FMLS2 (by element) — FMLS</a>	ARMv8.2-FHM
0	10	1111	<a href="#">USDOT (by element)</a>	ARMv8.2-I8MM
0	11	0000	UNALLOCATED	-
0	11	0100	UNALLOCATED	-
0	11	1111	<a href="#">BFMLALB, BFMLALT (by element)</a>	ARMv8.2-BF16
1		0000	<a href="#">MLA (by element)</a>	-
1		0010	<a href="#">UMLAL, UMLAL2 (by element)</a>	-
1		0100	<a href="#">MLS (by element)</a>	-
1		0110	<a href="#">UMLS, UMLS2 (by element)</a>	-
1		1010	<a href="#">UMULL, UMULL2 (by element)</a>	-
1		1011	UNALLOCATED	-
1		1101	<a href="#">SQRDMLAH (by element)</a>	ARMv8.1-RDMA
1		1110	<a href="#">UDOT (by element)</a>	ARMv8.2-DotProd
1		1111	<a href="#">SQRDMLSH (by element)</a>	ARMv8.1-RDMA
1	0x	1000	UNALLOCATED	-
1	0x	1100	UNALLOCATED	-
1	00	0001	UNALLOCATED	-
1	00	0011	UNALLOCATED	-
1	00	0101	UNALLOCATED	-
1	00	0111	UNALLOCATED	-
1	00	1001	<a href="#">FMULX (by element) — half-precision</a>	ARMv8.2-FP16
1	01	0xx1	<a href="#">FCMLA (by element)</a>	ARMv8.3-CompNum
1	1x	1001	<a href="#">FMULX (by element) — single-precision and double-precision</a>	-
1	10	0xx1	<a href="#">FCMLA (by element)</a>	ARMv8.3-CompNum
1	10	1000	<a href="#">FMLAL, FMLAL2 (by element) — FMLAL2</a>	ARMv8.2-FHM
1	10	1100	<a href="#">FMLS, FMLS2 (by element) — FMLS2</a>	ARMv8.2-FHM
1	11	0001	UNALLOCATED	-
1	11	0011	UNALLOCATED	-
1	11	0101	UNALLOCATED	-
1	11	0111	UNALLOCATED	-
1	11	1000	UNALLOCATED	-
1	11	1100	UNALLOCATED	-

### Cryptographic three-register, imm2

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).



31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	0	1	0			Rm			1	0	imm2	opcode					Rn						Rd	

Decode fields opcode	Instruction Details	Architecture Version
00	<a href="#">SM3TT1A</a>	ARMv8.2-SM3
01	<a href="#">SM3TT1B</a>	ARMv8.2-SM3
10	<a href="#">SM3TT2A</a>	ARMv8.2-SM3
11	<a href="#">SM3TT2B</a>	ARMv8.2-SM3

### Cryptographic three-register SHA 512

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	0	1	1			Rm			1	0	0	0	opcode				Rn						Rd	

Decode fields O opcode	Instruction Details	Architecture Version
0 00	<a href="#">SHA512H</a>	ARMv8.2-SHA2
0 01	<a href="#">SHA512H2</a>	ARMv8.2-SHA2
0 10	<a href="#">SHA512SU1</a>	ARMv8.2-SHA2
0 11	<a href="#">RAX1</a>	ARMv8.2-SHA3
1 00	<a href="#">SM3PARTW1</a>	ARMv8.2-SM3
1 01	<a href="#">SM3PARTW2</a>	ARMv8.2-SM3
1 10	<a href="#">SM4EKEY</a>	ARMv8.2-SM4
1 11	UNALLOCATED	-

### Cryptographic four-register

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	1	1	1	0	0	Op0				Rm			0			Ra				Rn							Rd	

Decode fields Op0	Instruction Details	Architecture Version
00	<a href="#">EOR3</a>	ARMv8.2-SHA3
01	<a href="#">BCAX</a>	ARMv8.2-SHA3
10	<a href="#">SM3SS1</a>	ARMv8.2-SM3
11	UNALLOCATED	-

### Cryptographic two-register SHA 512

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
1	1	0	0	1	1	1	0	1	1	0	0	0	0	0	0	1	0	0	0	opcode					Rn			Rd				

Decode fields opcode	Instruction Details	Architecture Version
00	<a href="#">SHA512SU0</a>	ARMv8.2-SHA2
01	<a href="#">SM4E</a>	ARMv8.2-SM4
1x	UNALLOCATED	-

**Conversion between floating-point and fixed-point**

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	S	1	1	1	1	0	ptype	0	rmode	opcode	scale				Rn				Rd											

Decode fields					Instruction Details		Architecture Version
sf	S	ptype	rmode	opcode	scale		
				1xx		UNALLOCATED	-
			x0	00x		UNALLOCATED	-
			x1	01x		UNALLOCATED	-
			0x	00x		UNALLOCATED	-
			1x	01x		UNALLOCATED	-
		10				UNALLOCATED	-
	1					UNALLOCATED	-
0					0xxxxx	UNALLOCATED	-
0	0	00	00	010		<a href="#">SCVTF (scalar, fixed-point) — 32-bit to single-precision</a>	-
0	0	00	00	011		<a href="#">UCVTF (scalar, fixed-point) — 32-bit to single-precision</a>	-
0	0	00	11	000		<a href="#">FCVTZS (scalar, fixed-point) — single-precision to 32-bit</a>	-
0	0	00	11	001		<a href="#">FCVTZU (scalar, fixed-point) — single-precision to 32-bit</a>	-
0	0	01	00	010		<a href="#">SCVTF (scalar, fixed-point) — 32-bit to double-precision</a>	-
0	0	01	00	011		<a href="#">UCVTF (scalar, fixed-point) — 32-bit to double-precision</a>	-
0	0	01	11	000		<a href="#">FCVTZS (scalar, fixed-point) — double-precision to 32-bit</a>	-
0	0	01	11	001		<a href="#">FCVTZU (scalar, fixed-point) — double-precision to 32-bit</a>	-
0	0	11	00	010		<a href="#">SCVTF (scalar, fixed-point) — 32-bit to half-precision</a>	ARMv8.2-FP16
0	0	11	00	011		<a href="#">UCVTF (scalar, fixed-point) — 32-bit to half-precision</a>	ARMv8.2-FP16
0	0	11	11	000		<a href="#">FCVTZS (scalar, fixed-point) — half-precision to 32-bit</a>	ARMv8.2-FP16
0	0	11	11	001		<a href="#">FCVTZU (scalar, fixed-point) — half-precision to 32-bit</a>	ARMv8.2-FP16
1	0	00	00	010		<a href="#">SCVTF (scalar, fixed-point) — 64-bit to single-precision</a>	-
1	0	00	00	011		<a href="#">UCVTF (scalar, fixed-point) — 64-bit to single-precision</a>	-
1	0	00	11	000		<a href="#">FCVTZS (scalar, fixed-point) — single-precision to 64-bit</a>	-
1	0	00	11	001		<a href="#">FCVTZU (scalar, fixed-point) — single-precision to 64-bit</a>	-
1	0	01	00	010		<a href="#">SCVTF (scalar, fixed-point) — 64-bit to double-precision</a>	-
1	0	01	00	011		<a href="#">UCVTF (scalar, fixed-point) — 64-bit to double-precision</a>	-
1	0	01	11	000		<a href="#">FCVTZS (scalar, fixed-point) — double-precision to 64-bit</a>	-
1	0	01	11	001		<a href="#">FCVTZU (scalar, fixed-point) — double-precision to 64-bit</a>	-
1	0	11	00	010		<a href="#">SCVTF (scalar, fixed-point) — 64-bit to half-precision</a>	ARMv8.2-FP16

sf	S	Decode fields			scale	Instruction Details	Architecture Version
		ptype	rmode	opcode			
1	0	11	00	011		<a href="#">UCVTF (scalar, fixed-point) — 64-bit to half-precision</a>	ARMv8.2-FP16
1	0	11	11	000		<a href="#">FCVTZS (scalar, fixed-point) — half-precision to 64-bit</a>	ARMv8.2-FP16
1	0	11	11	001		<a href="#">FCVTZU (scalar, fixed-point) — half-precision to 64-bit</a>	ARMv8.2-FP16

## Conversion between floating-point and integer

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sf	0	S	1	1	1	1	0	ptype	1	rmode	opcode		0	0	0	0	0	0	Rn						Rd						

sf	S	Decode fields			Instruction Details	Architecture Version
		ptype	rmode	opcode		
			x1	01x	UNALLOCATED	-
			x1	10x	UNALLOCATED	-
			1x	01x	UNALLOCATED	-
			1x	10x	UNALLOCATED	-
	0	10		0xx	UNALLOCATED	-
	0	10		10x	UNALLOCATED	-
	1				UNALLOCATED	-
0	0	00	x1	11x	UNALLOCATED	-
0	0	00	00	000	<a href="#">FCVTNS (scalar) — single-precision to 32-bit</a>	-
0	0	00	00	001	<a href="#">FCVTNU (scalar) — single-precision to 32-bit</a>	-
0	0	00	00	010	<a href="#">SCVTF (scalar, integer) — 32-bit to single-precision</a>	-
0	0	00	00	011	<a href="#">UCVTF (scalar, integer) — 32-bit to single-precision</a>	-
0	0	00	00	100	<a href="#">FCVTAS (scalar) — single-precision to 32-bit</a>	-
0	0	00	00	101	<a href="#">FCVTAU (scalar) — single-precision to 32-bit</a>	-
0	0	00	00	110	<a href="#">FMOV (general) — single-precision to 32-bit</a>	-
0	0	00	00	111	<a href="#">FMOV (general) — 32-bit to single-precision</a>	-
0	0	00	01	000	<a href="#">FCVTPS (scalar) — single-precision to 32-bit</a>	-
0	0	00	01	001	<a href="#">FCVTPU (scalar) — single-precision to 32-bit</a>	-
0	0	00	1x	11x	UNALLOCATED	-
0	0	00	10	000	<a href="#">FCVTMS (scalar) — single-precision to 32-bit</a>	-
0	0	00	10	001	<a href="#">FCVTMU (scalar) — single-precision to 32-bit</a>	-
0	0	00	11	000	<a href="#">FCVTZS (scalar, integer) — single-precision to 32-bit</a>	-
0	0	00	11	001	<a href="#">FCVTZU (scalar, integer) — single-precision to 32-bit</a>	-
0	0	01	0x	11x	UNALLOCATED	-
0	0	01	00	000	<a href="#">FCVTNS (scalar) — double-precision to 32-bit</a>	-
0	0	01	00	001	<a href="#">FCVTNU (scalar) — double-precision to 32-bit</a>	-
0	0	01	00	010	<a href="#">SCVTF (scalar, integer) — 32-bit to double-precision</a>	-
0	0	01	00	011	<a href="#">UCVTF (scalar, integer) — 32-bit to double-precision</a>	-
0	0	01	00	100	<a href="#">FCVTAS (scalar) — double-precision to 32-bit</a>	-
0	0	01	00	101	<a href="#">FCVTAU (scalar) — double-precision to 32-bit</a>	-

sf	S	Decode fields		opcode	Instruction Details	Architecture Version
		ptype	rmode			
0	0	01	01	000	<a href="#">FCVTPS (scalar)</a> — <a href="#">double-precision to 32-bit</a>	-
0	0	01	01	001	<a href="#">FCVTPU (scalar)</a> — <a href="#">double-precision to 32-bit</a>	-
0	0	01	10	000	<a href="#">FCVTMS (scalar)</a> — <a href="#">double-precision to 32-bit</a>	-
0	0	01	10	001	<a href="#">FCVTMU (scalar)</a> — <a href="#">double-precision to 32-bit</a>	-
0	0	01	10	11x	UNALLOCATED	-
0	0	01	11	000	<a href="#">FCVTZS (scalar, integer)</a> — <a href="#">double-precision to 32-bit</a>	-
0	0	01	11	001	<a href="#">FCVTZU (scalar, integer)</a> — <a href="#">double-precision to 32-bit</a>	-
0	0	01	11	110	<a href="#">FJCVTZS</a>	ARMv8.3-JConv
0	0	01	11	111	UNALLOCATED	-
0	0	10		11x	UNALLOCATED	-
0	0	11	00	000	<a href="#">FCVTNS (scalar)</a> — <a href="#">half-precision to 32-bit</a>	ARMv8.2-FP16
0	0	11	00	001	<a href="#">FCVTNU (scalar)</a> — <a href="#">half-precision to 32-bit</a>	ARMv8.2-FP16
0	0	11	00	010	<a href="#">SCVTF (scalar, integer)</a> — <a href="#">32-bit to half-precision</a>	ARMv8.2-FP16
0	0	11	00	011	<a href="#">UCVTF (scalar, integer)</a> — <a href="#">32-bit to half-precision</a>	ARMv8.2-FP16
0	0	11	00	100	<a href="#">FCVTAS (scalar)</a> — <a href="#">half-precision to 32-bit</a>	ARMv8.2-FP16
0	0	11	00	101	<a href="#">FCVTAU (scalar)</a> — <a href="#">half-precision to 32-bit</a>	ARMv8.2-FP16
0	0	11	00	110	<a href="#">FMOV (general)</a> — <a href="#">half-precision to 32-bit</a>	ARMv8.2-FP16
0	0	11	00	111	<a href="#">FMOV (general)</a> — <a href="#">32-bit to half-precision</a>	ARMv8.2-FP16
0	0	11	01	000	<a href="#">FCVTPS (scalar)</a> — <a href="#">half-precision to 32-bit</a>	ARMv8.2-FP16
0	0	11	01	001	<a href="#">FCVTPU (scalar)</a> — <a href="#">half-precision to 32-bit</a>	ARMv8.2-FP16
0	0	11	10	000	<a href="#">FCVTMS (scalar)</a> — <a href="#">half-precision to 32-bit</a>	ARMv8.2-FP16
0	0	11	10	001	<a href="#">FCVTMU (scalar)</a> — <a href="#">half-precision to 32-bit</a>	ARMv8.2-FP16
0	0	11	11	000	<a href="#">FCVTZS (scalar, integer)</a> — <a href="#">half-precision to 32-bit</a>	ARMv8.2-FP16
0	0	11	11	001	<a href="#">FCVTZU (scalar, integer)</a> — <a href="#">half-precision to 32-bit</a>	ARMv8.2-FP16
1	0	00		11x	UNALLOCATED	-
1	0	00	00	000	<a href="#">FCVTNS (scalar)</a> — <a href="#">single-precision to 64-bit</a>	-
1	0	00	00	001	<a href="#">FCVTNU (scalar)</a> — <a href="#">single-precision to 64-bit</a>	-
1	0	00	00	010	<a href="#">SCVTF (scalar, integer)</a> — <a href="#">64-bit to single-precision</a>	-
1	0	00	00	011	<a href="#">UCVTF (scalar, integer)</a> — <a href="#">64-bit to single-precision</a>	-
1	0	00	00	100	<a href="#">FCVTAS (scalar)</a> — <a href="#">single-precision to 64-bit</a>	-
1	0	00	00	101	<a href="#">FCVTAU (scalar)</a> — <a href="#">single-precision to 64-bit</a>	-
1	0	00	01	000	<a href="#">FCVTPS (scalar)</a> — <a href="#">single-precision to 64-bit</a>	-
1	0	00	01	001	<a href="#">FCVTPU (scalar)</a> — <a href="#">single-precision to 64-bit</a>	-
1	0	00	10	000	<a href="#">FCVTMS (scalar)</a> — <a href="#">single-precision to 64-bit</a>	-
1	0	00	10	001	<a href="#">FCVTMU (scalar)</a> — <a href="#">single-precision to 64-bit</a>	-
1	0	00	11	000	<a href="#">FCVTZS (scalar, integer)</a> — <a href="#">single-precision to 64-bit</a>	-
1	0	00	11	001	<a href="#">FCVTZU (scalar, integer)</a> — <a href="#">single-precision to 64-bit</a>	-
1	0	01	x1	11x	UNALLOCATED	-
1	0	01	00	000	<a href="#">FCVTNS (scalar)</a> — <a href="#">double-precision to 64-bit</a>	-
1	0	01	00	001	<a href="#">FCVTNU (scalar)</a> — <a href="#">double-precision to 64-bit</a>	-

sf	S	Decode fields		opcode	Instruction Details	Architecture Version
		ptype	rmode			
1	0	01	00	010	<a href="#">SCVTF (scalar, integer) — 64-bit to double-precision</a>	-
1	0	01	00	011	<a href="#">UCVTF (scalar, integer) — 64-bit to double-precision</a>	-
1	0	01	00	100	<a href="#">FCVTAS (scalar) — double-precision to 64-bit</a>	-
1	0	01	00	101	<a href="#">FCVTAU (scalar) — double-precision to 64-bit</a>	-
1	0	01	00	110	<a href="#">FMOV (general) — double-precision to 64-bit</a>	-
1	0	01	00	111	<a href="#">FMOV (general) — 64-bit to double-precision</a>	-
1	0	01	01	000	<a href="#">FCVTPS (scalar) — double-precision to 64-bit</a>	-
1	0	01	01	001	<a href="#">FCVTPU (scalar) — double-precision to 64-bit</a>	-
1	0	01	1x	11x	UNALLOCATED	-
1	0	01	10	000	<a href="#">FCVTMS (scalar) — double-precision to 64-bit</a>	-
1	0	01	10	001	<a href="#">FCVTMU (scalar) — double-precision to 64-bit</a>	-
1	0	01	11	000	<a href="#">FCVTZS (scalar, integer) — double-precision to 64-bit</a>	-
1	0	01	11	001	<a href="#">FCVTZU (scalar, integer) — double-precision to 64-bit</a>	-
1	0	10	x0	11x	UNALLOCATED	-
1	0	10	01	110	<a href="#">FMOV (general) — top half of 128-bit to 64-bit</a>	-
1	0	10	01	111	<a href="#">FMOV (general) — 64-bit to top half of 128-bit</a>	-
1	0	10	1x	11x	UNALLOCATED	-
1	0	11	00	000	<a href="#">FCVTNS (scalar) — half-precision to 64-bit</a>	ARMv8.2-FP16
1	0	11	00	001	<a href="#">FCVTNU (scalar) — half-precision to 64-bit</a>	ARMv8.2-FP16
1	0	11	00	010	<a href="#">SCVTF (scalar, integer) — 64-bit to half-precision</a>	ARMv8.2-FP16
1	0	11	00	011	<a href="#">UCVTF (scalar, integer) — 64-bit to half-precision</a>	ARMv8.2-FP16
1	0	11	00	100	<a href="#">FCVTAS (scalar) — half-precision to 64-bit</a>	ARMv8.2-FP16
1	0	11	00	101	<a href="#">FCVTAU (scalar) — half-precision to 64-bit</a>	ARMv8.2-FP16
1	0	11	00	110	<a href="#">FMOV (general) — half-precision to 64-bit</a>	ARMv8.2-FP16
1	0	11	00	111	<a href="#">FMOV (general) — 64-bit to half-precision</a>	ARMv8.2-FP16
1	0	11	01	000	<a href="#">FCVTPS (scalar) — half-precision to 64-bit</a>	ARMv8.2-FP16
1	0	11	01	001	<a href="#">FCVTPU (scalar) — half-precision to 64-bit</a>	ARMv8.2-FP16
1	0	11	10	000	<a href="#">FCVTMS (scalar) — half-precision to 64-bit</a>	ARMv8.2-FP16
1	0	11	10	001	<a href="#">FCVTMU (scalar) — half-precision to 64-bit</a>	ARMv8.2-FP16
1	0	11	11	000	<a href="#">FCVTZS (scalar, integer) — half-precision to 64-bit</a>	ARMv8.2-FP16
1	0	11	11	001	<a href="#">FCVTZU (scalar, integer) — half-precision to 64-bit</a>	ARMv8.2-FP16

### Floating-point data-processing (1 source)

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
M	0	S	1	1	1	1	0	ptype	1	opcode				1	0	0	0	0	Rn				Rd								

M	S	Decode fields		opcode	Instruction Details	Architecture Version
		ptype	rmode			
				1xxxxxx	UNALLOCATED	-
	1				UNALLOCATED	-

Decode fields				Instruction Details	Architecture Version
M	S	ptype	opcode		
0	0	00	000000	<a href="#">FMOV (register) — single-precision</a>	-
0	0	00	000001	<a href="#">FABS (scalar) — single-precision</a>	-
0	0	00	000010	<a href="#">FNEG (scalar) — single-precision</a>	-
0	0	00	000011	<a href="#">FSQRT (scalar) — single-precision</a>	-
0	0	00	000100	UNALLOCATED	-
0	0	00	000101	<a href="#">FCVT — single-precision to double-precision</a>	-
0	0	00	000110	UNALLOCATED	-
0	0	00	000111	<a href="#">FCVT — single-precision to half-precision</a>	-
0	0	00	001000	<a href="#">FRINTN (scalar) — single-precision</a>	-
0	0	00	001001	<a href="#">FRINTP (scalar) — single-precision</a>	-
0	0	00	001010	<a href="#">FRINTM (scalar) — single-precision</a>	-
0	0	00	001011	<a href="#">FRINTZ (scalar) — single-precision</a>	-
0	0	00	001100	<a href="#">FRINTA (scalar) — single-precision</a>	-
0	0	00	001101	UNALLOCATED	-
0	0	00	001110	<a href="#">FRINTX (scalar) — single-precision</a>	-
0	0	00	001111	<a href="#">FRINTI (scalar) — single-precision</a>	-
0	0	00	010000	<a href="#">FRINT32Z (scalar) — single-precision</a>	ARMv8.5-FRINT
0	0	00	010001	<a href="#">FRINT32X (scalar) — single-precision</a>	ARMv8.5-FRINT
0	0	00	010010	<a href="#">FRINT64Z (scalar) — single-precision</a>	ARMv8.5-FRINT
0	0	00	010011	<a href="#">FRINT64X (scalar) — single-precision</a>	ARMv8.5-FRINT
0	0	00	0101xx	UNALLOCATED	-
0	0	00	011xxx	UNALLOCATED	-
0	0	01	000000	<a href="#">FMOV (register) — double-precision</a>	-
0	0	01	000001	<a href="#">FABS (scalar) — double-precision</a>	-
0	0	01	000010	<a href="#">FNEG (scalar) — double-precision</a>	-
0	0	01	000011	<a href="#">FSQRT (scalar) — double-precision</a>	-
0	0	01	000100	<a href="#">FCVT — double-precision to single-precision</a>	-
0	0	01	000101	UNALLOCATED	-
0	0	01	000110	<a href="#">BFCVT</a>	ARMv8.2-BF16
0	0	01	000111	<a href="#">FCVT — double-precision to half-precision</a>	-
0	0	01	001000	<a href="#">FRINTN (scalar) — double-precision</a>	-
0	0	01	001001	<a href="#">FRINTP (scalar) — double-precision</a>	-
0	0	01	001010	<a href="#">FRINTM (scalar) — double-precision</a>	-
0	0	01	001011	<a href="#">FRINTZ (scalar) — double-precision</a>	-
0	0	01	001100	<a href="#">FRINTA (scalar) — double-precision</a>	-
0	0	01	001101	UNALLOCATED	-
0	0	01	001110	<a href="#">FRINTX (scalar) — double-precision</a>	-
0	0	01	001111	<a href="#">FRINTI (scalar) — double-precision</a>	-
0	0	01	010000	<a href="#">FRINT32Z (scalar) — double-precision</a>	ARMv8.5-FRINT
0	0	01	010001	<a href="#">FRINT32X (scalar) — double-precision</a>	ARMv8.5-FRINT
0	0	01	010010	<a href="#">FRINT64Z (scalar) — double-precision</a>	ARMv8.5-FRINT
0	0	01	010011	<a href="#">FRINT64X (scalar) — double-precision</a>	ARMv8.5-FRINT
0	0	01	0101xx	UNALLOCATED	-
0	0	01	011xxx	UNALLOCATED	-
0	0	10	0xxxxx	UNALLOCATED	-
0	0	11	000000	<a href="#">FMOV (register) — half-precision</a>	ARMv8.2-FP16
0	0	11	000001	<a href="#">FABS (scalar) — half-precision</a>	ARMv8.2-FP16

Decode fields				Instruction Details	Architecture Version
M	S	ptype	opcode		
0	0	11	000010	<a href="#">FNEG (scalar) — half-precision</a>	ARMv8.2-FP16
0	0	11	000011	<a href="#">FSQRT (scalar) — half-precision</a>	ARMv8.2-FP16
0	0	11	000100	<a href="#">FCVT — half-precision to single-precision</a>	-
0	0	11	000101	<a href="#">FCVT — half-precision to double-precision</a>	-
0	0	11	00011x	UNALLOCATED	-
0	0	11	001000	<a href="#">FRINTN (scalar) — half-precision</a>	ARMv8.2-FP16
0	0	11	001001	<a href="#">FRINTP (scalar) — half-precision</a>	ARMv8.2-FP16
0	0	11	001010	<a href="#">FRINTM (scalar) — half-precision</a>	ARMv8.2-FP16
0	0	11	001011	<a href="#">FRINTZ (scalar) — half-precision</a>	ARMv8.2-FP16
0	0	11	001100	<a href="#">FRINTA (scalar) — half-precision</a>	ARMv8.2-FP16
0	0	11	001101	UNALLOCATED	-
0	0	11	001110	<a href="#">FRINTX (scalar) — half-precision</a>	ARMv8.2-FP16
0	0	11	001111	<a href="#">FRINTI (scalar) — half-precision</a>	ARMv8.2-FP16
0	0	11	01xxxx	UNALLOCATED	-
1				UNALLOCATED	-

## Floating-point compare

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
M	0	S	1	1	1	1	0	ptype	1						Rm		op	1	0	0	0				Rn					opcode2	

Decode fields					Instruction Details	Architecture Version
M	S	ptype	op	opcode2		
				xxxx1	UNALLOCATED	-
				xxx1x	UNALLOCATED	-
				xx1xx	UNALLOCATED	-
			x1		UNALLOCATED	-
			1x		UNALLOCATED	-
		10			UNALLOCATED	-
	1				UNALLOCATED	-
0	0	00	00	00000	<a href="#">FCMP</a>	-
0	0	00	00	01000	<a href="#">FCMP</a>	-
0	0	00	00	10000	<a href="#">FCMPE</a>	-
0	0	00	00	11000	<a href="#">FCMPE</a>	-
0	0	01	00	00000	<a href="#">FCMP</a>	-
0	0	01	00	01000	<a href="#">FCMP</a>	-
0	0	01	00	10000	<a href="#">FCMPE</a>	-
0	0	01	00	11000	<a href="#">FCMPE</a>	-
0	0	11	00	00000	<a href="#">FCMP</a>	ARMv8.2-FP16
0	0	11	00	01000	<a href="#">FCMP</a>	ARMv8.2-FP16
0	0	11	00	10000	<a href="#">FCMPE</a>	ARMv8.2-FP16
0	0	11	00	11000	<a href="#">FCMPE</a>	ARMv8.2-FP16
1					UNALLOCATED	-

## Floating-point immediate

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
M	0	S	1	1	1	1	0	ptype	1	imm8								1	0	0	imm5				Rd						

Decode fields				Instruction Details								Architecture Version							
M	S	ptype	imm5																
			xxxx1	UNALLOCATED								-							
			xxx1x	UNALLOCATED								-							
			xx1xx	UNALLOCATED								-							
			x1xxx	UNALLOCATED								-							
			1xxxx	UNALLOCATED								-							
		10		UNALLOCATED								-							
	1			UNALLOCATED								-							
0	0	00	00000	<a href="#">FMOV (scalar, immediate) — single-precision</a>								-							
0	0	01	00000	<a href="#">FMOV (scalar, immediate) — double-precision</a>								-							
0	0	11	00000	<a href="#">FMOV (scalar, immediate) — half-precision</a>								ARMv8.2-FP16							
1				UNALLOCATED								-							

## Floating-point conditional compare

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
M	0	S	1	1	1	1	0	ptype	1	Rm				cond				0	1	Rn				op	nzcvc						

Decode fields				Instruction Details								Architecture Version							
M	S	ptype	op																
		10		UNALLOCATED								-							
	1			UNALLOCATED								-							
0	0	00	0	<a href="#">FCCMP — single-precision</a>								-							
0	0	00	1	<a href="#">FCCMPE — single-precision</a>								-							
0	0	01	0	<a href="#">FCCMP — double-precision</a>								-							
0	0	01	1	<a href="#">FCCMPE — double-precision</a>								-							
0	0	11	0	<a href="#">FCCMP — half-precision</a>								ARMv8.2-FP16							
0	0	11	1	<a href="#">FCCMPE — half-precision</a>								ARMv8.2-FP16							
1				UNALLOCATED								-							

## Floating-point data-processing (2 source)

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
M	0	S	1	1	1	1	0	ptype	1	Rm				opcode				1	0	Rn				Rd							

Decode fields				Instruction Details								Architecture Version							
M	S	ptype	opcode																
			1xx1	UNALLOCATED								-							
			1x1x	UNALLOCATED								-							
			11xx	UNALLOCATED								-							
		10		UNALLOCATED								-							
	1			UNALLOCATED								-							
0	0	00	0000	<a href="#">FMUL (scalar) — single-precision</a>								-							
0	0	00	0001	<a href="#">FDIV (scalar) — single-precision</a>								-							
0	0	00	0010	<a href="#">FADD (scalar) — single-precision</a>								-							
0	0	00	0011	<a href="#">FSUB (scalar) — single-precision</a>								-							



Decode fields				Instruction Details	Architecture Version
M	S	ptype	opcode		
0	0	00	0100	<a href="#">FMAX (scalar) — single-precision</a>	-
0	0	00	0101	<a href="#">FMIN (scalar) — single-precision</a>	-
0	0	00	0110	<a href="#">FMAXNM (scalar) — single-precision</a>	-
0	0	00	0111	<a href="#">FMINNM (scalar) — single-precision</a>	-
0	0	00	1000	<a href="#">FNMUL (scalar) — single-precision</a>	-
0	0	01	0000	<a href="#">FMUL (scalar) — double-precision</a>	-
0	0	01	0001	<a href="#">FDIV (scalar) — double-precision</a>	-
0	0	01	0010	<a href="#">FADD (scalar) — double-precision</a>	-
0	0	01	0011	<a href="#">FSUB (scalar) — double-precision</a>	-
0	0	01	0100	<a href="#">FMAX (scalar) — double-precision</a>	-
0	0	01	0101	<a href="#">FMIN (scalar) — double-precision</a>	-
0	0	01	0110	<a href="#">FMAXNM (scalar) — double-precision</a>	-
0	0	01	0111	<a href="#">FMINNM (scalar) — double-precision</a>	-
0	0	01	1000	<a href="#">FNMUL (scalar) — double-precision</a>	-
0	0	11	0000	<a href="#">FMUL (scalar) — half-precision</a>	ARMv8.2-FP16
0	0	11	0001	<a href="#">FDIV (scalar) — half-precision</a>	ARMv8.2-FP16
0	0	11	0010	<a href="#">FADD (scalar) — half-precision</a>	ARMv8.2-FP16
0	0	11	0011	<a href="#">FSUB (scalar) — half-precision</a>	ARMv8.2-FP16
0	0	11	0100	<a href="#">FMAX (scalar) — half-precision</a>	ARMv8.2-FP16
0	0	11	0101	<a href="#">FMIN (scalar) — half-precision</a>	ARMv8.2-FP16
0	0	11	0110	<a href="#">FMAXNM (scalar) — half-precision</a>	ARMv8.2-FP16
0	0	11	0111	<a href="#">FMINNM (scalar) — half-precision</a>	ARMv8.2-FP16
0	0	11	1000	<a href="#">FNMUL (scalar) — half-precision</a>	ARMv8.2-FP16
1				UNALLOCATED	-

### Floating-point conditional select

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
M	0	S	1	1	1	1	0	ptype	1	Rm				cond				1	1	Rn				Rd							

Decode fields			Instruction Details	Architecture Version
M	S	ptype		
		10	UNALLOCATED	-
	1		UNALLOCATED	-
0	0	00	<a href="#">FCSEL — single-precision</a>	-
0	0	01	<a href="#">FCSEL — double-precision</a>	-
0	0	11	<a href="#">FCSEL — half-precision</a>	ARMv8.2-FP16
1			UNALLOCATED	-

### Floating-point data-processing (3 source)

These instructions are under [Data Processing -- Scalar Floating-Point and Advanced SIMD](#).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
M	0	S	1	1	1	1	1	ptype	o1	Rm				o0	Ra				Rn				Rd												

M	Decode fields			o0	Instruction Details	Architecture Version
	S	ptype	o1			
		10			UNALLOCATED	-
	1				UNALLOCATED	-
0	0	00	0	0	<a href="#">FMADD — single-precision</a>	-
0	0	00	0	1	<a href="#">FMSUB — single-precision</a>	-
0	0	00	1	0	<a href="#">FNMADD — single-precision</a>	-
0	0	00	1	1	<a href="#">FNMSUB — single-precision</a>	-
0	0	01	0	0	<a href="#">FMADD — double-precision</a>	-
0	0	01	0	1	<a href="#">FMSUB — double-precision</a>	-
0	0	01	1	0	<a href="#">FNMADD — double-precision</a>	-
0	0	01	1	1	<a href="#">FNMSUB — double-precision</a>	-
0	0	11	0	0	<a href="#">FMADD — half-precision</a>	ARMv8.2-FP16
0	0	11	0	1	<a href="#">FMSUB — half-precision</a>	ARMv8.2-FP16
0	0	11	1	0	<a href="#">FNMADD — half-precision</a>	ARMv8.2-FP16
0	0	11	1	1	<a href="#">FNMSUB — half-precision</a>	ARMv8.2-FP16
1					UNALLOCATED	-

Internal version only: isa v32.03, AdvSIMD v29.02, pseudocode v2020-03, sve v2020-03\_rc1 ; Build timestamp: 2020-04-15T14:44

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## Shared Pseudocode Functions

This page displays common pseudocode functions shared by many pages.

### Pseudocodes

#### Library pseudocode for aarch32/debug/VCRMatch/AArch32.VCRMatch

```
// AArch32.VCRMatch()
// =====

boolean AArch32.VCRMatch(bits(32) vaddress)

    if UsingAArch32() && ELUsingAArch32(EL1) && IsZero(vaddress<1:0>) && PSTATE.EL != EL2 then
        // Each bit position in this string corresponds to a bit in DBGVCR and an exception vector.
        match_word = Zeros(32);

        if vaddress<31:5> == ExcVectorBase()<31:5> then
            if HaveEL(EL3) && !IsSecure() then
                match_word<UInt(vaddress<4:2>) + 24> = '1';        // Non-secure vectors
            else
                match_word<UInt(vaddress<4:2>) + 0> = '1';        // Secure vectors (or no EL3)

        if HaveEL(EL3) && ELUsingAArch32(EL3) && IsSecure() && vaddress<31:5> == MVBAR<31:5> then
            match_word<UInt(vaddress<4:2>) + 8> = '1';        // Monitor vectors

        // Mask out bits not corresponding to vectors.
        if !HaveEL(EL3) then
            mask = '00000000':'00000000':'00000000':'11011110'; // DBGVCR[31:8] are RES0
        elseif !ELUsingAArch32(EL3) then
            mask = '11011110':'00000000':'00000000':'11011110'; // DBGVCR[15:8] are RES0
        else
            mask = '11011110':'00000000':'11011100':'11011110';

        match_word = match_word AND DBGVCR AND mask;
        match = !IsZero(match_word);

        // Check for UNPREDICTABLE case - match on Prefetch Abort and Data Abort vectors
        if !IsZero(match_word<28:27,12:11,4:3>) && DebugTarget() == PSTATE.EL then
            match = ConstrainUnpredictableBool(Unpredictable_VCMATCHDAPA);
    else
        match = FALSE;

    return match;
```

#### Library pseudocode for aarch32/debug/authentication/AArch32.SelfHostedSecurePrivilegedInvasiveDebugEnabled

```
// AArch32.SelfHostedSecurePrivilegedInvasiveDebugEnabled()
// =====

boolean AArch32.SelfHostedSecurePrivilegedInvasiveDebugEnabled()
    // The definition of this function is IMPLEMENTATION DEFINED.
    // In the recommended interface, AArch32.SelfHostedSecurePrivilegedInvasiveDebugEnabled returns
    // the state of the (DBGEN AND SPIDEN) signal.
    if !HaveEL(EL3) && !IsSecure() then return FALSE;
    return DBGEN == HIGH && SPIDEN == HIGH;
```

## Library pseudocode for aarch32/debug/breakpoint/AArch32.BreakpointMatch

```
// AArch32.BreakpointMatch()
// =====
// Breakpoint matching in an AArch32 translation regime.

(boolean,boolean) AArch32.BreakpointMatch(integer n, bits(32) vaddress, integer size)
    assert ELUsingAArch32\(S1TranslationRegime\(\)\);
    assert n <= UInt\(DBGDIDR.BRPs\);

    enabled = DBGBCR[n].E == '1';
    ispriv = PSTATE.EL != EL0;
    linked = DBGBCR[n].BT == '0x01';
    isbreakpnt = TRUE;
    linked_to = FALSE;

    state_match = AArch32.StateMatch(DBGBCR[n].SSC, DBGBCR[n].HMC, DBGBCR[n].PMC,
                                    linked, DBGBCR[n].LBN, isbreakpnt, ispriv);
    (value_match, value_mismatch) = AArch32.BreakpointValueMatch(n, vaddress, linked_to);

    if size == 4 then // Check second halfword
        // If the breakpoint address and BAS of an Address breakpoint match the address of the
        // second halfword of an instruction, but not the address of the first halfword, it is
        // CONSTRAINED UNPREDICTABLE whether or not this breakpoint generates a Breakpoint debug
        // event.
        (match_i, mismatch_i) = AArch32.BreakpointValueMatch(n, vaddress + 2, linked_to);
        if !value_match && match_i then
            value_match = ConstrainUnpredictableBool\(Unpredictable\_BPMATCHHALF\);
        if value_mismatch && !mismatch_i then
            value_mismatch = ConstrainUnpredictableBool\(Unpredictable\_BPMISMATCHHALF\);
    if vaddress<1> == '1' && DBGBCR[n].BAS == '1111' then
        // The above notwithstanding, if DBGBCR[n].BAS == '1111', then it is CONSTRAINED
        // UNPREDICTABLE whether or not a Breakpoint debug event is generated for an instruction
        // at the address DBGBCR[n]+2.
        if value_match then value_match = ConstrainUnpredictableBool\(Unpredictable\_BPMATCHHALF\);
        if !value_mismatch then value_mismatch = ConstrainUnpredictableBool\(Unpredictable\_BPMISMATCHHALF\);

    match = value_match && state_match && enabled;
    mismatch = value_mismatch && state_match && enabled;

    return (match, mismatch);
```



```

// AArch32.BreakpointValueMatch()
// =====
// The first result is whether an Address Match or Context breakpoint is programmed on the
// instruction at "address". The second result is whether an Address Mismatch breakpoint is
// programmed on the instruction, that is, whether the instruction should be stepped.

(boolean,boolean) AArch32.BreakpointValueMatch(integer n, bits(32) vaddress, boolean linked_to)

// "n" is the identity of the breakpoint unit to match against.
// "vaddress" is the current instruction address, ignored if linked_to is TRUE and for Context
// matching breakpoints.
// "linked_to" is TRUE if this is a call from StateMatch for linking.

// If a non-existent breakpoint then it is CONSTRAINED UNPREDICTABLE whether this gives
// no match or the breakpoint is mapped to another UNKNOWN implemented breakpoint.
if n > UInt(DBGDIDR.BRPs) then
    (c, n) = ConstrainUnpredictableInteger(0, UInt(DBGDIDR.BRPs), Unpredictable_BPNOTIMPL);
    assert c IN {Constraint_DISABLED, Constraint_UNKNOWN};
    if c == Constraint_DISABLED then return (FALSE,FALSE);

// If this breakpoint is not enabled, it cannot generate a match. (This could also happen on a
// call from StateMatch for linking).
if DBGBCR[n].E == '0' then return (FALSE,FALSE);

context_aware = (n >= UInt(DBGDIDR.BRPs) - UInt(DBGDIDR.CTX_CMPs));

// If BT is set to a reserved type, behaves either as disabled or as a not-reserved type.
dbgtype = DBGBCR[n].BT;

if ((dbgtype IN {'011x','11xx'}) && !HaveVirtHostExt() && !HaveV82Debug()) || // Context matching
    (dbgtype == '010x' && HaltOnBreakpointOrWatchpoint()) || // Address mismatch
    (dbgtype != '0x0x' && !context_aware) || // Context matching
    (dbgtype == '1xxx' && !HaveEL(EL2))) then // EL2 extension
    (c, dbgtype) = ConstrainUnpredictableBits(Unpredictable_RESBPTYPE);
    assert c IN {Constraint_DISABLED, Constraint_UNKNOWN};
    if c == Constraint_DISABLED then return (FALSE,FALSE);
    // Otherwise the value returned by ConstrainUnpredictableBits must be a not-reserved value

// Determine what to compare against.
match_addr = (dbgtype == '0x0x');
mismatch   = (dbgtype == '010x');
match_vmid = (dbgtype == '10xx');
match_cid1 = (dbgtype == 'xx1x');
match_cid2 = (dbgtype == '11xx');
linked     = (dbgtype == 'xxx1');

// If this is a call from StateMatch, return FALSE if the breakpoint is not programmed for a
// VMID and/or context ID match, or if not context-aware. The above assertions mean that the
// code can just test for match_addr == TRUE to confirm all these things.
if linked_to && (!linked || match_addr) then return (FALSE,FALSE);

// If called from BreakpointMatch return FALSE for Linked context ID and/or VMID matches.
if !linked_to && linked && !match_addr then return (FALSE,FALSE);

// Do the comparison.
if match_addr then
    byte = UInt(vaddress<1:0>);
    assert byte IN {0,2}; // "vaddress" is halfword aligned
    byte_select_match = (DBGBCR[n].BAS<byte> == '1');
    BVR_match = vaddress<31:2> == DBGBCR[n]<31:2> && byte_select_match;
elseif match_cid1 then
    BVR_match = (PSTATE.EL != EL2 && CONTEXTIDR == DBGBCR[n]<31:0>);
if match_vmid then
    if ELUsingAArch32(EL2) then
        vmid = ZeroExtend(VTTBR.VMID, 16);
        bvr_vmid = ZeroExtend(DBGBCR[n]<7:0>, 16);
    elseif !Have16bitVMID() || VTCR_EL2.VS == '0' then
        vmid = ZeroExtend(VTTBR_EL2.VMID<7:0>, 16);
        bvr_vmid = ZeroExtend(DBGBCR[n]<7:0>, 16);
    else

```

```

        vmid = VTTBR_EL2.VMID;
        bvr_vmid = DBGXBVR[n]<15:0>;
        BXVR_match = (PSTATE.EL IN {EL0, EL1} && EL2Enabled() &&
            vmid == bvr_vmid);
    elsif match_cid2 then
        BXVR_match = ((HaveVirtHostExt() || HaveV82Debug()) && EL2Enabled() &&
            !ELUsingAArch32(EL2) &&
            DBGXBVR[n]<31:0> == CONTEXTIDR_EL2);

    bvr_match_valid = (match_addr || match_cid1);
    bxvr_match_valid = (match_vmid || match_cid2);

    match = (!bxvr_match_valid || BXVR_match) && (!bvr_match_valid || BVR_match);

    return (match && !mismatch, !match && mismatch);

```

## Library pseudocode for aarch32/debug/breakpoint/AArch32.StateMatch

```
// AArch32.StateMatch()
// =====
// Determine whether a breakpoint or watchpoint is enabled in the current mode and state.

boolean AArch32.StateMatch(bits(2) SSC, bit HMC, bits(2) PxC, boolean linked, bits(4) LBN,
                           boolean isbreakpt, boolean ispriv)
// "SSC", "HMC", "PxC" are the control fields from the DBGBCR[n] or DBGWCR[n] register.
// "linked" is TRUE if this is a linked breakpoint/watchpoint type.
// "LBN" is the linked breakpoint number from the DBGBCR[n] or DBGWCR[n] register.
// "isbreakpt" is TRUE for breakpoints, FALSE for watchpoints.
// "ispriv" is valid for watchpoints, and selects between privileged and unprivileged accesses.

// If parameters are set to a reserved type, behaves as either disabled or a defined type
(c, SSC, HMC, PxC) = CheckValidStateMatch(SSC, HMC, PxC, isbreakpt);
if c == Constraint_DISABLED then return FALSE;
// Otherwise the HMC,SSC,PxC values are either valid or the values returned by
// CheckValidStateMatch are valid.

PL2_match = HaveEL(EL2) && ((HMC == '1' && (SSC:PxC != '1000')) || SSC == '11');
PL1_match = PxC<0> == '1';
PL0_match = PxC<1> == '1';
SSU_match = isbreakpt && HMC == '0' && PxC == '00' && SSC != '11';

if !ispriv && !isbreakpt then
    priv_match = PL0_match;
elsif SSU_match then
    priv_match = PSTATE.M IN {M32_User,M32_Svc,M32_System};
else
    case PSTATE.EL of
        when EL3 priv_match = PL1_match;           // EL3 and EL1 are both PL1
        when EL2 priv_match = PL2_match;
        when EL1 priv_match = PL1_match;
        when EL0 priv_match = PL0_match;

    case SSC of
        when '00' security_state_match = TRUE;           // Both
        when '01' security_state_match = !IsSecure();    // Non-secure only
        when '10' security_state_match = IsSecure();     // Secure only
        when '11' security_state_match = (HMC == '1' || IsSecure()); // HMC=1 -> Both, 0 -> Secure only

    if linked then
        // "LBN" must be an enabled context-aware breakpoint unit. If it is not context-aware then
        // it is CONSTRAINED UNPREDICTABLE whether this gives no match, or LBN is mapped to some
        // UNKNOWN breakpoint that is context-aware.
        lbn = UInt(LBN);
        first_ctx_cmp = (UInt(DBGDIDR.BRPs) - UInt(DBGDIDR.CTX_CMPs));
        last_ctx_cmp = UInt(DBGDIDR.BRPs);
        if (lbn < first_ctx_cmp || lbn > last_ctx_cmp) then
            (c, lbn) = ConstrainUnpredictableInteger(first_ctx_cmp, last_ctx_cmp, Unpredictable_BPN0TCTX);
            assert c IN {Constraint_DISABLED, Constraint_NONE, Constraint_UNKNOWN};
            case c of
                when Constraint_DISABLED return FALSE;    // Disabled
                when Constraint_NONE linked = FALSE;     // No linking
                // Otherwise ConstrainUnpredictableInteger returned a context-aware breakpoint

        if linked then
            vaddress = bits(32) UNKNOWN;
            linked_to = TRUE;
            (linked_match,-) = AArch32.BreakpointValueMatch(lbn, vaddress, linked_to);

    return priv_match && security_state_match && (!linked || linked_match);
```



## Library pseudocode for aarch32/debug/enables/AArch32.GenerateDebugExceptions

```
// AArch32.GenerateDebugExceptions()
// =====

boolean AArch32.GenerateDebugExceptions()
    return AArch32.GenerateDebugExceptionsFrom(PSTATE.EL, IsSecure());
```

## Library pseudocode for aarch32/debug/enables/AArch32.GenerateDebugExceptionsFrom

```
// AArch32.GenerateDebugExceptionsFrom()
// =====

boolean AArch32.GenerateDebugExceptionsFrom(bits(2) from, boolean secure)

    if from == EL0 && !ELStateUsingAArch32(EL1, secure) then
        mask = bit UNKNOWN; // PSTATE.D mask, unused for EL0 case
        return AArch64.GenerateDebugExceptionsFrom(from, secure, mask);

    if DBGOSLSR.OSLK == '1' || DoubleLockStatus() || Halted() then
        return FALSE;

    if HaveEL(EL3) && secure then
        spd = if ELUsingAArch32(EL3) then SDCR.SPD else MDCR_EL3.SPD32;
        if spd<1> == '1' then
            enabled = spd<0> == '1';
        else
            // SPD == 0b01 is reserved, but behaves the same as 0b00.
            enabled = AArch32.SelfHostedSecurePrivilegedInvasiveDebugEnabled();
        if from == EL0 then enabled = enabled || SDER.SUIDEN == '1';
    else
        enabled = from != EL2;

    return enabled;
```

## Library pseudocode for aarch32/debug/pmu/AArch32.CheckForPMUOverflow

```
// AArch32.CheckForPMUOverflow()
// =====
// Signal Performance Monitors overflow IRQ and CTI overflow events

boolean AArch32.CheckForPMUOverflow()

    if !ELUsingAArch32(EL1) then return AArch64.CheckForPMUOverflow();
    pmuirq = PMCR.E == '1' && PMINTENSET<31> == '1' && PMOVSSET<31> == '1';
    for n = 0 to UInt(PMCR.N) - 1
        if HaveEL(EL2) then
            hpmn = if !ELUsingAArch32(EL2) then MDCR_EL2.HPMN else HDCR.HPMN;
            hpme = if !ELUsingAArch32(EL2) then MDCR_EL2.HPME else HDCR.HPME;
            E = (if n < UInt(hpmn) then PMCR.E else hpme);
        else
            E = PMCR.E;
        if E == '1' && PMINTENSET<n> == '1' && PMOVSSET<n> == '1' then pmuirq = TRUE;

    SetInterruptRequestLevel(InterruptID\_PMUIRQ, if pmuirq then HIGH else LOW);

    CTI_SetEventLevel(CrossTriggerIn\_PMUOverflow, if pmuirq then HIGH else LOW);

    // The request remains set until the condition is cleared. (For example, an interrupt handler
    // or cross-triggered event handler clears the overflow status flag by writing to PMOVSLR_EL0.)

    return pmuirq;
```

## Library pseudocode for aarch32/debug/pmu/AArch32.CountEvents

```
// AArch32.CountEvents()
// =====
// Return TRUE if counter "n" should count its event. For the cycle counter, n == 31.

boolean AArch32.CountEvents(integer n)
    assert n == 31 || n < UInt(PMCR.N);

    if !ELUsingAArch32(EL1) then return AArch64.CountEvents(n);
    // Event counting is disabled in Debug state
    debug = Halted();

    // In Non-secure state, some counters are reserved for EL2
    if HaveEL(EL2) then
        hpmn = if !ELUsingAArch32(EL2) then MDCR_EL2.HPMN else HDCR.HPMN;
        hpme = if !ELUsingAArch32(EL2) then MDCR_EL2.HPME else HDCR.HPME;
        if HaveHPMDExt() then
            hpmd = if !ELUsingAArch32(EL2) then MDCR_EL2.HPMD else HDCR.HPMD;
        E = if n < UInt(hpmn) || n == 31 then PMCR.E else hpme;
    else
        E = PMCR.E;
    enabled = E == '1' && PMCNTENSET<n> == '1';

    // Event counting in Secure state is prohibited unless any one of:
    // * EL3 is not implemented
    // * EL3 is using AArch64 and MDCR_EL3.SPME == 1
    // * EL3 is using AArch32 and SDCR.SPME == 1
    // * Executing at EL0, and SDER.SUNIDEN == 1.
    spme = (if ELUsingAArch32(EL3) then SDCR.SPME else MDCR_EL3.SPME);
    prohibited = HaveEL(EL3) && IsSecure() && spme == '0' && (PSTATE.EL != EL0 || SDER.SUNIDEN == '0');

    // Event counting at EL2 is prohibited if all of:
    // * The HPMD Extension is implemented
    // * Executing at EL2
    // * PMNx is not reserved for EL2
    // * HDCR.HPMD == 1
    if !prohibited && HaveEL(EL2) && HaveHPMDExt() && PSTATE.EL == EL2 && (n < UInt(hpmn) || n == 31) then
        prohibited = (hpmd == '1');

    // The IMPLEMENTATION DEFINED authentication interface might override software controls
    if prohibited && !HaveNoSecurePMUDisableOverride() then
        prohibited = !ExternalSecureNoninvasiveDebugEnabled();
    // For the cycle counter, PMCR.DP enables counting when otherwise prohibited
    if prohibited && n == 31 then prohibited = (PMCR.DP == '1');

    // Event counting can be filtered by the {P, U, NSK, NSU, NSH} bits
    filter = if n == 31 then PMCCFILTR else PMEVTYPER[n];

    P = filter<31>;
    U = filter<30>;
    NSK = if HaveEL(EL3) then filter<29> else '0';
    NSU = if HaveEL(EL3) then filter<28> else '0';
    NSH = if HaveEL(EL2) then filter<27> else '0';

    case PSTATE.EL of
        when EL0 filtered = if IsSecure() then U == '1' else U != NSU;
        when EL1 filtered = if IsSecure() then P == '1' else P != NSK;
        when EL2 filtered = (NSH == '0');
        when EL3 filtered = (P == '1');

    return !debug && enabled && !prohibited && !filtered;
```

## Library pseudocode for aarch32/debug/takeexceptiondbg/AArch32.EnterHypModeInDebugState

```
// AArch32.EnterHypModeInDebugState()
// =====
// Take an exception in Debug state to Hyp mode.

AArch32.EnterHypModeInDebugState(ExceptionRecord exception)
    SynchronizeContext();
    assert HaveEL(EL2) && !IsSecure() && ELUsingAArch32(EL2);

    AArch32.ReportHypEntry(exception);
    AArch32.WriteMode(M32_Hyp);
    SPSR[] = bits(32) UNKNOWN;
    ELR_hyp = bits(32) UNKNOWN;
    // In Debug state, the PE always execute T32 instructions when in AArch32 state, and
    // PSTATE.{SS,A,I,F} are not observable so behave as UNKNOWN.
    PSTATE.T = '1'; // PSTATE.J is RES0
    PSTATE.<SS,A,I,F> = bits(4) UNKNOWN;
    DLR = bits(32) UNKNOWN;
    DSPSR = bits(32) UNKNOWN;
    PSTATE.E = HSCTLR.EE;
    PSTATE.IL = '0';
    PSTATE.IT = '00000000';
    if HaveSSBSExt() then PSTATE.SSBS = bit UNKNOWN;
    EDSCR.ERR = '1';
    UpdateEDSCRFields();

    EndOfInstruction();
```

## Library pseudocode for aarch32/debug/takeexceptiondbg/AArch32.EnterModeInDebugState

```
// AArch32.EnterModeInDebugState()
// =====
// Take an exception in Debug state to a mode other than Monitor and Hyp mode.

AArch32.EnterModeInDebugState(bits(5) target_mode)
    SynchronizeContext();
    assert ELUsingAArch32(EL1) && PSTATE.EL != EL2;

    if PSTATE.M == M32_Monitor then SCR.NS = '0';
    AArch32.WriteMode(target_mode);
    SPSR[] = bits(32) UNKNOWN;
    R[14] = bits(32) UNKNOWN;
    // In Debug state, the PE always execute T32 instructions when in AArch32 state, and
    // PSTATE.{SS,A,I,F} are not observable so behave as UNKNOWN.
    PSTATE.T = '1'; // PSTATE.J is RES0
    PSTATE.<SS,A,I,F> = bits(4) UNKNOWN;
    DLR = bits(32) UNKNOWN;
    DSPSR = bits(32) UNKNOWN;
    PSTATE.E = SCTLR.EE;
    PSTATE.IL = '0';
    PSTATE.IT = '00000000';
    if HavePANExt() && SCTLR.SPAN == '0' then PSTATE.PAN = '1';
    if HaveSSBSExt() then PSTATE.SSBS = bit UNKNOWN;
    EDSCR.ERR = '1';
    UpdateEDSCRFields(); // Update EDSCR processor state flags.

    EndOfInstruction();
```

## Library pseudocode for aarch32/debug/takeexceptiondbg/ AArch32.EnterMonitorModeInDebugState

```
// AArch32.EnterMonitorModeInDebugState()
// =====
// Take an exception in Debug state to Monitor mode.

AArch32.EnterMonitorModeInDebugState()
    SynchronizeContext();
    assert HaveEL(EL3) && ELUsingAArch32(EL3);
    from_secure = IsSecure();
    if PSTATE.M == M32_Monitor then SCR.NS = '0';
    AArch32.WriteMode(M32_Monitor);
    SPSR[] = bits(32) UNKNOWN;
    R[14] = bits(32) UNKNOWN;
    // In Debug state, the PE always execute T32 instructions when in AArch32 state, and
    // PSTATE.{SS,A,I,F} are not observable so behave as UNKNOWN.
    PSTATE.T = '1'; // PSTATE.J is RES0
    PSTATE.<SS,A,I,F> = bits(4) UNKNOWN;
    PSTATE.E = SCTL.R.EE;
    PSTATE.IL = '0';
    PSTATE.IT = '00000000';
    if HavePANExt() then
        if !from_secure then
            PSTATE.PAN = '0';
        elsif SCTL.R.SPAN == '0' then
            PSTATE.PAN = '1';
    if HaveSSBSExt() then PSTATE.SSBS = bit UNKNOWN;
    DLR = bits(32) UNKNOWN;
    DSPSR = bits(32) UNKNOWN;
    EDSCR.ERR = '1';
    UpdateEDSCRFields(); // Update EDSCR processor state flags.

    EndOfInstruction();
```

## Library pseudocode for aarch32/debug/watchpoint/AArch32.WatchpointByteMatch

```
// AArch32.WatchpointByteMatch()
// =====

boolean AArch32.WatchpointByteMatch(integer n, bits(32) vaddress)

    bottom = if DBGWVR[n]<2> == '1' then 2 else 3;           // Word or doubleword
    byte_select_match = (DBGWCR[n].BAS<UInt(vaddress<bottom-1:0>)> != '0');
    mask = UInt(DBGWCR[n].MASK);

    // If DBGWCR[n].MASK is non-zero value and DBGWCR[n].BAS is not set to '11111111', or
    // DBGWCR[n].BAS specifies a non-contiguous set of bytes behavior is CONSTRAINED
    // UNPREDICTABLE.
    if mask > 0 && !IsOnes(DBGWCR[n].BAS) then
        byte_select_match = ConstrainUnpredictableBool(Unpredictable_WPMASKANDBAS);
    else
        LSB = (DBGWCR[n].BAS AND NOT(DBGWCR[n].BAS - 1)); MSB = (DBGWCR[n].BAS + LSB);
        if !IsZero(MSB AND (MSB - 1)) then                // Not contiguous
            byte_select_match = ConstrainUnpredictableBool(Unpredictable_WPBASCONTIGUOUS);
            bottom = 3;                                     // For the whole doubleword

    // If the address mask is set to a reserved value, the behavior is CONSTRAINED UNPREDICTABLE.
    if mask > 0 && mask <= 2 then
        (c, mask) = ConstrainUnpredictableInteger(3, 31, Unpredictable_RESWPMASK);
        assert c IN {Constraint_DISABLED, Constraint_NONE, Constraint_UNKNOWN};
        case c of
            when Constraint_DISABLED return FALSE;         // Disabled
            when Constraint_NONE     mask = 0;             // No masking
            // Otherwise the value returned by ConstrainUnpredictableInteger is a not-reserved value

    if mask > bottom then
        WVR_match = (vaddress<31:mask> == DBGWVR[n]<31:mask>);
        // If masked bits of DBGWVR_EL1[n] are not zero, the behavior is CONSTRAINED UNPREDICTABLE.
        if WVR_match && !IsZero(DBGWVR[n]<mask-1:bottom>) then
            WVR_match = ConstrainUnpredictableBool(Unpredictable_WPMASKEDBITS);
    else
        WVR_match = vaddress<31:bottom> == DBGWVR[n]<31:bottom>;

    return WVR_match && byte_select_match;
```

## Library pseudocode for aarch32/debug/watchpoint/AArch32.WatchpointMatch

```
// AArch32.WatchpointMatch()
// =====
// Watchpoint matching in an AArch32 translation regime.

boolean AArch32.WatchpointMatch(integer n, bits(32) vaddress, integer size, boolean ispriv,
                                boolean iswrite)
    assert ELUsingAArch32(S1TranslationRegime());
    assert n <= UInt(DBGDIDR.WRPs);

    // "ispriv" is FALSE for LDRT/STRT instructions executed at EL1 and all
    // load/stores at EL0, TRUE for all other load/stores. "iswrite" is TRUE for stores, FALSE for
    // loads.
    enabled = DBGWCR[n].E == '1';
    linked = DBGWCR[n].WT == '1';
    isbreakpnt = FALSE;

    state_match = AArch32.StateMatch(DBGWCR[n].SSC, DBGWCR[n].HMC, DBGWCR[n].PAC,
                                     linked, DBGWCR[n].LBN, isbreakpnt, ispriv);

    ls_match = (DBGWCR[n].LSC<(if iswrite then 1 else 0)> == '1');

    value_match = FALSE;
    for byte = 0 to size - 1
        value_match = value_match || AArch32.WatchpointByteMatch(n, vaddress + byte);

    return value_match && state_match && ls_match && enabled;
```

## Library pseudocode for aarch32/exceptions/aborts/AArch32.Abort

```
// AArch32.Abort()
// =====
// Abort and Debug exception handling in an AArch32 translation regime.

AArch32.Abort(bits(32) vaddress, FaultRecord fault)

    // Check if routed to AArch64 state
    route_to_aarch64 = PSTATE.EL == EL0 && !ELUsingAArch32\(EL1\);

    if !route_to_aarch64 && EL2Enabled\(\) && !ELUsingAArch32\(EL2\) then
        route_to_aarch64 = (HCR_EL2.TGE == '1' || IsSecondStage\(fault\) ||
            (HaveRASExt\(\) && HCR2.TEA == '1' && IsExternalAbort\(fault\)) ||
            (IsDebugException\(fault\) && MDCR_EL2.TDE == '1'));

    if !route_to_aarch64 && HaveEL\(EL3\) && !ELUsingAArch32\(EL3\) then
        route_to_aarch64 = SCR_EL3.EA == '1' && IsExternalAbort\(fault\);

    if route_to_aarch64 then
        AArch64.Abort\(ZeroExtend\(vaddress\), fault\);
    elseif fault.acctype == AccType\_IFETCH then
        AArch32.TakePrefetchAbortException\(vaddress, fault\);
    else
        AArch32.TakeDataAbortException\(vaddress, fault\);
```

## Library pseudocode for aarch32/exceptions/aborts/AArch32.AbortSyndrome

```
// AArch32.AbortSyndrome()
// =====
// Creates an exception syndrome record for Abort exceptions taken to Hyp mode
// from an AArch32 translation regime.

ExceptionRecord AArch32.AbortSyndrome(Exception exceptype, FaultRecord fault, bits(32) vaddress)
    exception = ExceptionSyndrome\(exceptype\);

    d_side = exceptype == Exception\_DataAbort;

    exception.syndrome = AArch32.FaultSyndrome\(d\_side, fault\);
    exception.vaddress = ZeroExtend\(vaddress\);
    if IPAValid\(fault\) then
        exception.ipavalid = TRUE;
        exception.NS = fault.ipaddress.NS;
        exception.ipaddress = ZeroExtend\(fault.ipaddress.address\);
    else
        exception.ipavalid = FALSE;

    return exception;
```

## Library pseudocode for aarch32/exceptions/aborts/AArch32.CheckPCAlignment

```
// AArch32.CheckPCAlignment()
// =====

AArch32.CheckPCAlignment()

    bits(32) pc = ThisInstrAddr\(\);
    if (CurrentInstrSet\(\) == InstrSet\_A32 && pc<1> == '1') || pc<0> == '1' then
        if AArch32.GeneralExceptionsToAArch64\(\) then AArch64.PCAlignmentFault\(\);

        // Generate an Alignment fault Prefetch Abort exception
        vaddress = pc;
        acctype = AccType\_IFETCH;
        iswrite = FALSE;
        secondstage = FALSE;
        AArch32.Abort\(vaddress, AArch32.AlignmentFault\(acctype, iswrite, secondstage\)\);
```

## Library pseudocode for aarch32/exceptions/aborts/AArch32.ReportDataAbort

```
// AArch32.ReportDataAbort()
// =====
// Report syndrome information for aborts taken to modes other than Hyp mode.

AArch32.ReportDataAbort(boolean route_to_monitor, FaultRecord fault, bits(32) vaddress)

    // The encoding used in the IFSR or DFSR can be Long-descriptor format or Short-descriptor
    // format. Normally, the current translation table format determines the format. For an abort
    // from Non-secure state to Monitor mode, the IFSR or DFSR uses the Long-descriptor format if
    // any of the following applies:
    // * The Secure TTBCR.EAE is set to 1.
    // * The abort is synchronous and either:
    //   - It is taken from Hyp mode.
    //   - It is taken from EL1 or EL0, and the Non-secure TTBCR.EAE is set to 1.
    long_format = FALSE;
    if route_to_monitor && !IsSecure() then
        long_format = TTBCR_S.EAE == '1';
        if !IsSErrorInterrupt(fault) && !long_format then
            long_format = PSTATE.EL == EL2 || TTBCR.EAE == '1';
    else
        long_format = TTBCR.EAE == '1';
    d_side = TRUE;
    if long_format then
        syndrome = AArch32.FaultStatusLD(d_side, fault);
    else
        syndrome = AArch32.FaultStatusSD(d_side, fault);

    if fault.acctype == AccType\_IC then
        if (!long_format &&
            boolean IMPLEMENTATION_DEFINED "Report I-cache maintenance fault in IFSR") then
            i_syndrome = syndrome;
            syndrome<10,3:0> = EncodeSDFSC(Fault\_ICacheMaint, 1);
        else
            i_syndrome = bits(32) UNKNOWN;
        if route_to_monitor then
            IFSR_S = i_syndrome;
        else
            IFSR = i_syndrome;

    if route_to_monitor then
        DFSR_S = syndrome;
        DFAR_S = vaddress;
    else
        DFSR = syndrome;
        DFAR = vaddress;

    return;
```

## Library pseudocode for aarch32/exceptions/aborts/AArch32.ReportPrefetchAbort

```
// AArch32.ReportPrefetchAbort()
// =====
// Report syndrome information for aborts taken to modes other than Hyp mode.

AArch32.ReportPrefetchAbort(boolean route_to_monitor, FaultRecord fault, bits(32) vaddress)
// The encoding used in the IFSR can be Long-descriptor format or Short-descriptor format.
// Normally, the current translation table format determines the format. For an abort from
// Non-secure state to Monitor mode, the IFSR uses the Long-descriptor format if any of the
// following applies:
// * The Secure TTBCR.EAE is set to 1.
// * It is taken from Hyp mode.
// * It is taken from EL1 or EL0, and the Non-secure TTBCR.EAE is set to 1.
long_format = FALSE;
if route_to_monitor && !IsSecure() then
    long_format = TTBCR_S.EAE == '1' || PSTATE.EL == EL2 || TTBCR.EAE == '1';
else
    long_format = TTBCR.EAE == '1';

d_side = FALSE;
if long_format then
    fsr = AArch32.FaultStatusLD(d_side, fault);
else
    fsr = AArch32.FaultStatusSD(d_side, fault);

if route_to_monitor then
    IFSR_S = fsr;
    IFAR_S = vaddress;
else
    IFSR = fsr;
    IFAR = vaddress;

return;
```

## Library pseudocode for aarch32/exceptions/aborts/AArch32.TakeDataAbortException

```
// AArch32.TakeDataAbortException()
// =====

AArch32.TakeDataAbortException(bits(32) vaddress, FaultRecord fault)
route_to_monitor = HaveEL(EL3) && SCR.EA == '1' && IsExternalAbort(fault);
route_to_hyp = (HaveEL(EL2) && !IsSecure() && PSTATE.EL IN {EL0, EL1} &&
    (HCR.TGE == '1' || IsSecondStage(fault) ||
    (HaveRASExt() && HCR2.TEA == '1' && IsExternalAbort(fault)) ||
    (IsDebugException(fault) && HDCR.TDE == '1')));
bits(32) preferred_exception_return = ThisInstrAddr();
vect_offset = 0x10;
lr_offset = 8;

if IsDebugException(fault) then DBGDSCRext.MOE = fault.debugmoe;
if route_to_monitor then
    AArch32.ReportDataAbort(route_to_monitor, fault, vaddress);
    AArch32.EnterMonitorMode(preferred_exception_return, lr_offset, vect_offset);
elseif PSTATE.EL == EL2 || route_to_hyp then
    exception = AArch32.AbortSyndrome(Exception\_DataAbort, fault, vaddress);
    if PSTATE.EL == EL2 then
        AArch32.EnterHypMode(exception, preferred_exception_return, vect_offset);
    else
        AArch32.EnterHypMode(exception, preferred_exception_return, 0x14);
else
    AArch32.ReportDataAbort(route_to_monitor, fault, vaddress);
    AArch32.EnterMode(M32\_Abort, preferred_exception_return, lr_offset, vect_offset);
```



## Library pseudocode for aarch32/exceptions/aborts/AArch32.TakePrefetchAbortException

```
// AArch32.TakePrefetchAbortException()
// =====

AArch32.TakePrefetchAbortException(bits(32) vaddress, FaultRecord fault)
    route_to_monitor = HaveEL\(EL3\) && SCR.EA == '1' && IsExternalAbort(fault);
    route_to_hyp = (HaveEL\(EL2\) && !IsSecure\(\) && PSTATE.EL IN {EL0, EL1} &&
        (HCR.TGE == '1' || IsSecondStage(fault) ||
        (HaveRASExt\(\) && HCR2.TEA == '1' && IsExternalAbort(fault)) ||
        (IsDebugException(fault) && HDCR.TDE == '1')));

    bits(32) preferred_exception_return = ThisInstrAddr\(\);

    vect_offset = 0x0C;

    lr_offset = 4;

    if IsDebugException(fault) then DBGDSCRext.MOE = fault.debugmoe;
    if route_to_monitor then
        AArch32.ReportPrefetchAbort(route_to_monitor, fault, vaddress);
        AArch32.EnterMonitorMode(preferred_exception_return, lr_offset, vect_offset);
    elseif PSTATE.EL == EL2 || route_to_hyp then
        if fault.statuscode == Fault\_Alignment then // PC Alignment fault
            exception = ExceptionSyndrome\(Exception\_PCAlignment\);
            exception.vaddress = ThisInstrAddr\(\);
        else
            exception = AArch32.AbortSyndrome\(Exception\_InstructionAbort, fault, vaddress\);
        if PSTATE.EL == EL2 then
            AArch32.EnterHypMode(exception, preferred_exception_return, vect_offset);
        else
            AArch32.EnterHypMode(exception, preferred_exception_return, 0x14);
    else
        AArch32.ReportPrefetchAbort(route_to_monitor, fault, vaddress);
        AArch32.EnterMode\(M32\_Abort, preferred\_exception\_return, lr\_offset, vect\_offset\);
```

## Library pseudocode for aarch32/exceptions/aborts/BranchTargetException

```
// BranchTargetException
// =====
// Raise branch target exception.

AArch64.BranchTargetException(bits(52) vaddress)

    route_to_el2 = PSTATE.EL == EL0 && EL2Enabled\(\) && HCR_EL2.TGE == '1';
    bits(64) preferred_exception_return = ThisInstrAddr\(\);
    vect_offset = 0x0;

    exception = ExceptionSyndrome\(Exception\_BranchTarget\);
    exception.syndrome<1:0> = PSTATE.BTYPE;
    exception.syndrome<24:2> = Zeros\(\); // RES0

    if UInt(PSTATE.EL) > UInt\(EL1\) then
        AArch64.TakeException(PSTATE.EL, exception, preferred_exception_return, vect_offset);
    elseif route_to_el2 then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch32/exceptions/asynch/AArch32.TakePhysicalFIQException

```
// AArch32.TakePhysicalFIQException()
// =====

AArch32.TakePhysicalFIQException()

    // Check if routed to AArch64 state
    route_to_aarch64 = PSTATE.EL == EL0 && !ELUsingAArch32(EL1);
    if !route_to_aarch64 && EL2Enabled() && !ELUsingAArch32(EL2) then
        route_to_aarch64 = HCR_EL2.TGE == '1' || (HCR_EL2.FMO == '1' && !IsInHost());

    if !route_to_aarch64 && HaveEL(EL3) && !ELUsingAArch32(EL3) then
        route_to_aarch64 = SCR_EL3.FIQ == '1';

    if route_to_aarch64 then AArch64.TakePhysicalFIQException();
    route_to_monitor = HaveEL(EL3) && SCR.FIQ == '1';
    route_to_hyp = (PSTATE.EL IN {EL0, EL1} && EL2Enabled() &&
        (HCR.TGE == '1' || HCR.FMO == '1'));
    bits(32) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x1C;
    lr_offset = 4;
    if route_to_monitor then
        AArch32.EnterMonitorMode(preferred_exception_return, lr_offset, vect_offset);
    elsif PSTATE.EL == EL2 || route_to_hyp then
        exception = ExceptionSyndrome(Exception_FIQ);
        AArch32.EnterHypMode(exception, preferred_exception_return, vect_offset);
    else
        AArch32.EnterMode(M32_FIQ, preferred_exception_return, lr_offset, vect_offset);
```

## Library pseudocode for aarch32/exceptions/asynch/AArch32.TakePhysicalIRQException

```
// AArch32.TakePhysicalIRQException()
// =====
// Take an enabled physical IRQ exception.

AArch32.TakePhysicalIRQException()

    // Check if routed to AArch64 state
    route_to_aarch64 = PSTATE.EL == EL0 && !ELUsingAArch32(EL1);
    if !route_to_aarch64 && EL2Enabled() && !ELUsingAArch32(EL2) then
        route_to_aarch64 = HCR_EL2.TGE == '1' || (HCR_EL2.IMO == '1' && !IsInHost());
    if !route_to_aarch64 && HaveEL(EL3) && !ELUsingAArch32(EL3) then
        route_to_aarch64 = SCR_EL3.IRQ == '1';

    if route_to_aarch64 then AArch64.TakePhysicalIRQException();

    route_to_monitor = HaveEL(EL3) && SCR.IRQ == '1';
    route_to_hyp = (PSTATE.EL IN {EL0, EL1} && EL2Enabled() &&
        (HCR.TGE == '1' || HCR.IMO == '1'));
    bits(32) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x18;
    lr_offset = 4;
    if route_to_monitor then
        AArch32.EnterMonitorMode(preferred_exception_return, lr_offset, vect_offset);
    elsif PSTATE.EL == EL2 || route_to_hyp then
        exception = ExceptionSyndrome(Exception_IRQ);
        AArch32.EnterHypMode(exception, preferred_exception_return, vect_offset);
    else
        AArch32.EnterMode(M32_IRQ, preferred_exception_return, lr_offset, vect_offset);
```

## Library pseudocode for aarch32/exceptions/asynch/AArch32.TakePhysicalSErrorException

```
// AArch32.TakePhysicalSErrorException()
// =====

AArch32.TakePhysicalSErrorException(boolean parity, bit extflag, bits(2) errortype,
                                     boolean impdef_syndrome, bits(24) full_syndrome)

    ClearPendingPhysicalSError();
    // Check if routed to AArch64 state
    route_to_aarch64 = PSTATE.EL == EL0 && !ELUsingAArch32(EL1);

    if !route_to_aarch64 && EL2Enabled() && !ELUsingAArch32(EL2) then
        route_to_aarch64 = (HCR_EL2.TGE == '1' || (!IsInHost() && HCR_EL2.AMO == '1'));
    if !route_to_aarch64 && HaveEL(EL3) && !ELUsingAArch32(EL3) then
        route_to_aarch64 = SCR_EL3.EA == '1';

    if route_to_aarch64 then
        AArch64.TakePhysicalSErrorException(impdef_syndrome, full_syndrome);

    route_to_monitor = HaveEL(EL3) && SCR.EA == '1';
    route_to_hyp = (PSTATE.EL IN {EL0, EL1} && EL2Enabled() &&
                   (HCR.TGE == '1' || HCR.AMO == '1'));
    bits(32) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x10;
    lr_offset = 8;

    fault = AArch32.AsynchExternalAbort(parity, errortype, extflag);
    vaddress = bits(32) UNKNOWN;
    if route_to_monitor then
        AArch32.ReportDataAbort(route_to_monitor, fault, vaddress);
        AArch32.EnterMonitorMode(preferred_exception_return, lr_offset, vect_offset);
    elseif PSTATE.EL == EL2 || route_to_hyp then
        exception = AArch32.AbortSyndrome(Exception_DataAbort, fault, vaddress);
        if PSTATE.EL == EL2 then
            AArch32.EnterHypMode(exception, preferred_exception_return, vect_offset);
        else
            AArch32.EnterHypMode(exception, preferred_exception_return, 0x14);
    else
        AArch32.ReportDataAbort(route_to_monitor, fault, vaddress);
        AArch32.EnterMode(M32_Abort, preferred_exception_return, lr_offset, vect_offset);
```

## Library pseudocode for aarch32/exceptions/asynch/AArch32.TakeVirtualFIQException

```
// AArch32.TakeVirtualFIQException()
// =====

AArch32.TakeVirtualFIQException()
    assert PSTATE.EL IN {EL0, EL1} && EL2Enabled();
    if ELUsingAArch32(EL2) then // Virtual IRQ enabled if TGE==0 and FMO==1
        assert HCR.TGE == '0' && HCR.FMO == '1';
    else
        assert HCR_EL2.TGE == '0' && HCR_EL2.FMO == '1';
    // Check if routed to AArch64 state
    if PSTATE.EL == EL0 && !ELUsingAArch32(EL1) then AArch64.TakeVirtualFIQException();

    bits(32) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x1C;
    lr_offset = 4;

    AArch32.EnterMode(M32_FIQ, preferred_exception_return, lr_offset, vect_offset);
```

## Library pseudocode for aarch32/exceptions/asynch/AArch32.TakeVirtualIRQException

```
// AArch32.TakeVirtualIRQException()
// =====

AArch32.TakeVirtualIRQException()
    assert PSTATE.EL IN {EL0, EL1} && EL2Enabled();

    if ELUsingAArch32(EL2) then // Virtual IRQs enabled if TGE==0 and IM0==1
        assert HCR.TGE == '0' && HCR.IM0 == '1';
    else
        assert HCR_EL2.TGE == '0' && HCR_EL2.IM0 == '1';

    // Check if routed to AArch64 state
    if PSTATE.EL == EL0 && !ELUsingAArch32(EL1) then AArch64.TakeVirtualIRQException();

    bits(32) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x18;
    lr_offset = 4;

    AArch32.EnterMode(M32_IRQ0, preferred_exception_return, lr_offset, vect_offset);
```

## Library pseudocode for aarch32/exceptions/asynch/AArch32.TakeVirtualSErrorException

```
// AArch32.TakeVirtualSErrorException()
// =====

AArch32.TakeVirtualSErrorException(bit extflag, bits(2) errortype, boolean impdef_syndrome, bits(24) fault_address)
    assert PSTATE.EL IN {EL0, EL1} && EL2Enabled();
    if ELUsingAArch32(EL2) then // Virtual SError enabled if TGE==0 and AM0==1
        assert HCR.TGE == '0' && HCR.AM0 == '1';
    else
        assert HCR_EL2.TGE == '0' && HCR_EL2.AM0 == '1';
    // Check if routed to AArch64 state
    if PSTATE.EL == EL0 && !ELUsingAArch32(EL1) then AArch64.TakeVirtualSErrorException(impdef_syndrome, fault_address);

    route_to_monitor = FALSE;

    bits(32) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x10;
    lr_offset = 8;

    vaddress = bits(32) UNKNOWN;
    parity = FALSE;
    if HaveRASExt() then
        if ELUsingAArch32(EL2) then
            fault = AArch32.AsynchExternalAbort(FALSE, VDFSR.AET, VDFSR.ExT);
        else
            fault = AArch32.AsynchExternalAbort(FALSE, VESR_EL2.AET, VESR_EL2.ExT);
    else
        fault = AArch32.AsynchExternalAbort(parity, errortype, extflag);

    ClearPendingVirtualSError();
    AArch32.ReportDataAbort(route_to_monitor, fault, vaddress);
    AArch32.EnterMode(M32_Abort, preferred_exception_return, lr_offset, vect_offset);
```

## Library pseudocode for aarch32/exceptions/debug/AArch32.SoftwareBreakpoint

```
// AArch32.SoftwareBreakpoint()
// =====

AArch32.SoftwareBreakpoint(bits(16) immediate)

    if (EL2Enabled() && !ELUsingAArch32(EL2) &&
        (HCR_EL2.TGE == '1' || MDCR_EL2.TDE == '1')) || !ELUsingAArch32(EL1) then
        AArch64.SoftwareBreakpoint(immediate);
    vaddress = bits(32) UNKNOWN;
    acctype = AccType_IFETCH;           // Take as a Prefetch Abort
    iswrite = FALSE;
    entry = DebugException_BKPT;

    fault = AArch32.DebugFault(acctype, iswrite, entry);
    AArch32.Abort(vaddress, fault);
```

## Library pseudocode for aarch32/exceptions/debug/DebugException

```
constant bits(4) DebugException_Breakpoint = '0001';
constant bits(4) DebugException_BKPT      = '0011';
constant bits(4) DebugException_VectorCatch = '0101';
constant bits(4) DebugException_Watchpoint = '1010';
```

## Library pseudocode for aarch32/exceptions/exceptions/AArch32.CheckAdvSIMDOrFPRegisterTraps

```
// AArch32.CheckAdvSIMDOrFPRegisterTraps()
// =====
// Check if an instruction that accesses an Advanced SIMD and
// floating-point System register is trapped by an appropriate HCR.TIDx
// ID group trap control.

AArch32.CheckAdvSIMDOrFPRegisterTraps(bits(4) reg)

    if PSTATE.EL == EL1 && EL2Enabled() then
        tid0 = if ELUsingAArch32(EL2) then HCR.TID0 else HCR_EL2.TID0;
        tid3 = if ELUsingAArch32(EL2) then HCR.TID3 else HCR_EL2.TID3;

        if (tid0 == '1' && reg == '0000')           // FPSID
            || (tid3 == '1' && reg IN {'0101', '0110', '0111'}) then // MVFRx
            if ELUsingAArch32(EL2) then
                AArch32.SystemAccessTrap(M32_Hyp, 0x8);           // Exception_AdvSIMDFPAccessTrap
            else
                AArch64.AArch32SystemAccessTrap(EL2, 0x8);        // Exception_AdvSIMDFPAccessTrap
```

## Library pseudocode for aarch32/exceptions/exceptions/AArch32.ExceptionClass

```
// AArch32.ExceptionClass()
// =====
// Returns the Exception Class and Instruction Length fields to be reported in HSR
(integer,bit) AArch32.ExceptionClass(Exception exceptype)

    il = if ThisInstrLength() == 32 then '1' else '0';

    case exceptype of
        when Exception_Uncategorized          ec = 0x00; il = '1';
        when Exception_WFxTrap                ec = 0x01;
        when Exception_CP15RRTTrap            ec = 0x03;
        when Exception_CP15RRTTrap            ec = 0x04;
        when Exception_CP14RRTTrap            ec = 0x05;
        when Exception_CP14DTTrap             ec = 0x06;
        when Exception_AdvSIMDFPAccessTrap    ec = 0x07;
        when Exception_FPIDTrap               ec = 0x08;
        when Exception_PACTrap                ec = 0x09;
        when Exception_TSTARTAccessTrap       ec = 0x1B;
        when Exception_CP14RRTTrap            ec = 0x0C;
        when Exception_BranchTarget           ec = 0x0D;
        when Exception_IllegalState           ec = 0x0E; il = '1';
        when Exception_SupervisorCall         ec = 0x11;
        when Exception_HypervisorCall         ec = 0x12;
        when Exception_MonitorCall            ec = 0x13;
        when Exception_ERetTrap               ec = 0x1A;
        when Exception_PACFail                ec = 0x1C;
        when Exception_InstructionAbort        ec = 0x20; il = '1';
        when Exception_PCAlignment            ec = 0x22; il = '1';
        when Exception_DataAbort              ec = 0x24;
        when Exception_NV2DataAbort           ec = 0x25;
        when Exception_FPtrappedException     ec = 0x28;
        otherwise                             Unreachable();

    if ec IN {0x20,0x24} && PSTATE.EL == EL2 then
        ec = ec + 1;

    return (ec,il);
```

## Library pseudocode for aarch32/exceptions/exceptions/AArch32.GeneralExceptionsToAArch64

```
// AArch32.GeneralExceptionsToAArch64()
// =====
// Returns TRUE if exceptions normally routed to EL1 are being handled at an Exception
// level using AArch64, because either EL1 is using AArch64 or TGE is in force and EL2
// is using AArch64.

boolean AArch32.GeneralExceptionsToAArch64()
    return ((PSTATE.EL == EL0 && !ELUsingAArch32(EL1)) ||
            (EL2Enabled() && !ELUsingAArch32(EL2) && HCR_EL2.TGE == '1'));
```

## Library pseudocode for aarch32/exceptions/exceptions/AArch32.ReportHypEntry

```
// AArch32.ReportHypEntry()
// =====
// Report syndrome information to Hyp mode registers.

AArch32.ReportHypEntry(ExceptionRecord exception)

    Exception exceptype = exception.exceptype;

    (ec,il) = AArch32.ExceptionClass(exceptype);
    iss = exception.syndrome;

    // IL is not valid for Data Abort exceptions without valid instruction syndrome information
    if ec IN {0x24,0x25} && iss<24> == '0' then
        il = '1';

    HSR = ec<5:0>:il:iss;

    if exceptype IN {Exception_InstructionAbort, Exception_PCAlignment} then
        HIFAR = exception.vaddress<31:0>;
        HDFAR = bits(32) UNKNOWN;
    elseif exceptype == Exception_DataAbort then
        HIFAR = bits(32) UNKNOWN;
        HDFAR = exception.vaddress<31:0>;

    if exception.ipavalid then
        HPFAR<31:4> = exception.ipaddress<39:12>;
    else
        HPFAR<31:4> = bits(28) UNKNOWN;

    return;
```

## Library pseudocode for aarch32/exceptions/exceptions/AArch32.ResetControlRegisters

```
// Resets System registers and memory-mapped control registers that have architecturally-defined
// reset values to those values.
AArch32.ResetControlRegisters(boolean cold_reset);
```

## Library pseudocode for aarch32/exceptions/exceptions/AArch32.TakeReset

```
// AArch32.TakeReset()
// =====
// Reset into AArch32 state

AArch32.TakeReset(boolean cold_reset)
    assert HighestELUsingAArch32\(\);

    // Enter the highest implemented Exception level in AArch32 state
    if HaveEL\(EL3\) then
        AArch32.WriteMode\(M32\_Svc\);
        SCR.NS = '0'; // Secure state
    elseif HaveEL\(EL2\) then
        AArch32.WriteMode\(M32\_Hyp\);
    else
        AArch32.WriteMode\(M32\_Svc\);

    // Reset the CP14 and CP15 registers and other system components
    AArch32.ResetControlRegisters\(cold\_reset\);
    FPEXC.EN = '0';

    // Reset all other PSTATE fields, including instruction set and endianness according to the
    // SCTLR values produced by the above call to ResetControlRegisters()
    PSTATE.<A,I,F> = '111'; // All asynchronous exceptions masked
    PSTATE.IT = '00000000'; // IT block state reset
    PSTATE.T = SCTLR.TE; // Instruction set: TE=0: A32, TE=1: T32. PSTATE.J is RES0.
    PSTATE.E = SCTLR.EE; // Endianness: EE=0: little-endian, EE=1: big-endian
    PSTATE.IL = '0'; // Clear Illegal Execution state bit

    // All registers, bits and fields not reset by the above pseudocode or by the BranchTo() call
    // below are UNKNOWN bitstrings after reset. In particular, the return information registers
    // R14 or ELR_hyp and SPSR have UNKNOWN values, so that it
    // is impossible to return from a reset in an architecturally defined way.
    AArch32.ResetGeneralRegisters\(\);
    AArch32.ResetSIMDFPRegisters\(\);
    AArch32.ResetSpecialRegisters\(\);
    ResetExternalDebugRegisters\(cold\_reset\);

    bits(32) rv; // IMPLEMENTATION DEFINED reset vector

    if HaveEL\(EL3\) then
        if MVBAR<0> == '1' then // Reset vector in MVBAR
            rv = MVBAR<31:1>:'0';
        else
            rv = bits(32) IMPLEMENTATION_DEFINED "reset vector address";
    else
        rv = RVBAR<31:1>:'0';

    // The reset vector must be correctly aligned
    assert rv<0> == '0' && (PSTATE.T == '1' || rv<1> == '0');

    BranchTo\(rv, BranchType\_RESET\);
```

## Library pseudocode for aarch32/exceptions/exceptions/ExcVectorBase

```
// ExcVectorBase()
// =====

bits(32) ExcVectorBase()
    if SCTLR.V == '1' then // Hivecs selected, base = 0xFFFF0000
        return Ones\(16\):Zeros\(16\);
    else
        return VBAR<31:5>:Zeros\(5\);
```



## Library pseudocode for aarch32/exceptions/ieeefp/AArch32.FPTrappedException

```
// AArch32.FPTrappedException()
// =====

AArch32.FPTrappedException(bits(8) accumulated_exceptions)
    if AArch32.GeneralExceptionsToAArch64\(\) then
        is_ase = FALSE;
        element = 0;
        AArch64.FPTrappedException(is_ase, element, accumulated_exceptions);
    FPExc.DEX = '1';
    FPExc.TFV = '1';
    FPExc<7,4:0> = accumulated_exceptions<7,4:0>; // IDF,IXF,UFF,OFF,DZF,I0F
    FPExc<10:8> = '111'; // VECITR is RES1

    AArch32.TakeUndefInstrException();
```

## Library pseudocode for aarch32/exceptions/syscalls/AArch32.CallHypervisor

```
// AArch32.CallHypervisor()
// =====
// Performs a HVC call

AArch32.CallHypervisor(bits(16) immediate)
    assert HaveEL\(EL2\);

    if !ELUsingAArch32\(EL2\) then
        AArch64.CallHypervisor(immediate);
    else
        AArch32.TakeHVCEException(immediate);
```

## Library pseudocode for aarch32/exceptions/syscalls/AArch32.CallSupervisor

```
// AArch32.CallSupervisor()
// =====
// Calls the Supervisor

AArch32.CallSupervisor(bits(16) immediate)

    if AArch32.CurrentCond\(\) != '1110' then
        immediate = bits(16) UNKNOWN;
    if AArch32.GeneralExceptionsToAArch64\(\) then
        AArch64.CallSupervisor(immediate);
    else
        AArch32.TakeSVCEException(immediate);
```

## Library pseudocode for aarch32/exceptions/syscalls/AArch32.TakeHVCEException

```
// AArch32.TakeHVCEException()
// =====

AArch32.TakeHVCEException(bits(16) immediate)
    assert HaveEL\(EL2\) && ELUsingAArch32\(EL2\);

    AArch32.ITAdvance();
    SSAdvance();
    bits(32) preferred_exception_return = NextInstrAddr();
    vect_offset = 0x08;

    exception = ExceptionSyndrome\(Exception\_HypervisorCall\);
    exception.syndrome<15:0> = immediate;

    if PSTATE.EL == EL2 then
        AArch32.EnterHypMode(exception, preferred_exception_return, vect_offset);
    else
        AArch32.EnterHypMode(exception, preferred_exception_return, 0x14);
```

## Library pseudocode for aarch32/exceptions/syscalls/AArch32.TakeSMCException

```
// AArch32.TakeSMCException()
// =====

AArch32.TakeSMCException()
    assert HaveEL(EL3) && ELUsingAArch32(EL3);
    AArch32.ITAdvance();
    SSAdvance();
    bits(32) preferred_exception_return = NextInstrAddr();
    vect_offset = 0x08;
    lr_offset = 0;

    AArch32.EnterMonitorMode(preferred_exception_return, lr_offset, vect_offset);
```

## Library pseudocode for aarch32/exceptions/syscalls/AArch32.TakeSVCException

```
// AArch32.TakeSVCException()
// =====

AArch32.TakeSVCException(bits(16) immediate)

    AArch32.ITAdvance();
    SSAdvance();
    route_to_hyp = PSTATE.EL == EL0 && EL2Enabled() && HCR.TGE == '1';

    bits(32) preferred_exception_return = NextInstrAddr();
    vect_offset = 0x08;
    lr_offset = 0;

    if PSTATE.EL == EL2 || route_to_hyp then
        exception = ExceptionSyndrome(Exception_SupervisorCall);
        exception.syndrome<15:0> = immediate;
        if PSTATE.EL == EL2 then
            AArch32.EnterHypMode(exception, preferred_exception_return, vect_offset);
        else
            AArch32.EnterHypMode(exception, preferred_exception_return, 0x14);
    else
        AArch32.EnterMode(M32_Svc, preferred_exception_return, lr_offset, vect_offset);
```

## Library pseudocode for aarch32/exceptions/takeexception/AArch32.EnterHypMode

```
// AArch32.EnterHypMode()
// =====
// Take an exception to Hyp mode.

AArch32.EnterHypMode(ExceptionRecord exception, bits(32) preferred_exception_return,
                    integer vect_offset)
    SynchronizeContext();
    assert HaveEL(EL2) && !IsSecure() && ELUsingAArch32(EL2);

    spsr = GetPSRFromPSTATE();
    if !(exception.exceptype IN {Exception_IRQ, Exception_FIQ}) then
        AArch32.ReportHypEntry(exception);
    AArch32.WriteMode(M32_Hyp);
    SPSR[] = spsr;
    ELR_hyp = preferred_exception_return;
    PSTATE.T = HSCTLR.TE; // PSTATE.J is RES0
    PSTATE.SS = '0';
    if !HaveEL(EL3) || SCR_GEN[].EA == '0' then PSTATE.A = '1';
    if !HaveEL(EL3) || SCR_GEN[].IRQ == '0' then PSTATE.I = '1';
    if !HaveEL(EL3) || SCR_GEN[].FIQ == '0' then PSTATE.F = '1';
    PSTATE.E = HSCTLR.EE;
    PSTATE.IL = '0';
    PSTATE.IT = '00000000';
    if HaveSSBSExt() then PSTATE.SSBS = HSCTLR.DSSBS;
    BranchTo(HVBAR<31:5>:vect_offset<4:0>, BranchType_EXCEPTION);

    EndOfInstruction();
```

## Library pseudocode for aarch32/exceptions/takeexception/AArch32.EnterMode

```
// AArch32.EnterMode()
// =====
// Take an exception to a mode other than Monitor and Hyp mode.

AArch32.EnterMode(bits(5) target_mode, bits(32) preferred_exception_return, integer lr_offset,
                 integer vect_offset)
    SynchronizeContext();
    assert ELUsingAArch32(EL1) && PSTATE.EL != EL2;

    spsr = GetPSRFromPSTATE();
    if PSTATE.M == M32_Monitor then SCR.NS = '0';
    AArch32.WriteMode(target_mode);
    SPSR[] = spsr;
    R[14] = preferred_exception_return + lr_offset;
    PSTATE.T = SCTLR.TE; // PSTATE.J is RES0
    PSTATE.SS = '0';
    if target_mode == M32_FIQ then
        PSTATE.<A,I,F> = '111';
    elsif target_mode IN {M32_Abort, M32_IRQ} then
        PSTATE.<A,I> = '11';
    else
        PSTATE.I = '1';
    PSTATE.E = SCTLR.EE;
    PSTATE.IL = '0';
    PSTATE.IT = '00000000';
    if HavePANExt() && SCTLR.SPAN == '0' then PSTATE.PAN = '1';
    if HaveSSBSExt() then PSTATE.SSBS = SCTLR.DSSBS;
    BranchTo(ExcVectorBase()<31:5>:vect_offset<4:0>, BranchType_EXCEPTION);

    EndOfInstruction();
```

## Library pseudocode for aarch32/exceptions/takeexception/AArch32.EnterMonitorMode

```
// AArch32.EnterMonitorMode()
// =====
// Take an exception to Monitor mode.

AArch32.EnterMonitorMode(bits(32) preferred_exception_return, integer lr_offset,
                        integer vect_offset)
    SynchronizeContext();
    assert HaveEL(EL3) && ELUsingAArch32(EL3);
    from_secure = IsSecure();
    spsr = GetPSRFromPSTATE();
    if PSTATE.M == M32_Monitor then SCR.NS = '0';
    AArch32.WriteMode(M32_Monitor);
    SPSR[] = spsr;
    R[14] = preferred_exception_return + lr_offset;
    PSTATE.T = SCTL.R.TE; // PSTATE.J is RES0
    PSTATE.SS = '0';
    PSTATE.<A,I,F> = '111';
    PSTATE.E = SCTL.R.EE;
    PSTATE.IL = '0';
    PSTATE.IT = '00000000';
    if HavePANExt() then
        if !from_secure then
            PSTATE.PAN = '0';
        elsif SCTL.R.SPAN == '0' then
            PSTATE.PAN = '1';
    if HaveSSBSEExt() then PSTATE.SSBS = SCTL.R.DSSBS;
    BranchTo(MVBAR<31:5>:vect_offset<4:0>, BranchType_EXCEPTION);

    EndOfInstruction();
```

## Library pseudocode for aarch32/exceptions/traps/AArch32.CheckAdvSIMDOrFPEEnabled

```
// AArch32.CheckAdvSIMDOrFPEEnabled()
// =====
// Check against CPACR, FPEXC, HCPTR, NSACR, and CPTR_EL3.

AArch32.CheckAdvSIMDOrFPEEnabled(boolean fpexc_check, boolean advsimd)
    if PSTATE.EL == EL0 && (!HaveEL(EL2) || (!ELUsingAArch32(EL2) && HCR_EL2.TGE == '0')) && !ELUsingAArch32(EL2)
        // The PE behaves as if FPEXC.EN is 1
        AArch64.CheckFPAdvSIMDEnabled();
    elsif PSTATE.EL == EL0 && HaveEL(EL2) && !ELUsingAArch32(EL2) && HCR_EL2.TGE == '1' && !ELUsingAArch32(EL2)
        if fpexc_check && HCR_EL2.RW == '0' then
            fpexc_en = bits(1) IMPLEMENTATION_DEFINED "FPEXC.EN value when TGE==1 and RW==0";
            if fpexc_en == '0' then UNDEFINED;
            AArch64.CheckFPAdvSIMDEnabled();
        else
            cpacr_asedis = CPACR.ASEDIS;
            cpacr_cp10 = CPACR.cp10;

            if HaveEL(EL3) && ELUsingAArch32(EL3) && !IsSecure() then
                // Check if access disabled in NSACR
                if NSACR.NSASEDIS == '1' then cpacr_asedis = '1';
                if NSACR.cp10 == '0' then cpacr_cp10 = '00';

            if PSTATE.EL != EL2 then
                // Check if Advanced SIMD disabled in CPACR
                if advsimd && cpacr_asedis == '1' then UNDEFINED;

                // Check if access disabled in CPACR
                case cpacr_cp10 of
                    when '00' disabled = TRUE;
                    when '01' disabled = PSTATE.EL == EL0;
                    when '10' disabled = ConstrainUnpredictableBool(Unpredictable_RESCPACR);
                    when '11' disabled = FALSE;
                if disabled then UNDEFINED;

            // If required, check FPEXC enabled bit.
            if fpexc_check && FPEXC.EN == '0' then UNDEFINED;

            AArch32.CheckFPAdvSIMDTrap(advsimd);    // Also check against HCPTR and CPTR_EL3
```

## Library pseudocode for aarch32/exceptions/traps/AArch32.CheckFPAdvSIMDTrap

```
// AArch32.CheckFPAdvSIMDTrap()
// =====
// Check against CPTR_EL2 and CPTR_EL3.

AArch32.CheckFPAdvSIMDTrap(boolean advsimd)
  if EL2Enabled\(\) && !ELUsingAArch32\(EL2\) then
    AArch64.CheckFPAdvSIMDTrap\(\);
  else
    if HaveEL\(EL2\) && !IsSecure\(\) then
      hcptr_tase = HCPTR.TASE;
      hcptr_cp10 = HCPTR.TCP10;

      if HaveEL\(EL3\) && ELUsingAArch32\(EL3\) && !IsSecure\(\) then
        // Check if access disabled in NSACR
        if NSACR.NSASEDIS == '1' then hcptr_tase = '1';
        if NSACR.cp10 == '0' then hcptr_cp10 = '1';

        // Check if access disabled in HCPTR
        if (advsimd && hcptr_tase == '1') || hcptr_cp10 == '1' then
          exception = ExceptionSyndrome\(Exception\_AdvSIMDFPAccessTrap\);
          exception.syndrome<24:20> = ConditionSyndrome\(\);

          if advsimd then
            exception.syndrome<5> = '1';
          else
            exception.syndrome<5> = '0';
            exception.syndrome<3:0> = '1010';           // coproc field, always 0xA

          if PSTATE.EL == EL2 then
            AArch32.TakeUndefInstrException\(exception\);
          else
            AArch32.TakeHypTrapException\(exception\);

    if HaveEL\(EL3\) && !ELUsingAArch32\(EL3\) then
      // Check if access disabled in CPTR_EL3
      if CPTR_EL3.TFP == '1' then AArch64.AdvSIMDFPAccessTrap\(EL3\);

  return;
```

## Library pseudocode for aarch32/exceptions/traps/AArch32.CheckForSMCUndefOrTrap

```
// AArch32.CheckForSMCUndefOrTrap()
// =====
// Check for UNDEFINED or trap on SMC instruction

AArch32.CheckForSMCUndefOrTrap()
  if !HaveEL\(EL3\) || PSTATE.EL == EL0 then
    UNDEFINED;

  if EL2Enabled\(\) && !ELUsingAArch32\(EL2\) then
    AArch64.CheckForSMCUndefOrTrap\(Zeros\(16\)\);
  else
    route_to_hyp = HaveEL\(EL2\) && !IsSecure\(\) && PSTATE.EL == EL1 && HCR.TSC == '1';
    if route_to_hyp then
      exception = ExceptionSyndrome\(Exception\_MonitorCall\);
      AArch32.TakeHypTrapException\(exception\);
```

## Library pseudocode for aarch32/exceptions/traps/AArch32.CheckForSVCTrap

```
// AArch32.CheckForSVCTrap()
// =====
// Check for trap on SVC instruction

AArch32.CheckForSVCTrap(bits(16) immediate)
    if HaveFGTExt() then
        route_to_el2 = FALSE;
        if PSTATE.EL == EL0 then
            route_to_el2 = !ELUsingAArch32(EL1) && EL2Enabled() && HFGITR_EL2.SVC_EL0 == '1' &&

        if route_to_el2 then
            exception = ExceptionSyndrome(Exception_SupervisorCall);
            exception.syndrome<15:0> = immediate;
            bits(64) preferred_exception_return = ThisInstrAddr();
            vect_offset = 0x0;

            AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch32/exceptions/traps/AArch32.CheckForWFXTrap

```
// AArch32.CheckForWFXTrap()
// =====
// Check for trap on WFE or WFI instruction

AArch32.CheckForWFXTrap(bits(2) target_el, boolean is_wfe)
    assert HaveEL(target_el);

    // Check for routing to AArch64
    if !ELUsingAArch32(target_el) then
        AArch64.CheckForWFXTrap(target_el, is_wfe);
        return;

    case target_el of
        when EL1
            trap = (if is_wfe then SCTLR.nTWE else SCTLR.nTWI) == '0';
        when EL2
            trap = (if is_wfe then HCR.TWE else HCR.TWI) == '1';
        when EL3
            trap = (if is_wfe then SCR.TWE else SCR.TWI) == '1';

    if trap then
        if target_el == EL1 && EL2Enabled() && !ELUsingAArch32(EL2) && HCR_EL2.TGE == '1' then
            AArch64.WFXTrap(target_el, is_wfe);

        if target_el == EL3 then
            AArch32.TakeMonitorTrapException();
        elseif target_el == EL2 then
            exception = ExceptionSyndrome(Exception_WFXTrap);
            exception.syndrome<24:20> = ConditionSyndrome();
            exception.syndrome<0> = if is_wfe then '1' else '0';
            AArch32.TakeHypTrapException(exception);
        else
            AArch32.TakeUndefInstrException();
```

## Library pseudocode for aarch32/exceptions/traps/AArch32.CheckITEnabled

```
// AArch32.CheckITEnabled()
// =====
// Check whether the T32 IT instruction is disabled.

AArch32.CheckITEnabled(bits(4) mask)
    if PSTATE.EL == EL2 then
        it_disabled = HSCTLR.ITD;
    else
        it_disabled = (if ELUsingAArch32(EL1) then SCTLR.ITD else SCTLR[.].ITD);
    if it_disabled == '1' then
        if mask != '1000' then UNDEFINED;

    // Otherwise whether the IT block is allowed depends on hw1 of the next instruction.
    next_instr = AArch32.MemSingle[NextInstrAddr(), 2, AccType_IFETCH, TRUE];

    if next_instr IN {'11xxxxxxxxxxxx', '1011xxxxxxxxxxxx', '10100xxxxxxxxxxxx',
                     '01001xxxxxxxxxxxx', '010001xxx1111xxx', '010001xx1xxxx111'} then
        // It is IMPLEMENTATION DEFINED whether the Undefined Instruction exception is
        // taken on the IT instruction or the next instruction. This is not reflected in
        // the pseudocode, which always takes the exception on the IT instruction. This
        // also does not take into account cases where the next instruction is UNPREDICTABLE.
        UNDEFINED;

    return;
```

## Library pseudocode for aarch32/exceptions/traps/AArch32.CheckIllegalState

```
// AArch32.CheckIllegalState()
// =====
// Check PSTATE.IL bit and generate Illegal Execution state exception if set.

AArch32.CheckIllegalState()
    if AArch32.GeneralExceptionsToAArch64() then
        AArch64.CheckIllegalState();
    elsif PSTATE.IL == '1' then
        route_to_hyp = PSTATE.EL == EL0 && EL2Enabled() && HCR.TGE == '1';

        bits(32) preferred_exception_return = ThisInstrAddr();
        vect_offset = 0x04;

        if PSTATE.EL == EL2 || route_to_hyp then
            exception = ExceptionSyndrome(Exception_IllegalState);
            if PSTATE.EL == EL2 then
                AArch32.EnterHypMode(exception, preferred_exception_return, vect_offset);
            else
                AArch32.EnterHypMode(exception, preferred_exception_return, 0x14);
        else
            AArch32.TakeUndefInstrException();
```

## Library pseudocode for aarch32/exceptions/traps/AArch32.CheckSETENDEnabled

```
// AArch32.CheckSETENDEnabled()
// =====
// Check whether the AArch32 SETEND instruction is disabled.

AArch32.CheckSETENDEnabled()
    if PSTATE.EL == EL2 then
        setend_disabled = HSCTLR.SED;
    else
        setend_disabled = (if ELUsingAArch32(EL1) then SCTLR.SED else SCTLR[.].SED);
    if setend_disabled == '1' then
        UNDEFINED;

    return;
```



## Library pseudocode for aarch32/exceptions/traps/AArch32.SystemAccessTrap

```
// AArch32.SystemAccessTrap()
// =====
// Trapped system register access.

AArch32.SystemAccessTrap(bits(5) mode, integer ec)
    (valid, target_el) = ELFromM32(mode);
    assert valid && HaveEL(target_el) && target_el != EL0 && UInt(target_el) >= UInt(PSTATE.EL);

    if target_el == EL2 then
        exception = AArch32.SystemAccessTrapSyndrome(ThisInstr(), ec);
        AArch32.TakeHypTrapException(exception);
    else
        AArch32.TakeUndefInstrException();
```

## Library pseudocode for aarch32/exceptions/traps/AArch32.SystemAccessTrapSyndrome

```
// AArch32.SystemAccessTrapSyndrome()
// =====
// Returns the syndrome information for traps on AArch32 MCR, MCRR, MRC, MRRC, and VMRS, VMSR instructions
// other than traps that are due to HCPTR or CPACR.

ExceptionRecord AArch32.SystemAccessTrapSyndrome(bits(32) instr, integer ec)
    ExceptionRecord exception;

    case ec of
        when 0x0    exception = ExceptionSyndrome(Exception_Uncategorized);
        when 0x3    exception = ExceptionSyndrome(Exception_CP15RTTTrap);
        when 0x4    exception = ExceptionSyndrome(Exception_CP15RRTTrap);
        when 0x5    exception = ExceptionSyndrome(Exception_CP14RTTTrap);
        when 0x6    exception = ExceptionSyndrome(Exception_CP14DTTTrap);
        when 0x7    exception = ExceptionSyndrome(Exception_AdvSIMDFPAccessTrap);
        when 0x8    exception = ExceptionSyndrome(Exception_FPIDTrap);
        when 0xC    exception = ExceptionSyndrome(Exception_CP14RRTTrap);
        otherwise   Unreachable();

    bits(20) iss = Zeros();

    if exception.exceptype IN {Exception_FPIDTrap, Exception_CP14RTTTrap, Exception_CP15RTTTrap} then
        // Trapped MRC/MCR, VMRS on FPSID
        iss<13:10> = instr<19:16>;        // CRn, Reg in case of VMRS
        iss<8:5>   = instr<15:12>;        // Rt
        iss<9>     = '0';                 // RES0

        if exception.exceptype != Exception_FPIDTrap then    // When trap is not for VMRS
            iss<19:17> = instr<7:5>;        // opc2
            iss<16:14> = instr<23:21>;      // opc1
            iss<4:1>   = instr<3:0>;        // CRm
        else //VMRS Access
            iss<19:17> = '000';            //opc2 - Hardcoded for VMRS
            iss<16:14> = '111';            //opc1 - Hardcoded for VMRS
            iss<4:1>   = '0000';           //CRm - Hardcoded for VMRS
        elsif exception.exceptype IN {Exception_CP14RRTTrap, Exception_AdvSIMDFPAccessTrap, Exception_CP15RRTTrap} then
            // Trapped MRRC/MCRR, VMRS/VMSR
            iss<19:16> = instr<7:4>;        // opc1
            iss<13:10> = instr<19:16>;      // Rt2
            iss<8:5>   = instr<15:12>;      // Rt
            iss<4:1>   = instr<3:0>;        // CRm
        elsif exception.exceptype == Exception_CP14DTTTrap then
            // Trapped LDC/STC
            iss<19:12> = instr<7:0>;        // imm8
            iss<4>     = instr<23>;         // U
            iss<2:1>   = instr<24,21>;      // P,W
            if instr<19:16> == '1111' then // Rn==15, LDC(Literal addressing)/STC
                iss<8:5> = bits(4) UNKNOWN;
                iss<3>   = '1';
            elsif exception.exceptype == Exception_Uncategorized then
                // Trapped for unknown reason
                iss<8:5> = instr<19:16>;    // Rn
                iss<3>   = '0';

            iss<0> = instr<20>;            // Direction

        exception.syndrome<24:20> = ConditionSyndrome();
        exception.syndrome<19:0>  = iss;

    return exception;
```

## Library pseudocode for aarch32/exceptions/traps/AArch32.TakeHypTrapException

```
// AArch32.TakeHypTrapException()
// =====
// Exceptions routed to Hyp mode as a Hyp Trap exception.

AArch32.TakeHypTrapException(integer ec)
    exception = AArch32.SystemAccessTrapSyndrome(ThisInstr(), ec);
    AArch32.TakeHypTrapException(exception);

// AArch32.TakeHypTrapException()
// =====
// Exceptions routed to Hyp mode as a Hyp Trap exception.

AArch32.TakeHypTrapException(ExceptionRecord exception)
    assert HaveEL(EL2) && !IsSecure() && ELUsingAArch32(EL2);

    bits(32) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x14;

    AArch32.EnterHypMode(exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch32/exceptions/traps/AArch32.TakeMonitorTrapException

```
// AArch32.TakeMonitorTrapException()
// =====
// Exceptions routed to Monitor mode as a Monitor Trap exception.

AArch32.TakeMonitorTrapException()
    assert HaveEL(EL3) && ELUsingAArch32(EL3);

    bits(32) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x04;
    lr_offset = if CurrentInstrSet() == InstrSet_A32 then 4 else 2;

    AArch32.EnterMonitorMode(preferred_exception_return, lr_offset, vect_offset);
```

## Library pseudocode for aarch32/exceptions/traps/AArch32.TakeUndefInstrException

```
// AArch32.TakeUndefInstrException()
// =====

AArch32.TakeUndefInstrException()
    exception = ExceptionSyndrome(Exception_Uncategorized);
    AArch32.TakeUndefInstrException(exception);

// AArch32.TakeUndefInstrException()
// =====

AArch32.TakeUndefInstrException(ExceptionRecord exception)

    route_to_hyp = PSTATE.EL == EL0 && EL2Enabled() && HCR.TGE == '1';
    bits(32) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x04;
    lr_offset = if CurrentInstrSet() == InstrSet_A32 then 4 else 2;

    if PSTATE.EL == EL2 then
        AArch32.EnterHypMode(exception, preferred_exception_return, vect_offset);
    elseif route_to_hyp then
        AArch32.EnterHypMode(exception, preferred_exception_return, 0x14);
    else
        AArch32.EnterMode(M32_Undef, preferred_exception_return, lr_offset, vect_offset);
```

## Library pseudocode for aarch32/exceptions/traps/AArch32.UndefinedFault

```
// AArch32.UndefinedFault()
// =====

AArch32.UndefinedFault()

    if AArch32.GeneralExceptionsToAArch64() then AArch64.UndefinedFault();
    AArch32.TakeUndefInstrException();
```

## Library pseudocode for aarch32/functions/aborts/AArch32.CreateFaultRecord

```
// AArch32.CreateFaultRecord()
// =====

FaultRecord AArch32.CreateFaultRecord(Fault statuscode, bits(40) ipaddress, bits(4) domain,
                                       integer level, AccType acctype, boolean write, bit extflag,
                                       bits(4) debugmoe, bits(2) errortype, boolean secondstage, boolean s2fslwalk)

    FaultRecord fault;
    fault.statuscode = statuscode;
    if (statuscode != Fault_None && PSTATE.EL != EL2 && TTBCR.EAE == '0' && !secondstage && !s2fslwalk &&
        AArch32.DomainValid(statuscode, level)) then
        fault.domain = domain;
    else
        fault.domain = bits(4) UNKNOWN;
    fault.debugmoe = debugmoe;
    fault.errortype = errortype;
    fault.ipaddress.NS = bit UNKNOWN;
    fault.ipaddress.address = ZeroExtend(ipaddress);
    fault.level = level;
    fault.acctype = acctype;
    fault.write = write;
    fault.extflag = extflag;
    fault.secondstage = secondstage;
    fault.s2fslwalk = s2fslwalk;

    return fault;
```

## Library pseudocode for aarch32/functions/aborts/AArch32.DomainValid

```
// AArch32.DomainValid()
// =====
// Returns TRUE if the Domain is valid for a Short-descriptor translation scheme.

boolean AArch32.DomainValid(Fault statuscode, integer level)
    assert statuscode != Fault_None;

    case statuscode of
        when Fault_Domain
            return TRUE;
        when Fault_Translation, Fault_AccessFlag, Fault_SyncExternalOnWalk, Fault_SyncParityOnWalk
            return level == 2;
        otherwise
            return FALSE;
```

## Library pseudocode for aarch32/functions/aborts/AArch32.FaultStatusLD

```
// AArch32.FaultStatusLD()
// =====
// Creates an exception fault status value for Abort and Watchpoint exceptions taken
// to Abort mode using AArch32 and Long-descriptor format.

bits(32) AArch32.FaultStatusLD(boolean d_side, FaultRecord fault)
    assert fault.statuscode != Fault\_None;

    bits(32) fsr = Zeros();
    if HaveRASExt() && IsAsyncAbort(fault) then fsr<15:14> = fault.errortype;
    if d_side then
        if fault.acctype IN {AccType\_DC, AccType\_IC, AccType\_AT} then
            fsr<13> = '1'; fsr<11> = '1';
        else
            fsr<11> = if fault.write then '1' else '0';
    if IsExternalAbort(fault) then fsr<12> = fault.extflag;
    fsr<9> = '1';
    fsr<5:0> = EncodeLDFSC(fault.statuscode, fault.level);

    return fsr;
```

## Library pseudocode for aarch32/functions/aborts/AArch32.FaultStatusSD

```
// AArch32.FaultStatusSD()
// =====
// Creates an exception fault status value for Abort and Watchpoint exceptions taken
// to Abort mode using AArch32 and Short-descriptor format.

bits(32) AArch32.FaultStatusSD(boolean d_side, FaultRecord fault)
    assert fault.statuscode != Fault\_None;

    bits(32) fsr = Zeros();
    if HaveRASExt() && IsAsyncAbort(fault) then fsr<15:14> = fault.errortype;
    if d_side then
        if fault.acctype IN {AccType\_DC, AccType\_IC, AccType\_AT} then
            fsr<13> = '1'; fsr<11> = '1';
        else
            fsr<11> = if fault.write then '1' else '0';
    if IsExternalAbort(fault) then fsr<12> = fault.extflag;
    fsr<9> = '0';
    fsr<10,3:0> = EncodeSDFSC(fault.statuscode, fault.level);
    if d_side then
        fsr<7:4> = fault.domain; // Domain field (data fault only)

    return fsr;
```

## Library pseudocode for aarch32/functions/aborts/AArch32.FaultSyndrome

```
// AArch32.FaultSyndrome()
// =====
// Creates an exception syndrome value for Abort and Watchpoint exceptions taken to
// AArch32 Hyp mode.

bits(25) AArch32.FaultSyndrome(boolean d_side, FaultRecord fault)
    assert fault.statuscode != Fault\_None;

    bits(25) iss = Zeros();
    if HaveRASExt() && IsAsyncAbort(fault) then iss<11:10> = fault.errortype; // AET
    if d_side then
        if IsSecondStage(fault) && !fault.s2fslwalk then iss<24:14> = LSInstructionSyndrome();
        if fault.acctype IN {AccType\_DC, AccType\_DC\_UNPRIV, AccType\_IC, AccType\_AT} then
            iss<8> = '1'; iss<6> = '1';
        else
            iss<6> = if fault.write then '1' else '0';
    if IsExternalAbort(fault) then iss<9> = fault.extflag;
    iss<7> = if fault.s2fslwalk then '1' else '0';
    iss<5:0> = EncodeLDFSC(fault.statuscode, fault.level);

    return iss;
```

## Library pseudocode for aarch32/functions/aborts/EncodeSDFSC

```
// EncodeSDFSC()
// =====
// Function that gives the Short-descriptor FSR code for different types of Fault
bits(5) EncodeSDFSC(Fault statuscode, integer level)

bits(5) result;
case statuscode of
  when Fault\_AccessFlag
    assert level IN {1,2};
    result = if level == 1 then '00011' else '00110';
  when Fault\_Alignment
    result = '00001';
  when Fault\_Permission
    assert level IN {1,2};
    result = if level == 1 then '01101' else '01111';
  when Fault\_Domain
    assert level IN {1,2};
    result = if level == 1 then '01001' else '01011';
  when Fault\_Translation
    assert level IN {1,2};
    result = if level == 1 then '00101' else '00111';
  when Fault\_SyncExternal
    result = '01000';
  when Fault\_SyncExternalOnWalk
    assert level IN {1,2};
    result = if level == 1 then '01100' else '01110';
  when Fault\_SyncParity
    result = '11001';
  when Fault\_SyncParityOnWalk
    assert level IN {1,2};
    result = if level == 1 then '11100' else '11110';
  when Fault\_AsyncParity
    result = '11000';
  when Fault\_AsyncExternal
    result = '10110';
  when Fault\_Debug
    result = '00010';
  when Fault\_TLBConflict
    result = '10000';
  when Fault\_Lockdown
    result = '10100'; // IMPLEMENTATION DEFINED
  when Fault\_Exclusive
    result = '10101'; // IMPLEMENTATION DEFINED
  when Fault\_ICacheMaint
    result = '00100';
  otherwise
    Unreachable\(\);

return result;
```

## Library pseudocode for aarch32/functions/common/A32ExpandImm

```
// A32ExpandImm()
// =====

bits(32) A32ExpandImm(bits(12) imm12)

// PSTATE.C argument to following function call does not affect the imm32 result.
(imm32, -) = A32ExpandImm\_C(imm12, PSTATE.C);

return imm32;
```

### Library pseudocode for aarch32/functions/common/A32ExpandImm\_C

```
// A32ExpandImm_C()
// =====

(bits(32), bit) A32ExpandImm_C(bits(12) imm12, bit carry_in)

    unrotated_value = ZeroExtend(imm12<7:0>, 32);
    (imm32, carry_out) = Shift_C(unrotated_value, SRTYPE_ROR, 2*UInt(imm12<11:8>), carry_in);

    return (imm32, carry_out);
```

### Library pseudocode for aarch32/functions/common/DecodeImmShift

```
// DecodeImmShift()
// =====

(SRType, integer) DecodeImmShift(bits(2) srtype, bits(5) imm5)

    case srtype of
        when '00'
            shift_t = SRTYPE_LSL; shift_n = UInt(imm5);
        when '01'
            shift_t = SRTYPE_LSR; shift_n = if imm5 == '00000' then 32 else UInt(imm5);
        when '10'
            shift_t = SRTYPE_ASR; shift_n = if imm5 == '00000' then 32 else UInt(imm5);
        when '11'
            if imm5 == '00000' then
                shift_t = SRTYPE_RRX; shift_n = 1;
            else
                shift_t = SRTYPE_ROR; shift_n = UInt(imm5);

    return (shift_t, shift_n);
```

### Library pseudocode for aarch32/functions/common/DecodeRegShift

```
// DecodeRegShift()
// =====

SRType DecodeRegShift(bits(2) srtype)
    case srtype of
        when '00' shift_t = SRTYPE_LSL;
        when '01' shift_t = SRTYPE_LSR;
        when '10' shift_t = SRTYPE_ASR;
        when '11' shift_t = SRTYPE_ROR;
    return shift_t;
```

### Library pseudocode for aarch32/functions/common/RRX

```
// RRX()
// =====

bits(N) RRX(bits(N) x, bit carry_in)
    (result, -) = RRX_C(x, carry_in);
    return result;
```

### Library pseudocode for aarch32/functions/common/RRX\_C

```
// RRX_C()
// =====

(bits(N), bit) RRX_C(bits(N) x, bit carry_in)
    result = carry_in : x<N-1:1>;
    carry_out = x<0>;
    return (result, carry_out);
```



## Library pseudocode for aarch32/functions/common/SRType

```
enumeration SRType {SRType_LSL, SRType_LSR, SRType_ASR, SRType_ROR, SRType_RRX};
```

## Library pseudocode for aarch32/functions/common/Shift

```
// Shift()
// =====

bits(N) Shift(bits(N) value, SRType srtype, integer amount, bit carry_in)
    (result, -) = Shift\_C(value, srtype, amount, carry_in);
    return result;
```

## Library pseudocode for aarch32/functions/common/Shift\_C

```
// Shift_C()
// =====

(bits(N), bit) Shift_C(bits(N) value, SRType srtype, integer amount, bit carry_in)
    assert !(srtype == SRType\_RRX && amount != 1);

    if amount == 0 then
        (result, carry_out) = (value, carry_in);
    else
        case srtype of
            when SRType\_LSL
                (result, carry_out) = LSL\_C(value, amount);
            when SRType\_LSR
                (result, carry_out) = LSR\_C(value, amount);
            when SRType\_ASR
                (result, carry_out) = ASR\_C(value, amount);
            when SRType\_ROR
                (result, carry_out) = ROR\_C(value, amount);
            when SRType\_RRX
                (result, carry_out) = RRX\_C(value, carry_in);

    return (result, carry_out);
```

## Library pseudocode for aarch32/functions/common/T32ExpandImm

```
// T32ExpandImm()
// =====

bits(32) T32ExpandImm(bits(12) imm12)

    // PSTATE.C argument to following function call does not affect the imm32 result.
    (imm32, -) = T32ExpandImm\_C(imm12, PSTATE.C);

    return imm32;
```

## Library pseudocode for aarch32/functions/common/T32ExpandImm\_C

```
// T32ExpandImm_C()
// =====

(bits(32), bit) T32ExpandImm_C(bits(12) imm12, bit carry_in)

    if imm12<11:10> == '00' then
        case imm12<9:8> of
            when '00'
                imm32 = ZeroExtend(imm12<7:0>, 32);
            when '01'
                imm32 = '00000000' : imm12<7:0> : '00000000' : imm12<7:0>;
            when '10'
                imm32 = imm12<7:0> : '00000000' : imm12<7:0> : '00000000';
            when '11'
                imm32 = imm12<7:0> : imm12<7:0> : imm12<7:0> : imm12<7:0>;
        carry_out = carry_in;
    else
        unrotated_value = ZeroExtend('1':imm12<6:0>, 32);
        (imm32, carry_out) = ROR_C(unrotated_value, UInt(imm12<11:7>));

    return (imm32, carry_out);
```

## Library pseudocode for aarch32/functions/coproc/AArch32.CheckCP15InstrCoarseTraps

```
// AArch32.CheckCP15InstrCoarseTraps()
// =====
// Check for coarse-grained CP15 traps in HSTR and HCR.

boolean AArch32.CheckCP15InstrCoarseTraps(integer CRn, integer nreg, integer CRm)

    // Check for coarse-grained Hyp traps
    if PSTATE.EL IN {EL0, EL1} && EL2Enabled() then
        if PSTATE.EL == EL0 && !ELUsingAArch32(EL2) then
            return AArch64.CheckCP15InstrCoarseTraps(CRn, nreg, CRm);
        // Check for MCR, MRC, MCRR and MRRC disabled by HSTR<CRn/CRm>
        major = if nreg == 1 then CRn else CRm;
        if !(major IN {4,14}) && HSTR<major> == '1' then
            return TRUE;

        // Check for MRC and MCR disabled by HCR.TIDCP
        if (HCR.TIDCP == '1' && nreg == 1 &&
            ((CRn == 9 && CRm IN {0,1,2, 5,6,7,8 }) ||
             (CRn == 10 && CRm IN {0,1, 4, 8 }) ||
             (CRn == 11 && CRm IN {0,1,2,3,4,5,6,7,8,15}))) then
            return TRUE;

    return FALSE;
```

## Library pseudocode for aarch32/functions/exclusive/AArch32.ExclusiveMonitorsPass

```
// AArch32.ExclusiveMonitorsPass()
// =====

// Return TRUE if the Exclusives monitors for the current PE include all of the addresses
// associated with the virtual address region of size bytes starting at address.
// The immediately following memory write must be to the same addresses.

boolean AArch32.ExclusiveMonitorsPass(bits(32) address, integer size)

    // It is IMPLEMENTATION DEFINED whether the detection of memory aborts happens
    // before or after the check on the local Exclusives monitor. As a result a failure
    // of the local monitor can occur on some implementations even if the memory
    // access would give an memory abort.

    acctype = AccType_ATOMIC;
    iswrite = TRUE;

    aligned = AArch32.CheckAlignment(address, size, acctype, iswrite);

    passed = AArch32.IsExclusiveVA(address, ProcessorID(), size);
    if !passed then
        return FALSE;

    memaddrdesc = AArch32.TranslateAddress(address, acctype, iswrite, aligned, size);
    // Check for aborts or debug exceptions
    if IsFault(memaddrdesc) then
        AArch32.Abort(address, memaddrdesc.fault);

    passed = IsExclusiveLocal(memaddrdesc.address, ProcessorID(), size);
    ClearExclusiveLocal(ProcessorID());

    if passed then
        if memaddrdesc.memattrs.shareable then
            passed = IsExclusiveGlobal(memaddrdesc.address, ProcessorID(), size);

    return passed;
```

## Library pseudocode for aarch32/functions/exclusive/AArch32.IsExclusiveVA

```
// An optional IMPLEMENTATION DEFINED test for an exclusive access to a virtual
// address region of size bytes starting at address.
//
// It is permitted (but not required) for this function to return FALSE and
// cause a store exclusive to fail if the virtual address region is not
// totally included within the region recorded by MarkExclusiveVA().
//
// It is always safe to return TRUE which will check the physical address only.
boolean AArch32.IsExclusiveVA(bits(32) address, integer processorid, integer size);
```

## Library pseudocode for aarch32/functions/exclusive/AArch32.MarkExclusiveVA

```
// Optionally record an exclusive access to the virtual address region of size bytes
// starting at address for processorid.
AArch32.MarkExclusiveVA(bits(32) address, integer processorid, integer size);
```

## Library pseudocode for aarch32/functions/exclusive/AArch32.SetExclusiveMonitors

```
// AArch32.SetExclusiveMonitors()
// =====

// Sets the Exclusives monitors for the current PE to record the addresses associated
// with the virtual address region of size bytes starting at address.

AArch32.SetExclusiveMonitors(bits(32) address, integer size)

    acctype = AccType\_ATOMIC;
    iswrite = FALSE;

    aligned = AArch32.CheckAlignment(address, size, acctype, iswrite);

    memaddrdesc = AArch32.TranslateAddress(address, acctype, iswrite, aligned, size);
    // Check for aborts or debug exceptions
    if IsFault(memaddrdesc) then
        return;

    if memaddrdesc.memattrs.shareable then
        MarkExclusiveGlobal(memaddrdesc.address, ProcessorID(), size);

    MarkExclusiveLocal(memaddrdesc.address, ProcessorID(), size);

    AArch32.MarkExclusiveVA(address, ProcessorID(), size);
```

## Library pseudocode for aarch32/functions/float/CheckAdvSIMDEnabled

```
// CheckAdvSIMDEnabled()
// =====

CheckAdvSIMDEnabled()

    fpexc_check = TRUE;
    advsimd = TRUE;

    AArch32.CheckAdvSIMDOrFPEEnabled(fpexc_check, advsimd);
    // Return from CheckAdvSIMDOrFPEEnabled() occurs only if Advanced SIMD access is permitted

    // Make temporary copy of D registers
    // _Dclone[] is used as input data for instruction pseudocode
    for i = 0 to 31
        _Dclone[i] = D[i];

    return;
```

## Library pseudocode for aarch32/functions/float/CheckAdvSIMDOrVFPEEnabled

```
// CheckAdvSIMDOrVFPEEnabled()
// =====

CheckAdvSIMDOrVFPEEnabled(boolean include_fpexc_check, boolean advsimd)
    AArch32.CheckAdvSIMDOrFPEEnabled(include_fpexc_check, advsimd);
    // Return from CheckAdvSIMDOrFPEEnabled() occurs only if VFP access is permitted
    return;
```

## Library pseudocode for aarch32/functions/float/CheckCryptoEnabled32

```
// CheckCryptoEnabled32()
// =====

CheckCryptoEnabled32()
    CheckAdvSIMDEnabled();
    // Return from CheckAdvSIMDEnabled() occurs only if access is permitted
    return;
```

## Library pseudocode for aarch32/functions/float/CheckVFPEEnabled

```
// CheckVFPEEnabled()
// =====

CheckVFPEEnabled(boolean include_fpexc_check)
    advsimd = FALSE;
    AArch32.CheckAdvSIMDOrFPEEnabled(include_fpexc_check, advsimd);
    // Return from CheckAdvSIMDOrFPEEnabled() occurs only if VFP access is permitted
    return;
```

## Library pseudocode for aarch32/functions/float/FPHalvedSub

```
// FPHalvedSub()
// =====

bits(N) FPHalvedSub(bits(N) op1, bits(N) op2, FPCRTType fpcr)
    assert N IN {16,32,64};
    rounding = FPRoundingMode(fpcr);
    (type1,sign1,value1) = FPUnpack(op1, fpcr);
    (type2,sign2,value2) = FPUnpack(op2, fpcr);
    (done,result) = FPProcessNaNs(type1, type2, op1, op2, fpcr);
    if !done then
        inf1 = (type1 == FPTYPE\_Infinity);  inf2 = (type2 == FPTYPE\_Infinity);
        zero1 = (type1 == FPTYPE\_Zero);      zero2 = (type2 == FPTYPE\_Zero);
        if inf1 && inf2 && sign1 == sign2 then
            result = FPDefaultNaN();
            FPProcessException(FPExc\_InvalidOp, fpcr);
        elsif (inf1 && sign1 == '0') || (inf2 && sign2 == '1') then
            result = FPInfinity('0');
        elsif (inf1 && sign1 == '1') || (inf2 && sign2 == '0') then
            result = FPInfinity('1');
        elsif zero1 && zero2 && sign1 != sign2 then
            result = FPZero(sign1);
        else
            result_value = (value1 - value2) / 2.0;
            if result_value == 0.0 then // Sign of exact zero result depends on rounding mode
                result_sign = if rounding == FPRounding\_NEGINF then '1' else '0';
                result = FPZero(result_sign);
            else
                result = FPRound(result_value, fpcr);
    return result;
```

## Library pseudocode for aarch32/functions/float/FPRSqrtStep

```
// FPRSqrtStep()
// =====

bits(N) FPRSqrtStep(bits(N) op1, bits(N) op2)
    assert N IN {16,32};
    FPCRTType fpcr = StandardFPSCRValue();
    (type1,sign1,value1) = FPUnpack(op1, fpcr);
    (type2,sign2,value2) = FPUnpack(op2, fpcr);
    (done,result) = FPProcessNaNs(type1, type2, op1, op2, fpcr);
    if !done then
        inf1 = (type1 == FPTYPE\_Infinity);  inf2 = (type2 == FPTYPE\_Infinity);
        zero1 = (type1 == FPTYPE\_Zero);      zero2 = (type2 == FPTYPE\_Zero);
        bits(N) product;
        if (inf1 && zero2) || (zero1 && inf2) then
            product = FPZero('0');
        else
            product = FPMul(op1, op2, fpcr);
        bits(N) three = FPThree('0');
        result = FPHalvedSub(three, product, fpcr);
    return result;
```

## Library pseudocode for aarch32/functions/float/FPRecipStep

```
// FPRecipStep()
// =====

bits(N) FPRecipStep(bits(N) op1, bits(N) op2)
    assert N IN {16,32};
    FPCRTType fpcr = StandardFPSCRValue();
    (type1,sign1,value1) = FPUnpack(op1, fpcr);
    (type2,sign2,value2) = FPUnpack(op2, fpcr);
    (done,result) = FPProcessNaNs(type1, type2, op1, op2, fpcr);
    if !done then
        inf1 = (type1 == FType\_Infinity);  inf2 = (type2 == FType\_Infinity);
        zero1 = (type1 == FType\_Zero);      zero2 = (type2 == FType\_Zero);
        bits(N) product;
        if (inf1 && zero2) || (zero1 && inf2) then
            product = FPZero('0');
        else
            product = FPMul(op1, op2, fpcr);
        bits(N) two = FPTwo('0');
        result = FPSub(two, product, fpcr);
    return result;
```

## Library pseudocode for aarch32/functions/float/StandardFPSCRValue

```
// StandardFPSCRValue()
// =====

FPCRTType StandardFPSCRValue()
    return '00000' : FPSCR.AHP : '110000' : FPSCR.FZ16 : '00000000000000000000';
```

## Library pseudocode for aarch32/functions/memory/AArch32.CheckAlignment

```
// AArch32.CheckAlignment()
// =====

boolean AArch32.CheckAlignment(bits(32) address, integer alignment, AccType acctype,
                                boolean iswrite)

    if PSTATE.EL == EL0 && !ELUsingAArch32\(S1TranslationRegime\(\)\) then
        A = SCTLR[].A; //use AArch64 register, when higher Exception level is using AArch64
    elsif PSTATE.EL == EL2 then
        A = HSCTLR.A;
    else
        A = SCTLR.A;
    aligned = (address == Align(address, alignment));
    atomic = acctype IN { AccType\_ATOMIC, AccType\_ATOMICRW, AccType\_ORDEREDATOMIC, AccType\_ORDEREDATOMICRW };
    ordered = acctype IN { AccType\_ORDERED, AccType\_ORDEREDRW, AccType\_LIMITEDORDERED, AccType\_ORDEREDATOMIC };
    vector = acctype == AccType\_VEC;

    // AccType\_VEC is used for SIMD element alignment checks only
    check = (atomic || ordered || vector || A == '1');

    if check && !aligned then
        secondstage = FALSE;
        AArch32.Abort(address, AArch32.AlignmentFault(acctype, iswrite, secondstage));

    return aligned;
```

## Library pseudocode for aarch32/functions/memory/AArch32.MemSingle

```
// AArch32.MemSingle[] - non-assignment (read) form
// =====
// Perform an atomic, little-endian read of 'size' bytes.

bits(size*8) AArch32.MemSingle[bits(32) address, integer size, AccType acctype, boolean wasaligned]
    assert size IN {1, 2, 4, 8, 16};
    assert address == Align(address, size);

    AddressDescriptor memaddrdesc;
    bits(size*8) value;
    iswrite = FALSE;

    memaddrdesc = AArch32.TranslateAddress(address, acctype, iswrite, wasaligned, size);
    // Check for aborts or debug exceptions
    if IsFault(memaddrdesc) then
        AArch32.Abort(address, memaddrdesc.fault);

    // Memory array access
    if HaveTME() then
        transactional = TSTATE.depth > 0 && !(acctype IN {AccType\_IFETCH, AccType\_PTW});
        accdesc = CreateAccessDescriptor(acctype, transactional);
    else
        accdesc = CreateAccessDescriptor(acctype);
    if HaveMTEExt() then
        if AArch64.AccessIsTagChecked(ZeroExtend(address, 64), acctype) then
            bits(4) ptag = AArch64.PhysicalTag(ZeroExtend(address, 64));
            if !AArch64.CheckTag(memaddrdesc, ptag, iswrite) then
                AArch64.TagCheckFail(ZeroExtend(address, 64), acctype, iswrite);
        value = _Mem[memaddrdesc, size, accdesc];
    return value;

// AArch32.MemSingle[] - assignment (write) form
// =====
// Perform an atomic, little-endian write of 'size' bytes.

AArch32.MemSingle[bits(32) address, integer size, AccType acctype, boolean wasaligned] = bits(size*8) val
    assert size IN {1, 2, 4, 8, 16};
    assert address == Align(address, size);

    AddressDescriptor memaddrdesc;
    iswrite = TRUE;

    memaddrdesc = AArch32.TranslateAddress(address, acctype, iswrite, wasaligned, size);
    // Check for aborts or debug exceptions
    if IsFault(memaddrdesc) then
        AArch32.Abort(address, memaddrdesc.fault);

    // Effect on exclusives
    if memaddrdesc.memattrs.shareable then
        ClearExclusiveByAddress(memaddrdesc.paddress, ProcessorID(), size);

    // Memory array access
    if HaveTME() then
        transactional = TSTATE.depth > 0;
        accdesc = CreateAccessDescriptor(acctype, transactional);
    else
        accdesc = CreateAccessDescriptor(acctype);
    if HaveMTEExt() then
        if AArch64.AccessIsTagChecked(ZeroExtend(address, 64), acctype) then
            bits(4) ptag = AArch64.PhysicalTag(ZeroExtend(address, 64));
            if !AArch64.CheckTag(memaddrdesc, ptag, iswrite) then
                AArch64.TagCheckFail(ZeroExtend(address, 64), acctype, iswrite);
    _Mem[memaddrdesc, size, accdesc] = value;
    return;
```

### Library pseudocode for aarch32/functions/memory/Hint\_PreloadData

```
Hint_PreloadData(bits(32) address);
```

### Library pseudocode for aarch32/functions/memory/Hint\_PreloadDataForWrite

```
Hint_PreloadDataForWrite(bits(32) address);
```

### Library pseudocode for aarch32/functions/memory/Hint\_PreloadInstr

```
Hint_PreloadInstr(bits(32) address);
```

### Library pseudocode for aarch32/functions/memory/MemA

```
// MemA[] - non-assignment form
// =====

bits(8*size) MemA(bits(32) address, integer size)
    acctype = AccType\_ATOMIC;
    return Mem\_with\_type[address, size, acctype];

// MemA[] - assignment form
// =====

MemA(bits(32) address, integer size) = bits(8*size) value
    acctype = AccType\_ATOMIC;
    Mem\_with\_type[address, size, acctype] = value;
    return;
```

### Library pseudocode for aarch32/functions/memory/MemO

```
// MemO[] - non-assignment form
// =====

bits(8*size) MemO(bits(32) address, integer size)
    acctype = AccType\_ORDERED;
    return Mem\_with\_type[address, size, acctype];

// MemO[] - assignment form
// =====

MemO(bits(32) address, integer size) = bits(8*size) value
    acctype = AccType\_ORDERED;
    Mem\_with\_type[address, size, acctype] = value;
    return;
```

### Library pseudocode for aarch32/functions/memory/MemU

```
// MemU[] - non-assignment form
// =====

bits(8*size) MemU(bits(32) address, integer size)
    acctype = AccType\_NORMAL;
    return Mem\_with\_type[address, size, acctype];

// MemU[] - assignment form
// =====

MemU(bits(32) address, integer size) = bits(8*size) value
    acctype = AccType\_NORMAL;
    Mem\_with\_type[address, size, acctype] = value;
    return;
```



## Library pseudocode for aarch32/functions/memory/MemU\_unpriv

```
// MemU_unpriv[] - non-assignment form
// =====

bits(8*size) MemU_unpriv[bits(32) address, integer size]
    acctype = AccType\_UNPRIV;
    return Mem\_with\_type[address, size, acctype];

// MemU_unpriv[] - assignment form
// =====

MemU_unpriv[bits(32) address, integer size] = bits(8*size) value
    acctype = AccType\_UNPRIV;
    Mem\_with\_type[address, size, acctype] = value;
    return;
```

## Library pseudocode for aarch32/functions/memory/Mem\_with\_type

```
// Mem_with_type[] - non-assignment (read) form
// =====
// Perform a read of 'size' bytes. The access byte order is reversed for a big-endian access.
// Instruction fetches would call AArch32.MemSingle directly.

bits(size*8) Mem_with_type[bits(32) address, integer size, AccType acctype]
  assert size IN {1, 2, 4, 8, 16};
  bits(size*8) value;
  boolean iswrite = FALSE;

  aligned = AArch32.CheckAlignment(address, size, acctype, iswrite);
  if !aligned then
    assert size > 1;
    value<7:0> = AArch32.MemSingle[address, 1, acctype, aligned];

    // For subsequent bytes it is CONSTRAINED UNPREDICTABLE whether an unaligned Device memory
    // access will generate an Alignment Fault, as to get this far means the first byte did
    // not, so we must be changing to a new translation page.
    c = ConstrainUnpredictable(Unpredictable_DEVPAGE2);
    assert c IN {Constraint_FAULT, Constraint_NONE};
    if c == Constraint_NONE then aligned = TRUE;

    for i = 1 to size-1
      value<8*i+7:8*i> = AArch32.MemSingle[address+i, 1, acctype, aligned];
  else
    value = AArch32.MemSingle[address, size, acctype, aligned];

  if BigEndian() then
    value = BigEndianReverse(value);
  return value;

// Mem_with_type[] - assignment (write) form
// =====
// Perform a write of 'size' bytes. The byte order is reversed for a big-endian access.

Mem_with_type[bits(32) address, integer size, AccType acctype] = bits(size*8) value
  boolean iswrite = TRUE;

  if BigEndian() then
    value = BigEndianReverse(value);

  aligned = AArch32.CheckAlignment(address, size, acctype, iswrite);

  if !aligned then
    assert size > 1;
    AArch32.MemSingle[address, 1, acctype, aligned] = value<7:0>;

    // For subsequent bytes it is CONSTRAINED UNPREDICTABLE whether an unaligned Device memory
    // access will generate an Alignment Fault, as to get this far means the first byte did
    // not, so we must be changing to a new translation page.
    c = ConstrainUnpredictable(Unpredictable_DEVPAGE2);
    assert c IN {Constraint_FAULT, Constraint_NONE};
    if c == Constraint_NONE then aligned = TRUE;

    for i = 1 to size-1
      AArch32.MemSingle[address+i, 1, acctype, aligned] = value<8*i+7:8*i>;
  else
    AArch32.MemSingle[address, size, acctype, aligned] = value;
  return;
```

## Library pseudocode for aarch32/functions/ras/AArch32.ESBOperation

```
// AArch32.ESBOperation()
// =====
// Perform the AArch32 ESB operation for ESB executed in AArch32 state

AArch32.ESBOperation()

    // Check if routed to AArch64 state
    route_to_aarch64 = PSTATE.EL == EL0 && !ELUsingAArch32(EL1);
    if !route_to_aarch64 && EL2Enabled() && !ELUsingAArch32(EL2) then
        route_to_aarch64 = HCR_EL2.TGE == '1' || HCR_EL2.AMO == '1';
    if !route_to_aarch64 && HaveEL(EL3) && !ELUsingAArch32(EL3) then
        route_to_aarch64 = SCR_EL3.EA == '1';

    if route_to_aarch64 then
        AArch64.ESBOperation();
        return;

    route_to_monitor = HaveEL(EL3) && ELUsingAArch32(EL3) && SCR.EA == '1';
    route_to_hyp = PSTATE.EL IN {EL0, EL1} && EL2Enabled() && (HCR.TGE == '1' || HCR.AMO == '1');

    if route_to_monitor then
        target = M32_Monitor;
    elsif route_to_hyp || PSTATE.M == M32_Hyp then
        target = M32_Hyp;
    else
        target = M32_Abort;

    if IsSecure() then
        mask_active = TRUE;
    elsif target == M32_Monitor then
        mask_active = SCR.AW == '1' && (!HaveEL(EL2) || (HCR.TGE == '0' && HCR.AMO == '0'));
    else
        mask_active = target == M32_Abort || PSTATE.M == M32_Hyp;

    mask_set = PSTATE.A == '1';
    (-, el) = ELFromM32(target);
    intdis = Halted() || ExternalDebugInterruptsDisabled(el);
    masked = intdis || (mask_active && mask_set);

    // Check for a masked Physical SError pending that can be synchronized
    // by an Error synchronization event.
    if masked && IsSynchronizablePhysicalSErrorPending() then
        syndrome32 = AArch32.PhysicalSErrorSyndrome();
        DISR = AArch32.ReportDeferredSError(syndrome32.AET, syndrome32.ExT);
        ClearPendingPhysicalSError();

    return;
```

## Library pseudocode for aarch32/functions/ras/AArch32.PhysicalSErrorSyndrome

```
// Return the SError syndrome
AArch32.SErrorSyndrome AArch32.PhysicalSErrorSyndrome();
```

## Library pseudocode for aarch32/functions/ras/AArch32.ReportDeferredSError

```
// AArch32.ReportDeferredSError()
// =====
// Return deferred SError syndrome

bits(32) AArch32.ReportDeferredSError(bits(2) AET, bit ExT)
    bits(32) target;
    target<31> = '1'; // A
    syndrome = Zeros(16);
    if PSTATE.EL == EL2 then
        syndrome<11:10> = AET; // AET
        syndrome<9> = ExT; // EA
        syndrome<5:0> = '010001'; // DFSC
    else
        syndrome<15:14> = AET; // AET
        syndrome<12> = ExT; // ExT
        syndrome<9> = TTBCR.EAE; // LPAE
        if TTBCR.EAE == '1' then // Long-descriptor format
            syndrome<5:0> = '010001'; // STATUS
        else // Short-descriptor format
            syndrome<10,3:0> = '10110'; // FS
    if HaveAnyAArch64() then
        target<24:0> = ZeroExtend(syndrome); // Any RES0 fields must be set to zero
    else
        target<15:0> = syndrome;
    return target;
```

## Library pseudocode for aarch32/functions/ras/AArch32.SErrorSyndrome

```
type AArch32.SErrorSyndrome is (
    bits(2) AET,
    bit ExT
)
```

## Library pseudocode for aarch32/functions/ras/AArch32.vESB0Operation

```
// AArch32.vESB0Operation()
// =====
// Perform the ESB operation for virtual SError interrupts executed in AArch32 state

AArch32.vESB0Operation()
    assert PSTATE.EL IN {EL0, EL1} && EL2Enabled();

    // Check for EL2 using AArch64 state
    if !ELUsingAArch32(EL2) then
        AArch64.vESB0Operation();
        return;

    // If physical SError interrupts are routed to Hyp mode, and TGE is not set, then a
    // virtual SError interrupt might be pending
    vSEI_enabled = HCR.TGE == '0' && HCR.AMO == '1';
    vSEI_pending = vSEI_enabled && HCR.VA == '1';
    vintdis = Halted() || ExternalDebugInterruptsDisabled(EL1);
    vmasked = vintdis || PSTATE.A == '1';

    // Check for a masked virtual SError pending
    if vSEI_pending && vmasked then
        VDISR = AArch32.ReportDeferredSError(VDFSR<15:14>, VDFSR<12>);
        HCR.VA = '0'; // Clear pending virtual SError

    return;
```

## Library pseudocode for aarch32/functions/registers/AArch32.ResetGeneralRegisters

```
// AArch32.ResetGeneralRegisters()
// =====

AArch32.ResetGeneralRegisters()

    for i = 0 to 7
        R[i] = bits(32) UNKNOWN;
    for i = 8 to 12
        Rmode[i, M32_User] = bits(32) UNKNOWN;
        Rmode[i, M32_FIQ] = bits(32) UNKNOWN;
    if HaveEL(EL2) then Rmode[13, M32_Hyp] = bits(32) UNKNOWN;    // No R14_hyp
    for i = 13 to 14
        Rmode[i, M32_User] = bits(32) UNKNOWN;
        Rmode[i, M32_FIQ] = bits(32) UNKNOWN;
        Rmode[i, M32_IRQ] = bits(32) UNKNOWN;
        Rmode[i, M32_Svc] = bits(32) UNKNOWN;
        Rmode[i, M32_Abort] = bits(32) UNKNOWN;
        Rmode[i, M32_Undef] = bits(32) UNKNOWN;
        if HaveEL(EL3) then Rmode[i, M32_Monitor] = bits(32) UNKNOWN;

    return;
```

## Library pseudocode for aarch32/functions/registers/AArch32.ResetSIMDFPRegisters

```
// AArch32.ResetSIMDFPRegisters()
// =====

AArch32.ResetSIMDFPRegisters()

    for i = 0 to 15
        Q[i] = bits(128) UNKNOWN;

    return;
```

## Library pseudocode for aarch32/functions/registers/AArch32.ResetSpecialRegisters

```
// AArch32.ResetSpecialRegisters()
// =====

AArch32.ResetSpecialRegisters()

    // AArch32 special registers
    SPSR_fiq = bits(32) UNKNOWN;
    SPSR_irq = bits(32) UNKNOWN;
    SPSR_svc = bits(32) UNKNOWN;
    SPSR_abt = bits(32) UNKNOWN;
    SPSR_und = bits(32) UNKNOWN;
    if HaveEL(EL2) then
        SPSR_hyp = bits(32) UNKNOWN;
        ELR_hyp = bits(32) UNKNOWN;
    if HaveEL(EL3) then
        SPSR_mon = bits(32) UNKNOWN;

    // External debug special registers
    DLR = bits(32) UNKNOWN;
    DSPSR = bits(32) UNKNOWN;

    return;
```

## Library pseudocode for aarch32/functions/registers/AArch32.ResetSystemRegisters

```
AArch32.ResetSystemRegisters(boolean cold_reset);
```

## Library pseudocode for aarch32/functions/registers/ALUExceptionReturn

```
// ALUExceptionReturn()
// =====

ALUExceptionReturn(bits(32) address)
  if PSTATE.EL == EL2 then
    UNDEFINED;
  elsif PSTATE.M IN {M32\_User,M32\_System} then
    UNPREDICTABLE; // UNDEFINED or NOP
  else
    AArch32.ExceptionReturn(address, SPSR[]);
```

## Library pseudocode for aarch32/functions/registers/ALUWritePC

```
// ALUWritePC()
// =====

ALUWritePC(bits(32) address)
  if CurrentInstrSet() == InstrSet\_A32 then
    BXWritePC(address, BranchType\_INDIR);
  else
    BranchWritePC(address, BranchType\_INDIR);
```

## Library pseudocode for aarch32/functions/registers/BXWritePC

```
// BXWritePC()
// =====

BXWritePC(bits(32) address, BranchType branch_type)
  if address<0> == '1' then
    SelectInstrSet(InstrSet\_T32);
    address<0> = '0';
  else
    SelectInstrSet(InstrSet\_A32);
    // For branches to an unaligned PC counter in A32 state, the processor takes the branch
    // and does one of:
    // * Forces the address to be aligned
    // * Leaves the PC unaligned, meaning the target generates a PC Alignment fault.
    if address<1> == '1' && ConstrainUnpredictableBool(Unpredictable\_A32FORCEALIGNPC) then
      address<1> = '0';
    BranchTo(address, branch_type);
```

## Library pseudocode for aarch32/functions/registers/BranchWritePC

```
// BranchWritePC()
// =====

BranchWritePC(bits(32) address, BranchType branch_type)
  if CurrentInstrSet() == InstrSet\_A32 then
    address<1:0> = '00';
  else
    address<0> = '0';
    BranchTo(address, branch_type);
```

## Library pseudocode for aarch32/functions/registers/D

```
// D[] - non-assignment form
// =====

bits(64) D[integer n]
    assert n >= 0 && n <= 31;
    base = (n MOD 2) * 64;
    bits(128) vreg = V[n DIV 2];
    return vreg<base+63:base>;

// D[] - assignment form
// =====

D[integer n] = bits(64) value
    assert n >= 0 && n <= 31;
    base = (n MOD 2) * 64;
    bits(128) vreg = V[n DIV 2];
    vreg<base+63:base> = value;
    V[n DIV 2] = vreg;
    return;
```

## Library pseudocode for aarch32/functions/registers/Din

```
// Din[] - non-assignment form
// =====

bits(64) Din[integer n]
    assert n >= 0 && n <= 31;
    return _Dclone[n];
```

## Library pseudocode for aarch32/functions/registers/LR

```
// LR - assignment form
// =====

LR = bits(32) value
    R[14] = value;
    return;

// LR - non-assignment form
// =====

bits(32) LR
    return R[14];
```

## Library pseudocode for aarch32/functions/registers/LoadWritePC

```
// LoadWritePC()
// =====

LoadWritePC(bits(32) address)
    BXWritePC(address, BranchType\_INDIR);
```

## Library pseudocode for aarch32/functions/registers/LookUpRIndex

```
// LookUpRIndex()
// =====

integer LookUpRIndex(integer n, bits(5) mode)
    assert n >= 0 && n <= 14;

    case n of // Select index by mode:      usr fiq irq svc abt und hyp
        when 8    result = RBankSelect(mode, 8, 24, 8, 8, 8, 8, 8);
        when 9    result = RBankSelect(mode, 9, 25, 9, 9, 9, 9, 9);
        when 10   result = RBankSelect(mode, 10, 26, 10, 10, 10, 10, 10);
        when 11   result = RBankSelect(mode, 11, 27, 11, 11, 11, 11, 11);
        when 12   result = RBankSelect(mode, 12, 28, 12, 12, 12, 12, 12);
        when 13   result = RBankSelect(mode, 13, 29, 17, 19, 21, 23, 15);
        when 14   result = RBankSelect(mode, 14, 30, 16, 18, 20, 22, 14);
        otherwise result = n;

    return result;
```

## Library pseudocode for aarch32/functions/registers/Monitor\_mode\_registers

```
bits(32) SP_mon;
bits(32) LR_mon;
```

## Library pseudocode for aarch32/functions/registers/PC

```
// PC - non-assignment form
// =====

bits(32) PC
    return R[15]; // This includes the offset from AArch32 state
```

## Library pseudocode for aarch32/functions/registers/PCStoreValue

```
// PCStoreValue()
// =====

bits(32) PCStoreValue()
    // This function returns the PC value. On architecture versions before Armv7, it
    // is permitted to instead return PC+4, provided it does so consistently. It is
    // used only to describe A32 instructions, so it returns the address of the current
    // instruction plus 8 (normally) or 12 (when the alternative is permitted).
    return PC;
```

## Library pseudocode for aarch32/functions/registers/Q

```
// Q[] - non-assignment form
// =====

bits(128) Q[integer n]
    assert n >= 0 && n <= 15;
    return V[n];

// Q[] - assignment form
// =====

Q[integer n] = bits(128) value
    assert n >= 0 && n <= 15;
    V[n] = value;
    return;
```



## Library pseudocode for aarch32/functions/registers/Qin

```
// Qin[] - non-assignment form
// =====

bits(128) Qin[integer n]
    assert n >= 0 && n <= 15;
    return Din[2*n+1]:Din[2*n];
```

## Library pseudocode for aarch32/functions/registers/R

```
// R[] - assignment form
// =====

R[integer n] = bits(32) value
    Rmode[n, PSTATE.M] = value;
    return;

// R[] - non-assignment form
// =====

bits(32) R[integer n]
    if n == 15 then
        offset = (if CurrentInstrSet() == InstrSet\_A32 then 8 else 4);
        return _PC<31:0> + offset;
    else
        return Rmode[n, PSTATE.M];
```

## Library pseudocode for aarch32/functions/registers/RBankSelect

```
// RBankSelect()
// =====

integer RBankSelect(bits(5) mode, integer usr, integer fiq, integer irq,
                    integer svc, integer abt, integer und, integer hyp)

    case mode of
        when M32\_User      result = usr;    // User mode
        when M32\_FIQ      result = fiq;    // FIQ mode
        when M32\_IRQ      result = irq;    // IRQ mode
        when M32\_Svc      result = svc;    // Supervisor mode
        when M32\_Abort     result = abt;    // Abort mode
        when M32\_Hyp       result = hyp;    // Hyp mode
        when M32\_Undef     result = und;    // Undefined mode
        when M32\_System    result = usr;    // System mode uses User mode registers
        otherwise          Unreachable(); // Monitor mode

    return result;
```

## Library pseudocode for aarch32/functions/registers/Rmode

```
// Rmode[] - non-assignment form
// =====

bits(32) Rmode[integer n, bits(5) mode]
    assert n >= 0 && n <= 14;

    // Check for attempted use of Monitor mode in Non-secure state.
    if !IsSecure() then assert mode != M32_Monitor;
    assert !BadMode(mode);

    if mode == M32_Monitor then
        if n == 13 then return SP_mon;
        elsif n == 14 then return LR_mon;
        else return _R[n]<31:0>;
    else
        return _R[LookupRIndex(n, mode)]<31:0>;

// Rmode[] - assignment form
// =====

Rmode[integer n, bits(5) mode] = bits(32) value
    assert n >= 0 && n <= 14;

    // Check for attempted use of Monitor mode in Non-secure state.
    if !IsSecure() then assert mode != M32_Monitor;
    assert !BadMode(mode);

    if mode == M32_Monitor then
        if n == 13 then SP_mon = value;
        elsif n == 14 then LR_mon = value;
        else _R[n]<31:0> = value;
    else
        // It is CONSTRAINED UNPREDICTABLE whether the upper 32 bits of the X
        // register are unchanged or set to zero. This is also tested for on
        // exception entry, as this applies to all AArch32 registers.
        if !HighestELUsingAArch32() && ConstrainUnpredictableBool(Unpredictable_ZEROUPPER) then
            _R[LookupRIndex(n, mode)] = ZeroExtend(value);
        else
            _R[LookupRIndex(n, mode)]<31:0> = value;

    return;
```

## Library pseudocode for aarch32/functions/registers/S

```
// S[] - non-assignment form
// =====

bits(32) S[integer n]
    assert n >= 0 && n <= 31;
    base = (n MOD 4) * 32;
    bits(128) vreg = V[n DIV 4];
    return vreg<base+31:base>;

// S[] - assignment form
// =====

S[integer n] = bits(32) value
    assert n >= 0 && n <= 31;
    base = (n MOD 4) * 32;
    bits(128) vreg = V[n DIV 4];
    vreg<base+31:base> = value;
    V[n DIV 4] = vreg;
    return;
```

## Library pseudocode for aarch32/functions/registers/SP

```
// SP - assignment form
// =====

SP = bits(32) value
  R[13] = value;
  return;

// SP - non-assignment form
// =====

bits(32) SP
  return R[13];
```

## Library pseudocode for aarch32/functions/registers/\_Dclone

```
array bits(64) _Dclone[0..31];
```

## Library pseudocode for aarch32/functions/system/AArch32.ExceptionReturn

```
// AArch32.ExceptionReturn()
// =====

AArch32.ExceptionReturn(bits(32) new_pc, bits(32) spsr)

  SynchronizeContext();

  // Attempts to change to an illegal mode or state will invoke the Illegal Execution state
  // mechanism
  SetPSTATEFromPSR(spsr);
  ClearExclusiveLocal(ProcessorID());
  SendEventLocal();

  if PSTATE.IL == '1' then
    // If the exception return is illegal, PC[1:0] are UNKNOWN
    new_pc<1:0> = bits(2) UNKNOWN;
  else
    // LR[1:0] or LR[0] are treated as being 0, depending on the target instruction set state
    if PSTATE.T == '1' then
      new_pc<0> = '0'; // T32
    else
      new_pc<1:0> = '00'; // A32

  BranchTo(new_pc, BranchType_ERET);
```

## Library pseudocode for aarch32/functions/system/AArch32.ExecutingATS1xPInstr

```
// AArch32.ExecutingATS1xPInstr()
// =====
// Return TRUE if current instruction is AT S1CPR/WP

boolean AArch32.ExecutingATS1xPInstr()
  if !HavePrivATExt() then return FALSE;

  instr = ThisInstr();
  if instr<24+:4> == '1110' && instr<8+:4> == '1111' then
    opc1 = instr<21+:3>;
    CRn = instr<16+:4>;
    CRm = instr<0+:4>;
    opc2 = instr<5+:3>;
    return (opc1 == '000' && CRn == '0111' && CRm == '1001' && opc2 IN {'000', '001'});
  else
    return FALSE;
```

### Library pseudocode for aarch32/functions/system/AArch32.ExecutingCP10or11Instr

```
// AArch32.ExecutingCP10or11Instr()
// =====

boolean AArch32.ExecutingCP10or11Instr()
    instr = ThisInstr();
    instr_set = CurrentInstrSet();
    assert instr_set IN {InstrSet_A32, InstrSet_T32};

    if instr_set == InstrSet_A32 then
        return ((instr<27:24> == '1110' || instr<27:25> == '110') && instr<11:8> == '101x');
    else // InstrSet_T32
        return (instr<31:28> == '111x' && (instr<27:24> == '1110' || instr<27:25> == '110') && instr<11:8> == '101x');
```

### Library pseudocode for aarch32/functions/system/AArch32.ExecutingLSMInstr

```
// AArch32.ExecutingLSMInstr()
// =====
// Returns TRUE if processor is executing a Load/Store Multiple instruction

boolean AArch32.ExecutingLSMInstr()
    instr = ThisInstr();
    instr_set = CurrentInstrSet();
    assert instr_set IN {InstrSet_A32, InstrSet_T32};

    if instr_set == InstrSet_A32 then
        return (instr<28+:4> != '1111' && instr<25+:3> == '100');
    else // InstrSet_T32
        if ThisInstrLength() == 16 then
            return (instr<12+:4> == '1100');
        else
            return (instr<25+:7> == '1110100' && instr<22> == '0');
```

### Library pseudocode for aarch32/functions/system/AArch32.ITAdvance

```
// AArch32.ITAdvance()
// =====

AArch32.ITAdvance()
    if PSTATE.IT<2:0> == '000' then
        PSTATE.IT = '00000000';
    else
        PSTATE.IT<4:0> = LSL(PSTATE.IT<4:0>, 1);
    return;
```

### Library pseudocode for aarch32/functions/system/AArch32.SysRegRead

```
// Read from a 32-bit AArch32 System register and return the register's contents.
bits(32) AArch32.SysRegRead(integer cp_num, bits(32) instr);
```

### Library pseudocode for aarch32/functions/system/AArch32.SysRegRead64

```
// Read from a 64-bit AArch32 System register and return the register's contents.
bits(64) AArch32.SysRegRead64(integer cp_num, bits(32) instr);
```

### Library pseudocode for aarch32/functions/system/AArch32.SysRegReadCanWriteAPSR

```
// AArch32.SysRegReadCanWriteAPSR()
// =====
// Determines whether the AArch32 System register read instruction can write to APSR flags.

boolean AArch32.SysRegReadCanWriteAPSR(integer cp_num, bits(32) instr)
    assert UsingAArch32();
    assert (cp_num IN {14,15});
    assert cp_num == UInt(instr<11:8>);

    opc1 = UInt(instr<23:21>);
    opc2 = UInt(instr<7:5>);
    CRn = UInt(instr<19:16>);
    CRm = UInt(instr<3:0>);

    if cp_num == 14 && opc1 == 0 && CRn == 0 && CRm == 1 && opc2 == 0 then // DBGDSCRint
        return TRUE;

    return FALSE;
```

### Library pseudocode for aarch32/functions/system/AArch32.SysRegWrite

```
// Write to a 32-bit AArch32 System register.
AArch32.SysRegWrite(integer cp_num, bits(32) instr, bits(32) val);
```

### Library pseudocode for aarch32/functions/system/AArch32.SysRegWrite64

```
// Write to a 64-bit AArch32 System register.
AArch32.SysRegWrite64(integer cp_num, bits(32) instr, bits(64) val);
```

### Library pseudocode for aarch32/functions/system/AArch32.WriteMode

```
// AArch32.WriteMode()
// =====
// Function for dealing with writes to PSTATE.M from AArch32 state only.
// This ensures that PSTATE.EL and PSTATE.SP are always valid.

AArch32.WriteMode(bits(5) mode)
    (valid,el) = ELFromM32(mode);
    assert valid;
    PSTATE.M = mode;
    PSTATE.EL = el;
    PSTATE.nRW = '1';
    PSTATE.SP = (if mode IN {M32_User,M32_System} then '0' else '1');
    return;
```

## Library pseudocode for aarch32/functions/system/AArch32.WriteModeByInstr

```
// AArch32.WriteModeByInstr()
// =====
// Function for dealing with writes to PSTATE.M from an AArch32 instruction, and ensuring that
// illegal state changes are correctly flagged in PSTATE.IL.

AArch32.WriteModeByInstr(bits(5) mode)
    (valid,el) = ELFromM32(mode);

    // 'valid' is set to FALSE if 'mode' is invalid for this implementation or the current value
    // of SCR.NS/SCR_EL3.NS. Additionally, it is illegal for an instruction to write 'mode' to
    // PSTATE.EL if it would result in any of:
    // * A change to a mode that would cause entry to a higher Exception level.
    if UInt(el) > UInt(PSTATE.EL) then
        valid = FALSE;

    // * A change to or from Hyp mode.
    if (PSTATE.M == M32\_Hyp || mode == M32\_Hyp) && PSTATE.M != mode then
        valid = FALSE;

    // * When EL2 is implemented, the value of HCR.TGE is '1', a change to a Non-secure EL1 mode.
    if PSTATE.M == M32\_Monitor && HaveEL(EL2) && el == EL1 && SCR.NS == '1' && HCR.TGE == '1' then
        valid = FALSE;

    if !valid then
        PSTATE.IL = '1';
    else
        AArch32.WriteMode(mode);
```

## Library pseudocode for aarch32/functions/system/BadMode

```
// BadMode()
// =====

boolean BadMode(bits(5) mode)
    // Return TRUE if 'mode' encodes a mode that is not valid for this implementation
    case mode of
        when M32\_Monitor
            valid = HaveAArch32EL(EL3);
        when M32\_Hyp
            valid = HaveAArch32EL(EL2);
        when M32\_FIQ, M32\_IRQ, M32\_Svc, M32\_Abort, M32\_Undef, M32\_System
            // If EL3 is implemented and using AArch32, then these modes are EL3 modes in Secure
            // state, and EL1 modes in Non-secure state. If EL3 is not implemented or is using
            // AArch64, then these modes are EL1 modes.
            // Therefore it is sufficient to test this implementation supports EL1 using AArch32.
            valid = HaveAArch32EL(EL1);
        when M32\_User
            valid = HaveAArch32EL(EL0);
        otherwise
            valid = FALSE; // Passed an illegal mode value
    return !valid;
```

## Library pseudocode for aarch32/functions/system/BankedRegisterAccessValid

```
// BankedRegisterAccessValid()
// =====
// Checks for MRS (Banked register) or MSR (Banked register) accesses to registers
// other than the SPSRs that are invalid. This includes ELR_hyp accesses.

BankedRegisterAccessValid(bits(5) SYSm, bits(5) mode)

    case SYSm of
        when '000xx', '00100' // R8_usr to R12_usr
            if mode != M32_FIQ then UNPREDICTABLE;
        when '00101' // SP_usr
            if mode == M32_System then UNPREDICTABLE;
        when '00110' // LR_usr
            if mode IN {M32_Hyp, M32_System} then UNPREDICTABLE;
        when '010xx', '0110x', '01110' // R8_fiq to R12_fiq, SP_fiq, LR_fiq
            if mode == M32_FIQ then UNPREDICTABLE;
        when '1000x' // LR_irq, SP_irq
            if mode == M32_IRQ then UNPREDICTABLE;
        when '1001x' // LR_svc, SP_svc
            if mode == M32_Svc then UNPREDICTABLE;
        when '1010x' // LR_abt, SP_abt
            if mode == M32_Abort then UNPREDICTABLE;
        when '1011x' // LR_und, SP_und
            if mode == M32_Undef then UNPREDICTABLE;
        when '1110x' // LR_mon, SP_mon
            if !HaveEL(EL3) || !IsSecure() || mode == M32_Monitor then UNPREDICTABLE;
        when '11110' // ELR_hyp, only from Monitor or Hyp mode
            if !HaveEL(EL2) || !(mode IN {M32_Monitor, M32_Hyp}) then UNPREDICTABLE;
        when '11111' // SP_hyp, only from Monitor mode
            if !HaveEL(EL2) || mode != M32_Monitor then UNPREDICTABLE;
        otherwise
            UNPREDICTABLE;

    return;
```

## Library pseudocode for aarch32/functions/system/CPSRWriteByInstr

```
// CPSRWriteByInstr()
// =====
// Update PSTATE.<N,Z,C,V,Q,GE,E,A,I,F,M> from a CPSR value written by an MSR instruction.

CPSRWriteByInstr(bits(32) value, bits(4) bytemask)
    privileged = PSTATE.EL != EL0; // PSTATE.<A,I,F,M> are not writable at EL0

    // Write PSTATE from 'value', ignoring bytes masked by 'bytemask'
    if bytemask<3> == '1' then
        PSTATE.<N,Z,C,V,Q> = value<31:27>;
        // Bits <26:24> are ignored

    if bytemask<2> == '1' then
        if HaveSSBSExt() then
            PSTATE.SSBS = value<23>;
        if privileged then
            PSTATE.PAN = value<22>;
        if HaveDITExt() then
            PSTATE.DIT = value<21>;
        // Bit <20> is RES0
        PSTATE.GE = value<19:16>;

    if bytemask<1> == '1' then
        // Bits <15:10> are RES0
        PSTATE.E = value<9>; // PSTATE.E is writable at EL0
        if privileged then
            PSTATE.A = value<8>;

    if bytemask<0> == '1' then
        if privileged then
            PSTATE.<I,F> = value<7:6>;
            // Bit <5> is RES0
            // AArch32.WriteModeByInstr() sets PSTATE.IL to 1 if this is an illegal mode change.
            AArch32.WriteModeByInstr(value<4:0>);
    return;
```

## Library pseudocode for aarch32/functions/system/ConditionPassed

```
// ConditionPassed()
// =====

boolean ConditionPassed()
    return ConditionHolds(AArch32.CurrentCond());
```

## Library pseudocode for aarch32/functions/system/CurrentCond

```
bits(4) AArch32.CurrentCond();
```

## Library pseudocode for aarch32/functions/system/InITBlock

```
// InITBlock()
// =====

boolean InITBlock()
    if CurrentInstrSet() == InstrSet\_T32 then
        return PSTATE.IT<3:0> != '0000';
    else
        return FALSE;
```



## Library pseudocode for aarch32/functions/system/LastInITBlock

```
// LastInITBlock()
// =====

boolean LastInITBlock()
    return (PSTATE.IT<3:0> == '1000');
```

## Library pseudocode for aarch32/functions/system/SPSRWriteByInstr

```
// SPSRWriteByInstr()
// =====

SPSRWriteByInstr(bits(32) value, bits(4) bytemask)

    new_spsr = SPSR[];

    if bytemask<3> == '1' then
        new_spsr<31:24> = value<31:24>; // N,Z,C,V,Q flags, IT[1:0],J bits

    if bytemask<2> == '1' then
        new_spsr<23:16> = value<23:16>; // IL bit, GE[3:0] flags

    if bytemask<1> == '1' then
        new_spsr<15:8> = value<15:8>; // IT[7:2] bits, E bit, A interrupt mask

    if bytemask<0> == '1' then
        new_spsr<7:0> = value<7:0>; // I,F interrupt masks, T bit, Mode bits

    SPSR[] = new_spsr; // UNPREDICTABLE if User or System mode

    return;
```

## Library pseudocode for aarch32/functions/system/SPSRAccessValid

```
// SPSRAccessValid()
// =====
// Checks for MRS (Banked register) or MSR (Banked register) accesses to the SPSRs
// that are UNPREDICTABLE

SPSRAccessValid(bits(5) SYSm, bits(5) mode)
    case SYSm of
        when '01110' // SPSR_fiq
            if mode == M32_FIQ then UNPREDICTABLE;
        when '10000' // SPSR_irq
            if mode == M32_IRQ then UNPREDICTABLE;
        when '10010' // SPSR_svc
            if mode == M32_Svc then UNPREDICTABLE;
        when '10100' // SPSR_abt
            if mode == M32_Abort then UNPREDICTABLE;
        when '10110' // SPSR_und
            if mode == M32_Undef then UNPREDICTABLE;
        when '11100' // SPSR_mon
            if !HaveEL(EL3) || mode == M32_Monitor || !IsSecure() then UNPREDICTABLE;
        when '11110' // SPSR_hyp
            if !HaveEL(EL2) || mode != M32_Monitor then UNPREDICTABLE;
        otherwise
            UNPREDICTABLE;

    return;
```

## Library pseudocode for aarch32/functions/system/SelectInstrSet

```
// SelectInstrSet()
// =====

SelectInstrSet(InstrSet iset)
    assert CurrentInstrSet() IN {InstrSet\_A32, InstrSet\_T32};
    assert iset IN {InstrSet\_A32, InstrSet\_T32};

    PSTATE.T = if iset == InstrSet\_A32 then '0' else '1';

    return;
```

## Library pseudocode for aarch32/functions/v6simd/Sat

```
// Sat()
// =====

bits(N) Sat(integer i, integer N, boolean unsigned)
    result = if unsigned then UnsignedSat(i, N) else SignedSat(i, N);
    return result;
```

## Library pseudocode for aarch32/functions/v6simd/SignedSat

```
// SignedSat()
// =====

bits(N) SignedSat(integer i, integer N)
    (result, -) = SignedSat0(i, N);
    return result;
```

## Library pseudocode for aarch32/functions/v6simd/UnsignedSat

```
// UnsignedSat()
// =====

bits(N) UnsignedSat(integer i, integer N)
    (result, -) = UnsignedSat0(i, N);
    return result;
```

## Library pseudocode for aarch32/translation/attrs/AArch32.CombineS1S2Desc

```
// AArch32.CombineS1S2Desc()
// =====
// Combines the address descriptors from stage 1 and stage 2

AddressDescriptor AArch32.CombineS1S2Desc(AddressDescriptor s1desc, AddressDescriptor s2desc)

    AddressDescriptor result;

    result.paddress = s2desc.paddress;

    apply_force_writeback = HaveStage2MemAttrControl() && HCR_EL2.FWB == '1';
    if IsFault(s1desc) || IsFault(s2desc) then
        result = if IsFault(s1desc) then s1desc else s2desc;
    else
        result.fault = AArch32.NoFault();
        if s2desc.memattrs.memtype == MemType_Device || (
            (apply_force_writeback && s1desc.memattrs.memtype == MemType_Device && s2desc.memattrs.inner
            (!apply_force_writeback && s1desc.memattrs.memtype == MemType_Device) ) then
            result.memattrs.memtype = MemType_Device;
            if s1desc.memattrs.memtype == MemType_Normal then
                result.memattrs.device = s2desc.memattrs.device;
            elseif s2desc.memattrs.memtype == MemType_Normal then
                result.memattrs.device = s1desc.memattrs.device;
            else
                // Both Device
                result.memattrs.device = CombineS1S2Device(s1desc.memattrs.device,
                                                            s2desc.memattrs.device);

            result.memattrs.tagged = FALSE;
            // S1 can be either Normal or Device, S2 is Normal.
        else
            result.memattrs.memtype = MemType_Normal;
            result.memattrs.device = DeviceType UNKNOWN;
            result.memattrs.inner = CombineS1S2AttrHints(s1desc.memattrs.inner, s2desc.memattrs.inner);
            result.memattrs.outer = CombineS1S2AttrHints(s1desc.memattrs.outer, s2desc.memattrs.outer);
            result.memattrs.shareable = (s1desc.memattrs.shareable || s2desc.memattrs.shareable);
            result.memattrs.outershareable = (s1desc.memattrs.outershareable ||
                                                s2desc.memattrs.outershareable);

            result.memattrs.tagged = (s1desc.memattrs.tagged &&
                                     result.memattrs.inner.attrs == MemAttr_WB &&
                                     result.memattrs.inner.hints == MemHint_RWA &&
                                     result.memattrs.outer.attrs == MemAttr_WB &&
                                     result.memattrs.outer.hints == MemHint_RWA);

    result.memattrs = MemAttrDefaults(result.memattrs);

    return result;
```

## Library pseudocode for aarch32/translation/attrs/AArch32.DefaultTEXDecode

```
// AArch32.DefaultTEXDecode()
// =====

MemoryAttributes AArch32.DefaultTEXDecode(bits(3) TEX, bit C, bit B, bit S, AccType acctype)

    MemoryAttributes memattrs;

    // Reserved values map to allocated values
    if (TEX == '001' && C:B == '01') || (TEX == '010' && C:B != '00') || TEX == '011' then
        bits(5) texcb;
        (-, texcb) = ConstrainUnpredictableBits(Unpredictable\_RESTEXCB);
        TEX = texcb<4:2>; C = texcb<1>; B = texcb<0>;

    case TEX:C:B of
        when '00000'
            // Device-nGnRnE
            memattrs.memtype = MemType\_Device;
            memattrs.device = DeviceType\_nGnRnE;
        when '00001', '01000'
            // Device-nGnRE
            memattrs.memtype = MemType\_Device;
            memattrs.device = DeviceType\_nGnRE;
        when '00010', '00011', '00100'
            // Write-back or Write-through Read allocate, or Non-cacheable
            memattrs.memtype = MemType\_Normal;
            memattrs.inner = ShortConvertAttrsHints(C:B, acctype, FALSE);
            memattrs.outer = ShortConvertAttrsHints(C:B, acctype, FALSE);
            memattrs.shareable = (S == '1');
        when '00110'
            memattrs = MemoryAttributes IMPLEMENTATION_DEFINED;
        when '00111'
            // Write-back Read and Write allocate
            memattrs.memtype = MemType\_Normal;
            memattrs.inner = ShortConvertAttrsHints('01', acctype, FALSE);
            memattrs.outer = ShortConvertAttrsHints('01', acctype, FALSE);
            memattrs.shareable = (S == '1');
        when '1xxxx'
            // Cacheable, TEX<1:0> = Outer attrs, {C,B} = Inner attrs
            memattrs.memtype = MemType\_Normal;
            memattrs.inner = ShortConvertAttrsHints(C:B, acctype, FALSE);
            memattrs.outer = ShortConvertAttrsHints(TEX<1:0>, acctype, FALSE);
            memattrs.shareable = (S == '1');
        otherwise
            // Reserved, handled above
            Unreachable();

    // transient bits are not supported in this format
    memattrs.inner.transient = FALSE;
    memattrs.outer.transient = FALSE;

    // distinction between inner and outer shareable is not supported in this format
    memattrs.outershareable = memattrs.shareable;
    memattrs.tagged = FALSE;

    return MemAttrDefaults(memattrs);
```

## Library pseudocode for aarch32/translation/attrs/AArch32.InstructionDevice

```
// AArch32.InstructionDevice()
// =====
// Instruction fetches from memory marked as Device but not execute-never might generate a
// Permission Fault but are otherwise treated as if from Normal Non-cacheable memory.

AddressDescriptor AArch32.InstructionDevice(AddressDescriptor addrdesc, bits(32) vaddress,
                                             bits(40) ipaddress, integer level, bits(4) domain,
                                             AccType acctype, boolean iswrite, boolean secondstage,
                                             boolean s2fslwalk)

    c = ConstrainUnpredictable(Unpredictable_INSTRDEVICE);
    assert c IN {Constraint_NONE, Constraint_FAULT};

    if c == Constraint_FAULT then
        addrdesc.fault = AArch32.PermissionFault(ipaddress, domain, level, acctype, iswrite,
                                                    secondstage, s2fslwalk);
    else
        addrdesc.memattrs.memtype = MemType_Normal;
        addrdesc.memattrs.inner.attrs = MemAttr_NC;
        addrdesc.memattrs.inner.hints = MemHint_No;
        addrdesc.memattrs.outer = addrdesc.memattrs.inner;
        addrdesc.memattrs.tagged = FALSE;
        addrdesc.memattrs = MemAttrDefaults(addrdesc.memattrs);

    return addrdesc;
```

## Library pseudocode for aarch32/translation/attrs/AArch32.RemappedTEXDecode

```
// AArch32.RemappedTEXDecode()
// =====

MemoryAttributes AArch32.RemappedTEXDecode(bits(3) TEX, bit C, bit B, bit S, AccType acctype)

    MemoryAttributes memattrs;

    region = UInt(TEX<0>:C:B);          // TEX<2:1> are ignored in this mapping scheme
    if region == 6 then
        memattrs = MemoryAttributes IMPLEMENTATION_DEFINED;
    else
        base = 2 * region;
        attrfield = PRRR<base+1:base>;

        if attrfield == '11' then      // Reserved, maps to allocated value
            (-, attrfield) = ConstrainUnpredictableBits(Unpredictable\_RESPRRR);

        case attrfield of
            when '00'                  // Device-nGnRnE
                memattrs.memtype = MemType\_Device;
                memattrs.device = DeviceType\_nGnRnE;
            when '01'                  // Device-nGnRE
                memattrs.memtype = MemType\_Device;
                memattrs.device = DeviceType\_nGnRE;
            when '10'
                memattrs.memtype = MemType\_Normal;
                memattrs.inner = ShortConvertAttrsHints(NMRR<base+1:base>, acctype, FALSE);
                memattrs.outer = ShortConvertAttrsHints(NMRR<base+17:base+16>, acctype, FALSE);
                s_bit = if S == '0' then PRRR.NS0 else PRRR.NS1;
                memattrs.shareable = (s_bit == '1');
                memattrs.outershareable = (s_bit == '1' && PRRR<region+24> == '0');
            when '11'
                Unreachable();

        // transient bits are not supported in this format
        memattrs.inner.transient = FALSE;
        memattrs.outer.transient = FALSE;
        memattrs.tagged = FALSE;

    return MemAttrDefaults(memattrs);
```

## Library pseudocode for aarch32/translation/attrs/AArch32.S1AttrDecode

```
// AArch32.S1AttrDecode()
// =====
// Converts the Stage 1 attribute fields, using the MAIR, to orthogonal
// attributes and hints.

MemoryAttributes AArch32.S1AttrDecode(bits(2) SH, bits(3) attr, AccType acctype)

    MemoryAttributes memattrs;

    if PSTATE.EL == EL2 then
        mair = HMAIR1:HMAIR0;
    else
        mair = MAIR1:MAIR0;
    index = 8 * UInt(attr);
    attrfield = mair<index+7:index>;

    memattrs.tagged = FALSE;
    if ((attrfield<7:4> != '0000' && attrfield<7:4> != '1111' && attrfield<3:0> == '0000') ||
        (attrfield<7:4> == '0000' && attrfield<3:0> != 'xx00')) then
        // Reserved, maps to an allocated value
        (-, attrfield) = ConstrainUnpredictableBits(Unpredictable_RESMAIR);
    if !HaveMTEExt() && attrfield<7:4> == '1111' && attrfield<3:0> == '0000' then
        // Reserved, maps to an allocated value
        (-, attrfield) = ConstrainUnpredictableBits(Unpredictable_RESMAIR);

    if attrfield<7:4> == '0000' then // Device
        memattrs.memtype = MemType_Device;
        case attrfield<3:0> of
            when '0000' memattrs.device = DeviceType_nGnRnE;
            when '0100' memattrs.device = DeviceType_nGnRE;
            when '1000' memattrs.device = DeviceType_nGRE;
            when '1100' memattrs.device = DeviceType_GRE;
            otherwise Unreachable(); // Reserved, handled above

    elsif attrfield<3:0> != '0000' then // Normal
        memattrs.memtype = MemType_Normal;
        memattrs.outer = LongConvertAttrsHints(attrfield<7:4>, acctype);
        memattrs.inner = LongConvertAttrsHints(attrfield<3:0>, acctype);
        memattrs.shareable = SH<1> == '1';
        memattrs.outershareable = SH == '10';
    elsif HaveMTEExt() && attrfield == '11110000' then // Normal, Tagged WB-RWA
        memattrs.memtype = MemType_Normal;
        memattrs.outer = LongConvertAttrsHints('1111', acctype); // WB_RWA
        memattrs.inner = LongConvertAttrsHints('1111', acctype); // WB_RWA
        memattrs.shareable = SH<1> == '1';
        memattrs.outershareable = SH == '10';
        memattrs.tagged = TRUE;
    else
        Unreachable(); // Reserved, handled above

    return MemAttrDefaults(memattrs);
```

## Library pseudocode for aarch32/translation/attrs/AArch32.TranslateAddressS1Off

```
// AArch32.TranslateAddressS1Off()
// =====
// Called for stage 1 translations when translation is disabled to supply a default translation.
// Note that there are additional constraints on instruction prefetching that are not described in
// this pseudocode.

TLBRecord AArch32.TranslateAddressS1Off(bits(32) vaddress, AccType acctype, boolean iswrite)
    assert ELUsingAArch32\(S1TranslationRegime\(\)\);

    TLBRecord result;

    default_cacheable = (HasS2Translation\(\) && ((if ELUsingAArch32\(EL2\) then HCR.DC else HCR_EL2.DC) == '1'))
    if default_cacheable then
        // Use default cacheable settings
        result.addrdesc.memattrs.memtype = MemType\_Normal;
        result.addrdesc.memattrs.inner.attrs = MemAttr\_WB; // Write-back
        result.addrdesc.memattrs.inner.hints = MemHint\_RWA;
        result.addrdesc.memattrs.shareable = FALSE;
        result.addrdesc.memattrs.outershareable = FALSE;
        result.addrdesc.memattrs.tagged = HCR_EL2.DCT == '1';
    elseif acctype != AccType\_IFETCH then
        // Treat data as Device
        result.addrdesc.memattrs.memtype = MemType\_Device;
        result.addrdesc.memattrs.device = DeviceType\_nGnRnE;
        result.addrdesc.memattrs.inner = MemAttrHints UNKNOWN;
        result.addrdesc.memattrs.tagged = FALSE;
    else
        // Instruction cacheability controlled by SCTLR/HSCTLR.I
        if PSTATE.EL == EL2 then
            cacheable = HSCTLR.I == '1';
        else
            cacheable = SCTLR.I == '1';
        result.addrdesc.memattrs.memtype = MemType\_Normal;
        if cacheable then
            result.addrdesc.memattrs.inner.attrs = MemAttr\_WT;
            result.addrdesc.memattrs.inner.hints = MemHint\_RA;
        else
            result.addrdesc.memattrs.inner.attrs = MemAttr\_NC;
            result.addrdesc.memattrs.inner.hints = MemHint\_No;
            result.addrdesc.memattrs.shareable = TRUE;
            result.addrdesc.memattrs.outershareable = TRUE;
            result.addrdesc.memattrs.tagged = FALSE;

    result.addrdesc.memattrs.outer = result.addrdesc.memattrs.inner;

    result.addrdesc.memattrs = MemAttrDefaults(result.addrdesc.memattrs);

    result.perms.ap = bits(3) UNKNOWN;
    result.perms.xn = '0';
    result.perms.pxn = '0';

    result.nG = bit UNKNOWN;
    result.contiguous = boolean UNKNOWN;
    result.domain = bits(4) UNKNOWN;
    result.level = integer UNKNOWN;
    result.blocksize = integer UNKNOWN;
    result.addrdesc.paddress.address = ZeroExtend(vaddress);
    result.addrdesc.paddress.NS = if IsSecure\(\) then '0' else '1';
    result.addrdesc.fault = AArch32.NoFault\(\);

    result.descupdate.AF = FALSE;
    result.descupdate.AP = FALSE;
    result.descupdate.descaddr = result.addrdesc;

    return result;
```



## Library pseudocode for aarch32/translation/checks/AArch32.AccessIsPrivileged

```
// AArch32.AccessIsPrivileged()
// =====

boolean AArch32.AccessIsPrivileged(AccType acctype)

    el = AArch32.AccessUsesEL(acctype);

    if el == EL0 then
        ispriv = FALSE;
    elsif el != EL1 then
        ispriv = TRUE;
    else
        ispriv = (acctype != AccType\_UNPRIV);

    return ispriv;
```

## Library pseudocode for aarch32/translation/checks/AArch32.AccessUsesEL

```
// AArch32.AccessUsesEL()
// =====
// Returns the Exception Level of the regime that will manage the translation for a given access type.

bits(2) AArch32.AccessUsesEL(AccType acctype)
    if acctype == AccType\_UNPRIV then
        return EL0;
    else
        return PSTATE.EL;
```

## Library pseudocode for aarch32/translation/checks/AArch32.CheckDomain

```
// AArch32.CheckDomain()
// =====

(boolean, FaultRecord) AArch32.CheckDomain(bits(4) domain, bits(32) vaddress, integer level,
AccType acctype, boolean iswrite)

    index = 2 * UInt(domain);
    attrfield = DACR<index+1:index>;

    if attrfield == '10' then // Reserved, maps to an allocated value
        // Reserved value maps to an allocated value
        (-, attrfield) = ConstrainUnpredictableBits(Unpredictable\_RESDACR);

    if attrfield == '00' then
        fault = AArch32.DomainFault(domain, level, acctype, iswrite);
    else
        fault = AArch32.NoFault();

    permissioncheck = (attrfield == '01');

    return (permissioncheck, fault);
```



```

// AArch32.CheckPermission()
// =====
// Function used for permission checking from AArch32 stage 1 translations

FaultRecord AArch32.CheckPermission(Permissions perms, bits(32) vaddress, integer level,
                                     bits(4) domain, bit NS, AccType acctype, boolean iswrite)
assert ELUsingAArch32\(S1TranslationRegime\(\)\);

if PSTATE.EL != EL2 then
    wxn = SCTLR.WXN == '1';
    if TTBCR.EAE == '1' || SCTLR.AFE == '1' || perms.ap<0> == '1' then
        priv_r = TRUE;
        priv_w = perms.ap<2> == '0';
        user_r = perms.ap<1> == '1';
        user_w = perms.ap<2:1> == '01';
    else
        priv_r = perms.ap<2:1> != '00';
        priv_w = perms.ap<2:1> == '01';
        user_r = perms.ap<1> == '1';
        user_w = FALSE;
    uwxn = SCTLR.UWXN == '1';

    ispriv = AArch32.AccessIsPrivileged(acctype);

    pan = if HavePANExt\(\) then PSTATE.PAN else '0';
    is_ldst = !(acctype IN {AccType\_DC, AccType\_DC\_UNPRIV, AccType\_AT, AccType\_IFETCH});
    is_atslxp = (acctype == AccType\_AT && AArch32.ExecutingATSlxPInstr\(\));
    if pan == '1' && user_r && ispriv && (is_ldst || is_atslxp) then
        priv_r = FALSE;
        priv_w = FALSE;

    user_xn = !user_r || perms.xn == '1' || (user_w && wxn);
    priv_xn = (!priv_r || perms.xn == '1' || perms.pxn == '1' ||
              (priv_w && wxn) || (user_w && uwxn));

    if ispriv then
        (r, w, xn) = (priv_r, priv_w, priv_xn);
    else
        (r, w, xn) = (user_r, user_w, user_xn);
else
    // Access from EL2
    wxn = HSCTLR.WXN == '1';
    r = TRUE;
    w = perms.ap<2> == '0';
    xn = perms.xn == '1' || (w && wxn);

    // Restriction on Secure instruction fetch
    if HaveEL\(EL3\) && IsSecure\(\) && NS == '1' then
        secure_instr_fetch = if ELUsingAArch32\(EL3\) then SCR.SIF else SCR_EL3.SIF;
        if secure_instr_fetch == '1' then xn = TRUE;

    if acctype == AccType\_IFETCH then
        fail = xn;
        failedread = TRUE;
    elsif acctype IN { AccType\_ATOMICRW, AccType\_ORDEREDRW, AccType\_ORDEREDATOMICRW } then
        fail = !r || !w;
        failedread = !r;
    elsif acctype == AccType\_DC then
        // DC maintenance instructions operating by VA, cannot fault from stage 1 translation.
        fail = FALSE;
    elsif iswrite then
        fail = !w;
        failedread = FALSE;
    else
        fail = !r;
        failedread = TRUE;

    if fail then
        secondstage = FALSE;
        s2fslwalk = FALSE;

```

```

    ipaddress = bits(40) UNKNOWN;
    return AArch32.PermissionFault(ipaddress, domain, level, acctype,
                                   !failedread, secondstage, s2fslwalk);
else
    return AArch32.NoFault();

```

### Library pseudocode for aarch32/translation/checks/AArch32.CheckS2Permission

```

// AArch32.CheckS2Permission()
// =====
// Function used for permission checking from AArch32 stage 2 translations

FaultRecord AArch32.CheckS2Permission(Permissions perms, bits(32) vaddress, bits(40) ipaddress,
                                       integer level, AccType acctype, boolean iswrite,
                                       boolean s2fslwalk)

    assert HaveEL(EL2) && !IsSecure() && ELUsingAArch32(EL2) && HasS2Translation();

    r = perms.ap<1> == '1';
    w = perms.ap<2> == '1';
    if HaveExtendedExecuteNeverExt() then
        case perms.xn:perms.xxn of
            when '00' xn = !r;
            when '01' xn = !r || PSTATE.EL == EL1;
            when '10' xn = TRUE;
            when '11' xn = !r || PSTATE.EL == EL0;
    else
        xn = !r || perms.xn == '1';
    // Stage 1 walk is checked as a read, regardless of the original type
    if acctype == AccType_IFETCH && !s2fslwalk then
        fail = xn;
        failedread = TRUE;
    elseif (acctype IN { AccType_ATOMICRW, AccType_ORDEREDRW, AccType_ORDEREDATOMICRW }) && !s2fslwalk then
        fail = !r || !w;
        failedread = !r;
    elseif acctype == AccType_DC && !s2fslwalk then
        // DC maintenance instructions operating by VA, do not generate Permission faults
        // from stage 2 translation, other than from stage 1 translation table walk.
        fail = FALSE;
    elseif iswrite && !s2fslwalk then
        fail = !w;
        failedread = FALSE;
    else
        fail = !r;
        failedread = !iswrite;

    if fail then
        domain = bits(4) UNKNOWN;
        secondstage = TRUE;
        return AArch32.PermissionFault(ipaddress, domain, level, acctype,
                                       !failedread, secondstage, s2fslwalk);
    else
        return AArch32.NoFault();

```

## Library pseudocode for aarch32/translation/debug/AArch32.CheckBreakpoint

```
// AArch32.CheckBreakpoint()
// =====
// Called before executing the instruction of length "size" bytes at "vaddress" in an AArch32
// translation regime, when either debug exceptions are enabled, or halting debug is enabled
// and halting is allowed.

FaultRecord AArch32.CheckBreakpoint(bits(32) vaddress, integer size)
    assert ELUsingAArch32\(S1TranslationRegime\(\)\);
    assert size IN {2,4};

    match = FALSE;
    mismatch = FALSE;

    for i = 0 to UInt\(DBGDIDR.BRPs\)
        (match_i, mismatch_i) = AArch32.BreakpointMatch(i, vaddress, size);
        match = match || match_i;
        mismatch = mismatch || mismatch_i;

    if match && HaltOnBreakpointOrWatchpoint\(\) then
        reason = DebugHalt\_Breakpoint;
        Halt(reason);
    elseif (match || mismatch) then
        acctype = AccType\_IFETCH;
        iswrite = FALSE;
        debugmoe = DebugException\_Breakpoint;
        return AArch32.DebugFault(acctype, iswrite, debugmoe);
    else
        return AArch32.NoFault();
```

## Library pseudocode for aarch32/translation/debug/AArch32.CheckDebug

```
// AArch32.CheckDebug()
// =====
// Called on each access to check for a debug exception or entry to Debug state.

FaultRecord AArch32.CheckDebug(bits(32) vaddress, AccType acctype, boolean iswrite, integer size)

    FaultRecord fault = AArch32.NoFault();

    d_side = (acctype != AccType\_IFETCH);
    generate_exception = AArch32.GenerateDebugExceptions() && DBGDSCRext.MDBGGen == '1';
    halt = HaltOnBreakpointOrWatchpoint();
    // Relative priority of Vector Catch and Breakpoint exceptions not defined in the architecture
    vector_catch_first = ConstrainUnpredictableBool\(Unpredictable\_BPVECTORCATCHPRI\);

    if !d_side && vector_catch_first && generate_exception then
        fault = AArch32.CheckVectorCatch(vaddress, size);

    if fault.statuscode == Fault\_None && (generate_exception || halt) then
        if d_side then
            fault = AArch32.CheckWatchpoint(vaddress, acctype, iswrite, size);
        else
            fault = AArch32.CheckBreakpoint(vaddress, size);

    if fault.statuscode == Fault\_None && !d_side && !vector_catch_first && generate_exception then
        return AArch32.CheckVectorCatch(vaddress, size);

    return fault;
```

## Library pseudocode for aarch32/translation/debug/AArch32.CheckVectorCatch

```
// AArch32.CheckVectorCatch()
// =====
// Called before executing the instruction of length "size" bytes at "vaddress" in an AArch32
// translation regime, when debug exceptions are enabled.

FaultRecord AArch32.CheckVectorCatch(bits(32) vaddress, integer size)
    assert ELUsingAArch32(S1TranslationRegime());

    match = AArch32.VCRMATCH(vaddress);
    if size == 4 && !match && AArch32.VCRMATCH(vaddress + 2) then
        match = ConstrainUnpredictableBool(Unpredictable_VCMATCHHALF);

    if match then
        acctype = AccType_IFETCH;
        iswrite = FALSE;
        debugmoe = DebugException_VectorCatch;
        return AArch32.DebugFault(acctype, iswrite, debugmoe);
    else
        return AArch32.NoFault();
```

## Library pseudocode for aarch32/translation/debug/AArch32.CheckWatchpoint

```
// AArch32.CheckWatchpoint()
// =====
// Called before accessing the memory location of "size" bytes at "address",
// when either debug exceptions are enabled for the access, or halting debug
// is enabled and halting is allowed.

FaultRecord AArch32.CheckWatchpoint(bits(32) vaddress, AccType acctype,
                                     boolean iswrite, integer size)
    assert ELUsingAArch32(S1TranslationRegime());

    match = FALSE;
    ispriv = AArch32.AccessIsPrivileged(acctype);

    for i = 0 to UInt(DBGDIDR.WRPs)
        match = match || AArch32.WatchpointMatch(i, vaddress, size, ispriv, iswrite);

    if match && HaltOnBreakpointOrWatchpoint() then
        reason = DebugHalt_Watchpoint;
        Halt(reason);
    elseif match then
        debugmoe = DebugException_Watchpoint;
        return AArch32.DebugFault(acctype, iswrite, debugmoe);
    else
        return AArch32.NoFault();
```

## Library pseudocode for aarch32/translation/faults/AArch32.AccessFlagFault

```
// AArch32.AccessFlagFault()
// =====

FaultRecord AArch32.AccessFlagFault(bits(40) ipaddress, bits(4) domain, integer level,
                                     AccType acctype, boolean iswrite, boolean secondstage,
                                     boolean s2fslwalk)

    extflag = bit UNKNOWN;
    debugmoe = bits(4) UNKNOWN;
    errortype = bits(2) UNKNOWN;
    return AArch32.CreateFaultRecord(Fault_AccessFlag, ipaddress, domain, level, acctype, iswrite,
                                     extflag, debugmoe, errortype, secondstage, s2fslwalk);
```

## Library pseudocode for aarch32/translation/faults/AArch32.AddressSizeFault

```
// AArch32.AddressSizeFault()
// =====

FaultRecord AArch32.AddressSizeFault(bits(40) ipaddress, bits(4) domain, integer level,
                                     AccType acctype, boolean iswrite, boolean secondstage,
                                     boolean s2fslwalk)

    extflag = bit UNKNOWN;
    debugmoe = bits(4) UNKNOWN;
    errortype = bits(2) UNKNOWN;
    return AArch32.CreateFaultRecord(Fault\_AddressSize, ipaddress, domain, level, acctype, iswrite,
                                     extflag, debugmoe, errortype, secondstage, s2fslwalk);
```

## Library pseudocode for aarch32/translation/faults/AArch32.AlignmentFault

```
// AArch32.AlignmentFault()
// =====

FaultRecord AArch32.AlignmentFault(AccType acctype, boolean iswrite, boolean secondstage)

    ipaddress = bits(40) UNKNOWN;
    domain = bits(4) UNKNOWN;
    level = integer UNKNOWN;
    extflag = bit UNKNOWN;
    debugmoe = bits(4) UNKNOWN;
    errortype = bits(2) UNKNOWN;
    s2fslwalk = boolean UNKNOWN;

    return AArch32.CreateFaultRecord(Fault\_Alignment, ipaddress, domain, level, acctype, iswrite,
                                     extflag, debugmoe, errortype, secondstage, s2fslwalk);
```

## Library pseudocode for aarch32/translation/faults/AArch32.AsynchExternalAbort

```
// AArch32.AsynchExternalAbort()
// =====
// Wrapper function for asynchronous external aborts

FaultRecord AArch32.AsynchExternalAbort(boolean parity, bits(2) errortype, bit extflag)

    faulttype = if parity then Fault\_AsyncParity else Fault\_AsyncExternal;
    ipaddress = bits(40) UNKNOWN;
    domain = bits(4) UNKNOWN;
    level = integer UNKNOWN;
    acctype = AccType\_NORMAL;
    iswrite = boolean UNKNOWN;
    debugmoe = bits(4) UNKNOWN;
    secondstage = FALSE;
    s2fslwalk = FALSE;

    return AArch32.CreateFaultRecord(faulttype, ipaddress, domain, level, acctype, iswrite, extflag,
                                     debugmoe, errortype, secondstage, s2fslwalk);
```

## Library pseudocode for aarch32/translation/faults/AArch32.DebugFault

```
// AArch32.DebugFault()
// =====

FaultRecord AArch32.DebugFault(AccType acctype, boolean iswrite, bits(4) debugmoe)

    ipaddress = bits(40) UNKNOWN;
    domain = bits(4) UNKNOWN;
    errortype = bits(2) UNKNOWN;
    level = integer UNKNOWN;
    extflag = bit UNKNOWN;
    secondstage = FALSE;
    s2fslwalk = FALSE;

    return AArch32.CreateFaultRecord(Fault\_Debug, ipaddress, domain, level, acctype, iswrite,
                                     extflag, debugmoe, errortype, secondstage, s2fslwalk);
```

## Library pseudocode for aarch32/translation/faults/AArch32.DomainFault

```
// AArch32.DomainFault()
// =====

FaultRecord AArch32.DomainFault(bits(4) domain, integer level, AccType acctype, boolean iswrite)

    ipaddress = bits(40) UNKNOWN;
    extflag = bit UNKNOWN;
    debugmoe = bits(4) UNKNOWN;
    errortype = bits(2) UNKNOWN;
    secondstage = FALSE;
    s2fslwalk = FALSE;

    return AArch32.CreateFaultRecord(Fault\_Domain, ipaddress, domain, level, acctype, iswrite,
                                     extflag, debugmoe, errortype, secondstage, s2fslwalk);
```

## Library pseudocode for aarch32/translation/faults/AArch32.NoFault

```
// AArch32.NoFault()
// =====

FaultRecord AArch32.NoFault()

    ipaddress = bits(40) UNKNOWN;
    domain = bits(4) UNKNOWN;
    level = integer UNKNOWN;
    acctype = AccType\_NORMAL;
    iswrite = boolean UNKNOWN;
    extflag = bit UNKNOWN;
    debugmoe = bits(4) UNKNOWN;
    errortype = bits(2) UNKNOWN;
    secondstage = FALSE;
    s2fslwalk = FALSE;

    return AArch32.CreateFaultRecord(Fault\_None, ipaddress, domain, level, acctype, iswrite,
                                     extflag, debugmoe, errortype, secondstage, s2fslwalk);
```



## Library pseudocode for aarch32/translation/faults/AArch32.PermissionFault

```
// AArch32.PermissionFault()
// =====

FaultRecord AArch32.PermissionFault(bits(40) ipaddress, bits(4) domain, integer level,
                                     AccType acctype, boolean iswrite, boolean secondstage,
                                     boolean s2fslwalk)

    extflag = bit UNKNOWN;
    debugmoe = bits(4) UNKNOWN;
    errortype = bits(2) UNKNOWN;
    return AArch32.CreateFaultRecord(Fault\_Permission, ipaddress, domain, level, acctype, iswrite,
                                     extflag, debugmoe, errortype, secondstage, s2fslwalk);
```

## Library pseudocode for aarch32/translation/faults/AArch32.TranslationFault

```
// AArch32.TranslationFault()
// =====

FaultRecord AArch32.TranslationFault(bits(40) ipaddress, bits(4) domain, integer level,
                                     AccType acctype, boolean iswrite, boolean secondstage,
                                     boolean s2fslwalk)

    extflag = bit UNKNOWN;
    debugmoe = bits(4) UNKNOWN;
    errortype = bits(2) UNKNOWN;
    return AArch32.CreateFaultRecord(Fault\_Translation, ipaddress, domain, level, acctype, iswrite,
                                     extflag, debugmoe, errortype, secondstage, s2fslwalk);
```

## Library pseudocode for aarch32/translation/translation/AArch32.FirstStageTranslate

```
// AArch32.FirstStageTranslate()
// =====
// Perform a stage 1 translation walk. The function used by Address Translation operations is
// similar except it uses the translation regime specified for the instruction.

AddressDescriptor AArch32.FirstStageTranslate(bits(32) vaddress, AccType acctype, boolean iswrite,
                                             boolean wasaligned, integer size)

    if PSTATE.EL == EL2 then
        s1_enabled = HSCTLR.M == '1';
    elseif EL2Enabled\(\) then
        tge = (if ELUsingAArch32\(EL2\) then HCR.TGE else HCR_EL2.TGE);
        dc = (if ELUsingAArch32\(EL2\) then HCR.DC else HCR_EL2.DC);
        s1_enabled = tge == '0' && dc == '0' && SCTLR.M == '1';
    else
        s1_enabled = SCTLR.M == '1';

    TLBRecord S1;
    S1.addrdesc.fault = AArch32.NoFault\(\);
    ipaddress = bits(40) UNKNOWN;
    secondstage = FALSE;
    s2fslwalk = FALSE;

    if s1_enabled then // First stage enabled
        use_long_descriptor_format = PSTATE.EL == EL2 || TTBCR.EAE == '1';
        if use_long_descriptor_format then
            S1 = AArch32.TranslationTableWalkLD(ipaddress, vaddress, acctype, iswrite, secondstage,
                                                s2fslwalk, size);
            permissioncheck = TRUE; domaincheck = FALSE;
        else
            S1 = AArch32.TranslationTableWalkSD(vaddress, acctype, iswrite, size);
            permissioncheck = TRUE; domaincheck = TRUE;
    else
        S1 = AArch32.TranslateAddressS10ff(vaddress, acctype, iswrite);
        permissioncheck = FALSE; domaincheck = FALSE;
        InGuardedPage = FALSE; // No memory is guarded when stage 1 address translation is disabled

    if !IsFault(S1.addrdesc) && UsingAArch32\(\) && HaveTrapLoadStoreMultipleDeviceExt\(\) && AArch32.ExecutingEL2 then
        if S1.addrdesc.memattrs.memtype == MemType\_Device && S1.addrdesc.memattrs.device != DeviceType\_GPIOP then
            nTLSMD = if S1TranslationRegime\(\) == EL2 then HSCTLR.nTLSMD else SCTLR.nTLSMD;
            if nTLSMD == '0' then
                S1.addrdesc.fault = AArch32.AlignmentFault(acctype, iswrite, secondstage);

    // Check for unaligned data accesses to Device memory
    if ((!wasaligned && acctype != AccType\_IFETCH) || (acctype == AccType\_DCZVA)
        && !IsFault(S1.addrdesc) && S1.addrdesc.memattrs.memtype == MemType\_Device then
        S1.addrdesc.fault = AArch32.AlignmentFault(acctype, iswrite, secondstage);
    if !IsFault(S1.addrdesc) && domaincheck then
        (permissioncheck, abort) = AArch32.CheckDomain(S1.domain, vaddress, S1.level, acctype,
                                                    iswrite);
        S1.addrdesc.fault = abort;

    if !IsFault(S1.addrdesc) && permissioncheck then
        S1.addrdesc.fault = AArch32.CheckPermission(S1.perms, vaddress, S1.level,
                                                    S1.domain, S1.addrdesc.paddress.NS,
                                                    acctype, iswrite);

    // Check for instruction fetches from Device memory not marked as execute-never. If there has
    // not been a Permission Fault then the memory is not marked execute-never.
    if (!IsFault(S1.addrdesc) && S1.addrdesc.memattrs.memtype == MemType\_Device &&
        acctype == AccType\_IFETCH) then
        S1.addrdesc = AArch32.InstructionDevice(S1.addrdesc, vaddress, ipaddress, S1.level,
                                                S1.domain, acctype, iswrite,
                                                secondstage, s2fslwalk);

    return S1.addrdesc;
```

## Library pseudocode for aarch32/translation/translation/AArch32.FullTranslate

```
// AArch32.FullTranslate()
// =====
// Perform both stage 1 and stage 2 translation walks for the current translation regime. The
// function used by Address Translation operations is similar except it uses the translation
// regime specified for the instruction.

AddressDescriptor AArch32.FullTranslate(bits(32) vaddress, AccType acctype, boolean iswrite,
                                         boolean wasaligned, integer size)

    // First Stage Translation
    S1 = AArch32.FirstStageTranslate(vaddress, acctype, iswrite, wasaligned, size);
    if !IsFault(S1) && !\(HaveNV2Ext\(\)\) && acctype == AccType\_NV2REGISTER && HasS2Translation\(\) then
        s2fslwalk = FALSE;
        result = AArch32.SecondStageTranslate(S1, vaddress, acctype, iswrite, wasaligned, s2fslwalk,
                                                size);
    else
        result = S1;

    return result;
```

## Library pseudocode for aarch32/translation/translation/AArch32.SecondStageTranslate

```
// AArch32.SecondStageTranslate()
// =====
// Perform a stage 2 translation walk. The function used by Address Translation operations is
// similar except it uses the translation regime specified for the instruction.

AddressDescriptor AArch32.SecondStageTranslate(AddressDescriptor S1, bits(32) vaddress,
                                              AccType acctype, boolean iswrite, boolean wasaligned,
                                              boolean s2fslwalk, integer size)

    assert HasS2Translation();
    assert IsZero(S1.paddress.address<47:40>);
    hwupdatewalk = FALSE;
    if !ELUsingAArch32(EL2) then
        return AArch64.SecondStageTranslate(S1, ZeroExtend(vaddress, 64), acctype, iswrite,
                                              wasaligned, s2fslwalk, size, hwupdatewalk);

    s2_enabled = HCR.VM == '1' || HCR.DC == '1';
    secondstage = TRUE;

    if s2_enabled then // Second stage enabled
        ipaddress = S1.paddress.address<39:0>;
        S2 = AArch32.TranslationTableWalkLD(ipaddress, vaddress, acctype, iswrite, secondstage,
                                              s2fslwalk, size);

        // Check for unaligned data accesses to Device memory
        if ((!wasaligned && acctype != AccType_IFETCH) || (acctype == AccType_DCZVA))
            && S2.addrdesc.memattrs.memtype == MemType_Device && !IsFault(S2.addrdesc) then
                S2.addrdesc.fault = AArch32.AlignmentFault(acctype, iswrite, secondstage);

        // Check for permissions on Stage2 translations
        if !IsFault(S2.addrdesc) then
            S2.addrdesc.fault = AArch32.CheckS2Permission(S2.perms, vaddress, ipaddress, S2.level,
                                                         acctype, iswrite, s2fslwalk);

        // Check for instruction fetches from Device memory not marked as execute-never. As there
        // has not been a Permission Fault then the memory is not marked execute-never.
        if (!s2fslwalk && !IsFault(S2.addrdesc) && S2.addrdesc.memattrs.memtype == MemType_Device &&
            acctype == AccType_IFETCH) then
            domain = bits(4) UNKNOWN;
            S2.addrdesc = AArch32.InstructionDevice(S2.addrdesc, vaddress, ipaddress, S2.level,
                                                    domain, acctype, iswrite,
                                                    secondstage, s2fslwalk);

        if (s2fslwalk && !IsFault(S2.addrdesc) &&
            S2.addrdesc.memattrs.memtype == MemType_Device) then
            // Check for protected table walk.
            if HCR.PTW == '1' then
                domain = bits(4) UNKNOWN;
                S2.addrdesc.fault = AArch32.PermissionFault(ipaddress,
                                                            domain, S2.level,
                                                            acctype, iswrite, secondstage, s2fslwalk);
            else
                // Translation table walk occurs as Normal Non-cacheable memory.
                S2.addrdesc.memattrs.memtype = MemType_Normal;
                S2.addrdesc.memattrs.inner.attrs = MemAttr_NC;
                S2.addrdesc.memattrs.outer.attrs = MemAttr_NC;
                S2.addrdesc.memattrs.shareable = TRUE;
                S2.addrdesc.memattrs.outershareable = TRUE;

        result = AArch32.CombineS1S2Desc(S1, S2.addrdesc);
    else
        result = S1;

    return result;
```

## Library pseudocode for aarch32/translation/translation/AArch32.SecondStageWalk

```
// AArch32.SecondStageWalk()
// =====
// Perform a stage 2 translation on a stage 1 translation page table walk access.
AddressDescriptor AArch32.SecondStageWalk(AddressDescriptor S1, bits(32) vaddress, AccType acctype,
                                           boolean iswrite, integer size)

    assert HasS2Translation();

    s2fslwalk = TRUE;
    wasaligned = TRUE;
    return AArch32.SecondStageTranslate(S1, vaddress, acctype, iswrite, wasaligned, s2fslwalk,
                                         size);
```

## Library pseudocode for aarch32/translation/translation/AArch32.TranslateAddress

```
// AArch32.TranslateAddress()
// =====
// Main entry point for translating an address
AddressDescriptor AArch32.TranslateAddress(bits(32) vaddress, AccType acctype, boolean iswrite,
                                           boolean wasaligned, integer size)

    if !ELUsingAArch32(S1TranslationRegime()) then
        return AArch64.TranslateAddress(ZeroExtend(vaddress, 64), acctype, iswrite, wasaligned,
                                         size);
    result = AArch32.FullTranslate(vaddress, acctype, iswrite, wasaligned, size);

    if !(acctype IN {AccType_PTW, AccType_IC, AccType_AT}) && !IsFault(result) then
        result.fault = AArch32.CheckDebug(vaddress, acctype, iswrite, size);

    // Update virtual address for abort functions
    result.vaddress = ZeroExtend(vaddress);

    return result;
```



```

// AArch32.TranslationTableWalkLD()
// =====
// Returns a result of a translation table walk using the Long-descriptor format
//
// Implementations might cache information from memory in any number of non-coherent TLB
// caching structures, and so avoid memory accesses that have been expressed in this
// pseudocode. The use of such TLBs is not expressed in this pseudocode.

TLBRecord AArch32.TranslationTableWalkLD(bits(40) ipaddress, bits(32) vaddress,
                                         AccType acctype, boolean iswrite, boolean secondstage,
                                         boolean s2fslwalk, integer size)

    if !secondstage then
        assert ELUsingAArch32(S1TranslationRegime());
    else
        assert HaveEL(EL2) && !IsSecure() && ELUsingAArch32(EL2) && HasS2Translation();

    TLBRecord result;
    AddressDescriptor descaddr;
    bits(64) baseregister;
    bits(40) inputaddr;          // Input Address is 'vaddress' for stage 1, 'ipaddress' for stage 2
    bit nswalk;                  // Stage 2 translation table walks are to Secure or to Non-secure PA

    result.descupdate.AF = FALSE;
    result.descupdate.AP = FALSE;

    domain = bits(4) UNKNOWN;

    descaddr.memattrs.memtype = MemType_Normal;

    // Fixed parameters for the page table walk:
    // grainsize = Log2(Size of Table)          - Size of Table is 4KB in AArch32
    // stride = Log2(Address per Level)         - Bits of address consumed at each level
    constant integer grainsize = 12;           // Log2(4KB page size)
    constant integer stride = grainsize - 3;    // Log2(page size / 8 bytes)

    // Derived parameters for the page table walk:
    // inputsize = Log2(Size of Input Address) - Input Address size in bits
    // level = Level to start walk from
    // This means that the number of levels after start level = 3-level

    if !secondstage then
        // First stage translation
        inputaddr = ZeroExtend(vaddress);
        el = AArch32.AccessUsesEL(acctype);
        if el == EL2 then
            inputsize = 32 - UInt(HTCR.T0SZ);
            basefound = inputsize == 32 || IsZero(inputaddr<31:inputsize>);
            disabled = FALSE;
            baseregister = HTTBR;
            descaddr.memattrs = WalkAttrDecode(HTCR.SH0, HTCR.ORGNO, HTCR.IRGN0, secondstage);
            reversedescriptors = HSCTLR.EE == '1';
            lookupsecure = FALSE;
            singlepriv = TRUE;
            hierattrsddisabled = AArch32.HaveHPDExt() && HTCR.HPD == '1';
        else
            basefound = FALSE;
            disabled = FALSE;
            t0size = UInt(TTBCR.T0SZ);
            if t0size == 0 || IsZero(inputaddr<31:(32-t0size)>) then
                inputsize = 32 - t0size;
                basefound = TRUE;
                baseregister = TTBR0;
                descaddr.memattrs = WalkAttrDecode(TTBCR.SH0, TTBCR.ORGNO, TTBCR.IRGN0, secondstage);
                hierattrsddisabled = AArch32.HaveHPDExt() && TTBCR.T2E == '1' && TTBCR2.HPD0 == '1';
            t1size = UInt(TTBCR.T1SZ);
            if (t1size == 0 && !basefound) || (t1size > 0 && IsOnes(inputaddr<31:(32-t1size)>)) then
                inputsize = 32 - t1size;
                basefound = TRUE;
                baseregister = TTBR1;
                descaddr.memattrs = WalkAttrDecode(TTBCR.SH1, TTBCR.ORGNO, TTBCR.IRGN1, secondstage);

```

```

        hierattrsdissabled = AArch32.HaveHPDExt() && TTBCR.T2E == '1' && TTBCR2.HPD1 == '1';
        reversedescriptors = SCTL.R.EE == '1';
        lookupsecure = IsSecure();
        singlepriv = FALSE;
// The starting level is the number of strides needed to consume the input address
level = 4 - (1 + ((inputsize - grainsize - 1) DIV stride));

else
// Second stage translation
inputaddr = ipaddress;
inputsize = 32 - SInt(VTCR.T0SZ);
// VTCR.S must match VTCR.T0SZ[3]
if VTCR.S != VTCR.T0SZ<3> then
    (-, inputsize) = ConstrainUnpredictableInteger(32-7, 32+8, Unpredictable_RESVTCRS);
basefound = inputsize == 40 || IsZero(inputaddr<39:inputsize>);
disabled = FALSE;
descaddr.memattrs = WalkAttrDecode(VTCR.SH0, VTCR.ORGNO, VTCR.IRGNO, secondstage);
reversedescriptors = HSCTL.R.EE == '1';
singlepriv = TRUE;

lookupsecure = FALSE;
baseregister = VTTBR;
startlevel = UInt(VTCR.SL0);
level = 2 - startlevel;
if level <= 0 then basefound = FALSE;

// Number of entries in the starting level table =
// (Size of Input Address)/((Address per level)^(Num levels remaining)*(Size of Table))
startsizecheck = inputsize - ((3 - level)*stride + grainsize); // Log2(Num of entries)

// Check for starting level table with fewer than 2 entries or longer than 16 pages.
// Lower bound check is: startsizecheck < Log2(2 entries)
// That is, VTCR.SL0 == '00' and SInt(VTCR.T0SZ) > 1, Size of Input Address < 2^31 bytes
// Upper bound check is: startsizecheck > Log2(pagesize/8*16)
// That is, VTCR.SL0 == '01' and SInt(VTCR.T0SZ) < -2, Size of Input Address > 2^34 bytes
if startsizecheck < 1 || startsizecheck > stride + 4 then basefound = FALSE;
if !basefound || disabled then
    level = 1; // AArch64 reports this as a level 0 fault
    result.addrdesc.fault = AArch32.TranslationFault(ipaddress, domain, level, acctype, iswrite,
                                                    secondstage, s2fslwalk);

    return result;

if !IsZero(baseregister<47:40>) then
    level = 0;
    result.addrdesc.fault = AArch32.AddressSizeFault(ipaddress, domain, level, acctype, iswrite,
                                                    secondstage, s2fslwalk);

    return result;

// Bottom bound of the Base address is:
// Log2(8 bytes per entry)+Log2(Number of entries in starting level table)
// Number of entries in starting level table =
// (Size of Input Address)/((Address per level)^(Num levels remaining)*(Size of Table))
baselowerbound = 3 + inputsize - ((3-level)*stride + grainsize); // Log2(Num of entries*8)
baseaddress = baseregister<39:baselowerbound>:Zeros(baselowerbound);

ns_table = if lookupsecure then '0' else '1';
ap_table = '00';
xn_table = '0';
pxn_table = '0';

addrselecttop = inputsize - 1;

repeat
    addrselectbottom = (3-level)*stride + grainsize;

    bits(40) index = ZeroExtend(inputaddr<addrselecttop:addrselectbottom>:'000');
    descaddr.paddress.address = ZeroExtend(baseaddress OR index);
    descaddr.paddress.NS = ns_table;

// If there are two stages of translation, then the first stage table walk addresses

```



```

// are themselves subject to translation
if secondstage || !HasS2Translation() || (HaveNV2Ext() && acctype == AccType_NV2REGISTER) then
    descaddr2 = descaddr;
else
    descaddr2 = AArch32.SecondStageWalk(descaddr, vaddress, acctype, iswrite, 8);
    // Check for a fault on the stage 2 walk
    if IsFault(descaddr2) then
        result.addrdesc.fault = descaddr2.fault;
        return result;

// Update virtual address for abort functions
descaddr2.vaddress = ZeroExtend(vaddress);

accdesc = CreateAccessDescriptorPTW(acctype, secondstage, s2fslwalk, level);
desc = _Mem[descaddr2, 8, accdesc];

if reversedescriptors then desc = BigEndianReverse(desc);

if desc<0> == '0' || (desc<1:0> == '01' && level == 3) then
    // Fault (00), Reserved (10), or Block (01) at level 3.
    result.addrdesc.fault = AArch32.TranslationFault(ipaddress, domain, level, acctype,
                                                    iswrite, secondstage, s2fslwalk);
    return result;

// Valid Block, Page, or Table entry
if desc<1:0> == '01' || level == 3 then // Block (01) or Page (11)
    blocktranslate = TRUE;
else // Table (11)
    if !IsZero(desc<47:40>) then
        result.addrdesc.fault = AArch32.AddressSizeFault(ipaddress, domain, level, acctype,
                                                         iswrite, secondstage, s2fslwalk);
        return result;

    baseaddress = desc<39:grainsize>:Zeros(grainsize);
    if !secondstage then
        // Unpack the upper and lower table attributes
        ns_table = ns_table OR desc<63>;
    if !secondstage && !hierattrsdissabled then
        ap_table<1> = ap_table<1> OR desc<62>; // read-only

        xn_table = xn_table OR desc<60>;
        // pxn_table and ap_table[0] apply only in EL1&0 translation regimes
        if !singlepriv then
            pxn_table = pxn_table OR desc<59>;
            ap_table<0> = ap_table<0> OR desc<61>; // privileged

    level = level + 1;
    addrselecttop = addrselectbottom - 1;
    blocktranslate = FALSE;
until blocktranslate;

// Unpack the descriptor into address and upper and lower block attributes
outputaddress = desc<39:addrselectbottom>:inputaddr<addrselectbottom-1:0>;

// Check the output address is inside the supported range
if !IsZero(desc<47:40>) then
    result.addrdesc.fault = AArch32.AddressSizeFault(ipaddress, domain, level, acctype,
                                                    iswrite, secondstage, s2fslwalk);
    return result;

// Check the access flag
if desc<10> == '0' then
    result.addrdesc.fault = AArch32.AccessFlagFault(ipaddress, domain, level, acctype,
                                                    iswrite, secondstage, s2fslwalk);
    return result;

xn = desc<54>; // Bit[54] of the block/page descriptor holds
pxn = desc<53>; // Bit[53] of the block/page descriptor holds
ap = desc<7:6>:'1'; // Bits[7:6] of the block/page descriptor holds
contiguousbit = desc<52>;
nG = desc<11>;

```

```

sh = desc<9:8>;
memattr = desc<5:2>;                                // AttrIndx and NS bit in stage 1

result.domain = bits(4) UNKNOWN;                    // Domains not used
result.level = level;
result.blocksize = 2^((3-level)*stride + grainsize);

// Stage 1 translation regimes also inherit attributes from the tables
if !secondstage then
    result.perms.xn      = xn OR xn_table;
    result.perms.ap<2>   = ap<2> OR ap_table<1>;      // Force read-only
    // PXN, nG and AP[1] apply only in EL1&0 stage 1 translation regimes
    if !singlepriv then
        result.perms.ap<1> = ap<1> AND NOT(ap_table<0>); // Force privileged only
        result.perms.pxn   = pxn OR pxn_table;
        // Pages from Non-secure tables are marked non-global in Secure EL1&0
        if IsSecure\(\) then
            result.nG = nG OR ns_table;
        else
            result.nG = nG;
    else
        result.perms.ap<1> = '1';
        result.perms.pxn   = '0';
        result.nG          = '0';
    result.GP = desc<50>;                            // Stage 1 block or pages might be guarded
    result.perms.ap<0>   = '1';
    result.addrdesc.memattrs = AArch32.S1AttrDecode(sh, memattr<2:0>, acctype);
    result.addrdesc.paddress.NS = memattr<3> OR ns_table;
else
    result.perms.ap<2:1> = ap<2:1>;
    result.perms.ap<0>   = '1';
    result.perms.xn      = xn;
    if HaveExtendedExecuteNeverExt\(\) then result.perms.xxn = desc<53>;
    result.perms.pxn     = '0';
    result.nG            = '0';
    if s2fslwalk then
        result.addrdesc.memattrs = S2AttrDecode(sh, memattr, AccType\_PTW);
    else
        result.addrdesc.memattrs = S2AttrDecode(sh, memattr, acctype);
    result.addrdesc.paddress.NS = '1';

result.addrdesc.paddress.address = ZeroExtend(outputaddress);
result.addrdesc.fault = AArch32.NoFault();
result.contiguous = contiguousbit == '1';
if HaveCommonNotPrivateTransExt\(\) then result.CnP = baseregister<0>;

return result;

```



```

// AArch32.TranslationTableWalkSD()
// =====
// Returns a result of a translation table walk using the Short-descriptor format
//
// Implementations might cache information from memory in any number of non-coherent TLB
// caching structures, and so avoid memory accesses that have been expressed in this
// pseudocode. The use of such TLBs is not expressed in this pseudocode.

TLBRecord AArch32.TranslationTableWalkSD(bits(32) vaddress, AccType acctype, boolean iswrite,
                                          integer size)
    assert ELUsingAArch32\(S1TranslationRegime\(\)\);

    // This is only called when address translation is enabled
    TLBRecord result;
    AddressDescriptor lldescaddr;
    AddressDescriptor l2descaddr;
    bits(40) outputaddress;

    // Variables for Abort functions
    ipaddress = bits(40) UNKNOWN;
    secondstage = FALSE;
    s2fslwalk = FALSE;
    NS = bit UNKNOWN;

    // Default setting of the domain
    domain = bits(4) UNKNOWN;
    level = 1;

    // Determine correct Translation Table Base Register to use.
    bits(64) ttbr;
    n = UInt(TTBCR.N);
    if n == 0 || IsZero(vaddress<31:(32-n)>) then
        ttbr = TTBR0;
        disabled = (TTBCR.PD0 == '1');
    else
        ttbr = TTBR1;
        disabled = (TTBCR.PD1 == '1');
        n = 0; // TTBR1 translation always works like N=0 TTBR0 translation

    // Check this Translation Table Base Register is not disabled.
    if disabled then
        level = 1;
        result.addrdesc.fault = AArch32.TranslationFault(ipaddress, domain, level, acctype, iswrite,
                                                         secondstage, s2fslwalk);

        return result;

    // Obtain descriptor from initial lookup.
    lldescaddr.paddress.address = ZeroExtend(ttbr<31:14-n>:vaddress<31-n:20>:'00');
    lldescaddr.paddress.NS = if IsSecure() then '0' else '1';
    IRGN = ttbr<0>:ttbr<6>; // TTBR.IRGN
    RGN = ttbr<4:3>; // TTBR.RGN
    SH = ttbr<1>:ttbr<5>; // TTBR.S:TTBR.NOS
    lldescaddr.memattrs = WalkAttrDecode(SH, RGN, IRGN, secondstage);

    if !HaveEL(EL2) || (IsSecure() && !IsSecureEL2Enabled()) then
        // if only 1 stage of translation
        lldescaddr2 = lldescaddr;
    else
        lldescaddr2 = AArch32.SecondStageWalk(lldescaddr, vaddress, acctype, iswrite, 4);
        // Check for a fault on the stage 2 walk
        if IsFault(lldescaddr2) then
            result.addrdesc.fault = lldescaddr2.fault;
            return result;

    // Update virtual address for abort functions
    lldescaddr2.vaddress = ZeroExtend(vaddress);

    accdesc = CreateAccessDescriptorPTW(acctype, secondstage, s2fslwalk, level);
    lldesc = _Mem[lldescaddr2, 4, accdesc];

```

```

if SCTL.R.EE == '1' then l1desc = BigEndianReverse(l1desc);

// Process descriptor from initial lookup.
case l1desc<1:0> of
  when '00' // Fault, Reserved
    level = 1;
    result.addrdesc.fault = AArch32.TranslationFault(ipaddress, domain, level, acctype,
                                                    iswrite, secondstage, s2fslwalk);
    return result;

  when '01' // Large page or Small page
    domain = l1desc<8:5>;
    level = 2;
    pxn = l1desc<2>;
    NS = l1desc<3>;

    // Obtain descriptor from level 2 lookup.
    l2descaddr.paddress.address = ZeroExtend(l1desc<31:10>:vaddress<19:12>:'00');
    l2descaddr.paddress.NS = if IsSecure() then '0' else '1';
    l2descaddr.memattrs = l1descaddr.memattrs;

    if !HaveEL(EL2) || (IsSecure() && !IsSecureEL2Enabled()) then
      // if only 1 stage of translation
      l2descaddr2 = l2descaddr;
    else
      l2descaddr2 = AArch32.SecondStageWalk(l2descaddr, vaddress, acctype, iswrite, 4);
      // Check for a fault on the stage 2 walk
      if IsFault(l2descaddr2) then
        result.addrdesc.fault = l2descaddr2.fault;
        return result;

    // Update virtual address for abort functions
    l2descaddr2.vaddress = ZeroExtend(vaddress);

    accdesc = CreateAccessDescriptorPTW(acctype, secondstage, s2fslwalk, level);
    l2desc = _Mem[l2descaddr2, 4, accdesc];

    if SCTL.R.EE == '1' then l2desc = BigEndianReverse(l2desc);

    // Process descriptor from level 2 lookup.
    if l2desc<1:0> == '00' then
      result.addrdesc.fault = AArch32.TranslationFault(ipaddress, domain, level, acctype,
                                                    iswrite, secondstage, s2fslwalk);
      return result;

    nG = l2desc<11>;
    S = l2desc<10>;
    ap = l2desc<9,5:4>;

    if SCTL.R.AFE == '1' && l2desc<4> == '0' then
      // Armv8 VMSAv8-32 does not support hardware management of the Access flag.
      result.addrdesc.fault = AArch32.AccessFlagFault(ipaddress, domain, level, acctype,
                                                    iswrite, secondstage, s2fslwalk);
      return result;

    if l2desc<1> == '0' then // Large page
      xn = l2desc<15>;
      tex = l2desc<14:12>;
      c = l2desc<3>;
      b = l2desc<2>;
      blocksize = 64;
      outputaddress = ZeroExtend(l2desc<31:16>:vaddress<15:0>);
    else // Small page
      tex = l2desc<8:6>;
      c = l2desc<3>;
      b = l2desc<2>;
      xn = l2desc<0>;
      blocksize = 4;
      outputaddress = ZeroExtend(l2desc<31:12>:vaddress<11:0>);

```

```

when '1x' // Section or Supersection
    NS = lldesc<19>;
    nG = lldesc<17>;
    S = lldesc<16>;
    ap = lldesc<15,11:10>;
    tex = lldesc<14:12>;
    xn = lldesc<4>;
    c = lldesc<3>;
    b = lldesc<2>;
    pxn = lldesc<0>;
    level = 1;

    if SCTL.AFE == '1' && lldesc<10> == '0' then
        // Armv8 VMSAv8-32 does not support hardware management of the Access flag.
        result.addrdesc.fault = AArch32.AccessFlagFault(ipaddress, domain, level, acctype,
                                                    iswrite, secondstage, s2fslwalk);
        return result;

    if lldesc<18> == '0' then // Section
        domain = lldesc<8:5>;
        blocksize = 1024;
        outputaddress = ZeroExtend(lldesc<31:20>:vaddress<19:0>);
    else // Supersection
        domain = '0000';
        blocksize = 16384;
        outputaddress = lldesc<8:5>:lldesc<23:20>:lldesc<31:24>:vaddress<23:0>;

// Decode the TEX, C, B and S bits to produce the TLBRecord's memory attributes
if SCTL.TRE == '0' then
    if RemapRegsHaveResetValues() then
        result.addrdesc.memattrs = AArch32.DefaultTEXDecode(tex, c, b, S, acctype);
    else
        result.addrdesc.memattrs = MemoryAttributes IMPLEMENTATION_DEFINED;
else
    result.addrdesc.memattrs = AArch32.RemappedTEXDecode(tex, c, b, S, acctype);

// Set the rest of the TLBRecord, try to add it to the TLB, and return it.
result.perms.ap = ap;
result.perms.xn = xn;
result.perms.pxn = pxn;
result.nG = nG;
result.domain = domain;
result.level = level;
result.blocksize = blocksize;
result.addrdesc.paddress.address = ZeroExtend(outputaddress);
result.addrdesc.paddress.NS = if IsSecure() then NS else '1';
result.addrdesc.fault = AArch32.NoFault();

return result;

```

### Library pseudocode for aarch32/translation/walk/RemapRegsHaveResetValues

```

boolean RemapRegsHaveResetValues();

```

## Library pseudocode for aarch64/debug/breakpoint/AArch64.BreakpointMatch

```
// AArch64.BreakpointMatch()
// =====
// Breakpoint matching in an AArch64 translation regime.

boolean AArch64.BreakpointMatch(integer n, bits(64) vaddress, AccType acctype, integer size)
    assert !ELUsingAArch32\(S1TranslationRegime\(\)\);
    assert n <= UInt(ID_AA64DFR0_EL1.BRPs);

    enabled = DBGBCR_EL1[n].E == '1';
    ispriv = PSTATE.EL != EL0;
    linked = DBGBCR_EL1[n].BT == '0x01';
    isbreakpnt = TRUE;
    linked_to = FALSE;

    state_match = AArch64.StateMatch(DBGBCR_EL1[n].SSC, DBGBCR_EL1[n].HMC, DBGBCR_EL1[n].PMC,
                                     linked, DBGBCR_EL1[n].LBN, isbreakpnt, acctype, ispriv);
    value_match = AArch64.BreakpointValueMatch(n, vaddress, linked_to);

    if HaveAnyAArch32\(\) && size == 4 then // Check second halfword
        // If the breakpoint address and BAS of an Address breakpoint match the address of the
        // second halfword of an instruction, but not the address of the first halfword, it is
        // CONSTRAINED UNPREDICTABLE whether or not this breakpoint generates a Breakpoint debug
        // event.
        match_i = AArch64.BreakpointValueMatch(n, vaddress + 2, linked_to);
        if !value_match && match_i then
            value_match = ConstrainUnpredictableBool(Unpredictable\_BPMATCHHALF);
    if vaddress<1> == '1' && DBGBCR_EL1[n].BAS == '1111' then
        // The above notwithstanding, if DBGBCR_EL1[n].BAS == '1111', then it is CONSTRAINED
        // UNPREDICTABLE whether or not a Breakpoint debug event is generated for an instruction
        // at the address DBGBCR_EL1[n]+2.
        if value_match then value_match = ConstrainUnpredictableBool(Unpredictable\_BPMATCHHALF);

    match = value_match && state_match && enabled;

    return match;
```





```

// AArch64.BreakpointValueMatch()
// =====

boolean AArch64.BreakpointValueMatch(integer n, bits(64) vaddress, boolean linked_to)

// "n" is the identity of the breakpoint unit to match against.
// "vaddress" is the current instruction address, ignored if linked_to is TRUE and for Context
// matching breakpoints.
// "linked_to" is TRUE if this is a call from StateMatch for linking.

// If a non-existent breakpoint then it is CONSTRAINED UNPREDICTABLE whether this gives
// no match or the breakpoint is mapped to another UNKNOWN implemented breakpoint.
if n > UInt(ID_AA64DFR0_EL1.BRPs) then
    (c, n) = ConstrainUnpredictableInteger(0, UInt(ID_AA64DFR0_EL1.BRPs), Unpredictable_BPNOTIMPL);
    assert c IN {Constraint_DISABLED, Constraint_UNKNOWN};
    if c == Constraint_DISABLED then return FALSE;

// If this breakpoint is not enabled, it cannot generate a match. (This could also happen on a
// call from StateMatch for linking).
if DBGBCR_EL1[n].E == '0' then return FALSE;

context_aware = (n >= UInt(ID_AA64DFR0_EL1.BRPs) - UInt(ID_AA64DFR0_EL1.CTX_CMPs));

// If BT is set to a reserved type, behaves either as disabled or as a not-reserved type.
dbgtype = DBGBCR_EL1[n].BT;

if ((dbgtype IN {'011x', '11xx'}) && !HaveVirtHostExt() && !HaveV82Debug()) || // Context matching
    dbgtype == '010x' || // Reserved
    (dbgtype != '0x0x' && !context_aware) || // Context matching
    (dbgtype == '1xxx' && !HaveEL(EL2))) then // EL2 extension
    (c, dbgtype) = ConstrainUnpredictableBits(Unpredictable_RESBPTYPE);
    assert c IN {Constraint_DISABLED, Constraint_UNKNOWN};
    if c == Constraint_DISABLED then return FALSE;
    // Otherwise the value returned by ConstrainUnpredictableBits must be a not-reserved value

// Determine what to compare against.
match_addr = (dbgtype == '0x0x');
match_vmid = (dbgtype == '10xx');
match_cid = (dbgtype == '001x');
match_cid1 = (dbgtype IN {'101x', 'x11x'});
match_cid2 = (dbgtype == '11xx');
linked = (dbgtype == 'xxx1');

// If this is a call from StateMatch, return FALSE if the breakpoint is not programmed for a
// VMID and/or context ID match, or if not context-aware. The above assertions mean that the
// code can just test for match_addr == TRUE to confirm all these things.
if linked_to && (!linked || match_addr) then return FALSE;

// If called from BreakpointMatch return FALSE for Linked context ID and/or VMID matches.
if !linked_to && linked && !match_addr then return FALSE;

// Do the comparison.
if match_addr then
    byte = UInt(vaddress<1:0>);
    if HaveAnyAArch32() then
        // T32 instructions can be executed at EL0 in an AArch64 translation regime.
        assert byte IN {0,2}; // "vaddress" is halfword aligned
        byte_select_match = (DBGBCR_EL1[n].BAS<byte> == '1');
    else
        assert byte == 0; // "vaddress" is word aligned
        byte_select_match = TRUE; // DBGBCR_EL1[n].BAS<byte> is RES1
    top = AddrTop(vaddress, TRUE, PSTATE.EL);
    BVR_match = vaddress<top:2> == DBGBCR_EL1[n]<top:2> && byte_select_match;
elseif match_cid then
    if IsInHost() then
        BVR_match = (CONTEXTIDR_EL2 == DBGBCR_EL1[n]<31:0>);
    else
        BVR_match = (PSTATE.EL IN {EL0, EL1} && CONTEXTIDR_EL1 == DBGBCR_EL1[n]<31:0>);
elseif match_cid1 then
    BVR_match = (PSTATE.EL IN {EL0, EL1} && !IsInHost() && CONTEXTIDR_EL1 == DBGBCR_EL1[n]<31:0>);

```

```

if match_vmid then
    if !Have16bitVMID() || VTCR_EL2.VS == '0' then
        vmid = ZeroExtend(VTTBR_EL2.VMID<7:0>, 16);
        bvr_vmid = ZeroExtend(DBGBVR_EL1[n]<39:32>, 16);
    else
        vmid = VTTBR_EL2.VMID;
        bvr_vmid = DBGBVR_EL1[n]<47:32>;
    BXVR_match = (PSTATE.EL IN {EL0, EL1} && EL2Enabled() &&
        !IsInHost() &&
        vmid == bvr_vmid);
elseif match_cid2 then
    BXVR_match = ((HaveVirtHostExt() || HaveV82Debug()) && EL2Enabled() &&
        DBGBVR_EL1[n]<63:32> == CONTEXTIDR_EL2);

bvr_match_valid = (match_addr || match_cid || match_cid1);
bxvr_match_valid = (match_vmid || match_cid2);

match = (!bxvr_match_valid || BXVR_match) && (!bvr_match_valid || BVR_match);

return match;

```

## Library pseudocode for aarch64/debug/breakpoint/AArch64.StateMatch

```
// AArch64.StateMatch()
// =====
// Determine whether a breakpoint or watchpoint is enabled in the current mode and state.

boolean AArch64.StateMatch(bits(2) SSC, bit HMC, bits(2) PxC, boolean linked, bits(4) LBN,
                           boolean isbreaknt, AccType acctype, boolean ispriv)
// "SSC", "HMC", "PxC" are the control fields from the DBGBCR[n] or DBGWCR[n] register.
// "linked" is TRUE if this is a linked breakpoint/watchpoint type.
// "LBN" is the linked breakpoint number from the DBGBCR[n] or DBGWCR[n] register.
// "isbreaknt" is TRUE for breakpoints, FALSE for watchpoints.
// "ispriv" is valid for watchpoints, and selects between privileged and unprivileged accesses.

// If parameters are set to a reserved type, behaves as either disabled or a defined type
(c, SSC, HMC, PxC) = CheckValidStateMatch(SSC, HMC, PxC, isbreaknt);
if c == Constraint\_DISABLED then return FALSE;
// Otherwise the HMC,SSC,PxC values are either valid or the values returned by
// CheckValidStateMatch are valid.

EL3_match = HaveEL(EL3) && HMC == '1' && SSC<0> == '0';
EL2_match = HaveEL(EL2) && ((HMC == '1' && (SSC:PxC != '1000')) || SSC == '11');
EL1_match = PxC<0> == '1';
EL0_match = PxC<1> == '1';

if HaveNV2Ext() && acctype == AccType\_NV2REGISTER && !isbreaknt then
    priv_match = EL2_match;
elsif !ispriv && !isbreaknt then
    priv_match = EL0_match;
else
    case PSTATE.EL of
        when EL3 priv_match = EL3_match;
        when EL2 priv_match = EL2_match;
        when EL1 priv_match = EL1_match;
        when EL0 priv_match = EL0_match;

case SSC of
    when '00' security_state_match = TRUE; // Both
    when '01' security_state_match = !IsSecure(); // Non-secure only
    when '10' security_state_match = IsSecure(); // Secure only
    when '11' security_state_match = (HMC == '1' || IsSecure()); // HMC=1 -> Both, 0 -> Secure only

if linked then
    // "LBN" must be an enabled context-aware breakpoint unit. If it is not context-aware then
    // it is CONSTRAINED UNPREDICTABLE whether this gives no match, or LBN is mapped to some
    // UNKNOWN breakpoint that is context-aware.
    lbn = UInt(LBN);
    first_ctx_cmp = (UInt(ID_AA64DFR0_EL1.BRPs) - UInt(ID_AA64DFR0_EL1.CTX_CMPs));
    last_ctx_cmp = UInt(ID_AA64DFR0_EL1.BRPs);
    if (lbn < first_ctx_cmp || lbn > last_ctx_cmp) then
        (c, lbn) = ConstrainUnpredictableInteger(first_ctx_cmp, last_ctx_cmp, Unpredictable\_BPN0TCTX);
        assert c IN {Constraint\_DISABLED, Constraint\_NONE, Constraint\_UNKNOWN};
        case c of
            when Constraint\_DISABLED return FALSE; // Disabled
            when Constraint\_NONE linked = FALSE; // No linking
            // Otherwise ConstrainUnpredictableInteger returned a context-aware breakpoint

if linked then
    vaddress = bits(64) UNKNOWN;
    linked_to = TRUE;
    linked_match = AArch64.BreakpointValueMatch(lbn, vaddress, linked_to);

return priv_match && security_state_match && (!linked || linked_match);
```

## Library pseudocode for aarch64/debug/enables/AArch64.GenerateDebugExceptions

```
// AArch64.GenerateDebugExceptions()
// =====

boolean AArch64.GenerateDebugExceptions()
    return AArch64.GenerateDebugExceptionsFrom(PSTATE.EL, IsSecure(), PSTATE.D);
```

## Library pseudocode for aarch64/debug/enables/AArch64.GenerateDebugExceptionsFrom

```
// AArch64.GenerateDebugExceptionsFrom()
// =====

boolean AArch64.GenerateDebugExceptionsFrom(bits(2) from, boolean secure, bit mask)

    if OSLSR_EL1.OSLK == '1' || DoubleLockStatus() || Halted() then
        return FALSE;

    route_to_el2 = HaveEL(EL2) && (!secure || IsSecureEL2Enabled()) && (HCR_EL2.TGE == '1' || MDCR_EL2.TD == '1');
    target = (if route_to_el2 then EL2 else EL1);
    enabled = !HaveEL(EL3) || !secure || MDCR_EL3.SDD == '0';

    if from == target then
        enabled = enabled && MDCR_EL1.KDE == '1' && mask == '0';
    else
        enabled = enabled && UInt(target) > UInt(from);

    return enabled;
```

## Library pseudocode for aarch64/debug/pmu/AArch64.CheckForPMUOverflow

```
// AArch64.CheckForPMUOverflow()
// =====
// Signal Performance Monitors overflow IRQ and CTI overflow events

boolean AArch64.CheckForPMUOverflow()

    pmuirq = PMCR_EL0.E == '1' && PMINTENSET_EL1<31> == '1' && PMOVSSET_EL0<31> == '1';
    for n = 0 to UInt(PMCR_EL0.N) - 1
        if HaveEL(EL2) then
            E = (if n < UInt(MDCR_EL2.HPMN) then PMCR_EL0.E else MDCR_EL2.HPME);
        else
            E = PMCR_EL0.E;
        if E == '1' && PMINTENSET_EL1<n> == '1' && PMOVSSET_EL0<n> == '1' then pmuirq = TRUE;

    SetInterruptRequestLevel(InterruptID\_PMUIRQ, if pmuirq then HIGH else LOW);

    CTI_SetEventLevel(CrossTriggerIn\_PMUOverflow, if pmuirq then HIGH else LOW);

    // The request remains set until the condition is cleared. (For example, an interrupt handler
    // or cross-triggered event handler clears the overflow status flag by writing to PMOVSCLR_EL0.)

    return pmuirq;
```

## Library pseudocode for aarch64/debug/pmu/AArch64.CountEvents

```
// AArch64.CountEvents()
// =====
// Return TRUE if counter "n" should count its event. For the cycle counter, n == 31.

boolean AArch64.CountEvents(integer n)
    assert n == 31 || n < UInt(PMCR_EL0.N);

    // Event counting is disabled in Debug state
    debug = Halted();

    // In Non-secure state, some counters are reserved for EL2
    if HaveEL(EL2) then
        E = if n < UInt(MDCR_EL2.HPMN) || n == 31 then PMCR_EL0.E else MDCR_EL2.HPME;
    else
        E = PMCR_EL0.E;
    enabled = E == '1' && PMCNTENSET_EL0<n> == '1';

    // Event counting in Secure state is prohibited unless any one of:
    // * EL3 is not implemented
    // * EL3 is using AArch64 and MDCR_EL3.SPME == 1
    prohibited = HaveEL(EL3) && IsSecure() && MDCR_EL3.SPME == '0';

    // Event counting at EL2 is prohibited if all of:
    // * The HPMD Extension is implemented
    // * Executing at EL2
    // * PMNx is not reserved for EL2
    // * MDCR_EL2.HPMD == 1
    if !prohibited && HaveEL(EL2) && HaveHPMDExt() && PSTATE.EL == EL2 && (n < UInt(MDCR_EL2.HPMN) || n == 31)
        prohibited = (MDCR_EL2.HPMD == '1');

    // The IMPLEMENTATION DEFINED authentication interface might override software controls
    if prohibited && !HaveNoSecurePMUDisableOverride() then
        prohibited = !ExternalSecureNoninvasiveDebugEnabled();
    // For the cycle counter, PMCR_EL0.DP enables counting when otherwise prohibited
    if prohibited && n == 31 then prohibited = (PMCR_EL0.DP == '1');

    // Event counting can be filtered by the {P, U, NSK, NSU, NSH, M, SH} bits
    filter = if n == 31 then PMCCFILTR else PMEVTYPER[n];

    P = filter<31>;
    U = filter<30>;
    NSK = if HaveEL(EL3) then filter<29> else '0';
    NSU = if HaveEL(EL3) then filter<28> else '0';
    NSH = if HaveEL(EL2) then filter<27> else '0';
    M = if HaveEL(EL3) then filter<26> else '0';
    SH = if HaveEL(EL3) && HaveSecureEL2Ext() then filter<24> else '0';

    case PSTATE.EL of
        when EL0 filtered = if IsSecure() then U == '1' else U != NSU;
        when EL1 filtered = if IsSecure() then P == '1' else P != NSK;
        when EL2 filtered = (if IsSecure() then NSH == SH else NSH == '0');
        when EL3 filtered = (M != P);

    return !debug && enabled && !prohibited && !filtered;
```

## Library pseudocode for aarch64/debug/statisticalprofiling/CheckProfilingBufferAccess

```
// CheckProfilingBufferAccess()
// =====

SysRegAccess CheckProfilingBufferAccess()
    if !HaveStatisticalProfiling() || PSTATE.EL == EL0 || UsingAArch32() then
        return SysRegAccess_UNDEFINED;

    if PSTATE.EL == EL1 && EL2Enabled() && MDCR_EL2.E2PB<0> != '1' then
        return SysRegAccess_TrapToEL2;

    if HaveEL(EL3) && PSTATE.EL != EL3 && MDCR_EL3.NSPB != SCR_EL3.NS:'1' then
        return SysRegAccess_TrapToEL3;

    return SysRegAccess_OK;
```

## Library pseudocode for aarch64/debug/statisticalprofiling/CheckStatisticalProfilingAccess

```
// CheckStatisticalProfilingAccess()
// =====

SysRegAccess CheckStatisticalProfilingAccess()
    if !HaveStatisticalProfiling() || PSTATE.EL == EL0 || UsingAArch32() then
        return SysRegAccess_UNDEFINED;

    if PSTATE.EL == EL1 && EL2Enabled() && MDCR_EL2.TPMS == '1' then
        return SysRegAccess_TrapToEL2;

    if HaveEL(EL3) && PSTATE.EL != EL3 && MDCR_EL3.NSPB != SCR_EL3.NS:'1' then
        return SysRegAccess_TrapToEL3;

    return SysRegAccess_OK;
```

## Library pseudocode for aarch64/debug/statisticalprofiling/CollectContextIDR1

```
// CollectContextIDR1()
// =====

boolean CollectContextIDR1()
    if !StatisticalProfilingEnabled() then return FALSE;
    if PSTATE.EL == EL2 then return FALSE;
    if EL2Enabled() && HCR_EL2.TGE == '1' then return FALSE;
    return PMSCR_EL1.CX == '1';
```

## Library pseudocode for aarch64/debug/statisticalprofiling/CollectContextIDR2

```
// CollectContextIDR2()
// =====

boolean CollectContextIDR2()
    if !StatisticalProfilingEnabled() then return FALSE;
    if !EL2Enabled() then return FALSE;
    return PMSCR_EL2.CX == '1';
```

## Library pseudocode for aarch64/debug/statisticalprofiling/CollectPhysicalAddress

```
// CollectPhysicalAddress()
// =====

boolean CollectPhysicalAddress()
    if !StatisticalProfilingEnabled() then return FALSE;
    (secure, el) = ProfilingBufferOwner();
    if ((!secure && HaveEL(EL2)) || IsSecureEL2Enabled()) then
        return PMSCR_EL2.PA == '1' && (el == EL2 || PMSCR_EL1.PA == '1');
    else
        return PMSCR_EL1.PA == '1';
```

## Library pseudocode for aarch64/debug/statisticalprofiling/CollectRecord

```
// CollectRecord()
// =====

boolean CollectRecord(bits(64) events, integer total_latency, OpType optype)
    assert StatisticalProfilingEnabled();

    // Filtering by event
    if PMSFCR_EL1.FE == '1' && !IsZero(PMSEVFR_EL1) then
        bits(64) mask = 0xFFFF0000FF00F0AA<63:0>; // Bits [63:48,31:24,15:12,7,5,3,1]
        if HaveStatisticalProfiling() then
            mask<11> = '1'; // Alignment flag
            if HaveSVE() then mask<18:17> = Ones(); // Predicate flags
            e = events AND mask;
            m = PMSEVFR_EL1 AND mask;
            if !IsZero(NOT(e) AND m) then return FALSE;

    // Filtering by type
    if PMSFCR_EL1.FT == '1' && !IsZero(PMSFCR_EL1.<B,LD,ST>) then
        case optype of
            when OpType\_Branch
                if PMSFCR_EL1.B == '0' then return FALSE;
            when OpType\_Load
                if PMSFCR_EL1.LD == '0' then return FALSE;
            when OpType\_Store
                if PMSFCR_EL1.ST == '0' then return FALSE;
            when OpType\_LoadAtomic
                if PMSFCR_EL1.<LD,ST> == '00' then return FALSE;
            otherwise
                return FALSE;

    // Filtering by latency
    if PMSFCR_EL1.FL == '1' && !IsZero(PMSLATFR_EL1.MINLAT) then
        if total_latency < UInt(PMSLATFR_EL1.MINLAT) then
            return FALSE;

    // Check for UNPREDICTABLE cases
    if ((PMSFCR_EL1.FE == '1' && !IsZero(PMSEVFR_EL1)) ||
        (PMSFCR_EL1.FT == '1' && !IsZero(PMSFCR_EL1.<B,LD,ST>)) ||
        (PMSFCR_EL1.FL == '1' && !IsZero(PMSLATFR_EL1.MINLAT))) then
        return ConstrainUnpredictableBool(Unpredictable\_BADPMSFCR);

    return TRUE;
```

## Library pseudocode for aarch64/debug/statisticalprofiling/CollectTimeStamp

```
// CollectTimeStamp()
// =====

TimeStamp CollectTimeStamp()
    if !StatisticalProfilingEnabled() then return TimeStamp_None;
    (secure, el) = ProfilingBufferOwner();
    if el == EL2 then
        if PMSCR_EL2.TS == '0' then return TimeStamp_None;
    else
        if PMSCR_EL1.TS == '0' then return TimeStamp_None;
    if EL2Enabled() then
        case PMSCR_EL2.PCT of
            when '00'
                return TimeStamp_Virtual;
            when '01'
                if el == EL2 then return TimeStamp_Physical;
            when '11'
                if (el == EL2 || PMSCR_EL1.PCT != '00') && HaveECVExt() then
                    return TimeStamp_OffsetPhysical;
            otherwise
                Unreachable();

    case PMSCR_EL1.PCT of
        when '00' return TimeStamp_Virtual;
        when '01' return TimeStamp_Physical;
        when '11' if HaveECVExt() then return TimeStamp_OffsetPhysical;
        otherwise Unreachable();
```

## Library pseudocode for aarch64/debug/statisticalprofiling/OpType

```
enumeration OpType {
    OpType_Load,           // Any memory-read operation other than atomics, compare-and-swap, and swap
    OpType_Store,          // Any memory-write operation, including atomics without return
    OpType_LoadAtomic,     // Atomics with return, compare-and-swap and swap
    OpType_Branch,         // Software write to the PC
    OpType_Other           // Any other class of operation
};
```

## Library pseudocode for aarch64/debug/statisticalprofiling/ProfilingBufferEnabled

```
// ProfilingBufferEnabled()
// =====

boolean ProfilingBufferEnabled()
    if !HaveStatisticalProfiling() then return FALSE;
    (secure, el) = ProfilingBufferOwner();
    non_secure_bit = if secure then '0' else '1';
    return (!ELUsingAArch32(el) && non_secure_bit == SCR_EL3.NS &&
        PMBLIMITR_EL1.E == '1' && PMBSR_EL1.S == '0');
```

## Library pseudocode for aarch64/debug/statisticalprofiling/ProfilingBufferOwner

```
// ProfilingBufferOwner()
// =====

(boolean, bits(2)) ProfilingBufferOwner()
    secure = if HaveEL(EL3) then (MDCR_EL3.NSPB<1> == '0') else IsSecure();
    el = if !secure && HaveEL(EL2) && MDCR_EL2.E2PB == '00' then EL2 else EL1;
    return (secure, el);
```



## Library pseudocode for aarch64/debug/statisticalprofiling/ProfilingSynchronizationBarrier

```
// Barrier to ensure that all existing profiling data has been formatted, and profiling buffer
// addresses have been translated such that writes to the profiling buffer have been initiated.
// A following DSB completes when writes to the profiling buffer have completed.
ProfilingSynchronizationBarrier();
```

## Library pseudocode for aarch64/debug/statisticalprofiling/StatisticalProfilingEnabled

```
// StatisticalProfilingEnabled()
// =====

boolean StatisticalProfilingEnabled()
    if !HaveStatisticalProfiling() || UsingAArch32() || !ProfilingBufferEnabled() then
        return FALSE;

    in_host = EL2Enabled() && HCR_EL2.TGE == '1';
    (secure, el) = ProfilingBufferOwner();
    if UInt(el) < UInt(PSTATE.EL) || secure != IsSecure() || (in_host && el == EL1) then
        return FALSE;

    case PSTATE.EL of
        when EL3 Unreachable();
        when EL2 spe_bit = PMSCR_EL2.E2SPE;
        when EL1 spe_bit = PMSCR_EL1.E1SPE;
        when EL0 spe_bit = (if in_host then PMSCR_EL2.E0HSPE else PMSCR_EL1.E0SPE);

    return spe_bit == '1';
```

## Library pseudocode for aarch64/debug/statisticalprofiling/SysRegAccess

```
enumeration SysRegAccess { SysRegAccess_OK,
                           SysRegAccess_UNDEFINED,
                           SysRegAccess_TrapToEL1,
                           SysRegAccess_TrapToEL2,
                           SysRegAccess_TrapToEL3 };
```

## Library pseudocode for aarch64/debug/statisticalprofiling/TimeStamp

```
enumeration TimeStamp {
    TimeStamp_None,           // No timestamp
    TimeStamp_CoreSight,      // CoreSight time (IMPLEMENTATION DEFINED)
    TimeStamp_Physical,       // Physical counter value with no offset
    TimeStamp_OffsetPhysical,  // Physical counter value minus CNTPOFF_EL2
    TimeStamp_Virtual };      // Physical counter value minus CNTVOFF_EL2
```

## Library pseudocode for aarch64/debug/takeexceptiondbg/AArch64.TakeExceptionInDebugState

```
// AArch64.TakeExceptionInDebugState()
// =====
// Take an exception in Debug state to an Exception Level using AArch64.

AArch64.TakeExceptionInDebugState(bits(2) target_el, ExceptionRecord exception)
    assert HaveEL(target_el) && !ELUsingAArch32(target_el) && UInt(target_el) >= UInt(PSTATE.EL);

    sync_errors = HaveIESB() && SCTLR[target_el].IESB == '1';
    if HaveDoubleFaultExt() then
        sync_errors = sync_errors || (SCR_EL3.EA == '1' && SCR_EL3.NMEA == '1' && target_el == EL3);
    // SCTLR[].IESB might be ignored in Debug state.
    if !ConstrainUnpredictableBool(Unpredictable\_IESBinDebug) then
        sync_errors = FALSE;

    if HaveTME() && TSTATE.depth > 0 then
        case exception.exceptype of
            when Exception\_SoftwareBreakpoint cause = TMFailure\_DBG;
            when Exception\_Breakpoint cause = TMFailure\_DBG;
            when Exception\_Watchpoint cause = TMFailure\_DBG;
            when Exception\_SoftwareStep cause = TMFailure\_DBG;
            otherwise cause = TMFailure\_ERR;
        FailTransaction(cause, FALSE);

    SynchronizeContext();

    // If coming from AArch32 state, the top parts of the X[] registers might be set to zero
    from_32 = UsingAArch32();
    if from_32 then AArch64.MaybeZeroRegisterUppers();
    MaybeZeroSVEUppers(target_el);

    AArch64.ReportException(exception, target_el);

    PSTATE.EL = target_el;
    PSTATE.nRW = '0';
    PSTATE.SP = '1';

    SPSR[] = bits(32) UNKNOWN;
    ELR[] = bits(64) UNKNOWN;

    // PSTATE.{SS,D,A,I,F} are not observable and ignored in Debug state, so behave as if UNKNOWN.
    PSTATE.<SS,D,A,I,F> = bits(5) UNKNOWN;
    PSTATE.IL = '0';
    if from_32 then // Coming from AArch32
        PSTATE.IT = '00000000';
        PSTATE.T = '0'; // PSTATE.J is RES0
    if (HavePANExt() && (PSTATE.EL == EL1 || (PSTATE.EL == EL2 && ELIsInHost(EL0))) &&
        SCTLR[].SPAN == '0') then
        PSTATE.PAN = '1';
    if HaveUA0Ext() then PSTATE.UA0 = '0';
    if HaveBTIExt() then PSTATE.BTYPE = '00';
    if HaveSSBSEExt() then PSTATE.SSBS = bit UNKNOWN;
    if HaveMTEExt() then PSTATE.TCO = '1';

    DLR_EL0 = bits(64) UNKNOWN;
    DSPSR_EL0 = bits(32) UNKNOWN;

    EDSCR.ERR = '1';
    UpdateEDSCRFields(); // Update EDSCR processor state flags.

    if sync_errors then
        SynchronizeErrors();

    EndOfInstruction();
```

## Library pseudocode for aarch64/debug/watchpoint/AArch64.WatchpointByteMatch

```
// AArch64.WatchpointByteMatch()
// =====

boolean AArch64.WatchpointByteMatch(integer n, AccType acctype, bits(64) vaddress)

    el = if HaveNV2Ext\(\) && acctype == AccType\_NV2REGISTER then EL2 else PSTATE.EL;
    top = AddrTop(vaddress, FALSE, el);
    bottom = if DBGWVR_EL1[n]<2> == '1' then 2 else 3;           // Word or doubleword
    byte_select_match = (DBGWCR_EL1[n].BAS<UInt(vaddress<bottom-1:0>)> != '0');
    mask = UInt(DBGWCR_EL1[n].MASK);

    // If DBGWCR_EL1[n].MASK is non-zero value and DBGWCR_EL1[n].BAS is not set to '11111111', or
    // DBGWCR_EL1[n].BAS specifies a non-contiguous set of bytes behavior is CONSTRAINED
    // UNPREDICTABLE.
    if mask > 0 && !IsOnes(DBGWCR_EL1[n].BAS) then
        byte_select_match = ConstrainUnpredictableBool(Unpredictable\_WPMASKANDBAS);
    else
        LSB = (DBGWCR_EL1[n].BAS AND NOT(DBGWCR_EL1[n].BAS - 1)); MSB = (DBGWCR_EL1[n].BAS + LSB);
        if !IsZero(MSB AND (MSB - 1)) then                       // Not contiguous
            byte_select_match = ConstrainUnpredictableBool(Unpredictable\_WPBASCONTIGUOUS);
            bottom = 3;                                           // For the whole doubleword

    // If the address mask is set to a reserved value, the behavior is CONSTRAINED UNPREDICTABLE.
    if mask > 0 && mask <= 2 then
        (c, mask) = ConstrainUnpredictableInteger(3, 31, Unpredictable\_RESWPMASK);
        assert c IN {Constraint\_DISABLED, Constraint\_NONE, Constraint\_UNKNOWN};
        case c of
            when Constraint\_DISABLED return FALSE;             // Disabled
            when Constraint\_NONE mask = 0;                     // No masking
            // Otherwise the value returned by ConstrainUnpredictableInteger is a not-reserved value

    if mask > bottom then
        WVR_match = (vaddress<top:mask> == DBGWVR_EL1[n]<top:mask>);
        // If masked bits of DBGWVR_EL1[n] are not zero, the behavior is CONSTRAINED UNPREDICTABLE.
        if WVR_match && !IsZero(DBGWVR_EL1[n]<mask-1:bottom>) then
            WVR_match = ConstrainUnpredictableBool(Unpredictable\_WPMASKEDBITS);
    else
        WVR_match = vaddress<top:bottom> == DBGWVR_EL1[n]<top:bottom>;

    return WVR_match && byte_select_match;
```

## Library pseudocode for aarch64/debug/watchpoint/AArch64.WatchpointMatch

```
// AArch64.WatchpointMatch()
// =====
// Watchpoint matching in an AArch64 translation regime.

boolean AArch64.WatchpointMatch(integer n, bits(64) vaddress, integer size, boolean ispriv,
                                AccType acctype, boolean iswrite)
    assert !ELUsingAArch32(S1TranslationRegime());
    assert n <= UInt(ID_AA64DFR0_EL1.WRPs);

    // "ispriv" is FALSE for LDTR/STTR instructions executed at EL1 and all
    // load/stores at EL0, TRUE for all other load/stores. "iswrite" is TRUE for stores, FALSE for
    // loads.
    enabled = DBGWCR_EL1[n].E == '1';
    linked = DBGWCR_EL1[n].WT == '1';
    isbreakpnt = FALSE;

    state_match = AArch64.StateMatch(DBGWCR_EL1[n].SSC, DBGWCR_EL1[n].HMC, DBGWCR_EL1[n].PAC,
                                     linked, DBGWCR_EL1[n].LBN, isbreakpnt, acctype, ispriv);

    ls_match = (DBGWCR_EL1[n].LSC<(if iswrite then 1 else 0)> == '1');

    value_match = FALSE;
    for byte = 0 to size - 1
        value_match = value_match || AArch64.WatchpointByteMatch(n, acctype, vaddress + byte);

    return value_match && state_match && ls_match && enabled;
```

## Library pseudocode for aarch64/exceptions/aborts/AArch64.Abort

```
// AArch64.Abort()
// =====
// Abort and Debug exception handling in an AArch64 translation regime.

AArch64.Abort(bits(64) vaddress, FaultRecord fault)

    if IsDebugException(fault) then
        if fault.acctype == AccType_IFETCH then
            if UsingAArch32() && fault.debugmoe == DebugException_VectorCatch then
                AArch64.VectorCatchException(fault);
            else
                AArch64.BreakpointException(fault);
        else
            AArch64.WatchpointException(vaddress, fault);
    elsif fault.acctype == AccType_IFETCH then
        AArch64.InstructionAbort(vaddress, fault);
    else
        AArch64.DataAbort(vaddress, fault);
```

## Library pseudocode for aarch64/exceptions/aborts/AArch64.AbortSyndrome

```
// AArch64.AbortSyndrome()
// =====
// Creates an exception syndrome record for Abort and Watchpoint exceptions
// from an AArch64 translation regime.

ExceptionRecord AArch64.AbortSyndrome(Exception exceptype, FaultRecord fault, bits(64) vaddress)
    exception = ExceptionSyndrome(exceptype);

    d_side = exceptype IN {Exception_DataAbort, Exception_NV2DataAbort, Exception_Watchpoint, Exception_MVADataAbort}
    exception.syndrome = AArch64.FaultSyndrome(d_side, fault);
    exception.vaddress = ZeroExtend(vaddress);
    if IPAValid(fault) then
        exception.ipavalid = TRUE;
        exception.NS = fault.ipaddress.NS;
        exception.ipaddress = fault.ipaddress.address;
    else
        exception.ipavalid = FALSE;

    return exception;
```

## Library pseudocode for aarch64/exceptions/aborts/AArch64.CheckPCAlignment

```
// AArch64.CheckPCAlignment()
// =====

AArch64.CheckPCAlignment()

    bits(64) pc = ThisInstrAddr();
    if pc<1:0> != '00' then
        AArch64.PCAlignmentFault();
```

## Library pseudocode for aarch64/exceptions/aborts/AArch64.DataAbort

```
// AArch64.DataAbort()
// =====

AArch64.DataAbort(bits(64) vaddress, FaultRecord fault)
    route_to_el3 = HaveEL(EL3) && SCR_EL3.EA == '1' && IsExternalAbort(fault);
    route_to_el2 = (PSTATE.EL IN {EL0, EL1} && EL2Enabled() && (HCR_EL2.TGE == '1' ||
        (HaveRASExt() && HCR_EL2.TEA == '1' && IsExternalAbort(fault)) ||
        (HaveNV2Ext() && fault.acctype == AccType_NV2REGISTER) ||
        IsSecondStage(fault)));

    bits(64) preferred_exception_return = ThisInstrAddr();
    if (HaveDoubleFaultExt() && (PSTATE.EL == EL3 || route_to_el3) &&
        IsExternalAbort(fault) && SCR_EL3.EASE == '1') then
        vect_offset = 0x180;
    else
        vect_offset = 0x0;
    if HaveNV2Ext() && fault.acctype == AccType_NV2REGISTER then
        exception = AArch64.AbortSyndrome(Exception_NV2DataAbort, fault, vaddress);
    else
        exception = AArch64.AbortSyndrome(Exception_DataAbort, fault, vaddress);
    if PSTATE.EL == EL3 || route_to_el3 then
        AArch64.TakeException(EL3, exception, preferred_exception_return, vect_offset);
    elsif PSTATE.EL == EL2 || route_to_el2 then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/aborts/AArch64.EffectiveTCF

```
// AArch64.EffectiveTCF()
// =====
// Returns the TCF field applied to tag check faults in the given Exception Level.

bits(2) AArch64.EffectiveTCF(bits(2) el)
    bits(2) tcf;

    if el == EL3 then
        tcf = SCTLR_EL3.TCF;
    elsif el == EL2 then
        tcf = SCTLR_EL2.TCF;
    elsif el == EL1 then
        tcf = SCTLR_EL1.TCF;
    elsif el == EL0 && HCR_EL2.<E2H,TGE> == '11' then
        tcf = SCTLR_EL2.TCF0;
    elsif el == EL0 && HCR_EL2.<E2H,TGE> != '11' then
        tcf = SCTLR_EL1.TCF0;

    if tcf == '11' then
        (-,tcf) = ConstrainUnpredictableBits(Unpredictable\_RESTCF);

    return tcf;
```

## Library pseudocode for aarch64/exceptions/aborts/AArch64.InstructionAbort

```
// AArch64.InstructionAbort()
// =====

AArch64.InstructionAbort(bits(64) vaddress, FaultRecord fault)
    // External aborts on instruction fetch must be taken synchronously
    if HaveDoubleFaultExt() then assert fault.statuscode != Fault\_AsyncExternal;
    route_to_el3 = HaveEL(EL3) && SCR_EL3.EA == '1' && IsExternalAbort(fault);
    route_to_el2 = (PSTATE.EL IN {EL0, EL1} && EL2Enabled() &&
        (HCR_EL2.TGE == '1' || IsSecondStage(fault) ||
        (HaveRASExt() && HCR_EL2.TEA == '1' && IsExternalAbort(fault))));

    bits(64) preferred_exception_return = ThisInstrAddr();

    if (HaveDoubleFaultExt() && (PSTATE.EL == EL3 || route_to_el3) &&
        IsExternalAbort(fault) && SCR_EL3.EASE == '1') then
        vect_offset = 0x180;
    else
        vect_offset = 0x0;

    exception = AArch64.AbortSyndrome(Exception\_InstructionAbort, fault, vaddress);

    if PSTATE.EL == EL3 || route_to_el3 then
        AArch64.TakeException(EL3, exception, preferred_exception_return, vect_offset);
    elsif PSTATE.EL == EL2 || route_to_el2 then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/aborts/AArch64.PCAlignmentFault

```
// AArch64.PCAlignmentFault()
// =====
// Called on unaligned program counter in AArch64 state.

AArch64.PCAlignmentFault()

    bits(64) preferred_exception_return = ThisInstrAddr\(\);
    vect_offset = 0x0;

    exception = ExceptionSyndrome\(Exception\_PCAlignment\);
    exception.vaddress = ThisInstrAddr\(\);

    if UInt(PSTATE.EL) > UInt(EL1) then
        AArch64.TakeException(PSTATE.EL, exception, preferred_exception_return, vect_offset);
    elsif EL2Enabled() && HCR_EL2.TGE == '1' then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/aborts/AArch64.RaiseTagCheckFault

```
// AArch64.RaiseTagCheckFault()
// =====
// Raise a tag check fault exception.

AArch64.RaiseTagCheckFault(bits(64) va, boolean write)
    bits(2) target_el;
    bits(64) preferred_exception_return = ThisInstrAddr\(\);
    integer vect_offset = 0x0;

    if PSTATE.EL == EL0 then
        target_el = if HCR_EL2.TGE == '0' then EL1 else EL2;
    else
        target_el = PSTATE.EL;

    exception = ExceptionSyndrome\(Exception\_DataAbort\);
    exception.syndrome<5:0> = '010001';
    if write then
        exception.syndrome<6> = '1';
    exception.vaddress = bits(4) UNKNOWN : va<59:0>;

    AArch64.TakeException(target_el, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/aborts/AArch64.ReportTagCheckFail

```
// AArch64.ReportTagCheckFail()
// =====
// Records a tag check fault exception into the appropriate TCFR_ELx.

AArch64.ReportTagCheckFail(bits(2) el, bit ttbr)
    if el == EL3 then
        assert ttbr == '0';
        TFSR_EL3.TF0 = '1';
    elseif el == EL2 then
        if ttbr == '0' then
            TFSR_EL2.TF0 = '1';
        else
            TFSR_EL2.TF1 = '1';
    elseif el == EL1 then
        if ttbr == '0' then
            TFSR_EL1.TF0 = '1';
        else
            TFSR_EL1.TF1 = '1';
    elseif el == EL0 then
        if ttbr == '0' then
            TFSRE0_EL1.TF0 = '1';
        else
            TFSRE0_EL1.TF1 = '1';
```

## Library pseudocode for aarch64/exceptions/aborts/AArch64.SPAlignmentFault

```
// AArch64.SPAlignmentFault()
// =====
// Called on an unaligned stack pointer in AArch64 state.

AArch64.SPAlignmentFault()

    bits(64) preferred_exception_return = ThisInstrAddr\(\);
    vect_offset = 0x0;

    exception = ExceptionSyndrome\(Exception\_SPAlignment\);

    if UInt\(PSTATE.EL\) > UInt\(EL1\) then
        AArch64.TakeException(PSTATE.EL, exception, preferred_exception_return, vect_offset);
    elseif EL2Enabled\(\) && HCR_EL2.TGE == '1' then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/aborts/AArch64.TagCheckFault

```
// AArch64.TagCheckFault()
// =====
// Handle a tag check fault condition.

AArch64.TagCheckFail(bits(64) vaddress, AccType acctype, boolean iswrite)
    bits(2) el;
    if AArch64.AccessIsPrivileged(acctype) then
        el = PSTATE.EL;
    else
        el = EL0;

    bits(2) tcf = AArch64.EffectiveTCF(el);
    if tcf == '01' then
        AArch64.RaiseTagCheckFault(vaddress, iswrite);
    elseif tcf == '10' then
        AArch64.ReportTagCheckFail(el, vaddress<55>);
```



## Library pseudocode for aarch64/exceptions/aborts/BranchTargetException

```
// BranchTargetException
// =====
// Raise branch target exception.

AArch64.BranchTargetException(bits(52) vaddress)

    route_to_el2 = PSTATE.EL == EL0 && EL2Enabled\(\) && HCR_EL2.TGE == '1';
    bits(64) preferred_exception_return = ThisInstrAddr\(\);
    vect_offset = 0x0;

    exception = ExceptionSyndrome\(Exception\_BranchTarget\);
    exception.syndrome<1:0> = PSTATE.BTYPE;
    exception.syndrome<24:2> = Zeros\(\);          // RES0

    if UInt(PSTATE.EL) > UInt(EL1) then
        AArch64.TakeException(PSTATE.EL, exception, preferred_exception_return, vect_offset);
    elsif route_to_el2 then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/asynch/AArch64.TakePhysicalFIQException

```
// AArch64.TakePhysicalFIQException()
// =====

AArch64.TakePhysicalFIQException()

    route_to_el3 = HaveEL(EL3) && SCR_EL3.FIQ == '1';
    route_to_el2 = (PSTATE.EL IN {EL0, EL1} && EL2Enabled\(\) &&
        (HCR_EL2.TGE == '1' || HCR_EL2.FMO == '1'));
    bits(64) preferred_exception_return = ThisInstrAddr\(\);
    vect_offset = 0x100;
    exception = ExceptionSyndrome\(Exception\_FIQ\);

    if route_to_el3 then
        AArch64.TakeException(EL3, exception, preferred_exception_return, vect_offset);
    elsif PSTATE.EL == EL2 || route_to_el2 then
        assert PSTATE.EL != EL3;
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        assert PSTATE.EL IN {EL0, EL1};
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/asynch/AArch64.TakePhysicalIRQException

```
// AArch64.TakePhysicalIRQException()
// =====
// Take an enabled physical IRQ exception.

AArch64.TakePhysicalIRQException()

    route_to_el3 = HaveEL(EL3) && SCR_EL3.IRQ == '1';
    route_to_el2 = (PSTATE.EL IN {EL0, EL1} && EL2Enabled() &&
                    (HCR_EL2.TGE == '1' || HCR_EL2.IMO == '1'));
    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x80;

    exception = ExceptionSyndrome(Exception_IRQ);

    if route_to_el3 then
        AArch64.TakeException(EL3, exception, preferred_exception_return, vect_offset);
    elsif PSTATE.EL == EL2 || route_to_el2 then
        assert PSTATE.EL != EL3;
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        assert PSTATE.EL IN {EL0, EL1};
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/asynch/AArch64.TakePhysicalSErrorException

```
// AArch64.TakePhysicalSErrorException()
// =====

AArch64.TakePhysicalSErrorException(boolean impdef_syndrome, bits(24) syndrome)

    route_to_el3 = HaveEL(EL3) && SCR_EL3.EA == '1';
    route_to_el2 = (PSTATE.EL IN {EL0, EL1} && EL2Enabled() &&
                    (HCR_EL2.TGE == '1' || (!IsInHost() && HCR_EL2.AMO == '1')));
    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x180;

    exception = ExceptionSyndrome(Exception_SError);
    exception.syndrome<24> = if impdef_syndrome then '1' else '0';
    exception.syndrome<23:0> = syndrome;

    ClearPendingPhysicalSError();

    if PSTATE.EL == EL3 || route_to_el3 then
        AArch64.TakeException(EL3, exception, preferred_exception_return, vect_offset);
    elsif PSTATE.EL == EL2 || route_to_el2 then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/asynch/AArch64.TakeVirtualFIQException

```
// AArch64.TakeVirtualFIQException()
// =====

AArch64.TakeVirtualFIQException()
    assert PSTATE.EL IN {EL0, EL1} && EL2Enabled();
    assert HCR_EL2.TGE == '0' && HCR_EL2.FMO == '1'; // Virtual IRQ enabled if TGE==0 and FMO==1

    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x100;

    exception = ExceptionSyndrome(Exception_FIQ);

    AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/asynch/AArch64.TakeVirtualIRQException

```
// AArch64.TakeVirtualIRQException()
// =====

AArch64.TakeVirtualIRQException()
    assert PSTATE.EL IN {EL0, EL1} && EL2Enabled();
    assert HCR_EL2.TGE == '0' && HCR_EL2.IMO == '1'; // Virtual IRQ enabled if TGE==0 and IMO==1

    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x80;

    exception = ExceptionSyndrome(Exception_IRQ);

    AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/asynch/AArch64.TakeVirtualSErrorException

```
// AArch64.TakeVirtualSErrorException()
// =====

AArch64.TakeVirtualSErrorException(boolean impdef_syndrome, bits(24) syndrome)

    assert PSTATE.EL IN {EL0, EL1} && EL2Enabled();
    assert HCR_EL2.TGE == '0' && HCR_EL2.AMO == '1'; // Virtual SError enabled if TGE==0 and AMO==1

    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x180;

    exception = ExceptionSyndrome(Exception_SError);
    if HaveRASExt() then
        exception.syndrome<24> = VESR_EL2.IDS;
        exception.syndrome<23:0> = VESR_EL2.ISS;
    else
        exception.syndrome<24> = if impdef_syndrome then '1' else '0';
        if impdef_syndrome then exception.syndrome<23:0> = syndrome;

    ClearPendingVirtualSError();
    AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/debug/AArch64.BreakpointException

```
// AArch64.BreakpointException()
// =====

AArch64.BreakpointException(FaultRecord fault)
    assert PSTATE.EL != EL3;

    route_to_el2 = (PSTATE.EL IN {EL0, EL1} && EL2Enabled() &&
        (HCR_EL2.TGE == '1' || MDCR_EL2.TDE == '1'));

    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x0;

    vaddress = bits(64) UNKNOWN;
    exception = AArch64.AbortSyndrome(Exception_Breakpoint, fault, vaddress);

    if PSTATE.EL == EL2 || route_to_el2 then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/debug/AArch64.SoftwareBreakpoint

```
// AArch64.SoftwareBreakpoint()
// =====

AArch64.SoftwareBreakpoint(bits(16) immediate)

    route_to_el2 = (PSTATE.EL IN {EL0, EL1} &&
                    EL2Enabled() && (HCR_EL2.TGE == '1' || MDCR_EL2.TDE == '1'));

    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x0;

    exception = ExceptionSyndrome(Exception_SoftwareBreakpoint);
    exception.syndrome<15:0> = immediate;

    if UInt(PSTATE.EL) > UInt(EL1) then
        AArch64.TakeException(PSTATE.EL, exception, preferred_exception_return, vect_offset);
    elsif route_to_el2 then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/debug/AArch64.SoftwareStepException

```
// AArch64.SoftwareStepException()
// =====

AArch64.SoftwareStepException()
    assert PSTATE.EL != EL3;

    route_to_el2 = (PSTATE.EL IN {EL0, EL1} && EL2Enabled() &&
                    (HCR_EL2.TGE == '1' || MDCR_EL2.TDE == '1'));

    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x0;

    exception = ExceptionSyndrome(Exception_SoftwareStep);
    if SoftwareStep_DidNotStep() then
        exception.syndrome<24> = '0';
    else
        exception.syndrome<24> = '1';
        exception.syndrome<6> = if SoftwareStep_SteppedEX() then '1' else '0';

    if PSTATE.EL == EL2 || route_to_el2 then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/debug/AArch64.VectorCatchException

```
// AArch64.VectorCatchException()
// =====
// Vector Catch taken from EL0 or EL1 to EL2. This can only be called when debug exceptions are
// being routed to EL2, as Vector Catch is a legacy debug event.

AArch64.VectorCatchException(FaultRecord fault)
    assert PSTATE.EL != EL2;
    assert EL2Enabled() && (HCR_EL2.TGE == '1' || MDCR_EL2.TDE == '1');

    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x0;

    vaddress = bits(64) UNKNOWN;
    exception = AArch64.AbortSyndrome(Exception_VectorCatch, fault, vaddress);

    AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/debug/AArch64.WatchpointException

```
// AArch64.WatchpointException()
// =====

AArch64.WatchpointException(bits(64) vaddress, FaultRecord fault)
    assert PSTATE.EL != EL3;

    route_to_el2 = (PSTATE.EL IN {EL0, EL1} && EL2Enabled\(\) &&
        (HCR_EL2.TGE == '1' || MDCR_EL2.TDE == '1'));

    bits(64) preferred_exception_return = ThisInstrAddr\(\);
    vect_offset = 0x0;

    if HaveNV2Ext\(\) && fault.acctype == AccType\_NV2REGISTER then
        exception = AArch64.AbortSyndrome(Exception\_NV2Watchpoint, fault, vaddress);
    else
        exception = AArch64.AbortSyndrome(Exception\_Watchpoint, fault, vaddress);

    if PSTATE.EL == EL2 || route_to_el2 then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/exceptions/AArch64.ExceptionClass

```
// AArch64.ExceptionClass()
// =====
// Returns the Exception Class and Instruction Length fields to be reported in ESR

(integer,bit) AArch64.ExceptionClass(Exception exceptype, bits(2) target_el)

    il = if ThisInstrLength() == 32 then '1' else '0';
    from_32 = UsingAArch32();
    assert from_32 || il == '1';          // AArch64 instructions always 32-bit

    case exceptype of
        when Exception_Uncategorized          ec = 0x00; il = '1';
        when Exception_WFxTrap                ec = 0x01;
        when Exception_CP15RTTTrap            ec = 0x03;          assert from_32;
        when Exception_CP15RRTTrap            ec = 0x04;          assert from_32;
        when Exception_CP14RTTTrap            ec = 0x05;          assert from_32;
        when Exception_CP14DTTTrap            ec = 0x06;          assert from_32;
        when Exception_AdvSIMDFPAccessTrap    ec = 0x07;
        when Exception_FPIDTrap                ec = 0x08;
        when Exception_PACTrap                 ec = 0x09;
        when Exception_TSTARTAccessTrap        ec = 0x1B;
        when Exception_CP14RRTTrap            ec = 0x0C;          assert from_32;
        when Exception_BranchTarget            ec = 0x0D;
        when Exception_IllegalState            ec = 0x0E; il = '1';
        when Exception_SupervisorCall          ec = 0x11;
        when Exception_HypervisorCall          ec = 0x12;
        when Exception_MonitorCall             ec = 0x13;
        when Exception_SystemRegisterTrap      ec = 0x18;          assert !from_32;
        when Exception_SVEAccessTrap           ec = 0x19;          assert !from_32;
        when Exception_ERetTrap                ec = 0x1A;
        when Exception_PACFail                 ec = 0x1C;
        when Exception_InstructionAbort         ec = 0x20; il = '1';
        when Exception_PCAlignment             ec = 0x22; il = '1';
        when Exception_DataAbort               ec = 0x24;
        when Exception_NV2DataAbort            ec = 0x25;
        when Exception_SPAlignment             ec = 0x26; il = '1'; assert !from_32;
        when Exception_FPtrappedException      ec = 0x28;
        when Exception_SError                  ec = 0x2F; il = '1';
        when Exception_Breakpoint              ec = 0x30; il = '1';
        when Exception_SoftwareStep            ec = 0x32; il = '1';
        when Exception_Watchpoint              ec = 0x34; il = '1';
        when Exception_NV2Watchpoint           ec = 0x35; il = '1';
        when Exception_SoftwareBreakpoint      ec = 0x38;
        when Exception_VectorCatch             ec = 0x3A; il = '1'; assert from_32;
        otherwise                             Unreachable();

    if ec IN {0x20,0x24,0x30,0x32,0x34} && target_el == PSTATE.EL then
        ec = ec + 1;

    if ec IN {0x11,0x12,0x13,0x28,0x38} && !from_32 then
        ec = ec + 4;

    return (ec,il);
```

## Library pseudocode for aarch64/exceptions/exceptions/AArch64.ReportException

```
// AArch64.ReportException()
// =====
// Report syndrome information for exception taken to AArch64 state.
AArch64.ReportException(ExceptionRecord exception, bits(2) target_el)

    Exception exceptype = exception.exceptype;

    (ec,il) = AArch64.ExceptionClass(exceptype, target_el);
    iss = exception.syndrome;

    // IL is not valid for Data Abort exceptions without valid instruction syndrome information
    if ec IN {0x24,0x25} && iss<24> == '0' then
        il = '1';

    ESR[target_el] = ec<5:0>:il:iss;

    if exceptype IN {Exception_InstructionAbort, Exception_PCAlignment, Exception_DataAbort,
                    Exception_NV2DataAbort, Exception_NV2Watchpoint,
                    Exception_Watchpoint} then
        FAR[target_el] = exception.vaddress;
    else
        FAR[target_el] = bits(64) UNKNOWN;

    if target_el == EL2 then
        if exception.ipavalid then
            HPFAR_EL2<43:4> = exception.ipaddress<51:12>;
            if IsSecureEL2Enabled() && IsSecure() then
                HPFAR_EL2.NS = exception.NS;
            else
                HPFAR_EL2.NS = '0';
        else
            HPFAR_EL2<43:4> = bits(40) UNKNOWN;

    return;
```

## Library pseudocode for aarch64/exceptions/exceptions/AArch64.ResetControlRegisters

```
// Resets System registers and memory-mapped control registers that have architecturally-defined
// reset values to those values.
AArch64.ResetControlRegisters(boolean cold_reset);
```

## Library pseudocode for aarch64/exceptions/exceptions/AArch64.TakeReset

```
// AArch64.TakeReset()
// =====
// Reset into AArch64 state

AArch64.TakeReset(boolean cold_reset)
    assert !HighestELUsingAArch32\(\);

    // Enter the highest implemented Exception level in AArch64 state
    PSTATE.nRW = '0';
    if HaveEL\(EL3\) then
        PSTATE.EL = EL3;
    elsif HaveEL\(EL2\) then
        PSTATE.EL = EL2;
    else
        PSTATE.EL = EL1;

    // Reset the system registers and other system components
    AArch64.ResetControlRegisters(cold_reset);

    // Reset all other PSTATE fields
    PSTATE.SP = '1';           // Select stack pointer
    PSTATE.<D,A,I,F> = '1111'; // All asynchronous exceptions masked
    PSTATE.SS = '0';           // Clear software step bit
    PSTATE.DIT = '0';          // PSTATE.DIT is reset to 0 when resetting into AArch64
    PSTATE.IL = '0';           // Clear Illegal Execution state bit

    TSTATE.depth = 0;          // Non-transactional state

    // All registers, bits and fields not reset by the above pseudocode or by the BranchTo() call
    // below are UNKNOWN bitstrings after reset. In particular, the return information registers
    // ELR_ELx and SPSR_ELx have UNKNOWN values, so that it
    // is impossible to return from a reset in an architecturally defined way.
    AArch64.ResetGeneralRegisters();
    AArch64.ResetSIMDFPRegisters();
    AArch64.ResetSpecialRegisters();
    ResetExternalDebugRegisters(cold_reset);

    bits(64) rv;               // IMPLEMENTATION DEFINED reset vector

    if HaveEL\(EL3\) then
        rv = RVBAR_EL3;
    elsif HaveEL\(EL2\) then
        rv = RVBAR_EL2;
    else
        rv = RVBAR_EL1;

    // The reset vector must be correctly aligned
    assert IsZero(rv<63:PAMax()>) && IsZero(rv<1:0>);

    BranchTo(rv, BranchType\_RESET);
```



## Library pseudocode for aarch64/exceptions/ieeefp/AArch64.FPTrappedException

```
// AArch64.FPTrappedException()
// =====

AArch64.FPTrappedException(boolean is_ase, integer element, bits(8) accumulated_exceptions)
    exception = ExceptionSyndrome\(Exception\_FPTrappedException\);
    if is_ase then
        if boolean IMPLEMENTATION_DEFINED "vector instructions set TFV to 1" then
            exception.syndrome<23> = '1'; // TFV
        else
            exception.syndrome<23> = '0'; // TFV
    else
        exception.syndrome<23> = '1'; // TFV
    exception.syndrome<10:8> = bits(3) UNKNOWN; // VECITR
    if exception.syndrome<23> == '1' then
        exception.syndrome<7,4:0> = accumulated_exceptions<7,4:0>; // IDF,IXF,UFF,OFF,DZF,IOf
    else
        exception.syndrome<7,4:0> = bits(6) UNKNOWN;

    route_to_el2 = EL2Enabled\(\) && HCR_EL2.TGE == '1';

    bits(64) preferred_exception_return = ThisInstrAddr\(\);
    vect_offset = 0x0;

    if UInt\(PSTATE.EL\) > UInt\(EL1\) then
        AArch64.TakeException(PSTATE.EL, exception, preferred_exception_return, vect_offset);
    elsif route_to_el2 then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/syscalls/AArch64.CallHypervisor

```
// AArch64.CallHypervisor()
// =====
// Performs a HVC call

AArch64.CallHypervisor(bits(16) immediate)
    assert HaveEL\(EL2\);

    if UsingAArch32\(\) then AArch32.ITAdvance\(\);
    SSAdvance\(\);
    bits(64) preferred_exception_return = NextInstrAddr\(\);
    vect_offset = 0x0;

    exception = ExceptionSyndrome\(Exception\_HypervisorCall\);
    exception.syndrome<15:0> = immediate;

    if PSTATE.EL == EL3 then
        AArch64.TakeException(EL3, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/syscalls/AArch64.CallSecureMonitor

```
// AArch64.CallSecureMonitor()
// =====

AArch64.CallSecureMonitor(bits(16) immediate)
    assert HaveEL(EL3) && !ELUsingAArch32(EL3);
    if UsingAArch32() then AArch32.ITAdvance();
    SSAdvance();
    bits(64) preferred_exception_return = NextInstrAddr();
    vect_offset = 0x0;

    exception = ExceptionSyndrome(Exception_MonitorCall);
    exception.syndrome<15:0> = immediate;

    AArch64.TakeException(EL3, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/syscalls/AArch64.CallSupervisor

```
// AArch64.CallSupervisor()
// =====
// Calls the Supervisor

AArch64.CallSupervisor(bits(16) immediate)

    if UsingAArch32() then AArch32.ITAdvance();
    SSAdvance();
    route_to_el2 = PSTATE.EL == EL0 && EL2Enabled() && HCR_EL2.TGE == '1';

    bits(64) preferred_exception_return = NextInstrAddr();
    vect_offset = 0x0;

    exception = ExceptionSyndrome(Exception_SupervisorCall);
    exception.syndrome<15:0> = immediate;

    if UInt(PSTATE.EL) > UInt(EL1) then
        AArch64.TakeException(PSTATE.EL, exception, preferred_exception_return, vect_offset);
    elsif route_to_el2 then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```



```

// AArch64.TakeException()
// =====
// Take an exception to an Exception Level using AArch64.

AArch64.TakeException(bits(2) target_el, ExceptionRecord exception,
                      bits(64) preferred_exception_return, integer vect_offset)
assert HaveEL(target_el) && !ELUsingAArch32(target_el) && UInt(target_el) >= UInt(PSTATE.EL);

sync_errors = HaveIESB() && SCTLR[target_el].IESB == '1';
if HaveDoubleFaultExt() then
    sync_errors = sync_errors || (SCR_EL3.EA == '1' && SCR_EL3.NMEA == '1' && target_el == EL3);
if sync_errors && InsertIESBBeforeException(target_el) then
    SynchronizeErrors();
    iesb_req = FALSE;
    sync_errors = FALSE;
    TakeUnmaskedPhysicalSErrorInterrupts(iesb_req);

if HaveTME() && TSTATE.depth > 0 then
    case exception.exceptype of
        when Exception\_SoftwareBreakpoint cause = TMFailure\_DBG;
        when Exception\_Breakpoint cause = TMFailure\_DBG;
        when Exception\_Watchpoint cause = TMFailure\_DBG;
        when Exception\_SoftwareStep cause = TMFailure\_DBG;
        otherwise cause = TMFailure\_ERR;
    FailTransaction(cause, FALSE);

SynchronizeContext();

// If coming from AArch32 state, the top parts of the X[] registers might be set to zero
from_32 = UsingAArch32();
if from_32 then AArch64.MaybeZeroRegisterUppers();
MaybeZeroSVEUppers(target_el);

if UInt(target_el) > UInt(PSTATE.EL) then
    boolean lower_32;
    if target_el == EL3 then
        if EL2Enabled() then
            lower_32 = ELUsingAArch32(EL2);
        else
            lower_32 = ELUsingAArch32(EL1);
    elsif IsInHost() && PSTATE.EL == EL0 && target_el == EL2 then
        lower_32 = ELUsingAArch32(EL0);
    else
        lower_32 = ELUsingAArch32(target_el - 1);
    vect_offset = vect_offset + (if lower_32 then 0x600 else 0x400);

elsif PSTATE.SP == '1' then
    vect_offset = vect_offset + 0x200;

spsr = GetPSRFromPSTATE();

if PSTATE.EL == EL1 && target_el == EL1 && EL2Enabled() then
    if HaveNV2Ext() && (HCR_EL2.<NV,NV1,NV2> == '100' || HCR_EL2.<NV,NV1,NV2> == '111') then
        spsr<3:2> = '10';
    else
        if HaveNVExt() && HCR_EL2.<NV,NV1> == '10' then
            spsr<3:2> = '10';

if HaveBTIExt() then
    // SPSR[].BTYP is only guaranteed valid for these exception types
    if exception.exceptype IN {Exception\_SError, Exception\_IRQ, Exception\_FIQ,
                             Exception\_SoftwareStep, Exception\_PCAlignment,
                             Exception\_InstructionAbort, Exception\_Breakpoint,
                             Exception\_VectorCatch, Exception\_SoftwareBreakpoint,
                             Exception\_IllegalState, Exception\_BranchTarget} then
        zero_btype = FALSE;
    else
        zero_btype = ConstrainUnpredictableBool(Unpredictable\_ZEROBTYP);
    if zero_btype then spsr<11:10> = '00';

```

```

if HaveNV2Ext() && exception.exceptype == Exception_NV2DataAbort && target_el == EL3 then
    // external aborts are configured to be taken to EL3
    exception.exceptype = Exception_DataAbort;
if !(exception.exceptype IN {Exception_IRQ, Exception_FIQ}) then
    AArch64.ReportException(exception, target_el);

PSTATE.EL = target_el;
PSTATE.nRW = '0';
PSTATE.SP = '1';

SPSR[] = spsr;
ELR[] = preferred_exception_return;

PSTATE.SS = '0';
PSTATE.<D,A,I,F> = '1111';
PSTATE.IL = '0';
if from_32 then // Coming from AArch32
    PSTATE.IT = '00000000';
    PSTATE.T = '0'; // PSTATE.J is RES0
if (HavePANExt() && (PSTATE.EL == EL1 || (PSTATE.EL == EL2 && ELIsInHost(EL0))) &&
    SCTLRL.SPAN == '0') then
    PSTATE.PAN = '1';
if HaveUA0Ext() then PSTATE.UA0 = '0';
if HaveBTIExt() then PSTATE.BTYPE = '00';
if HaveSSBSExt() then PSTATE.SSBS = SCTLRL.DSSBS;
if HaveMTEExt() then PSTATE.TCO = '1';

BranchTo(VBAR[]<63:11>:vect_offset<10:0>, BranchType_EXCEPTION);

if sync_errors then
    SynchronizeErrors();
    iesb_req = TRUE;
    TakeUnmaskedPhysicalSErrorInterrupts(iesb_req);

EndOfInstruction();

```

### Library pseudocode for aarch64/exceptions/traps/AArch64.AArch32SystemAccessTrap

```

// AArch64.AArch32SystemAccessTrap()
// =====
// Trapped AARCH32 system register access.

AArch64.AArch32SystemAccessTrap(bits(2) target_el, integer ec)
    assert HaveEL(target_el) && target_el != EL0 && UInt(target_el) >= UInt(PSTATE.EL);

    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x0;

    exception = AArch64.AArch32SystemAccessTrapSyndrome(ThisInstr(), ec);
    AArch64.TakeException(target_el, exception, preferred_exception_return, vect_offset);

```



```

// AArch64.AArch32SystemAccessTrapSyndrome()
// =====
// Returns the syndrome information for traps on AArch32 MCR, MCRR, MRC, MRRC, and VMRS, VMSR instructions
// other than traps that are due to HCPTR or CPACR.

ExceptionRecord AArch64.AArch32SystemAccessTrapSyndrome(bits(32) instr, integer ec)
    ExceptionRecord exception;

    case ec of
        when 0x0    exception = ExceptionSyndrome(Exception_Uncategorized);
        when 0x3    exception = ExceptionSyndrome(Exception_CP15RTTTrap);
        when 0x4    exception = ExceptionSyndrome(Exception_CP15RRTTTrap);
        when 0x5    exception = ExceptionSyndrome(Exception_CP14RTTTrap);
        when 0x6    exception = ExceptionSyndrome(Exception_CP14DTTTrap);
        when 0x7    exception = ExceptionSyndrome(Exception_AdvSIMDFPAccessTrap);
        when 0x8    exception = ExceptionSyndrome(Exception_FPIDTrap);
        when 0xC    exception = ExceptionSyndrome(Exception_CP14RRTTTrap);
        otherwise   Unreachable();

    bits(20) iss = Zeros();

    if exception.exceptype IN {Exception_FPIDTrap, Exception_CP14RTTTrap, Exception_CP15RTTTrap} then
        // Trapped MRC/MCR, VMRS on FPSID
        if exception.exceptype != Exception_FPIDTrap then // When trap is not for VMRS
            iss<19:17> = instr<7:5>; // opc2
            iss<16:14> = instr<23:21>; // opc1
            iss<13:10> = instr<19:16>; // CRn
            iss<4:1> = instr<3:0>; // CRm
        else
            iss<19:17> = '000';
            iss<16:14> = '111';
            iss<13:10> = instr<19:16>; // reg
            iss<4:1> = '0000';

            if instr<20> == '1' && instr<15:12> == '1111' then // MRC, Rt==15
                iss<9:5> = '11111';
            elsif instr<20> == '0' && instr<15:12> == '1111' then // MCR, Rt==15
                iss<9:5> = bits(5) UNKNOWN;
            else
                iss<9:5> = LookUpRIndex(UInt(instr<15:12>), PSTATE.M)<4:0>;
        elsif exception.exceptype IN {Exception_CP14RRTTTrap, Exception_AdvSIMDFPAccessTrap, Exception_CP15RRTTTrap} then
            // Trapped MRRC/MCRR, VMRS/VMSR
            iss<19:16> = instr<7:4>; // opc1
            if instr<19:16> == '1111' then // Rt2==15
                iss<14:10> = bits(5) UNKNOWN;
            else
                iss<14:10> = LookUpRIndex(UInt(instr<19:16>), PSTATE.M)<4:0>;

            if instr<15:12> == '1111' then // Rt==15
                iss<9:5> = bits(5) UNKNOWN;
            else
                iss<9:5> = LookUpRIndex(UInt(instr<15:12>), PSTATE.M)<4:0>;
            iss<4:1> = instr<3:0>; // CRm
        elsif exception.exceptype == Exception_CP14DTTTrap then
            // Trapped LDC/STC
            iss<19:12> = instr<7:0>; // imm8
            iss<4> = instr<23>; // U
            iss<2:1> = instr<24,21>; // P,W
            if instr<19:16> == '1111' then // Rn==15, LDC(Literal addressing)/STC
                iss<9:5> = bits(5) UNKNOWN;
                iss<3> = '1';
            elsif exception.exceptype == Exception_Uncategorized then
                // Trapped for unknown reason
                iss<9:5> = LookUpRIndex(UInt(instr<19:16>), PSTATE.M)<4:0>; // Rn
                iss<3> = '0';

            iss<0> = instr<20>; // Direction

            exception.syndrome<24:20> = ConditionSyndrome();
            exception.syndrome<19:0> = iss;

```

```
return exception;
```

### Library pseudocode for aarch64/exceptions/traps/AArch64.AdvSIMDFPAccessTrap

```
// AArch64.AdvSIMDFPAccessTrap()
// =====
// Trapped access to Advanced SIMD or FP registers due to CPACR[].

AArch64.AdvSIMDFPAccessTrap(bits(2) target_el)
    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x0;

    route_to_el2 = (target_el == EL1 && EL2Enabled() && HCR_EL2.TGE == '1');

    if route_to_el2 then
        exception = ExceptionSyndrome(Exception_Uncategorized);
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        exception = ExceptionSyndrome(Exception_AdvSIMDFPAccessTrap);
        exception.syndrome<24:20> = ConditionSyndrome();
        AArch64.TakeException(target_el, exception, preferred_exception_return, vect_offset);

    return;
```

### Library pseudocode for aarch64/exceptions/traps/AArch64.CheckCP15InstrCoarseTraps

```
// AArch64.CheckCP15InstrCoarseTraps()
// =====
// Check for coarse-grained AArch32 CP15 traps in HSTR_EL2 and HCR_EL2.

boolean AArch64.CheckCP15InstrCoarseTraps(integer CRn, integer nreg, integer CRm)

    // Check for coarse-grained Hyp traps
    if PSTATE.EL IN {EL0, EL1} && EL2Enabled() then
        // Check for MCR, MRC, MCRR and MRRC disabled by HSTR_EL2<CRn/CRm>
        major = if nreg == 1 then CRn else CRm;
        if !IsInHost() && !(major IN {4,14}) && HSTR_EL2<major> == '1' then
            return TRUE;

        // Check for MRC and MCR disabled by HCR_EL2.TIDCP
        if (HCR_EL2.TIDCP == '1' && nreg == 1 &&
            ((CRn == 9 && CRm IN {0,1,2, 5,6,7,8 }) ||
             (CRn == 10 && CRm IN {0,1, 4, 8 }) ||
             (CRn == 11 && CRm IN {0,1,2,3,4,5,6,7,8,15}))) then
            return TRUE;

    return FALSE;
```

### Library pseudocode for aarch64/exceptions/traps/AArch64.CheckFPAdvSIMDEnabled

```
// AArch64.CheckFPAdvSIMDEnabled()
// =====
// Check against CPACR[]

AArch64.CheckFPAdvSIMDEnabled()
    if PSTATE.EL IN {EL0, EL1} && !IsInHost() then
        // Check if access disabled in CPACR_EL1
        case CPACR_EL1.FPEN of
            when 'x0' disabled = TRUE;
            when '01' disabled = PSTATE.EL == EL0;
            when '11' disabled = FALSE;
        if disabled then AArch64.AdvSIMDFPAccessTrap(EL1);

    AArch64.CheckFPAdvSIMDTrap(); // Also check against CPTR_EL2 and CPTR_EL3
```



## Library pseudocode for aarch64/exceptions/traps/AArch64.CheckFPAdvSIMDTrap

```
// AArch64.CheckFPAdvSIMDTrap()
// =====
// Check against CPTR_EL2 and CPTR_EL3.

AArch64.CheckFPAdvSIMDTrap()
    if PSTATE.EL IN {EL0, EL1, EL2} && EL2Enabled() then
        // Check if access disabled in CPTR_EL2
        if HaveVirtHostExt() && HCR_EL2.E2H == '1' then
            case CPTR_EL2.FPEN of
                when 'x0' disabled = TRUE;
                when '01' disabled = PSTATE.EL == EL0 && HCR_EL2.TGE == '1';
                when '11' disabled = FALSE;
            if disabled then AArch64.AdvSIMDFPAccessTrap(EL2);
        else
            if CPTR_EL2.TFP == '1' then AArch64.AdvSIMDFPAccessTrap(EL2);

    if HaveEL(EL3) then
        // Check if access disabled in CPTR_EL3
        if CPTR_EL3.TFP == '1' then AArch64.AdvSIMDFPAccessTrap(EL3);

    return;
```

## Library pseudocode for aarch64/exceptions/traps/AArch64.CheckForERetTrap

```
// AArch64.CheckForERetTrap()
// =====
// Check for trap on ERET, ERETAA, ERETAB instruction

AArch64.CheckForERetTrap(boolean eret_with_pac, boolean pac_uses_key_a)

    route_to_el2 = FALSE;
    // Non-secure EL1 execution of ERET, ERETAA, ERETAB when either HCR_EL2.NV or HFGITR_EL2.ERET is set,
    // is trapped to EL2
    route_to_el2 = PSTATE.EL == EL1 && EL2Enabled() && ( (HaveNVExt() && HCR_EL2.NV == '1') ||
    if route_to_el2 then
        ExceptionRecord exception;
        bits(64) preferred_exception_return = ThisInstrAddr();
        vect_offset = 0x0;
        exception = ExceptionSyndrome(Exception_ERetTrap);
        if !eret_with_pac then // ERET
            exception.syndrome<1> = '0';
            exception.syndrome<0> = '0'; // RES0
        else
            exception.syndrome<1> = '1';
            if pac_uses_key_a then // ERETAA
                exception.syndrome<0> = '0';
            else // ERETAB
                exception.syndrome<0> = '1';
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/traps/AArch64.CheckForSMCUndefOrTrap

```
// AArch64.CheckForSMCUndefOrTrap()
// =====
// Check for UNDEFINED or trap on SMC instruction

AArch64.CheckForSMCUndefOrTrap(bits(16) imm)
    route_to_el2 = PSTATE.EL == EL1 && EL2Enabled() && HCR_EL2.TSC == '1';
    if PSTATE.EL == EL0 then UNDEFINED;
    if !HaveEL(EL3) then
        if PSTATE.EL == EL1 && EL2Enabled() then
            if HaveNVExt() && HCR_EL2.NV == '1' && HCR_EL2.TSC == '1' then
                route_to_el2 = TRUE;
            else
                UNDEFINED;
        else
            UNDEFINED;
    else
        route_to_el2 = PSTATE.EL == EL1 && EL2Enabled() && HCR_EL2.TSC == '1';
    if route_to_el2 then
        bits(64) preferred_exception_return = ThisInstrAddr();
        vect_offset = 0x0;
        exception = ExceptionSyndrome(Exception_MonitorCall);
        exception.syndrome<15:0> = imm;
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/traps/AArch64.CheckForSVCTrap

```
// AArch64.CheckForSVCTrap()
// =====
// Check for trap on SVC instruction

AArch64.CheckForSVCTrap(bits(16) immediate)
    if HaveFGTExt() then
        route_to_el2 = FALSE;
        if PSTATE.EL == EL0 then
            route_to_el2 = !ELUsingAArch32(EL0) && !ELUsingAArch32(EL1) && EL2Enabled() && HFGITR_EL2.SVC_EL0 == '1';
        elif PSTATE.EL == EL1 then
            route_to_el2 = !ELUsingAArch32(EL1) && EL2Enabled() && HFGITR_EL2.SVC_EL1 == '1' &&
                !ELUsingAArch32(EL2) && EL2Enabled() && HFGITR_EL2.SVC_EL2 == '1';
        if route_to_el2 then
            exception = ExceptionSyndrome(Exception_SupervisorCall);
            exception.syndrome<15:0> = immediate;
            bits(64) preferred_exception_return = ThisInstrAddr();
            vect_offset = 0x0;

            AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/traps/AArch64.CheckForWFXTrap

```
// AArch64.CheckForWFXTrap()
// =====
// Check for trap on WFE or WFI instruction

AArch64.CheckForWFXTrap(bits(2) target_el, boolean is_wfe)
    assert HaveEL(target_el);

    case target_el of
        when EL1
            trap = (if is_wfe then SCTLR[].nTWE else SCTLR[].nTWI) == '0';
        when EL2
            trap = (if is_wfe then HCR_EL2.TWE else HCR_EL2.TWI) == '1';
        when EL3
            trap = (if is_wfe then SCR_EL3.TWE else SCR_EL3.TWI) == '1';

    if trap then
        AArch64.WFXTrap(target_el, is_wfe);
```

## Library pseudocode for aarch64/exceptions/traps/AArch64.CheckIllegalState

```
// AArch64.CheckIllegalState()
// =====
// Check PSTATE.IL bit and generate Illegal Execution state exception if set.

AArch64.CheckIllegalState()
    if PSTATE.IL == '1' then
        route_to_el2 = PSTATE.EL == EL0 && EL2Enabled\(\) && HCR_EL2.TGE == '1';

        bits(64) preferred_exception_return = ThisInstrAddr\(\);
        vect_offset = 0x0;

        exception = ExceptionSyndrome\(Exception\_IllegalState\);

        if UInt(PSTATE.EL) > UInt(EL1) then
            AArch64.TakeException(PSTATE.EL, exception, preferred_exception_return, vect_offset);
        elsif route_to_el2 then
            AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
        else
            AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/traps/AArch64.MonitorModeTrap

```
// AArch64.MonitorModeTrap()
// =====
// Trapped use of Monitor mode features in a Secure EL1 AArch32 mode

AArch64.MonitorModeTrap()
    bits(64) preferred_exception_return = ThisInstrAddr\(\);
    vect_offset = 0x0;

    exception = ExceptionSyndrome\(Exception\_Uncategorized\);

    if IsSecureEL2Enabled\(\) then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    AArch64.TakeException(EL3, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/traps/AArch64.SystemAccessTrap

```
// AArch64.SystemAccessTrap()
// =====
// Trapped access to AArch64 system register or system instruction.

AArch64.SystemAccessTrap(bits(2) target_el, integer ec)
    assert HaveEL(target_el) && target_el != EL0 && UInt(target_el) >= UInt(PSTATE.EL);

    bits(64) preferred_exception_return = ThisInstrAddr\(\);
    vect_offset = 0x0;

    exception = AArch64.SystemAccessTrapSyndrome\(ThisInstr\(\), ec\);
    AArch64.TakeException(target_el, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/exceptions/traps/AArch64.SystemAccessTrapSyndrome

```
// AArch64.SystemAccessTrapSyndrome()
// =====
// Returns the syndrome information for traps on AArch64 MSR/MRS instructions.

ExceptionRecord AArch64.SystemAccessTrapSyndrome(bits(32) instr, integer ec)
    ExceptionRecord exception;
    case ec of
        when 0x0 // Trapped access due to unknown reason
            exception = ExceptionSyndrome(Exception_Uncategorized);
        when 0x7 // Trapped access to SVE, Advance SIMD
            exception = ExceptionSyndrome(Exception_AdvSIMDFPAccessTrap);
            exception.syndrome<24:20> = ConditionSyndrome();
        when 0x18 // Trapped access to system register
            exception = ExceptionSyndrome(Exception_SystemRegisterTrap);
            instr = ThisInstr();
            exception.syndrome<21:20> = instr<20:19>; // Op0
            exception.syndrome<19:17> = instr<7:5>; // Op2
            exception.syndrome<16:14> = instr<18:16>; // Op1
            exception.syndrome<13:10> = instr<15:12>; // CRn
            exception.syndrome<9:5> = instr<4:0>; // Rt
            exception.syndrome<4:1> = instr<11:8>; // CRm
            exception.syndrome<0> = instr<21>; // Direction
        when 0x19 // Trapped access to SVE System register
            exception = ExceptionSyndrome(Exception_SVEAccessTrap);
        otherwise
            Unreachable();

    return exception;
```

## Library pseudocode for aarch64/exceptions/traps/AArch64.UndefinedFault

```
// AArch64.UndefinedFault()
// =====

AArch64.UndefinedFault()

    route_to_el2 = PSTATE.EL == EL0 && EL2Enabled() && HCR_EL2.TGE == '1';
    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x0;

    exception = ExceptionSyndrome(Exception_Uncategorized);

    if UInt(PSTATE.EL) > UInt(EL1) then
        AArch64.TakeException(PSTATE.EL, exception, preferred_exception_return, vect_offset);
    elsif route_to_el2 then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

### Library pseudocode for aarch64/exceptions/traps/AArch64.WFETrapDelay

```
// AArch64.WFETrapDelay()
// =====
// Returns TRUE when delay in trap to WFE is enabled with value to amount of delay,
// FALSE otherwise.

(boolean, integer) WFETrapDelay(bits(2) target_el)
  case target_el of
    when EL1
      if !IsInHost() then
        delay_enabled = SCTLR_EL1.TWEDEn == '1';
        delay          = 1 << (UInt(SCTLR_EL1.TWEDEL) + 8);
      else
        delay_enabled = SCTLR_EL2.TWEDEn == '1';
        delay          = 1 << (UInt(SCTLR_EL2.TWEDEL) + 8);
    when EL2
      delay_enabled = HCR_EL2.TWEDEn == '1';
      delay          = 1 << (UInt(HCR_EL2.TWEDEL) + 8);
    when EL3
      delay_enabled = SCR_EL3.TWEDEn == '1';
      delay          = 1 << (UInt(SCR_EL3.TWEDEL) + 8);

  return (delay_enabled, delay);
```

### Library pseudocode for aarch64/exceptions/traps/AArch64.WFxTrap

```
// AArch64.WFxTrap()
// =====

AArch64.WFxTrap(bits(2) target_el, boolean is_wfe)
  assert UInt(target_el) > UInt(PSTATE.EL);

  bits(64) preferred_exception_return = ThisInstrAddr();
  vect_offset = 0x0;

  exception = ExceptionSyndrome(Exception\_WFxTrap);
  exception.syndrome<24:20> = ConditionSyndrome();
  exception.syndrome<0> = if is_wfe then '1' else '0';

  if target_el == EL1 && EL2Enabled() && HCR_EL2.TGE == '1' then
    AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
  else
    AArch64.TakeException(target_el, exception, preferred_exception_return, vect_offset);
```

### Library pseudocode for aarch64/exceptions/traps/AArch64.WaitForEventUntilDelay

```
// AArch64.WaitForEventUntilDelay()
// =====
// Returns TRUE if WaitForEvent() returns before WFE trap delay expires,
// FALSE otherwise.

boolean AArch64.WaitForEventUntilDelay(boolean delay_enabled, integer delay)
  boolean eventarrived = FALSE;
  // set eventarrived to TRUE if WaitForEvent() returns before
  // 'delay' expires when delay_enabled is TRUE.
  return eventarrived;
```

### Library pseudocode for aarch64/exceptions/traps/CheckFPAdvSIMDEnabled64

```
// CheckFPAdvSIMDEnabled64()
// =====
// AArch64 instruction wrapper

CheckFPAdvSIMDEnabled64()
  AArch64.CheckFPAdvSIMDEnabled();
```

## Library pseudocode for aarch64/functions/aborts/AArch64.CreateFaultRecord

```
// AArch64.CreateFaultRecord()
// =====

FaultRecord AArch64.CreateFaultRecord(Fault statuscode, bits(52) ipaddress, boolean NS,
                                       integer level, AccType acctype, boolean write, bit extflag,
                                       bits(2) errortype, boolean secondstage, boolean s2fslwalk)

    FaultRecord fault;
    fault.statuscode = statuscode;
    fault.domain = bits(4) UNKNOWN;           // Not used from AArch64
    fault.debugmoe = bits(4) UNKNOWN;         // Not used from AArch64
    fault.errortype = errortype;
    fault.ipaddress.NS = if NS then '1' else '0';
    fault.ipaddress.address = ipaddress;
    fault.level = level;
    fault.acctype = acctype;
    fault.write = write;
    fault.extflag = extflag;
    fault.secondstage = secondstage;
    fault.s2fslwalk = s2fslwalk;

    return fault;
```

## Library pseudocode for aarch64/functions/aborts/AArch64.FaultSyndrome

```
// AArch64.FaultSyndrome()
// =====
// Creates an exception syndrome value for Abort and Watchpoint exceptions taken to
// an Exception Level using AArch64.

bits(25) AArch64.FaultSyndrome(boolean d_side, FaultRecord fault)
    assert fault.statuscode != Fault\_None;

    bits(25) iss = Zeros();
    if HaveRASExt() && IsExternalSyncAbort(fault) then iss<12:11> = fault.errortype; // SET
    if d_side then
        if IsSecondStage(fault) && !fault.s2fslwalk then iss<24:14> = LSInstructionSyndrome();
        if HaveNV2Ext() && fault.acctype == AccType\_NV2REGISTER then
            iss<13> = '1'; // Value of '1' indicates fault is generated by use of VNCR_EL2
        if fault.acctype IN {AccType\_DC, AccType\_DC\_UNPRIV, AccType\_IC, AccType\_AT} then
            iss<8> = '1'; iss<6> = '1';
        else
            iss<6> = if fault.write then '1' else '0';
    if IsExternalAbort(fault) then iss<9> = fault.extflag;
    iss<7> = if fault.s2fslwalk then '1' else '0';
    iss<5:0> = EncodeLDFSC(fault.statuscode, fault.level);

    return iss;
```

## Library pseudocode for aarch64/functions/exclusive/AArch64.ExclusiveMonitorsPass

```
// AArch64.ExclusiveMonitorsPass()
// =====

// Return TRUE if the Exclusives monitors for the current PE include all of the addresses
// associated with the virtual address region of size bytes starting at address.
// The immediately following memory write must be to the same addresses.

boolean AArch64.ExclusiveMonitorsPass(bits(64) address, integer size)

    // It is IMPLEMENTATION DEFINED whether the detection of memory aborts happens
    // before or after the check on the local Exclusives monitor. As a result a failure
    // of the local monitor can occur on some implementations even if the memory
    // access would give an memory abort.

    acctype = AccType\_ATOMIC;
    iswrite = TRUE;

    aligned = AArch64.CheckAlignment(address, size, acctype, iswrite);

    passed = AArch64.IsExclusiveVA(address, ProcessorID(), size);
    if !passed then
        return FALSE;

    memaddrdesc = AArch64.TranslateAddress(address, acctype, iswrite, aligned, size);
    // Check for aborts or debug exceptions
    if IsFault(memaddrdesc) then
        AArch64.Abort(address, memaddrdesc.fault);

    passed = IsExclusiveLocal(memaddrdesc.address, ProcessorID(), size);
    ClearExclusiveLocal(ProcessorID());

    if passed then
        if memaddrdesc.memattrs.shareable then
            passed = IsExclusiveGlobal(memaddrdesc.address, ProcessorID(), size);

    return passed;
```

## Library pseudocode for aarch64/functions/exclusive/AArch64.IsExclusiveVA

```
// An optional IMPLEMENTATION DEFINED test for an exclusive access to a virtual
// address region of size bytes starting at address.
//
// It is permitted (but not required) for this function to return FALSE and
// cause a store exclusive to fail if the virtual address region is not
// totally included within the region recorded by MarkExclusiveVA().
//
// It is always safe to return TRUE which will check the physical address only.
boolean AArch64.IsExclusiveVA(bits(64) address, integer processorid, integer size);
```

## Library pseudocode for aarch64/functions/exclusive/AArch64.MarkExclusiveVA

```
// Optionally record an exclusive access to the virtual address region of size bytes
// starting at address for processorid.
AArch64.MarkExclusiveVA(bits(64) address, integer processorid, integer size);
```

## Library pseudocode for aarch64/functions/exclusive/AArch64.SetExclusiveMonitors

```
// AArch64.SetExclusiveMonitors()
// =====

// Sets the Exclusives monitors for the current PE to record the addresses associated
// with the virtual address region of size bytes starting at address.

AArch64.SetExclusiveMonitors(bits(64) address, integer size)

    acctype = AccType\_ATOMIC;
    iswrite = FALSE;

    aligned = AArch64.CheckAlignment(address, size, acctype, iswrite);

    memaddrdesc = AArch64.TranslateAddress(address, acctype, iswrite, aligned, size);
    // Check for aborts or debug exceptions
    if IsFault(memaddrdesc) then
        return;

    if memaddrdesc.memattrs.shareable then
        MarkExclusiveGlobal(memaddrdesc.address, ProcessorID(), size);

    MarkExclusiveLocal(memaddrdesc.address, ProcessorID(), size);

    AArch64.MarkExclusiveVA(address, ProcessorID(), size);
```

## Library pseudocode for aarch64/functions/fusedrstep/FPRSqrtStepFused

```
// FPRSqrtStepFused()
// =====

bits(N) FPRSqrtStepFused(bits(N) op1, bits(N) op2)
    assert N IN {16, 32, 64};
    bits(N) result;
    op1 = FPNeg(op1);
    (type1,sign1,value1) = FPUntpack(op1, FPCR);
    (type2,sign2,value2) = FPUntpack(op2, FPCR);
    (done,result) = FPProcessNaNs(type1, type2, op1, op2, FPCR);
    if !done then
        inf1 = (type1 == FPType\_Infinity);
        inf2 = (type2 == FPType\_Infinity);
        zero1 = (type1 == FPType\_Zero);
        zero2 = (type2 == FPType\_Zero);
        if (inf1 && zero2) || (zero1 && inf2) then
            result = FPOnePointFive('0');
        elsif inf1 || inf2 then
            result = FPIInfinity(sign1 EOR sign2);
        else
            // Fully fused multiply-add and halve
            result_value = (3.0 + (value1 * value2)) / 2.0;
            if result_value == 0.0 then
                // Sign of exact zero result depends on rounding mode
                sign = if FPRoundingMode(FPCR) == FPRounding\_NEGINE then '1' else '0';
                result = FPZero(sign);
            else
                result = FPRound(result_value, FPCR);
    return result;
```



## Library pseudocode for aarch64/functions/fusedrstep/FPRecipStepFused

```
// FPRecipStepFused()
// =====

bits(N) FPRecipStepFused(bits(N) op1, bits(N) op2)
    assert N IN {16, 32, 64};
    bits(N) result;
    op1 = FPNeg(op1);
    (type1,sign1,value1) = FPUntpack(op1, FPCR);
    (type2,sign2,value2) = FPUntpack(op2, FPCR);
    (done,result) = FPProcessNaNs(type1, type2, op1, op2, FPCR);
    if !done then
        inf1 = (type1 == FPType\_Infinity);
        inf2 = (type2 == FPType\_Infinity);
        zero1 = (type1 == FPType\_Zero);
        zero2 = (type2 == FPType\_Zero);
        if (inf1 && zero2) || (zero1 && inf2) then
            result = FPTwo('0');
        elsif inf1 || inf2 then
            result = FPIfinity(sign1 EOR sign2);
        else
            // Fully fused multiply-add
            result_value = 2.0 + (value1 * value2);
            if result_value == 0.0 then
                // Sign of exact zero result depends on rounding mode
                sign = if FPRoundingMode(FPCR) == FPRounding\_NEGINF then '1' else '0';
                result = FPZero(sign);
            else
                result = FPRound(result_value, FPCR);
    return result;
```

## Library pseudocode for aarch64/functions/memory/AArch64.AccessIsTagChecked

```
// AArch64.AccessIsTagChecked()
// =====
// TRUE if a given access is tag-checked, FALSE otherwise.

boolean AArch64.AccessIsTagChecked(bits(64) vaddr, AccType acctype)
    if PSTATE.M<4> == '1' then return FALSE;

    if EffectiveTBI(vaddr, FALSE, PSTATE.EL) == '0' then
        return FALSE;

    if EffectiveTCMA(vaddr, PSTATE.EL) == '1' && (vaddr<59:55> == '00000' || vaddr<59:55> == '11111') then
        return FALSE;

    if !AArch64.AllocationTagAccessIsEnabled(acctype) then
        return FALSE;

    if acctype IN {AccType\_IFETCH, AccType\_PTW} then
        return FALSE;

    if acctype == AccType\_NV2REGISTER then
        return FALSE;

    if PSTATE.TCO=='1' then
        return FALSE;

    if !IsTagCheckedInstruction() then
        return FALSE;

    return TRUE;
```

## Library pseudocode for aarch64/functions/memory/AArch64.AddressWithAllocationTag

```
// AArch64.AddressWithAllocationTag()
// =====
// Generate a 64-bit value containing a Logical Address Tag from a 64-bit
// virtual address and an Allocation Tag.
// If the extension is disabled, treats the Allocation Tag as '0000'.

bits(64) AArch64.AddressWithAllocationTag(bits(64) address, AccType acctype, bits(4) allocation_tag)
    bits(64) result = address;
    bits(4) tag;
    if AArch64.AllocationTagAccessIsEnabled(acctype) then
        tag = allocation_tag;
    else
        tag = '0000';
    result<59:56> = tag;
    return result;
```

## Library pseudocode for aarch64/functions/memory/AArch64.AllocationTagFromAddress

```
// AArch64.AllocationTagFromAddress()
// =====
// Generate an Allocation Tag from a 64-bit value containing a Logical Address Tag.

bits(4) AArch64.AllocationTagFromAddress(bits(64) tagged_address)
    return tagged_address<59:56>;
```

## Library pseudocode for aarch64/functions/memory/AArch64.CheckAlignment

```
// AArch64.CheckAlignment()
// =====

boolean AArch64.CheckAlignment(bits(64) address, integer alignment, AccType acctype,
                                boolean iswrite)

    aligned = (address == Align(address, alignment));
    atomic = acctype IN { AccType\_ATOMIC, AccType\_ATOMICRW, AccType\_ORDEREDATOMIC, AccType\_ORDEREDATOMICRW };
    ordered = acctype IN { AccType\_ORDERED, AccType\_ORDEREDRW, AccType\_LIMITEDORDERED, AccType\_ORDEREDATOMIC };
    vector = acctype == AccType\_VEC;
    if SCTLR[].A == '1' then check = TRUE;
    elseif HaveUA16Ext() then
        check = (UInt(address<0+:4>) + alignment > 16) && ((ordered && SCTLR[].nAA == '0') || atomic);
    else check = atomic || ordered;

    if check && !aligned then
        secondstage = FALSE;
        AArch64.Abort(address, AArch64.AlignmentFault(acctype, iswrite, secondstage));

    return aligned;
```

## Library pseudocode for aarch64/functions/memory/AArch64.CheckTag

```
// AArch64.CheckTag()
// =====
// Performs a Tag Check operation for a memory access and returns
// whether the check passed

boolean AArch64.CheckTag(AddressDescriptor memaddrdesc, bits(4) ptag, boolean write)
    if memaddrdesc.memattrs.tagged then
        return ptag == \_MemTag[memaddrdesc];
    else
        return TRUE;
```

## Library pseudocode for aarch64/functions/memory/AArch64.MemSingle

```
// AArch64.MemSingle[] - non-assignment (read) form
// =====
// Perform an atomic, little-endian read of 'size' bytes.

bits(size*8) AArch64.MemSingle[bits(64) address, integer size, AccType acctype, boolean wasaligned]
  assert size IN {1, 2, 4, 8, 16};
  assert address == Align(address, size);

  AddressDescriptor memaddrdesc;
  bits(size*8) value;
  iswrite = FALSE;

  memaddrdesc = AArch64.TranslateAddress(address, acctype, iswrite, wasaligned, size);
  // Check for aborts or debug exceptions
  if IsFault(memaddrdesc) then
    AArch64.Abort(address, memaddrdesc.fault);

  // Memory array access
  if HaveTME() then
    transactional = TSTATE.depth > 0 && !(acctype IN {AccType\_IFETCH, AccType\_PTW});
    accdesc = CreateAccessDescriptor(acctype, transactional);
  else
    accdesc = CreateAccessDescriptor(acctype);
  if HaveMTEExt() then
    if AArch64.AccessIsTagChecked(ZeroExtend(address, 64), acctype) then
      bits(4) ptag = AArch64.PhysicalTag(ZeroExtend(address, 64));
      if !AArch64.CheckTag(memaddrdesc, ptag, iswrite) then
        AArch64.TagCheckFail(ZeroExtend(address, 64), acctype, iswrite);
    value = \_Mem[memaddrdesc, size, accdesc];
  return value;

// AArch64.MemSingle[] - assignment (write) form
// =====
// Perform an atomic, little-endian write of 'size' bytes.

AArch64.MemSingle[bits(64) address, integer size, AccType acctype, boolean wasaligned] = bits(size*8) val
  assert size IN {1, 2, 4, 8, 16};
  assert address == Align(address, size);

  AddressDescriptor memaddrdesc;
  iswrite = TRUE;

  memaddrdesc = AArch64.TranslateAddress(address, acctype, iswrite, wasaligned, size);
  // Check for aborts or debug exceptions
  if IsFault(memaddrdesc) then
    AArch64.Abort(address, memaddrdesc.fault);

  // Effect on exclusives
  if memaddrdesc.memattrs.shareable then
    ClearExclusiveByAddress(memaddrdesc.paddress, ProcessorID(), size);

  // Memory array access
  if HaveTME() then
    transactional = TSTATE.depth > 0;
    accdesc = CreateAccessDescriptor(acctype, transactional);
  else
    accdesc = CreateAccessDescriptor(acctype);
  if HaveMTEExt() then
    if AArch64.AccessIsTagChecked(ZeroExtend(address, 64), acctype) then
      bits(4) ptag = AArch64.PhysicalTag(ZeroExtend(address, 64));
      if !AArch64.CheckTag(memaddrdesc, ptag, iswrite) then
        AArch64.TagCheckFail(ZeroExtend(address, 64), acctype, iswrite);
    \_Mem[memaddrdesc, size, accdesc] = value;
  return;
```

## Library pseudocode for aarch64/functions/memory/AArch64.MemTag

```
// AArch64.MemTag[] - non-assignment (read) form
// =====
// Load an Allocation Tag from memory.

bits(4) AArch64.MemTag[bits(64) address, AccType acctype]
    assert acctype == AccType_NORMAL;
    AddressDescriptor memaddrdesc;
    bits(4) value;
    iswrite = FALSE;

    memaddrdesc = AArch64.TranslateAddress(address, acctype, iswrite, TRUE, TAG_GRANULE);
    // Check for aborts or debug exceptions
    if IsFault(memaddrdesc) then
        AArch64.Abort(address, memaddrdesc.fault);

    // Return the granule tag if tagging is enabled...
    if AArch64.AllocationTagAccessIsEnabled(acctype) && memaddrdesc.memattrs.tagged then
        return _MemTag[memaddrdesc];
    else
        // ...otherwise read tag as zero.
        return '0000';

// AArch64.MemTag[] - assignment (write) form
// =====
// Store an Allocation Tag to memory.

AArch64.MemTag[bits(64) address, AccType acctype] = bits(4) value
    assert acctype == AccType_NORMAL;
    AddressDescriptor memaddrdesc;
    iswrite = TRUE;

    // Stores of allocation tags must be aligned
    if address != Align(address, TAG_GRANULE) then
        boolean secondstage = FALSE;
        AArch64.Abort(address, AArch64.AlignmentFault(acctype, iswrite, secondstage));

    wasaligned = TRUE;
    memaddrdesc = AArch64.TranslateAddress(address, acctype, iswrite, wasaligned, TAG_GRANULE);

    // Check for aborts or debug exceptions
    if IsFault(memaddrdesc) then
        AArch64.Abort(address, memaddrdesc.fault);

    // Memory array access
    if AArch64.AllocationTagAccessIsEnabled(acctype) && memaddrdesc.memattrs.tagged then
        _MemTag[memaddrdesc] = value;
```

## Library pseudocode for aarch64/functions/memory/AArch64.PhysicalTag

```
// AArch64.PhysicalTag()
// =====
// Generate a Physical Tag from a Logical Tag in an address

bits(4) AArch64.PhysicalTag(bits(64) vaddr)
    return vaddr<59:56>;
```

## Library pseudocode for aarch64/functions/memory/AArch64.TranslateAddressForAtomicAccess

```
// AArch64.TranslateAddressForAtomicAccess()
// =====
// Performs an alignment check for atomic memory operations.
// Also translates 64-bit Virtual Address into Physical Address.

AddressDescriptor AArch64.TranslateAddressForAtomicAccess(bits(64) address, integer sizeinbits)
    boolean iswrite = FALSE;
    size = sizeinbits DIV 8;

    assert size IN {1, 2, 4, 8, 16};

    aligned = AArch64.CheckAlignment(address, size, AccType_ATOMICRW, iswrite);

    // MMU or MPU lookup
    memaddrdesc = AArch64.TranslateAddress(address, AccType_ATOMICRW, iswrite, aligned, size);

    // Check for aborts or debug exceptions
    if IsFault(memaddrdesc) then
        AArch64.Abort(address, memaddrdesc.fault);

    // Effect on exclusives
    if memaddrdesc.memattrs.shareable then
        ClearExclusiveByAddress(memaddrdesc.paddress, ProcessorID(), size);

    if HaveMTEExt() && AArch64.AccessIsTagChecked(address, AccType_ATOMICRW) then
        bits(4) ptag = AArch64.PhysicalTag(address);
        if !AArch64.CheckTag(memaddrdesc, ptag, iswrite) then
            AArch64.TagCheckFail(address, AccType_ATOMICRW, iswrite);

    return memaddrdesc;
```

## Library pseudocode for aarch64/functions/memory/CheckSPAlignment

```
// CheckSPAlignment()
// =====
// Check correct stack pointer alignment for AArch64 state.

CheckSPAlignment()
    bits(64) sp = SP[];
    if PSTATE.EL == EL0 then
        stack_align_check = (SCTLR[].SA0 != '0');
    else
        stack_align_check = (SCTLR[].SA != '0');

    if stack_align_check && sp != Align(sp, 16) then
        AArch64.SPAlignmentFault();

    return;
```

## Library pseudocode for aarch64/functions/memory/IsBlockDescriptorNTBitValid

```
// If the implementation supports changing the block size without a break-before-make
// approach, then for implementations that have level 1 or 2 support, the nT bit in
// the block descriptor is valid.
boolean IsBlockDescriptorNTBitValid();
```

## Library pseudocode for aarch64/functions/memory/IsTagCheckedInstruction

```
// Returns True if the current instruction uses tag-checked memory access,
// False otherwise.
boolean IsTagCheckedInstruction();
```



```

// Mem[] - non-assignment (read) form
// =====
// Perform a read of 'size' bytes. The access byte order is reversed for a big-endian access.
// Instruction fetches would call AArch64.MemSingle directly.

bits(size*8) Mem[bits(64) address, integer size, AccType acctype]
    assert size IN {1, 2, 4, 8, 16};
    bits(size*8) value;
    boolean iswrite = FALSE;

    aligned = AArch64.CheckAlignment(address, size, acctype, iswrite);
    if size != 16 || !(acctype IN {AccType\_VEC, AccType\_VECSTREAM}) then
        atomic = aligned;
    else
        // 128-bit SIMD&FP loads are treated as a pair of 64-bit single-copy atomic accesses
        // 64-bit aligned.
        atomic = address == Align(address, 8);

    if !atomic then
        assert size > 1;
        value<7:0> = AArch64.MemSingle[address, 1, acctype, aligned];

        // For subsequent bytes it is CONSTRAINED UNPREDICTABLE whether an unaligned Device memory
        // access will generate an Alignment Fault, as to get this far means the first byte did
        // not, so we must be changing to a new translation page.
        if !aligned then
            c = ConstrainUnpredictable(Unpredictable\_DEVPAGE2);
            assert c IN {Constraint\_FAULT, Constraint\_NONE};
            if c == Constraint\_NONE then aligned = TRUE;

            for i = 1 to size-1
                value<8*i+7:8*i> = AArch64.MemSingle[address+i, 1, acctype, aligned];
        elseif size == 16 && acctype IN {AccType\_VEC, AccType\_VECSTREAM} then
            value<63:0> = AArch64.MemSingle[address, 8, acctype, aligned];
            value<127:64> = AArch64.MemSingle[address+8, 8, acctype, aligned];
        else
            value = AArch64.MemSingle[address, size, acctype, aligned];

    if (HaveNV2Ext() && acctype == AccType\_NV2REGISTER && SCTLR_EL2.EE == '1') || BigEndian() then
        value = BigEndianReverse(value);
    return value;

// Mem[] - assignment (write) form
// =====
// Perform a write of 'size' bytes. The byte order is reversed for a big-endian access.

Mem[bits(64) address, integer size, AccType acctype] = bits(size*8) value
    boolean iswrite = TRUE;

    if (HaveNV2Ext() && acctype == AccType\_NV2REGISTER && SCTLR_EL2.EE == '1') || BigEndian() then
        value = BigEndianReverse(value);

    aligned = AArch64.CheckAlignment(address, size, acctype, iswrite);
    if size != 16 || !(acctype IN {AccType\_VEC, AccType\_VECSTREAM}) then
        atomic = aligned;
    else
        // 128-bit SIMD&FP stores are treated as a pair of 64-bit single-copy atomic accesses
        // 64-bit aligned.
        atomic = address == Align(address, 8);

    if !atomic then
        assert size > 1;
        AArch64.MemSingle[address, 1, acctype, aligned] = value<7:0>;

        // For subsequent bytes it is CONSTRAINED UNPREDICTABLE whether an unaligned Device memory
        // access will generate an Alignment Fault, as to get this far means the first byte did
        // not, so we must be changing to a new translation page.
        if !aligned then
            c = ConstrainUnpredictable(Unpredictable\_DEVPAGE2);
            assert c IN {Constraint\_FAULT, Constraint\_NONE};

```

```

        if c == Constraint\_NONE then aligned = TRUE;

        for i = 1 to size-1
            AArch64.MemSingle[address+i, 1, acctype, aligned] = value<8*i+7:8*i>;
        elsif size == 16 && acctype IN {AccType\_VEC, AccType\_VECSTREAM} then
            AArch64.MemSingle[address, 8, acctype, aligned] = value<63:0>;
            AArch64.MemSingle[address+8, 8, acctype, aligned] = value<127:64>;
        else
            AArch64.MemSingle[address, size, acctype, aligned] = value;
        return;

```

## Library pseudocode for aarch64/functions/memory/MemAtomic

```

// MemAtomic()
// =====
// Performs load and store memory operations for a given virtual address.

bits(size) MemAtomic(bits(64) address, MemAtomicOp op, bits(size) value, AccType ldacctype, AccType stacctype,
bits(size) newvalue;
memaddrdesc = AArch64.TranslateAddressForAtomicAccess(address, size);
ldaccdesc = CreateAccessDescriptor(ldacctype);
staccdesc = CreateAccessDescriptor(stacctype);

// All observers in the shareability domain observe the
// following load and store atomically.
oldvalue = _Mem[memaddrdesc, size DIV 8, ldaccdesc];
if BigEndian() then
    oldvalue = BigEndianReverse(oldvalue);

case op of
    when MemAtomicOp\_ADD      newvalue = oldvalue + value;
    when MemAtomicOp\_BIC      newvalue = oldvalue AND NOT(value);
    when MemAtomicOp\_EOR      newvalue = oldvalue EOR value;
    when MemAtomicOp\_ORR      newvalue = oldvalue OR value;
    when MemAtomicOp\_SMAX     newvalue = if SInt(oldvalue) > SInt(value) then oldvalue else value;
    when MemAtomicOp\_SMIN     newvalue = if SInt(oldvalue) > SInt(value) then value else oldvalue;
    when MemAtomicOp\_UMAX     newvalue = if UInt(oldvalue) > UInt(value) then oldvalue else value;
    when MemAtomicOp\_UMIN     newvalue = if UInt(oldvalue) > UInt(value) then value else oldvalue;
    when MemAtomicOp\_SWP      newvalue = value;

if BigEndian() then
    newvalue = BigEndianReverse(newvalue);
_Mem[memaddrdesc, size DIV 8, staccdesc] = newvalue;

// Load operations return the old (pre-operation) value
return oldvalue;

```



## Library pseudocode for aarch64/functions/memory/MemAtomicCompareAndSwap

```
// MemAtomicCompareAndSwap()
// =====
// Compares the value stored at the passed-in memory address against the passed-in expected
// value. If the comparison is successful, the value at the passed-in memory address is swapped
// with the passed-in new_value.

bits(size) MemAtomicCompareAndSwap(bits(64) address, bits(size) expectedvalue,
                                   bits(size) newvalue, AccType ldacctype, AccType stacctype)
    memaddrdesc = AArch64.TranslateAddressForAtomicAccess(address, size);
    ldaccdesc = CreateAccessDescriptor(ldacctype);
    staccdesc = CreateAccessDescriptor(stacctype);

    // All observers in the shareability domain observe the
    // following load and store atomically.
    oldvalue = _Mem[memaddrdesc, size DIV 8, ldaccdesc];
    if BigEndian() then
        oldvalue = BigEndianReverse(oldvalue);

    if oldvalue == expectedvalue then
        if BigEndian() then
            newvalue = BigEndianReverse(newvalue);
        _Mem[memaddrdesc, size DIV 8, staccdesc] = newvalue;
    return oldvalue;
```

## Library pseudocode for aarch64/functions/memory/NVMem

```
// NVMem[] - non-assignment form
// =====
// This function is the load memory access for the transformed System register read access
// when Enhanced Nested Virtualisation is enabled with HCR_EL2.NV2 = 1.
// The address for the load memory access is calculated using
// the formula SignExtend(VNCR_EL2.BADDR : Offset<11:0>, 64) where,
// * VNCR_EL2.BADDR holds the base address of the memory location, and
// * Offset is the unique offset value defined architecturally for each System register that
// supports transformation of register access to memory access.

bits(64) NVMem[integer offset]
    assert offset > 0;
    bits(64) address = SignExtend(VNCR_EL2.BADDR:offset<11:0>, 64);
    return Mem[address, 8, AccType\_NV2REGISTER];

// NVMem[] - assignment form
// =====
// This function is the store memory access for the transformed System register write access
// when Enhanced Nested Virtualisation is enabled with HCR_EL2.NV2 = 1.
// The address for the store memory access is calculated using
// the formula SignExtend(VNCR_EL2.BADDR : Offset<11:0>, 64) where,
// * VNCR_EL2.BADDR holds the base address of the memory location, and
// * Offset is the unique offset value defined architecturally for each System register that
// supports transformation of register access to memory access.

NVMem[integer offset] = bits(64) value
    assert offset > 0;
    bits(64) address = SignExtend(VNCR_EL2.BADDR:offset<11:0>, 64);
    Mem[address, 8, AccType\_NV2REGISTER] = value;
    return;
```

## Library pseudocode for aarch64/functions/memory/SetTagCheckedInstruction

```
// Flag the current instruction as using/not using memory tag checking.
SetTagCheckedInstruction(boolean checked);
```

## Library pseudocode for aarch64/functions/memory/\_MemTag

```
// This _MemTag[] accessor is the hardware operation which perform a single-copy atomic,  
// Allocation Tag granule aligned, memory access from the tag in PA space.  
//  
// The function address the array using desc.paddress which supplies:  
// * A 52-bit physical address  
// * A single NS bit to select between Secure and Non-secure parts of the array.  
//  
// The accdesc descriptor describes the access type: normal, exclusive, ordered, streaming,  
// etc and other parameters required to access the physical memory or for setting syndrome  
// register in the event of an external abort.  
bits(4) _MemTag[AddressDescriptor desc, AccessDescriptor accdesc];  
  
// This _MemTag[] accessor is the hardware operation which perform a single-copy atomic,  
// Allocation Tag granule aligned, memory access to the tag in PA space.  
//  
// The functions address the array using desc.paddress which supplies:  
// * A 52-bit physical address  
// * A single NS bit to select between Secure and Non-secure parts of the array.  
//  
// The accdesc descriptor describes the access type: normal, exclusive, ordered, streaming,  
// etc and other parameters required to access the physical memory or for setting syndrome  
// register in the event of an external abort.  
_MemTag[AddressDescriptor desc, AccessDescriptor accdesc] = bits(4) value;
```



```

// AddPAC()
// =====
// Calculates the pointer authentication code for a 64-bit quantity and then
// inserts that into pointer authentication code field of that 64-bit quantity.

bits(64) AddPAC(bits(64) ptr, bits(64) modifier, bits(128) K, boolean data)
    bits(64) PAC;
    bits(64) result;
    bits(64) ext_ptr;
    bits(64) extfield;
    bit selbit;
    boolean tbi = EffectiveTBI(ptr, !data, PSTATE.EL) == '1';
    integer top_bit = if tbi then 55 else 63;

    // If tagged pointers are in use for a regime with two TTBRs, use bit<55> of
    // the pointer to select between upper and lower ranges, and preserve this.
    // This handles the awkward case where there is apparently no correct choice between
    // the upper and lower address range - ie an addr of 1xxxxxxx0... with TBI0=0 and TBI1=1
    // and 0xxxxxxx1 with TBI1=0 and TBI0=1:
    if PtrHasUpperAndLowerAddRanges() then
        assert S1TranslationRegime() IN {EL1, EL2};
        if S1TranslationRegime() == EL1 then
            // EL1 translation regime registers
            if data then
                if TCR_EL1.TBI1 == '1' || TCR_EL1.TBI0 == '1' then
                    selbit = ptr<55>;
                else
                    selbit = ptr<63>;
            else
                if ((TCR_EL1.TBI1 == '1' && TCR_EL1.TBID1 == '0') ||
                    (TCR_EL1.TBI0 == '1' && TCR_EL1.TBID0 == '0')) then
                    selbit = ptr<55>;
                else
                    selbit = ptr<63>;
        else
            // EL2 translation regime registers
            if data then
                if TCR_EL2.TBI1 == '1' || TCR_EL2.TBI0 == '1' then
                    selbit = ptr<55>;
                else
                    selbit = ptr<63>;
            else
                if ((TCR_EL2.TBI1 == '1' && TCR_EL2.TBID1 == '0') ||
                    (TCR_EL2.TBI0 == '1' && TCR_EL2.TBID0 == '0')) then
                    selbit = ptr<55>;
                else
                    selbit = ptr<63>;
    else selbit = if tbi then ptr<55> else ptr<63>;

    integer bottom_PAC_bit = CalculateBottomPACBit(selbit);

    // The pointer authentication code field takes all the available bits in between
    extfield = Replicate(selbit, 64);

    // Compute the pointer authentication code for a ptr with good extension bits
    if tbi then
        ext_ptr = ptr<63:56>:extfield<(56-bottom_PAC_bit)-1:0>:ptr<bottom_PAC_bit-1:0>;
    else
        ext_ptr = extfield<(64-bottom_PAC_bit)-1:0>:ptr<bottom_PAC_bit-1:0>;

    PAC = ComputePAC(ext_ptr, modifier, K<127:64>, K<63:0>);

    // Check if the ptr has good extension bits and corrupt the pointer authentication code if not
    if !IsZero(ptr<top_bit:bottom_PAC_bit>) && !IsOnes(ptr<top_bit:bottom_PAC_bit>) then
        if HaveEnhancedPAC() then
            PAC = 0x0000000000000000<63:0>;
        elseif !HaveEnhancedPAC2() then
            PAC<top_bit-1> = NOT(PAC<top_bit-1>);

    // preserve the determination between upper and lower address at bit<55> and insert PAC

```

```

if !HaveEnhancedPAC2() then
  if tbi then
    result = ptr<63:56>:selbit:PAC<54:bottom_PAC_bit>:ptr<bottom_PAC_bit-1:0>;
  else
    result = PAC<63:56>:selbit:PAC<54:bottom_PAC_bit>:ptr<bottom_PAC_bit-1:0>;
else
  if tbi then
    result = ptr<63:56>:selbit:(ptr<54:bottom_PAC_bit> EOR PAC<54:bottom_PAC_bit>):ptr<bottom_PAC_bit-1:0>;
  else
    result = (ptr<63:56> EOR PAC<63:56>):selbit:(ptr<54:bottom_PAC_bit> EOR
      PAC<54:bottom_PAC_bit>):ptr<bottom_PAC_bit-1:0>;
return result;

```

## Library pseudocode for aarch64/functions/pac/addpacda/AddPACDA

```

// AddPACDA()
// =====
// Returns a 64-bit value containing X, but replacing the pointer authentication code
// field bits with a pointer authentication code, where the pointer authentication
// code is derived using a cryptographic algorithm as a combination of X, Y and the
// APDAKey_EL1.

bits(64) AddPACDA(bits(64) X, bits(64) Y)
  boolean TrapEL2;
  boolean TrapEL3;
  bits(1) Enable;
  bits(128) APDAKey_EL1;

  APDAKey_EL1 = APDAKeyHi_EL1<63:0> : APDAKeyLo_EL1<63:0>;
  case PSTATE.EL of
    when EL0
      boolean IsEL1Regime = S1TranslationRegime() == EL1;
      Enable = if IsEL1Regime then SCTLRL_EL1.EnDA else SCTLRL_EL2.EnDA;
      TrapEL2 = (EL2Enabled() && HCR_EL2.API == '0' &&
        (HCR_EL2.TGE == '0' || HCR_EL2.E2H == '0'));
      TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
    when EL1
      Enable = SCTLRL_EL1.EnDA;
      TrapEL2 = EL2Enabled() && HCR_EL2.API == '0';
      TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
    when EL2
      Enable = SCTLRL_EL2.EnDA;
      TrapEL2 = FALSE;
      TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
    when EL3
      Enable = SCTLRL_EL3.EnDA;
      TrapEL2 = FALSE;
      TrapEL3 = FALSE;

  if Enable == '0' then return X;
  elsif TrapEL2 then TrapPACUse(EL2);
  elsif TrapEL3 then TrapPACUse(EL3);
  else return AddPAC(X, Y, APDAKey_EL1, TRUE);

```

## Library pseudocode for aarch64/functions/pac/addpacdb/AddPACDB

```
// AddPACDB()
// =====
// Returns a 64-bit value containing X, but replacing the pointer authentication code
// field bits with a pointer authentication code, where the pointer authentication
// code is derived using a cryptographic algorithm as a combination of X, Y and the
// APDBKey_EL1.

bits(64) AddPACDB(bits(64) X, bits(64) Y)
    boolean TrapEL2;
    boolean TrapEL3;
    bits(1) Enable;
    bits(128) APDBKey_EL1;

    APDBKey_EL1 = APDBKeyHi_EL1<63:0> : APDBKeyLo_EL1<63:0>;
    case PSTATE.EL of
        when EL0
            boolean IsEL1Regime = S1TranslationRegime() == EL1;
            Enable = if IsEL1Regime then SCTLRL_EL1.EnDB else SCTLRL_EL2.EnDB;
            TrapEL2 = (EL2Enabled() && HCR_EL2.API == '0' &&
                (HCR_EL2.TGE == '0' || HCR_EL2.E2H == '0'));
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL1
            Enable = SCTLRL_EL1.EnDB;
            TrapEL2 = EL2Enabled() && HCR_EL2.API == '0';
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL2
            Enable = SCTLRL_EL2.EnDB;
            TrapEL2 = FALSE;
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL3
            Enable = SCTLRL_EL3.EnDB;
            TrapEL2 = FALSE;
            TrapEL3 = FALSE;

    if Enable == '0' then return X;
    elsif TrapEL2 then TrapPACUse(EL2);
    elsif TrapEL3 then TrapPACUse(EL3);
    else return AddPAC(X, Y, APDBKey_EL1, TRUE);
```

## Library pseudocode for aarch64/functions/pac/addpacga/AddPACGA

```
// AddPACGA()
// =====
// Returns a 64-bit value where the lower 32 bits are 0, and the upper 32 bits contain
// a 32-bit pointer authentication code which is derived using a cryptographic
// algorithm as a combination of X, Y and the APGAKey_EL1.

bits(64) AddPACGA(bits(64) X, bits(64) Y)
    boolean TrapEL2;
    boolean TrapEL3;
    bits(128) APGAKey_EL1;

    APGAKey_EL1 = APGAKeyHi_EL1<63:0> : APGAKeyLo_EL1<63:0>;
    case PSTATE.EL of
        when EL0
            TrapEL2 = (EL2Enabled() && HCR_EL2.API == '0' &&
                        (HCR_EL2.TGE == '0' || HCR_EL2.E2H == '0'));
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL1
            TrapEL2 = EL2Enabled() && HCR_EL2.API == '0';
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL2
            TrapEL2 = FALSE;
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL3
            TrapEL2 = FALSE;
            TrapEL3 = FALSE;

    if TrapEL2 then TrapPACUse(EL2);
    elsif TrapEL3 then TrapPACUse(EL3);
    else return ComputePAC(X, Y, APGAKey_EL1<127:64>, APGAKey_EL1<63:0><63:32>:Zeros(32));
```

## Library pseudocode for aarch64/functions/pac/addpacia/AddPACIA

```
// AddPACIA()
// =====
// Returns a 64-bit value containing X, but replacing the pointer authentication code
// field bits with a pointer authentication code, where the pointer authentication
// code is derived using a cryptographic algorithm as a combination of X, Y, and the
// APIAKey_EL1.

bits(64) AddPACIA(bits(64) X, bits(64) Y)
    boolean TrapEL2;
    boolean TrapEL3;
    bits(1) Enable;
    bits(128) APIAKey_EL1;

    APIAKey_EL1 = APIAKeyHi_EL1<63:0>:APIAKeyLo_EL1<63:0>;
    case PSTATE.EL of
        when EL0
            boolean IsEL1Regime = S1TranslationRegime() == EL1;
            Enable = if IsEL1Regime then SCTLRL_EL1.EnIA else SCTLRL_EL2.EnIA;
            TrapEL2 = (EL2Enabled() && HCR_EL2.API == '0' &&
                (HCR_EL2.TGE == '0' || HCR_EL2.E2H == '0'));
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL1
            Enable = SCTLRL_EL1.EnIA;
            TrapEL2 = EL2Enabled() && HCR_EL2.API == '0';
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL2
            Enable = SCTLRL_EL2.EnIA;
            TrapEL2 = FALSE;
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL3
            Enable = SCTLRL_EL3.EnIA;
            TrapEL2 = FALSE;
            TrapEL3 = FALSE;

    if Enable == '0' then return X;
    elsif TrapEL2 then TrapPACUse(EL2);
    elsif TrapEL3 then TrapPACUse(EL3);
    else return AddPAC(X, Y, APIAKey_EL1, FALSE);
```



## Library pseudocode for aarch64/functions/pac/addpacib/AddPACIB

```
// AddPACIB()
// =====
// Returns a 64-bit value containing X, but replacing the pointer authentication code
// field bits with a pointer authentication code, where the pointer authentication
// code is derived using a cryptographic algorithm as a combination of X, Y and the
// APIBKey_EL1.

bits(64) AddPACIB(bits(64) X, bits(64) Y)
    boolean TrapEL2;
    boolean TrapEL3;
    bits(1) Enable;
    bits(128) APIBKey_EL1;

    APIBKey_EL1 = APIBKeyHi_EL1<63:0> : APIBKeyLo_EL1<63:0>;
    case PSTATE.EL of
        when EL0
            boolean IsEL1Regime = S1TranslationRegime() == EL1;
            Enable = if IsEL1Regime then SCTLR_EL1.EnIB else SCTLR_EL2.EnIB;
            TrapEL2 = (EL2Enabled() && HCR_EL2.API == '0' &&
                (HCR_EL2.TGE == '0' || HCR_EL2.E2H == '0'));
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL1
            Enable = SCTLR_EL1.EnIB;
            TrapEL2 = EL2Enabled() && HCR_EL2.API == '0';
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL2
            Enable = SCTLR_EL2.EnIB;
            TrapEL2 = FALSE;
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL3
            Enable = SCTLR_EL3.EnIB;
            TrapEL2 = FALSE;
            TrapEL3 = FALSE;

    if Enable == '0' then return X;
    elsif TrapEL2 then TrapPACUse(EL2);
    elsif TrapEL3 then TrapPACUse(EL3);
    else return AddPAC(X, Y, APIBKey_EL1, FALSE);
```

## Library pseudocode for aarch64/functions/pac/auth/AArch64.PACFailException

```
// AArch64.PACFailException()
// =====
// Generates a PAC Fail Exception

AArch64.PACFailException(bits(2) syndrome)
    route_to_el2 = PSTATE.EL == EL0 && EL2Enabled() && HCR_EL2.TGE == '1';
    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x0;

    exception = ExceptionSyndrome(Exception_PACFail);
    exception.syndrome<1:0> = syndrome;
    exception.syndrome<24:2> = Zeros(); // RES0

    if UInt(PSTATE.EL) > UInt(EL0) then
        AArch64.TakeException(PSTATE.EL, exception, preferred_exception_return, vect_offset);
    elsif route_to_el2 then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(EL1, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/functions/pac/auth/Auth

```
// Auth()
// =====
// Restores the upper bits of the address to be all zeros or all ones (based on the
// value of bit[55]) and computes and checks the pointer authentication code. If the
// check passes, then the restored address is returned. If the check fails, the
// second-top and third-top bits of the extension bits in the pointer authentication code
// field are corrupted to ensure that accessing the address will give a translation fault.

bits(64) Auth(bits(64) ptr, bits(64) modifier, bits(128) K, boolean data, bit key_number, boolean is_combined)
    bits(64) PAC;
    bits(64) result;
    bits(64) original_ptr;
    bits(2) error_code;
    bits(64) extfield;

    // Reconstruct the extension field used of adding the PAC to the pointer
    boolean tbi = EffectiveTBI(ptr, !data, PSTATE.EL) == '1';
    integer bottom_PAC_bit = CalculateBottomPACBit(ptr<55>);
    extfield = Replicate(ptr<55>, 64);

    if tbi then
        original_ptr = ptr<63:56>:extfield<56-bottom_PAC_bit-1:0>:ptr<bottom_PAC_bit-1:0>;
    else
        original_ptr = extfield<64-bottom_PAC_bit-1:0>:ptr<bottom_PAC_bit-1:0>;

    PAC = ComputePAC(original_ptr, modifier, K<127:64>, K<63:0>);
    // Check pointer authentication code
    if tbi then
        if !HaveEnhancedPAC2() then
            if PAC<54:bottom_PAC_bit> == ptr<54:bottom_PAC_bit> then
                result = original_ptr;
            else
                error_code = key_number:NOT(key_number);
                result = original_ptr<63:55>:error_code:original_ptr<52:0>;
        else
            result = ptr;
            result<54:bottom_PAC_bit> = result<54:bottom_PAC_bit> EOR PAC<54:bottom_PAC_bit>;
            if HaveFPACCombined() || (HaveFPAC() && !is_combined) then
                if result<54:bottom_PAC_bit> != Replicate(result<55>, (55-bottom_PAC_bit)) then
                    error_code = (if data then '1' else '0'):key_number;
                    AArch64.PACFailException(error_code);
            else
                if !HaveEnhancedPAC2() then
                    if PAC<54:bottom_PAC_bit> == ptr<54:bottom_PAC_bit> && PAC<63:56> == ptr<63:56> then
                        result = original_ptr;
                    else
                        error_code = key_number:NOT(key_number);
                        result = original_ptr<63>:error_code:original_ptr<60:0>;
                else
                    result = ptr;
                    result<54:bottom_PAC_bit> = result<54:bottom_PAC_bit> EOR PAC<54:bottom_PAC_bit>;
                    result<63:56> = result<63:56> EOR PAC<63:56>;
                    if HaveFPACCombined() || (HaveFPAC() && !is_combined) then
                        if result<63:bottom_PAC_bit> != Replicate(result<55>, (64-bottom_PAC_bit)) then
                            error_code = (if data then '1' else '0'):key_number;
                            AArch64.PACFailException(error_code);
    return result;
```

## Library pseudocode for aarch64/functions/pac/authda/AuthDA

```
// AuthDA()
// =====
// Returns a 64-bit value containing X, but replacing the pointer authentication code
// field bits with the extension of the address bits. The instruction checks a pointer
// authentication code in the pointer authentication code field bits of X, using the same
// algorithm and key as AddPACDA().

bits(64) AuthDA(bits(64) X, bits(64) Y, boolean is_combined)
    boolean TrapEL2;
    boolean TrapEL3;
    bits(1) Enable;
    bits(128) APDAKey_EL1;

    APDAKey_EL1 = APDAKeyHi_EL1<63:0> : APDAKeyLo_EL1<63:0>;
    case PSTATE.EL of
        when EL0
            boolean IsEL1Regime = S1TranslationRegime() == EL1;
            Enable = if IsEL1Regime then SCTLRL_EL1.EnDA else SCTLRL_EL2.EnDA;
            TrapEL2 = (EL2Enabled() && HCR_EL2.API == '0' &&
                (HCR_EL2.TGE == '0' || HCR_EL2.E2H == '0'));
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL1
            Enable = SCTLRL_EL1.EnDA;
            TrapEL2 = EL2Enabled() && HCR_EL2.API == '0';
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL2
            Enable = SCTLRL_EL2.EnDA;
            TrapEL2 = FALSE;
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL3
            Enable = SCTLRL_EL3.EnDA;
            TrapEL2 = FALSE;
            TrapEL3 = FALSE;

    if Enable == '0' then return X;
    elsif TrapEL2 then TrapPACUse(EL2);
    elsif TrapEL3 then TrapPACUse(EL3);
    else return Auth(X, Y, APDAKey_EL1, TRUE, '0', is_combined);
```

## Library pseudocode for aarch64/functions/pac/authdb/AuthDB

```
// AuthDB()
// =====
// Returns a 64-bit value containing X, but replacing the pointer authentication code
// field bits with the extension of the address bits. The instruction checks a
// pointer authentication code in the pointer authentication code field bits of X, using
// the same algorithm and key as AddPACDB().

bits(64) AuthDB(bits(64) X, bits(64) Y, boolean is_combined)
    boolean TrapEL2;
    boolean TrapEL3;
    bits(1) Enable;
    bits(128) APDBKey_EL1;

    APDBKey_EL1 = APDBKeyHi_EL1<63:0> : APDBKeyLo_EL1<63:0>;
    case PSTATE.EL of
        when EL0
            boolean IsEL1Regime = S1TranslationRegime() == EL1;
            Enable = if IsEL1Regime then SCTLRL_EL1.EnDB else SCTLRL_EL2.EnDB;
            TrapEL2 = (EL2Enabled() && HCR_EL2.API == '0' &&
                (HCR_EL2.TGE == '0' || HCR_EL2.E2H == '0'));
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL1
            Enable = SCTLRL_EL1.EnDB;
            TrapEL2 = EL2Enabled() && HCR_EL2.API == '0';
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL2
            Enable = SCTLRL_EL2.EnDB;
            TrapEL2 = FALSE;
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL3
            Enable = SCTLRL_EL3.EnDB;
            TrapEL2 = FALSE;
            TrapEL3 = FALSE;

    if Enable == '0' then return X;
    elsif TrapEL2 then TrapPACUse(EL2);
    elsif TrapEL3 then TrapPACUse(EL3);
    else return Auth(X, Y, APDBKey_EL1, TRUE, '1', is_combined);
```

## Library pseudocode for aarch64/functions/pac/authia/AuthIA

```
// AuthIA()
// =====
// Returns a 64-bit value containing X, but replacing the pointer authentication code
// field bits with the extension of the address bits. The instruction checks a pointer
// authentication code in the pointer authentication code field bits of X, using the same
// algorithm and key as AddPACIA().

bits(64) AuthIA(bits(64) X, bits(64) Y, boolean is_combined)
    boolean TrapEL2;
    boolean TrapEL3;
    bits(1) Enable;
    bits(128) APIAKey_EL1;

    APIAKey_EL1 = APIAKeyHi_EL1<63:0> : APIAKeyLo_EL1<63:0>;
    case PSTATE.EL of
        when EL0
            boolean IsEL1Regime = S1TranslationRegime() == EL1;
            Enable = if IsEL1Regime then SCTLRL_EL1.EnIA else SCTLRL_EL2.EnIA;
            TrapEL2 = (EL2Enabled() && HCR_EL2.API == '0' &&
                (HCR_EL2.TGE == '0' || HCR_EL2.E2H == '0'));
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL1
            Enable = SCTLRL_EL1.EnIA;
            TrapEL2 = EL2Enabled() && HCR_EL2.API == '0';
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL2
            Enable = SCTLRL_EL2.EnIA;
            TrapEL2 = FALSE;
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL3
            Enable = SCTLRL_EL3.EnIA;
            TrapEL2 = FALSE;
            TrapEL3 = FALSE;

    if Enable == '0' then return X;
    elsif TrapEL2 then TrapPACUse(EL2);
    elsif TrapEL3 then TrapPACUse(EL3);
    else return Auth(X, Y, APIAKey_EL1, FALSE, '0', is_combined);
```

## Library pseudocode for aarch64/functions/pac/authib/AuthIB

```
// AuthIB()
// =====
// Returns a 64-bit value containing X, but replacing the pointer authentication code
// field bits with the extension of the address bits. The instruction checks a pointer
// authentication code in the pointer authentication code field bits of X, using the same
// algorithm and key as AddPACIB().

bits(64) AuthIB(bits(64) X, bits(64) Y, boolean is_combined)
    boolean TrapEL2;
    boolean TrapEL3;
    bits(1) Enable;
    bits(128) APIBKey_EL1;

    APIBKey_EL1 = APIBKeyHi_EL1<63:0> : APIBKeyLo_EL1<63:0>;
    case PSTATE.EL of
        when EL0
            boolean IsEL1Regime = S1TranslationRegime() == EL1;
            Enable = if IsEL1Regime then SCTLRL_EL1.EnIB else SCTLRL_EL2.EnIB;
            TrapEL2 = (EL2Enabled() && HCR_EL2.API == '0' &&
                (HCR_EL2.TGE == '0' || HCR_EL2.E2H == '0'));
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL1
            Enable = SCTLRL_EL1.EnIB;
            TrapEL2 = EL2Enabled() && HCR_EL2.API == '0';
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL2
            Enable = SCTLRL_EL2.EnIB;
            TrapEL2 = FALSE;
            TrapEL3 = HaveEL(EL3) && SCR_EL3.API == '0';
        when EL3
            Enable = SCTLRL_EL3.EnIB;
            TrapEL2 = FALSE;
            TrapEL3 = FALSE;

    if Enable == '0' then return X;
    elsif TrapEL2 then TrapPACUse(EL2);
    elsif TrapEL3 then TrapPACUse(EL3);
    else return Auth(X, Y, APIBKey_EL1, FALSE, '1', is_combined);
```

## Library pseudocode for aarch64/functions/pac/calcbottompacbit/CalculateBottomPACBit

```
// CalculateBottomPACBit()
// =====

integer CalculateBottomPACBit(bit top_bit)
    integer tsz_field;

    if PtrHasUpperAndLowerAddRanges\(\) then
        assert S1TranslationRegime\(\) IN {EL1, EL2};
        if S1TranslationRegime\(\) == EL1 then
            // EL1 translation regime registers
            tsz_field = if top_bit == '1' then UInt(TCR_EL1.T1SZ) else UInt(TCR_EL1.T0SZ);
            using64k = if top_bit == '1' then TCR_EL1.TG1 == '11' else TCR_EL1.TG0 == '01';
        else
            // EL2 translation regime registers
            assert HaveEL(EL2);
            tsz_field = if top_bit == '1' then UInt(TCR_EL2.T1SZ) else UInt(TCR_EL2.T0SZ);
            using64k = if top_bit == '1' then TCR_EL2.TG1 == '11' else TCR_EL2.TG0 == '01';
    else
        tsz_field = if PSTATE.EL == EL2 then UInt(TCR_EL2.T0SZ) else UInt(TCR_EL3.T0SZ);
        using64k = if PSTATE.EL == EL2 then TCR_EL2.TG0 == '01' else TCR_EL3.TG0 == '01';

    max_limit_tsz_field = (if !HaveSmallPageTblExt\(\) then 39 else if using64k then 47 else 48);
    if tsz_field > max_limit_tsz_field then
        // TCR_ELx.TySZ is out of range
        c = ConstrainUnpredictable(Unpredictable\_RESTnSZ);
        assert c IN {Constraint\_FORCE, Constraint\_NONE};
        if c == Constraint\_FORCE then tsz_field = max_limit_tsz_field;
    tszmin = if using64k && VAMax() == 52 then 12 else 16;
    if tsz_field < tszmin then
        c = ConstrainUnpredictable(Unpredictable\_RESTnSZ);
        assert c IN {Constraint\_FORCE, Constraint\_NONE};
        if c == Constraint\_FORCE then tsz_field = tszmin;
    return (64-tsz_field);
```

## Library pseudocode for aarch64/functions/pac/computepac/ComputePAC

```
array bits(64) RC[0..4];

bits(64) ComputePAC(bits(64) data, bits(64) modifier, bits(64) key0, bits(64) key1)
    bits(64) workingval;
    bits(64) runningmod;
    bits(64) roundkey;
    bits(64) modk0;
    constant bits(64) Alpha = 0xC0AC29B7C97C50DD<63:0>;

    RC[0] = 0x0000000000000000<63:0>;
    RC[1] = 0x13198A2E03707344<63:0>;
    RC[2] = 0xA4093822299F31D0<63:0>;
    RC[3] = 0x082EFA98EC4E6C89<63:0>;
    RC[4] = 0x452821E638D01377<63:0>;

    modk0 = key0<0>:key0<63:2>:(key0<63> EOR key0<1>);
    runningmod = modifier;
    workingval = data EOR key0;
    for i = 0 to 4
        roundkey = key1 EOR runningmod;
        workingval = workingval EOR roundkey;
        workingval = workingval EOR RC[i];
        if i > 0 then
            workingval = PACCellShuffle(workingval);
            workingval = PACMult(workingval);
            workingval = PACSub(workingval);
            runningmod = TweakShuffle(runningmod<63:0>);
        roundkey = modk0 EOR runningmod;
        workingval = workingval EOR roundkey;
        workingval = PACCellShuffle(workingval);
        workingval = PACMult(workingval);
        workingval = PACSub(workingval);
        workingval = PACCellShuffle(workingval);
        workingval = PACMult(workingval);
        workingval = key1 EOR workingval;
        workingval = PACCellInvShuffle(workingval);
        workingval = PACInvSub(workingval);
        workingval = PACMult(workingval);
        workingval = PACCellInvShuffle(workingval);
        workingval = workingval EOR key0;
        workingval = workingval EOR runningmod;
        for i = 0 to 4
            workingval = PACInvSub(workingval);
            if i < 4 then
                workingval = PACMult(workingval);
                workingval = PACCellInvShuffle(workingval);
            runningmod = TweakInvShuffle(runningmod<63:0>);
            roundkey = key1 EOR runningmod;
            workingval = workingval EOR RC[4-i];
            workingval = workingval EOR roundkey;
            workingval = workingval EOR Alpha;
        workingval = workingval EOR modk0;

    return workingval;
```



## Library pseudocode for aarch64/functions/pac/computepac/PACCellInvShuffle

```
// PACCellInvShuffle()
// =====

bits(64) PACCellInvShuffle(bits(64) indata)
    bits(64) outdata;
    outdata<3:0> = indata<15:12>;
    outdata<7:4> = indata<27:24>;
    outdata<11:8> = indata<51:48>;
    outdata<15:12> = indata<39:36>;
    outdata<19:16> = indata<59:56>;
    outdata<23:20> = indata<47:44>;
    outdata<27:24> = indata<7:4>;
    outdata<31:28> = indata<19:16>;
    outdata<35:32> = indata<35:32>;
    outdata<39:36> = indata<55:52>;
    outdata<43:40> = indata<31:28>;
    outdata<47:44> = indata<11:8>;
    outdata<51:48> = indata<23:20>;
    outdata<55:52> = indata<3:0>;
    outdata<59:56> = indata<43:40>;
    outdata<63:60> = indata<63:60>;
    return outdata;
```

## Library pseudocode for aarch64/functions/pac/computepac/PACCellShuffle

```
// PACCellShuffle()
// =====

bits(64) PACCellShuffle(bits(64) indata)
    bits(64) outdata;
    outdata<3:0> = indata<55:52>;
    outdata<7:4> = indata<27:24>;
    outdata<11:8> = indata<47:44>;
    outdata<15:12> = indata<3:0>;
    outdata<19:16> = indata<31:28>;
    outdata<23:20> = indata<51:48>;
    outdata<27:24> = indata<7:4>;
    outdata<31:28> = indata<43:40>;
    outdata<35:32> = indata<35:32>;
    outdata<39:36> = indata<15:12>;
    outdata<43:40> = indata<59:56>;
    outdata<47:44> = indata<23:20>;
    outdata<51:48> = indata<11:8>;
    outdata<55:52> = indata<39:36>;
    outdata<59:56> = indata<19:16>;
    outdata<63:60> = indata<63:60>;
    return outdata;
```

## Library pseudocode for aarch64/functions/pac/computepac/PACInvSub

```
// PACInvSub()
// =====

bits(64) PACInvSub(bits(64) Tinput)
// This is a 4-bit substitution from the PRINCE-family cipher

bits(64) Toutput;
for i = 0 to 15
  case Tinput<4*i+3:4*i> of
    when '0000' Toutput<4*i+3:4*i> = '0101';
    when '0001' Toutput<4*i+3:4*i> = '1110';
    when '0010' Toutput<4*i+3:4*i> = '1101';
    when '0011' Toutput<4*i+3:4*i> = '1000';
    when '0100' Toutput<4*i+3:4*i> = '1010';
    when '0101' Toutput<4*i+3:4*i> = '1011';
    when '0110' Toutput<4*i+3:4*i> = '0001';
    when '0111' Toutput<4*i+3:4*i> = '1001';
    when '1000' Toutput<4*i+3:4*i> = '0010';
    when '1001' Toutput<4*i+3:4*i> = '0110';
    when '1010' Toutput<4*i+3:4*i> = '1111';
    when '1011' Toutput<4*i+3:4*i> = '0000';
    when '1100' Toutput<4*i+3:4*i> = '0100';
    when '1101' Toutput<4*i+3:4*i> = '1100';
    when '1110' Toutput<4*i+3:4*i> = '0111';
    when '1111' Toutput<4*i+3:4*i> = '0011';
  return Toutput;
```

## Library pseudocode for aarch64/functions/pac/computepac/PACMult

```
// PACMult()
// =====

bits(64) PACMult(bits(64) Sinput)
  bits(4) t0;
  bits(4) t1;
  bits(4) t2;
  bits(4) t3;
  bits(64) Soutput;

  for i = 0 to 3
    t0<3:0> = RotCell(Sinput<4*(i+8)+3:4*(i+8)>, 1) EOR RotCell(Sinput<4*(i+4)+3:4*(i+4)>, 2);
    t0<3:0> = t0<3:0> EOR RotCell(Sinput<4*(i)+3:4*(i)>, 1);
    t1<3:0> = RotCell(Sinput<4*(i+12)+3:4*(i+12)>, 1) EOR RotCell(Sinput<4*(i+4)+3:4*(i+4)>, 1);
    t1<3:0> = t1<3:0> EOR RotCell(Sinput<4*(i)+3:4*(i)>, 2);
    t2<3:0> = RotCell(Sinput<4*(i+12)+3:4*(i+12)>, 2) EOR RotCell(Sinput<4*(i+8)+3:4*(i+8)>, 1);
    t2<3:0> = t2<3:0> EOR RotCell(Sinput<4*(i)+3:4*(i)>, 1);
    t3<3:0> = RotCell(Sinput<4*(i+12)+3:4*(i+12)>, 1) EOR RotCell(Sinput<4*(i+8)+3:4*(i+8)>, 2);
    t3<3:0> = t3<3:0> EOR RotCell(Sinput<4*(i+4)+3:4*(i+4)>, 1);
    Soutput<4*i+3:4*i> = t3<3:0>;
    Soutput<4*(i+4)+3:4*(i+4)> = t2<3:0>;
    Soutput<4*(i+8)+3:4*(i+8)> = t1<3:0>;
    Soutput<4*(i+12)+3:4*(i+12)> = t0<3:0>;
  return Soutput;
```

## Library pseudocode for aarch64/functions/pac/computepac/PACSub

```
// PACSub()
// =====

bits(64) PACSub(bits(64) Tinput)
// This is a 4-bit substitution from the PRINCE-family cipher
bits(64) Toutput;
for i = 0 to 15
    case Tinput<4*i+3:4*i> of
        when '0000' Toutput<4*i+3:4*i> = '1011';
        when '0001' Toutput<4*i+3:4*i> = '0110';
        when '0010' Toutput<4*i+3:4*i> = '1000';
        when '0011' Toutput<4*i+3:4*i> = '1111';
        when '0100' Toutput<4*i+3:4*i> = '1100';
        when '0101' Toutput<4*i+3:4*i> = '0000';
        when '0110' Toutput<4*i+3:4*i> = '1001';
        when '0111' Toutput<4*i+3:4*i> = '1110';
        when '1000' Toutput<4*i+3:4*i> = '0011';
        when '1001' Toutput<4*i+3:4*i> = '0111';
        when '1010' Toutput<4*i+3:4*i> = '0100';
        when '1011' Toutput<4*i+3:4*i> = '0101';
        when '1100' Toutput<4*i+3:4*i> = '1101';
        when '1101' Toutput<4*i+3:4*i> = '0010';
        when '1110' Toutput<4*i+3:4*i> = '0001';
        when '1111' Toutput<4*i+3:4*i> = '1010';
return Toutput;
```

## Library pseudocode for aarch64/functions/pac/computepac/RotCell

```
// RotCell()
// =====

bits(4) RotCell(bits(4) incell, integer amount)
    bits(8) tmp;
    bits(4) outcell;

    // assert amount>3 || amount<1;
    tmp<7:0> = incell<3:0>:incell<3:0>;
    outcell = tmp<7-amount:4-amount>;
    return outcell;
```

## Library pseudocode for aarch64/functions/pac/computepac/TweakCellInvRot

```
// TweakCellInvRot()
// =====

bits(4) TweakCellInvRot(bits(4)incell)
    bits(4) outcell;
    outcell<3> = incell<2>;
    outcell<2> = incell<1>;
    outcell<1> = incell<0>;
    outcell<0> = incell<0> EOR incell<3>;
    return outcell;
```

## Library pseudocode for aarch64/functions/pac/computepac/TweakCellRot

```
// TweakCellRot()
// =====

bits(4) TweakCellRot(bits(4) incell)
    bits(4) outcell;
    outcell<3> = incell<0> EOR incell<1>;
    outcell<2> = incell<3>;
    outcell<1> = incell<2>;
    outcell<0> = incell<1>;
    return outcell;
```

## Library pseudocode for aarch64/functions/pac/computepac/TweakInvShuffle

```
// TweakInvShuffle()
// =====

bits(64) TweakInvShuffle(bits(64) indata)
    bits(64) outdata;
    outdata<3:0> = TweakCellInvRot(indata<51:48>);
    outdata<7:4> = indata<55:52>;
    outdata<11:8> = indata<23:20>;
    outdata<15:12> = indata<27:24>;
    outdata<19:16> = indata<3:0>;
    outdata<23:20> = indata<7:4>;
    outdata<27:24> = TweakCellInvRot(indata<11:8>);
    outdata<31:28> = indata<15:12>;
    outdata<35:32> = TweakCellInvRot(indata<31:28>);
    outdata<39:36> = TweakCellInvRot(indata<63:60>);
    outdata<43:40> = TweakCellInvRot(indata<59:56>);
    outdata<47:44> = TweakCellInvRot(indata<19:16>);
    outdata<51:48> = indata<35:32>;
    outdata<55:52> = indata<39:36>;
    outdata<59:56> = indata<43:40>;
    outdata<63:60> = TweakCellInvRot(indata<47:44>);
    return outdata;
```

## Library pseudocode for aarch64/functions/pac/computepac/TweakShuffle

```
// TweakShuffle()
// =====

bits(64) TweakShuffle(bits(64) indata)
    bits(64) outdata;
    outdata<3:0> = indata<19:16>;
    outdata<7:4> = indata<23:20>;
    outdata<11:8> = TweakCellRot(indata<27:24>);
    outdata<15:12> = indata<31:28>;
    outdata<19:16> = TweakCellRot(indata<47:44>);
    outdata<23:20> = indata<11:8>;
    outdata<27:24> = indata<15:12>;
    outdata<31:28> = TweakCellRot(indata<35:32>);
    outdata<35:32> = indata<51:48>;
    outdata<39:36> = indata<55:52>;
    outdata<43:40> = indata<59:56>;
    outdata<47:44> = TweakCellRot(indata<63:60>);
    outdata<51:48> = TweakCellRot(indata<3:0>);
    outdata<55:52> = indata<7:4>;
    outdata<59:56> = TweakCellRot(indata<43:40>);
    outdata<63:60> = TweakCellRot(indata<39:36>);
    return outdata;
```

## Library pseudocode for aarch64/functions/pac/pac/HaveEnhancedPAC

```
// HaveEnhancedPAC()
// =====
// Returns TRUE if support for EnhancedPAC is implemented, FALSE otherwise.

boolean HaveEnhancedPAC()
    return ( HavePACExt()
        && boolean IMPLEMENTATION_DEFINED "Has enhanced PAC functionality" );
```

## Library pseudocode for aarch64/functions/pac/pac/HaveEnhancedPAC2

```
// HaveEnhancedPAC2()
// =====
// Returns TRUE if support for EnhancedPAC2 is implemented, FALSE otherwise.

boolean HaveEnhancedPAC2()
    return HasArchVersion(ARMv8p6) || (HasArchVersion(ARMv8p3) && boolean IMPLEMENTATION_DEFINED "Has enh
```

## Library pseudocode for aarch64/functions/pac/pac/HaveFPAC

```
// HaveFPAC()
// =====
// Returns TRUE if support for FPAC is implemented, FALSE otherwise.

boolean HaveFPAC()
    return HaveEnhancedPAC2() && boolean IMPLEMENTATION_DEFINED "Has FPAC functionality";
```

## Library pseudocode for aarch64/functions/pac/pac/HaveFPACCombined

```
// HaveFPACCombined()
// =====
// Returns TRUE if support for FPACCombined is implemented, FALSE otherwise.

boolean HaveFPACCombined()
    return HaveFPAC() && boolean IMPLEMENTATION_DEFINED "Has FPAC Combined functionality";
```

## Library pseudocode for aarch64/functions/pac/pac/HavePACExt

```
// HavePACExt()
// =====
// Returns TRUE if support for the PAC extension is implemented, FALSE otherwise.

boolean HavePACExt()
    return HasArchVersion(ARMv8p3);
```

## Library pseudocode for aarch64/functions/pac/pac/PtrHasUpperAndLowerAddRanges

```
// PtrHasUpperAndLowerAddRanges()
// =====
// Returns TRUE if the pointer has upper and lower address ranges, FALSE otherwise.

boolean PtrHasUpperAndLowerAddRanges()
    return PSTATE.EL == EL1 || PSTATE.EL == EL0 || (PSTATE.EL == EL2 && HCR_EL2.E2H == '1');
```

## Library pseudocode for aarch64/functions/pac/strip/Strip

```
// Strip()
// =====
// Strip() returns a 64-bit value containing A, but replacing the pointer authentication
// code field bits with the extension of the address bits. This can apply to either
// instructions or data, where, as the use of tagged pointers is distinct, it might be
// handled differently.

bits(64) Strip(bits(64) A, boolean data)
    bits(64) original_ptr;
    bits(64) extfield;
    boolean tbi = EffectiveTBI(A, !data, PSTATE.EL) == '1';
    integer bottom_PAC_bit = CalculateBottomPACBit(A<55>);
    extfield = Replicate(A<55>, 64);

    if tbi then
        original_ptr = A<63:56>:extfield< 56-bottom_PAC_bit-1:0>:A<bottom_PAC_bit-1:0>;
    else
        original_ptr = extfield< 64-bottom_PAC_bit-1:0>:A<bottom_PAC_bit-1:0>;

    return original_ptr;
```

## Library pseudocode for aarch64/functions/pac/trappacuse/TrapPACUse

```
// TrapPACUse()
// =====
// Used for the trapping of the pointer authentication functions by higher exception
// levels.

TrapPACUse(bits(2) target_el)
    assert HaveEL(target_el) && target_el != EL0 && UInt(target_el) >= UInt(PSTATE.EL);

    bits(64) preferred_exception_return = ThisInstrAddr();
    ExceptionRecord exception;
    vect_offset = 0;
    exception = ExceptionSyndrome(Exception_PACTrap);
    AArch64.TakeException(target_el, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/functions/ras/AArch64.ESBOperation

```
// AArch64.ESBOperation()
// =====
// Perform the AArch64 ESB operation, either for ESB executed in AArch64 state, or for
// ESB in AArch32 state when SError interrupts are routed to an Exception level using
// AArch64

AArch64.ESBOperation()

    route_to_el3 = HaveEL(EL3) && SCR_EL3.EA == '1';
    route_to_el2 = (EL2Enabled() &&
        (HCR_EL2.TGE == '1' || HCR_EL2.AMO == '1'));

    target = if route_to_el3 then EL3 elsif route_to_el2 then EL2 else EL1;

    if target == EL1 then
        mask_active = PSTATE.EL IN {EL0, EL1};
    elsif HaveVirtHostExt() && target == EL2 && HCR_EL2.<E2H,TGE> == '11' then
        mask_active = PSTATE.EL IN {EL0, EL2};
    else
        mask_active = PSTATE.EL == target;

    mask_set = (PSTATE.A == '1' && (!HaveDoubleFaultExt() || SCR_EL3.EA == '0' ||
        PSTATE.EL != EL3 || SCR_EL3.NMEA == '0'));
    intdis = Halted() || ExternalDebugInterruptsDisabled(target);
    masked = (UInt(target) < UInt(PSTATE.EL)) || intdis || (mask_active && mask_set);

    // Check for a masked Physical SError pending that can be synchronized
    // by an Error synchronization event.
    if masked && IsSynchronizablePhysicalSErrorPending() then
        // This function might be called for an interworking case, and INTdis is masking
        // the SError interrupt.
        if ELUsingAArch32(S1TranslationRegime()) then
            syndrome32 = AArch32.PhysicalSErrorSyndrome();
            DISR = AArch32.ReportDeferredSError(syndrome32.AET, syndrome32.ExT);
        else
            implicit_esb = FALSE;
            syndrome64 = AArch64.PhysicalSErrorSyndrome(implicit_esb);
            DISR_EL1 = AArch64.ReportDeferredSError(syndrome64.<31:0>);
            ClearPendingPhysicalSError(); // Set ISR_EL1.A to 0

    return;
```

## Library pseudocode for aarch64/functions/ras/AArch64.PhysicalSErrorSyndrome

```
// Return the SError syndrome
bits(25) AArch64.PhysicalSErrorSyndrome(boolean implicit_esb);
```

## Library pseudocode for aarch64/functions/ras/AArch64.ReportDeferredSError

```
// AArch64.ReportDeferredSError()
// =====
// Generate deferred SError syndrome

bits(64) AArch64.ReportDeferredSError(bits(25) syndrome)
    bits(64) target;
    target<31> = '1';           // A
    target<24> = syndrome<24>; // IDS
    target<23:0> = syndrome<23:0>; // ISS
    return target;
```

## Library pseudocode for aarch64/functions/ras/AArch64.vESBOperation

```
// AArch64.vESBOperation()
// =====
// Perform the AArch64 ESB operation for virtual SError interrupts, either for ESB
// executed in AArch64 state, or for ESB in AArch32 state with EL2 using AArch64 state

AArch64.vESBOperation()
    assert PSTATE.EL IN {EL0, EL1} && EL2Enabled();

    // If physical SError interrupts are routed to EL2, and TGE is not set, then a virtual
    // SError interrupt might be pending
    vSEI_enabled = HCR_EL2.TGE == '0' && HCR_EL2.AM0 == '1';
    vSEI_pending = vSEI_enabled && HCR_EL2.VSE == '1';
    vintdis      = Halted() || ExternalDebugInterruptsDisabled(EL1);
    vmasked      = vintdis || PSTATE.A == '1';

    // Check for a masked virtual SError pending
    if vSEI_pending && vmasked then
        // This function might be called for the interworking case, and INTdis is masking
        // the virtual SError interrupt.
        if ELUsingAArch32(EL1) then
            VDISR = AArch32.ReportDeferredSError(VDFSR<15:14>, VDFSR<12>);
        else
            VDISR_EL2 = AArch64.ReportDeferredSError(VSESR_EL2<24:0><31:0>);
            HCR_EL2.VSE = '0';           // Clear pending virtual SError

    return;
```

## Library pseudocode for aarch64/functions/registers/AArch64.MaybeZeroRegisterUppers

```
// AArch64.MaybeZeroRegisterUppers()
// =====
// On taking an exception to AArch64 from AArch32, it is CONSTRAINED UNPREDICTABLE whether the top
// 32 bits of registers visible at any lower Exception level using AArch32 are set to zero.

AArch64.MaybeZeroRegisterUppers()
    assert UsingAArch32();           // Always called from AArch32 state before entering AArch64 state

    if PSTATE.EL == EL0 && !ELUsingAArch32(EL1) then
        first = 0; last = 14; include_R15 = FALSE;
    elsif PSTATE.EL IN {EL0, EL1} && EL2Enabled() && !ELUsingAArch32(EL2) then
        first = 0; last = 30; include_R15 = FALSE;
    else
        first = 0; last = 30; include_R15 = TRUE;

    for n = first to last
        if (n != 15 || include_R15) && ConstrainUnpredictableBool(Unpredictable_ZEROUPPER) then
            _R[n]<63:32> = Zeros();

    return;
```

## Library pseudocode for aarch64/functions/registers/AArch64.ResetGeneralRegisters

```
// AArch64.ResetGeneralRegisters()
// =====

AArch64.ResetGeneralRegisters()

    for i = 0 to 30
        X[i] = bits(64) UNKNOWN;

    return;
```

## Library pseudocode for aarch64/functions/registers/AArch64.ResetSIMDFPRegisters

```
// AArch64.ResetSIMDFPRegisters()
// =====

AArch64.ResetSIMDFPRegisters()

    for i = 0 to 31
        V[i] = bits(128) UNKNOWN;

    return;
```

## Library pseudocode for aarch64/functions/registers/AArch64.ResetSpecialRegisters

```
// AArch64.ResetSpecialRegisters()
// =====

AArch64.ResetSpecialRegisters()

    // AArch64 special registers
    SP_EL0 = bits(64) UNKNOWN;
    SP_EL1 = bits(64) UNKNOWN;
    SPSR_EL1 = bits(32) UNKNOWN;
    ELR_EL1 = bits(64) UNKNOWN;
    if HaveEL\(EL2\) then
        SP_EL2 = bits(64) UNKNOWN;
        SPSR_EL2 = bits(32) UNKNOWN;
        ELR_EL2 = bits(64) UNKNOWN;
    if HaveEL\(EL3\) then
        SP_EL3 = bits(64) UNKNOWN;
        SPSR_EL3 = bits(32) UNKNOWN;
        ELR_EL3 = bits(64) UNKNOWN;

    // AArch32 special registers that are not architecturally mapped to AArch64 registers
    if HaveAArch32EL\(EL1\) then
        SPSR_fiq = bits(32) UNKNOWN;
        SPSR_irq = bits(32) UNKNOWN;
        SPSR_abt = bits(32) UNKNOWN;
        SPSR_und = bits(32) UNKNOWN;

    // External debug special registers
    DLR_EL0 = bits(64) UNKNOWN;
    DSPSR_EL0 = bits(32) UNKNOWN;

    return;
```

## Library pseudocode for aarch64/functions/registers/AArch64.ResetSystemRegisters

```
AArch64.ResetSystemRegisters(boolean cold_reset);
```



## Library pseudocode for aarch64/functions/registers/PC

```
// PC - non-assignment form
// =====
// Read program counter.

bits(64) PC[]
return _PC;
```

## Library pseudocode for aarch64/functions/registers/SP

```
// SP[] - assignment form
// =====
// Write to stack pointer from either a 32-bit or a 64-bit value.

SP[] = bits(width) value
assert width IN {32,64};
if PSTATE.SP == '0' then
    SP_EL0 = ZeroExtend(value);
else
    case PSTATE.EL of
        when EL0 SP_EL0 = ZeroExtend(value);
        when EL1 SP_EL1 = ZeroExtend(value);
        when EL2 SP_EL2 = ZeroExtend(value);
        when EL3 SP_EL3 = ZeroExtend(value);
    return;

// SP[] - non-assignment form
// =====
// Read stack pointer with implicit slice of 8, 16, 32 or 64 bits.

bits(width) SP[]
assert width IN {8,16,32,64};
if PSTATE.SP == '0' then
    return SP_EL0<width-1:0>;
else
    case PSTATE.EL of
        when EL0 return SP_EL0<width-1:0>;
        when EL1 return SP_EL1<width-1:0>;
        when EL2 return SP_EL2<width-1:0>;
        when EL3 return SP_EL3<width-1:0>;
```

## Library pseudocode for aarch64/functions/registers/V

```
// V[] - assignment form
// =====
// Write to SIMD&FP register with implicit extension from
// 8, 16, 32, 64 or 128 bits.

V[integer n] = bits(width) value
assert n >= 0 && n <= 31;
assert width IN {8,16,32,64,128};
integer vlen = if IsSVEEnabled(PSTATE.EL) then VL else 128;
if ConstrainUnpredictableBool(Unpredictable\_SVEZERoupper) then
    _Z[n] = ZeroExtend(value);
else
    _Z[n]<vlen-1:0> = ZeroExtend(value);

// V[] - non-assignment form
// =====
// Read from SIMD&FP register with implicit slice of 8, 16
// 32, 64 or 128 bits.

bits(width) V[integer n]
assert n >= 0 && n <= 31;
assert width IN {8,16,32,64,128};
return _Z[n]<width-1:0>;
```

## Library pseudocode for aarch64/functions/registers/Vpart

```
// Vpart[] - non-assignment form
// =====
// Reads a 128-bit SIMD&FP register in up to two parts:
// part 0 returns the bottom 8, 16, 32 or 64 bits of a value held in the register;
// part 1 returns the top half of the bottom 64 bits or the top half of the 128-bit
// value held in the register.

bits(width) Vpart[integer n, integer part]
    assert n >= 0 && n <= 31;
    assert part IN {0, 1};
    if part == 0 then
        assert width < 128;
        return V[n];
    else
        assert width IN {32,64};
        bits(128) vreg = V[n];
        return vreg<(width * 2)-1:width>;

// Vpart[] - assignment form
// =====
// Writes a 128-bit SIMD&FP register in up to two parts:
// part 0 zero extends a 8, 16, 32, or 64-bit value to fill the whole register;
// part 1 inserts a 64-bit value into the top half of the register.

Vpart[integer n, integer part] = bits(width) value
    assert n >= 0 && n <= 31;
    assert part IN {0, 1};
    if part == 0 then
        assert width < 128;
        V[n] = value;
    else
        assert width == 64;
        bits(64) vreg = V[n];
        V[n] = value<63:0> : vreg;
```

## Library pseudocode for aarch64/functions/registers/X

```
// X[] - assignment form
// =====
// Write to general-purpose register from either a 32-bit or a 64-bit value.

X[integer n] = bits(width) value
    assert n >= 0 && n <= 31;
    assert width IN {32,64};
    if n != 31 then
        _R[n] = ZeroExtend(value);
    return;

// X[] - non-assignment form
// =====
// Read from general-purpose register with implicit slice of 8, 16, 32 or 64 bits.

bits(width) X[integer n]
    assert n >= 0 && n <= 31;
    assert width IN {8,16,32,64};
    if n != 31 then
        return _R[n]<width-1:0>;
    else
        return Zeros(width);
```

## Library pseudocode for aarch64/functions/sve/AArch32.IsFPEnabled

```
// AArch32.IsFPEnabled()
// =====
// Returns TRUE if access to the SIMD&FP instructions or System registers are
// enabled at the target exception level in AArch32 state and FALSE otherwise.

boolean AArch32.IsFPEnabled(bits(2) el)
    if el == EL0 && !ELUsingAArch32\(EL1\) then
        return AArch64.IsFPEnabled(el);

    if HaveEL\(EL3\) && ELUsingAArch32\(EL3\) && !IsSecure\(\) then
        // Check if access disabled in NSACR
        if NSACR.cp10 == '0' then return FALSE;

    if el IN {EL0, EL1} then
        // Check if access disabled in CPACR
        case CPACR.cp10 of
            when '00' disabled = TRUE;
            when '01' disabled = el == EL0;
            when '10' disabled = ConstrainUnpredictableBool\(Unpredictable\_RESCPACR\);
            when '11' disabled = FALSE;
        if disabled then return FALSE;

    if el IN {EL0, EL1, EL2} && EL2Enabled\(\) then
        if !ELUsingAArch32\(EL2\) then
            return AArch64.IsFPEnabled\(EL2\);
        if HCPTR.TCP10 == '1' then return FALSE;

    if HaveEL\(EL3\) && !ELUsingAArch32\(EL3\) then
        // Check if access disabled in CPTR_EL3
        if CPTR_EL3.TFP == '1' then return FALSE;

    return TRUE;
```

## Library pseudocode for aarch64/functions/sve/AArch64.IsFPEnabled

```
// AArch64.IsFPEnabled()
// =====
// Returns TRUE if access to the SIMD&FP instructions or System registers are
// enabled at the target exception level in AArch64 state and FALSE otherwise.

boolean AArch64.IsFPEnabled(bits(2) el)
    // Check if access disabled in CPACR_EL1
    if el IN {EL0, EL1} && !IsInHost\(\) then
        // Check FP&SIMD at EL0/EL1
        case CPACR_EL1.FPEN of
            when 'x0' disabled = TRUE;
            when '01' disabled = el == EL0;
            when '11' disabled = FALSE;
        if disabled then return FALSE;

    // Check if access disabled in CPTR_EL2
    if el IN {EL0, EL1, EL2} && EL2Enabled\(\) then
        if HaveVirtHostExt\(\) && HCR_EL2.E2H == '1' then
            case CPTR_EL2.FPEN of
                when 'x0' disabled = TRUE;
                when '01' disabled = el == EL0 && HCR_EL2.TGE == '1';
                when '11' disabled = FALSE;
            if disabled then return FALSE;
        else
            if CPTR_EL2.TFP == '1' then return FALSE;

    // Check if access disabled in CPTR_EL3
    if HaveEL\(EL3\) then
        if CPTR_EL3.TFP == '1' then return FALSE;

    return TRUE;
```

## Library pseudocode for aarch64/functions/sve/BitDeposit

```
// BitDeposit()
// =====
// Deposit the least significant bits from DATA into result positions
// selected by non-zero bits in MASK, setting other result bits to zero.

bits(N) BitDeposit (bits(N) data, bits(N) mask)
    bits(N) res = Zeros();
    integer db = 0;
    for rb = 0 to N-1
        if mask<rb> == '1' then
            res<rb> = data<db>;
            db = db + 1;
    return res;
```

## Library pseudocode for aarch64/functions/sve/BitExtract

```
// BitExtract()
// =====
// Extract and pack DATA bits selected by the non-zero bits in MASK into
// the least significant result bits, setting other result bits to zero.

bits(N) BitExtract (bits(N) data, bits(N) mask)
    bits(N) res = Zeros();
    integer rb = 0;
    for db = 0 to N-1
        if mask<db> == '1' then
            res<rb> = data<db>;
            rb = rb + 1;
    return res;
```

## Library pseudocode for aarch64/functions/sve/BitGroup

```
// BitGroup()
// =====
// Extract and pack DATA bits selected by the non-zero bits in MASK into
// the least significant result bits, and pack unselected bits into the
// most significant result bits.

bits(N) BitGroup (bits(N) data, bits(N) mask)
    bits(N) res;
    integer rb = 0;

    // compress masked bits to right
    for db = 0 to N-1
        if mask<db> == '1' then
            res<rb> = data<db>;
            rb = rb + 1;
    // compress unmasked bits to left
    for db = 0 to N-1
        if mask<db> == '0' then
            res<rb> = data<db>;
            rb = rb + 1;
    return res;
```

## Library pseudocode for aarch64/functions/sve/CeilPow2

```
// CeilPow2()
// =====

// For a positive integer X, return the smallest power of 2 >= X

integer CeilPow2(integer x)
    if x == 0 then return 0;
    if x == 1 then return 2;
    return FloorPow2(x - 1) * 2;
```

## Library pseudocode for aarch64/functions/sve/CheckSVEEnabled

```
// CheckSVEEnabled()
// =====
// Checks for traps on SVE instructions and instructions that
// access SVE System registers.

CheckSVEEnabled()
    // Check if access disabled in CPACR_EL1
    if PSTATE.EL IN {EL0, EL1} && !IsInHost() then
        // Check SVE at EL0/EL1
        case CPACR_EL1.ZEN of
            when 'x0' disabled = TRUE;
            when '01' disabled = PSTATE.EL == EL0;
            when '11' disabled = FALSE;
        if disabled then SVEAccessTrap(EL1);

        // Check SIMD&FP at EL0/EL1
        case CPACR_EL1.FPEN of
            when 'x0' disabled = TRUE;
            when '01' disabled = PSTATE.EL == EL0;
            when '11' disabled = FALSE;
        if disabled then AArch64.AdvSIMDFPAccessTrap(EL1);

    // Check if access disabled in CPTR_EL2
    if PSTATE.EL IN {EL0, EL1, EL2} && EL2Enabled() then
        if HaveVirtHostExt() && HCR_EL2.E2H == '1' then
            // Check SVE at EL2
            case CPTR_EL2.ZEN of
                when 'x0' disabled = TRUE;
                when '01' disabled = PSTATE.EL == EL0 && HCR_EL2.TGE == '1';
                when '11' disabled = FALSE;
            if disabled then SVEAccessTrap(EL2);

            // Check SIMD&FP at EL2
            case CPTR_EL2.FPEN of
                when 'x0' disabled = TRUE;
                when '01' disabled = PSTATE.EL == EL0 && HCR_EL2.TGE == '1';
                when '11' disabled = FALSE;
            if disabled then AArch64.AdvSIMDFPAccessTrap(EL2);
        else
            if CPTR_EL2.TZ == '1' then SVEAccessTrap(EL2);
            if CPTR_EL2.TFP == '1' then AArch64.AdvSIMDFPAccessTrap(EL2);

    // Check if access disabled in CPTR_EL3
    if HaveEL(EL3) then
        if CPTR_EL3.EZ == '0' then SVEAccessTrap(EL3);
        if CPTR_EL3.TFP == '1' then AArch64.AdvSIMDFPAccessTrap(EL3);
```

## Library pseudocode for aarch64/functions/sve/DecodePredCount

```
// DecodePredCount()
// =====

integer DecodePredCount(bits(5) pattern, integer esize)
  integer elements = VL DIV esize;
  integer numElem;
  case pattern of
    when '00000' numElem = FloorPow2(elements);
    when '00001' numElem = if elements >= 1 then 1 else 0;
    when '00010' numElem = if elements >= 2 then 2 else 0;
    when '00011' numElem = if elements >= 3 then 3 else 0;
    when '00100' numElem = if elements >= 4 then 4 else 0;
    when '00101' numElem = if elements >= 5 then 5 else 0;
    when '00110' numElem = if elements >= 6 then 6 else 0;
    when '00111' numElem = if elements >= 7 then 7 else 0;
    when '01000' numElem = if elements >= 8 then 8 else 0;
    when '01001' numElem = if elements >= 16 then 16 else 0;
    when '01010' numElem = if elements >= 32 then 32 else 0;
    when '01011' numElem = if elements >= 64 then 64 else 0;
    when '01100' numElem = if elements >= 128 then 128 else 0;
    when '01101' numElem = if elements >= 256 then 256 else 0;
    when '11101' numElem = elements - (elements MOD 4);
    when '11110' numElem = elements - (elements MOD 3);
    when '11111' numElem = elements;
    otherwise    numElem = 0;
  return numElem;
```

## Library pseudocode for aarch64/functions/sve/ElemFFR

```
// ElemFFR[] - non-assignment form
// =====

bit ElemFFR[integer e, integer esize]
  return ElemP[_FFR, e, esize];

// ElemFFR[] - assignment form
// =====

ElemFFR[integer e, integer esize] = bit value
  integer psize = esize DIV 8;
  integer n = e * psize;
  assert n >= 0 && (n + psize) <= PL;
  _FFR<n+psize-1:n> = ZeroExtend(value, psize);
  return;
```

## Library pseudocode for aarch64/functions/sve/ElemP

```
// ElemP[] - non-assignment form
// =====

bit ElemP[bits(N) pred, integer e, integer esize]
  integer n = e * (esize DIV 8);
  assert n >= 0 && n < N;
  return pred<n>;

// ElemP[] - assignment form
// =====

ElemP[bits(N) &pred, integer e, integer esize] = bit value
  integer psize = esize DIV 8;
  integer n = e * psize;
  assert n >= 0 && (n + psize) <= N;
  pred<n+psize-1:n> = ZeroExtend(value, psize);
  return;
```

## Library pseudocode for aarch64/functions/sve/FFR

```
// FFR[] - non-assignment form
// =====

bits(width) FFR[]
    assert width == PL;
    return _FFR<width-1:0>;

// FFR[] - assignment form
// =====

FFR[] = bits(width) value
    assert width == PL;
    if ConstrainUnpredictableBool(Unpredictable\_SVEZEROUPPER) then
        _FFR = ZeroExtend(value);
    else
        _FFR<width-1:0> = value;
```

## Library pseudocode for aarch64/functions/sve/FPCompareNE

```
// FPCompareNE()
// =====

boolean FPCompareNE(bits(N) op1, bits(N) op2, FPCRTType fpcr)
    assert N IN {16,32,64};
    (type1,sign1,value1) = FPUntpack(op1, fpcr);
    (type2,sign2,value2) = FPUntpack(op2, fpcr);
    if type1==FPTType\_SNaN || type1==FPTType\_QNaN || type2==FPTType\_SNaN || type2==FPTType\_QNaN then
        result = TRUE;
        if type1==FPTType\_SNaN || type2==FPTType\_SNaN then
            FPProcessException(FPExc\_InvalidOp, fpcr);
    else // All non-NaN cases can be evaluated on the values produced by FPUntpack()
        result = (value1 != value2);
    return result;
```

## Library pseudocode for aarch64/functions/sve/FPCompareUN

```
// FPCompareUN()
// =====

boolean FPCompareUN(bits(N) op1, bits(N) op2, FPCRTType fpcr)
    assert N IN {16,32,64};
    (type1,sign1,value1) = FPUntpack(op1, fpcr);
    (type2,sign2,value2) = FPUntpack(op2, fpcr);
    if type1==FPTType\_SNaN || type2==FPTType\_SNaN then
        FPProcessException(FPExc\_InvalidOp, fpcr);
    return (type1==FPTType\_SNaN || type1==FPTType\_QNaN || type2==FPTType\_SNaN || type2==FPTType\_QNaN);
```

## Library pseudocode for aarch64/functions/sve/FPConvertSVE

```
// FPConvertSVE()
// =====

bits(M) FPConvertSVE(bits(N) op, FPCRTType fpcr, FPRounding rounding)
    fpcr.AHP = '0';
    return FPConvert(op, fpcr, rounding);

// FPConvertSVE()
// =====

bits(M) FPConvertSVE(bits(N) op, FPCRTType fpcr)
    fpcr.AHP = '0';
    return FPConvert(op, fpcr, FPRoundingMode(fpcr));
```

## Library pseudocode for aarch64/functions/sve/FPExpA

```
// FPExpA()
// =====

bits(N) FPExpA(bits(N) op)
    assert N IN {16,32,64};
    bits(N) result;
    bits(N) coeff;
    integer idx = if N == 16 then UInt(op<4:0>) else UInt(op<5:0>);
    coeff = FPExpCoefficient[idx];
    if N == 16 then
        result<15:0> = '0':op<9:5>:coeff<9:0>;
    elsif N == 32 then
        result<31:0> = '0':op<13:6>:coeff<22:0>;
    else // N == 64
        result<63:0> = '0':op<16:6>:coeff<51:0>;

    return result;
```





```

// FPExpCoefficient()
// =====

bits(N) FPExpCoefficient[integer index]
  assert N IN {16,32,64};
  integer result;

  if N == 16 then
    case index of
      when 0 result = 0x0000;
      when 1 result = 0x0016;
      when 2 result = 0x002d;
      when 3 result = 0x0045;
      when 4 result = 0x005d;
      when 5 result = 0x0075;
      when 6 result = 0x008e;
      when 7 result = 0x00a8;
      when 8 result = 0x00c2;
      when 9 result = 0x00dc;
      when 10 result = 0x00f8;
      when 11 result = 0x0114;
      when 12 result = 0x0130;
      when 13 result = 0x014d;
      when 14 result = 0x016b;
      when 15 result = 0x0189;
      when 16 result = 0x01a8;
      when 17 result = 0x01c8;
      when 18 result = 0x01e8;
      when 19 result = 0x0209;
      when 20 result = 0x022b;
      when 21 result = 0x024e;
      when 22 result = 0x0271;
      when 23 result = 0x0295;
      when 24 result = 0x02ba;
      when 25 result = 0x02e0;
      when 26 result = 0x0306;
      when 27 result = 0x032e;
      when 28 result = 0x0356;
      when 29 result = 0x037f;
      when 30 result = 0x03a9;
      when 31 result = 0x03d4;

    elsif N == 32 then
      case index of
        when 0 result = 0x000000;
        when 1 result = 0x0164d2;
        when 2 result = 0x02cd87;
        when 3 result = 0x043a29;
        when 4 result = 0x05aac3;
        when 5 result = 0x071f62;
        when 6 result = 0x08980f;
        when 7 result = 0x0a14d5;
        when 8 result = 0x0b95c2;
        when 9 result = 0x0dladf;
        when 10 result = 0x0ea43a;
        when 11 result = 0x1031dc;
        when 12 result = 0x11c3d3;
        when 13 result = 0x135a2b;
        when 14 result = 0x14f4f0;
        when 15 result = 0x16942d;
        when 16 result = 0x1837f0;
        when 17 result = 0x19e046;
        when 18 result = 0x1b8d3a;
        when 19 result = 0x1d3eda;
        when 20 result = 0x1ef532;
        when 21 result = 0x20b051;
        when 22 result = 0x227043;
        when 23 result = 0x243516;
        when 24 result = 0x25fed7;
        when 25 result = 0x27cd94;

```

```

when 26 result = 0x29a15b;
when 27 result = 0x2b7a3a;
when 28 result = 0x2d583f;
when 29 result = 0x2f3b79;
when 30 result = 0x3123f6;
when 31 result = 0x3311c4;
when 32 result = 0x3504f3;
when 33 result = 0x36fd92;
when 34 result = 0x38fbaf;
when 35 result = 0x3aff5b;
when 36 result = 0x3d08a4;
when 37 result = 0x3f179a;
when 38 result = 0x412c4d;
when 39 result = 0x4346cd;
when 40 result = 0x45672a;
when 41 result = 0x478d75;
when 42 result = 0x49b9be;
when 43 result = 0x4bec15;
when 44 result = 0x4e248c;
when 45 result = 0x506334;
when 46 result = 0x52a81e;
when 47 result = 0x54f35b;
when 48 result = 0x5744fd;
when 49 result = 0x599d16;
when 50 result = 0x5bfbb8;
when 51 result = 0x5e60f5;
when 52 result = 0x60ccdf;
when 53 result = 0x633f89;
when 54 result = 0x65b907;
when 55 result = 0x68396a;
when 56 result = 0x6ac0c7;
when 57 result = 0x6d4f30;
when 58 result = 0x6fe4ba;
when 59 result = 0x728177;
when 60 result = 0x75257d;
when 61 result = 0x77d0df;
when 62 result = 0x7a83b3;
when 63 result = 0x7d3e0c;

```

```
else // N == 64
```

```
  case index of
```

```

    when 0 result = 0x00000000000000;
    when 1 result = 0x02C9A3E778061;
    when 2 result = 0x059B0D3158574;
    when 3 result = 0x0874518759BC8;
    when 4 result = 0x0B5586CF9890F;
    when 5 result = 0x0E3EC32D3D1A2;
    when 6 result = 0x11301D0125B51;
    when 7 result = 0x1429AAEA92DE0;
    when 8 result = 0x172B83C7D517B;
    when 9 result = 0x1A35BEB6FCB75;
    when 10 result = 0x1D4873168B9AA;
    when 11 result = 0x2063B88628CD6;
    when 12 result = 0x2387A6E756238;
    when 13 result = 0x26B4565E27CDD;
    when 14 result = 0x29E9DF51FDEE1;
    when 15 result = 0x2D285A6E4030B;
    when 16 result = 0x306FE0A31B715;
    when 17 result = 0x33C08B26416FF;
    when 18 result = 0x371A7373AA9CB;
    when 19 result = 0x3A7DB34E59FF7;
    when 20 result = 0x3DEA64C123422;
    when 21 result = 0x4160A21F72E2A;
    when 22 result = 0x44E086061892D;
    when 23 result = 0x486A2B5C13CD0;
    when 24 result = 0x4BFDAD5362A27;
    when 25 result = 0x4F9B2769D2CA7;
    when 26 result = 0x5342B569D4F82;
    when 27 result = 0x56F4736B527DA;
    when 28 result = 0x5AB07DD485429;

```

```

when 29 result = 0x5E76F15AD2148;
when 30 result = 0x6247EB03A5585;
when 31 result = 0x6623882552225;
when 32 result = 0x6A09E667F3BCD;
when 33 result = 0x6DFB23C651A2F;
when 34 result = 0x71F75E8EC5F74;
when 35 result = 0x75FEB564267C9;
when 36 result = 0x7A11473EB0187;
when 37 result = 0x7E2F336CF4E62;
when 38 result = 0x82589994CCE13;
when 39 result = 0x868D99B4492ED;
when 40 result = 0x8ACE5422AA0DB;
when 41 result = 0x8F1AE99157736;
when 42 result = 0x93737B0CDC5E5;
when 43 result = 0x97D829FDE4E50;
when 44 result = 0x9C49182A3F090;
when 45 result = 0xA0C667B5DE565;
when 46 result = 0xA5503B23E255D;
when 47 result = 0xA9E6B5579FDBF;
when 48 result = 0xAE89F995AD3AD;
when 49 result = 0xB33A2B84F15FB;
when 50 result = 0xB7F76F2FB5E47;
when 51 result = 0xBCC1E904BC1D2;
when 52 result = 0xC199BDD85529C;
when 53 result = 0xC67F12E57D14B;
when 54 result = 0xCB720DCEF9069;
when 55 result = 0xD072D4A07897C;
when 56 result = 0xD5818DCFBA487;
when 57 result = 0xDA9E603DB3285;
when 58 result = 0xDFC97337B9B5F;
when 59 result = 0xE502EE78B3FF6;
when 60 result = 0xEA4AFA2A490DA;
when 61 result = 0xEFA1BEE615A27;
when 62 result = 0xF50765B6E4540;
when 63 result = 0xFA7C1819E90D8;

```

```
return result<N-1:0>;
```

## Library pseudocode for aarch64/functions/sve/FPLogB

```

// FPLogB()
// =====

bits(N) FPLogB(bits(N) op, FPCRTType fpcr)
  assert N IN {16,32,64};

  (fptype,sign,value) = FPUunpack(op, fpcr);
  if fptype == FPTType\_SNaN || fptype == FPTType\_QNaN || fptype == FPTType\_Zero then
    FPProcessException(FPExc\_InvalidOp, fpcr);
    result = -(2^(N-1)); // MinInt, 100..00
  elsif fptype == FPTType\_Infinity then
    result = 2^(N-1) - 1; // MaxInt, 011..11
  else
    // FPUunpack has already scaled a subnormal input
    value = Abs(value);
    result = 0;
    while value < 1.0 do
      value = value * 2.0;
      result = result - 1;
    while value >= 2.0 do
      value = value / 2.0;
      result = result + 1;
  return result<N-1:0>;

```

## Library pseudocode for aarch64/functions/sve/FPMinNormal

```
// FPMinNormal()
// =====

bits(N) FPMinNormal(bit sign)
  assert N IN {16,32,64};
  constant integer E = (if N == 16 then 5 elsif N == 32 then 8 else 11);
  constant integer F = N - (E + 1);
  exp = Zeros(E-1):'1';
  frac = Zeros(F);
  return sign : exp : frac;
```

## Library pseudocode for aarch64/functions/sve/FPOne

```
// FPOne()
// =====

bits(N) FPOne(bit sign)
  assert N IN {16,32,64};
  constant integer E = (if N == 16 then 5 elsif N == 32 then 8 else 11);
  constant integer F = N - (E + 1);
  exp = '0':Ones(E-1);
  frac = Zeros(F);
  return sign : exp : frac;
```

## Library pseudocode for aarch64/functions/sve/FPPointFive

```
// FPPointFive()
// =====

bits(N) FPPointFive(bit sign)
  assert N IN {16,32,64};
  constant integer E = (if N == 16 then 5 elsif N == 32 then 8 else 11);
  constant integer F = N - (E + 1);
  exp = '0':Ones(E-2):'0';
  frac = Zeros(F);
  return sign : exp : frac;
```

## Library pseudocode for aarch64/functions/sve/FPProcess

```
// FPProcess()
// =====

bits(N) FPProcess(bits(N) input)
  bits(N) result;
  assert N IN {16,32,64};
  (fptype,sign,value) = FPUnpack(input, FPCR);
  if fptype == FPTType\_SNaN || fptype == FPTType\_QNaN then
    result = FPProcessNaN(fptype, input, FPCR);
  elsif fptype == FPTType\_Infinity then
    result = FPInfinity(sign);
  elsif fptype == FPTType\_Zero then
    result = FPZero(sign);
  else
    result = FPRound(value, FPCR);
  return result;
```

## Library pseudocode for aarch64/functions/sve/FPScale

```
// FPScale()
// =====

bits(N) FPScale(bits (N) op, integer scale, FPCRTType fpcr)
    assert N IN {16,32,64};
    (fptype,sign,value) = FPUnpack(op, fpcr);
    if fptype == FPTType\_SNaN || fptype == FPTType\_QNaN then
        result = FPProcessNaN(fptype, op, fpcr);
    elsif fptype == FPTType\_Zero then
        result = FPZero(sign);
    elsif fptype == FPTType\_Infinity then
        result = FPInfinity(sign);
    else
        result = FPRound(value * (2.0^scale), fpcr);
    return result;
```

## Library pseudocode for aarch64/functions/sve/FPTrigMAdd

```
// FPTrigMAdd()
// =====

bits(N) FPTrigMAdd(integer x, bits(N) op1, bits(N) op2, FPCRTType fpcr)
    assert N IN {16,32,64};
    assert x >= 0;
    assert x < 8;
    bits(N) coeff;

    if op2<N-1> == '1' then
        x = x + 8;
    op2<N-1> = '0';

    coeff = FPTrigMAddCoefficient[x];
    result = FPMulAdd(coeff, op1, op2, fpcr);

    return result;
```

## Library pseudocode for aarch64/functions/sve/FPTrigMAddCoefficient

```
// FPTrigMAddCoefficient()
// =====

bits(N) FPTrigMAddCoefficient[integer index]
  assert N IN {16,32,64};
  integer result;

  if N == 16 then
    case index of
      when 0 result = 0x3c00;
      when 1 result = 0xb155;
      when 2 result = 0x2030;
      when 3 result = 0x0000;
      when 4 result = 0x0000;
      when 5 result = 0x0000;
      when 6 result = 0x0000;
      when 7 result = 0x0000;
      when 8 result = 0x3c00;
      when 9 result = 0xb800;
      when 10 result = 0x293a;
      when 11 result = 0x0000;
      when 12 result = 0x0000;
      when 13 result = 0x0000;
      when 14 result = 0x0000;
      when 15 result = 0x0000;
    elsif N == 32 then
      case index of
        when 0 result = 0x3f800000;
        when 1 result = 0xbe2aaaab;
        when 2 result = 0x3c088886;
        when 3 result = 0xb95008b9;
        when 4 result = 0x36369d6d;
        when 5 result = 0x00000000;
        when 6 result = 0x00000000;
        when 7 result = 0x00000000;
        when 8 result = 0x3f800000;
        when 9 result = 0xbf000000;
        when 10 result = 0x3d2aaaa6;
        when 11 result = 0xbab60705;
        when 12 result = 0x37cd37cc;
        when 13 result = 0x00000000;
        when 14 result = 0x00000000;
        when 15 result = 0x00000000;
      else // N == 64
        case index of
          when 0 result = 0x3ff0000000000000;
          when 1 result = 0xbfc5555555555543;
          when 2 result = 0x3f8111111110f30c;
          when 3 result = 0xbf2a01a019b92fc6;
          when 4 result = 0x3ec71de351f3d22b;
          when 5 result = 0xbe5ae5e2b60f7b91;
          when 6 result = 0x3de5d8408868552f;
          when 7 result = 0x0000000000000000;
          when 8 result = 0x3ff0000000000000;
          when 9 result = 0xbfe0000000000000;
          when 10 result = 0x3fa5555555555536;
          when 11 result = 0xbf56c16c16c13a0b;
          when 12 result = 0x3efa01a019b1e8d8;
          when 13 result = 0xbe927e4f7282f468;
          when 14 result = 0x3e21ee96d2641b13;
          when 15 result = 0xbda8f76380fbb401;

  return result<N-1:0>;
```

### Library pseudocode for aarch64/functions/sve/FPTrigSMul

```
// FPTrigSMul()
// =====

bits(N) FPTrigSMul(bits(N) op1, bits(N) op2, FPCRTType fpcr)
    assert N IN {16,32,64};
    result = FPMul(op1, op1, fpcr);
    (fptype, sign, value) = FPUntpack(result, fpcr);
    if (fptype != FPType\_QNaN) && (fptype != FPType\_SNaN) then
        result<N-1> = op2<0>;

    return result;
```

### Library pseudocode for aarch64/functions/sve/FPTrigSSel

```
// FPTrigSSel()
// =====

bits(N) FPTrigSSel(bits(N) op1, bits(N) op2)
    assert N IN {16,32,64};
    bits(N) result;

    if op2<0> == '1' then
        result = FP0ne(op2<1>);
    else
        result = op1;
        result<N-1> = result<N-1> EOR op2<1>;

    return result;
```

### Library pseudocode for aarch64/functions/sve/FirstActive

```
// FirstActive()
// =====

bit FirstActive(bits(N) mask, bits(N) x, integer esize)
    integer elements = N DIV (esize DIV 8);
    for e = 0 to elements-1
        if ElemP[mask, e, esize] == '1' then return ElemP[x, e, esize];
    return '0';
```

### Library pseudocode for aarch64/functions/sve/FloorPow2

```
// FloorPow2()
// =====
// For a positive integer X, return the largest power of 2 <= X

integer FloorPow2(integer x)
    assert x >= 0;
    integer n = 1;
    if x == 0 then return 0;
    while x >= 2^n do
        n = n + 1;
    return 2^(n - 1);
```

### Library pseudocode for aarch64/functions/sve/HaveSVE

```
// HaveSVE()
// =====

boolean HaveSVE()
    return HasArchVersion(ARMv8p2) && boolean IMPLEMENTATION_DEFINED "Have SVE ISA";
```



### Library pseudocode for aarch64/functions/sve/HaveSVE2

```
// HaveSVE2()  
// =====  
// Returns TRUE if the SVE2 extension is implemented, FALSE otherwise.  
  
boolean HaveSVE2()  
    return HaveSVE() && boolean IMPLEMENTATION_DEFINED "Have SVE2 extension";
```

### Library pseudocode for aarch64/functions/sve/HaveSVE2AES

```
// HaveSVE2AES()  
// =====  
// Returns TRUE if the SVE2 AES extension is implemented, FALSE otherwise.  
  
boolean HaveSVE2AES()  
    return HaveSVE2() && boolean IMPLEMENTATION_DEFINED "Have SVE2 AES extension";
```

### Library pseudocode for aarch64/functions/sve/HaveSVE2BitPerm

```
// HaveSVE2BitPerm()  
// =====  
// Returns TRUE if the SVE2 Bit Permissions extension is implemented, FALSE otherwise.  
  
boolean HaveSVE2BitPerm()  
    return HaveSVE2() && boolean IMPLEMENTATION_DEFINED "Have SVE2 BitPerm extension";
```

### Library pseudocode for aarch64/functions/sve/HaveSVE2PMULL128

```
// HaveSVE2PMULL128()  
// =====  
// Returns TRUE if the SVE2 128 bit PMULL extension is implemented, FALSE otherwise.  
  
boolean HaveSVE2PMULL128()  
    return HaveSVE2() && boolean IMPLEMENTATION_DEFINED "Have SVE2 128 bit PMULL extension";
```

### Library pseudocode for aarch64/functions/sve/HaveSVE2SHA3

```
// HaveSVE2SHA3()  
// =====  
// Returns TRUE if the SVE2 SHA3 extension is implemented, FALSE otherwise.  
  
boolean HaveSVE2SHA3()  
    return HaveSVE2() && boolean IMPLEMENTATION_DEFINED "Have SVE2 SHA3 extension";
```

### Library pseudocode for aarch64/functions/sve/HaveSVE2SM4

```
// HaveSVE2SM4()  
// =====  
// Returns TRUE if the SVE2 SM4 extension is implemented, FALSE otherwise.  
  
boolean HaveSVE2SM4()  
    return HaveSVE2() && boolean IMPLEMENTATION_DEFINED "Have SVE2 SM4 extension";
```

### Library pseudocode for aarch64/functions/sve/HaveSVEFP32MatMulExt

```
// HaveSVEFP32MatMulExt()  
// =====  
// Returns TRUE if single-precision floating-point matrix multiply instruction support implemented and FA  
  
boolean HaveSVEFP32MatMulExt()  
    return HaveSVE() && boolean IMPLEMENTATION_DEFINED "Have SVE FP32 Matrix Multiply extension";
```

### Library pseudocode for aarch64/functions/sve/HaveSVEFP64MatMulExt

```
// HaveSVEFP64MatMulExt()
// =====
// Returns TRUE if double-precision floating-point matrix multiply instruction support implemented and FALSE otherwise.

boolean HaveSVEFP64MatMulExt()
    return HaveSVE() && boolean IMPLEMENTATION_DEFINED "Have SVE FP64 Matrix Multiply extension";
```

### Library pseudocode for aarch64/functions/sve/ImplementedSVEVectorLength

```
// ImplementedSVEVectorLength()
// =====
// Reduce SVE vector length to a supported value (e.g. power of two)

integer ImplementedSVEVectorLength(integer nbits)
    return integer IMPLEMENTATION_DEFINED;
```

### Library pseudocode for aarch64/functions/sve/IsEven

```
// IsEven()
// =====

boolean IsEven(integer val)
    return val MOD 2 == 0;
```

### Library pseudocode for aarch64/functions/sve/IsFPEnabled

```
// IsFPEnabled()
// =====
// Returns TRUE if accesses to the Advanced SIMD and floating-point
// registers are enabled at the target exception level in the current
// execution state and FALSE otherwise.

boolean IsFPEnabled(bits(2) el)
    if ELUsingAArch32(el) then
        return AArch32.IsFPEnabled(el);
    else
        return AArch64.IsFPEnabled(el);
```

### Library pseudocode for aarch64/functions/sve/IsOdd

```
// IsOdd()
// =====

boolean IsOdd(integer val)
    return val MOD 2 == 1;
```

## Library pseudocode for aarch64/functions/sve/IsSVEEnabled

```
// IsSVEEnabled()
// =====
// Returns TRUE if access to SVE instructions and System registers is
// enabled at the target exception level and FALSE otherwise.

boolean IsSVEEnabled(bits(2) el)
    if ELUsingAArch32(el) then
        return FALSE;

    // Check if access disabled in CPACR_EL1
    if el IN {EL0, EL1} && !IsInHost() then
        // Check SVE at EL0/EL1
        case CPACR_EL1.ZEN of
            when 'x0' disabled = TRUE;
            when '01' disabled = el == EL0;
            when '11' disabled = FALSE;
        if disabled then return FALSE;

    // Check if access disabled in CPTR_EL2
    if el IN {EL0, EL1, EL2} && EL2Enabled() then
        if HaveVirtHostExt() && HCR_EL2.E2H == '1' then
            case CPTR_EL2.ZEN of
                when 'x0' disabled = TRUE;
                when '01' disabled = el == EL0 && HCR_EL2.TGE == '1';
                when '11' disabled = FALSE;
            if disabled then return FALSE;
        else
            if CPTR_EL2.TZ == '1' then return FALSE;

    // Check if access disabled in CPTR_EL3
    if HaveEL(EL3) then
        if CPTR_EL3.EZ == '0' then return FALSE;

    return TRUE;
```

## Library pseudocode for aarch64/functions/sve/LastActive

```
// LastActive()
// =====

bit LastActive(bits(N) mask, bits(N) x, integer esize)
    integer elements = N DIV (esize DIV 8);
    for e = elements-1 downto 0
        if ElemP[mask, e, esize] == '1' then return ElemP[x, e, esize];
    return '0';
```

## Library pseudocode for aarch64/functions/sve/LastActiveElement

```
// LastActiveElement()
// =====

integer LastActiveElement(bits(N) mask, integer esize)
    assert esize IN {8, 16, 32, 64};
    integer elements = VL DIV esize;
    for e = elements-1 downto 0
        if ElemP[mask, e, esize] == '1' then return e;
    return -1;
```

## Library pseudocode for aarch64/functions/sve/MAX\_PL

```
constant integer MAX_PL = 256;
```

## Library pseudocode for aarch64/functions/sve/MAX\_VL

```
constant integer MAX_VL = 2048;
```

## Library pseudocode for aarch64/functions/sve/MaybeZeroSVEUppers

```
// MaybeZeroSVEUppers()
// =====

MaybeZeroSVEUppers(bits(2) target_el)
    boolean lower_enabled;

    if UInt(target_el) <= UInt(PSTATE.EL) || !IsSVEEnabled(target_el) then
        return;

    if target_el == EL3 then
        if EL2Enabled() then
            lower_enabled = IsFPEEnabled(EL2);
        else
            lower_enabled = IsFPEEnabled(EL1);
    elsif target_el == EL2 then
        assert !ELUsingAArch32(EL2);
        if HCR_EL2.TGE == '0' then
            lower_enabled = IsFPEEnabled(EL1);
        else
            lower_enabled = IsFPEEnabled(EL0);
    else
        assert target_el == EL1 && !ELUsingAArch32(EL1);
        lower_enabled = IsFPEEnabled(EL0);

    if lower_enabled then
        integer vl = if IsSVEEnabled(PSTATE.EL) then VL else 128;
        integer pl = vl DIV 8;
        for n = 0 to 31
            if ConstrainUnpredictableBool(Unpredictable_SVEZEROUPPER) then
                _Z[n] = ZeroExtend(_Z[n]<vl-1:0>);
        for n = 0 to 15
            if ConstrainUnpredictableBool(Unpredictable_SVEZEROUPPER) then
                _P[n] = ZeroExtend(_P[n]<pl-1:0>);
        if ConstrainUnpredictableBool(Unpredictable_SVEZEROUPPER) then
            _FFR = ZeroExtend(_FFR<pl-1:0>);
```

## Library pseudocode for aarch64/functions/sve/MemNF

```
// MemNF[] - non-assignment form
// =====

(bits(8*size), boolean) MemNF(bits(64) address, integer size, AccType acctype]
    assert size IN {1, 2, 4, 8, 16};
    bits(8*size) value;

    aligned = (address == Align(address, size));
    A = SCTLR[].A;

    if !aligned && (A == '1') then
        return (bits(8*size) UNKNOWN, TRUE);

    atomic = aligned || size == 1;

    if !atomic then
        (value<7:0>, bad) = MemSingleNF[address, 1, acctype, aligned];

        if bad then
            return (bits(8*size) UNKNOWN, TRUE);

        // For subsequent bytes it is CONSTRAINED UNPREDICTABLE whether an unaligned Device memory
        // access will generate an Alignment Fault, as to get this far means the first byte did
        // not, so we must be changing to a new translation page.
        if !aligned then
            c = ConstrainUnpredictable(Unpredictable\_DEVPAGE2);
            assert c IN {Constraint\_FAULT, Constraint\_NONE};
            if c == Constraint\_NONE then aligned = TRUE;

        for i = 1 to size-1
            (value<8*i+7:8*i>, bad) = MemSingleNF[address+i, 1, acctype, aligned];

            if bad then
                return (bits(8*size) UNKNOWN, TRUE);
    else
        (value, bad) = MemSingleNF[address, size, acctype, aligned];
        if bad then
            return (bits(8*size) UNKNOWN, TRUE);

    if BigEndian() then
        value = BigEndianReverse(value);

    return (value, FALSE);
```

## Library pseudocode for aarch64/functions/sve/MemSingleNF

```
// MemSingleNF[] - non-assignment form
// =====

(bits(8*size), boolean) MemSingleNF(bits(64) address, integer size, AccType acctype, boolean wasaligned)
    bits(8*size) value;
    boolean iswrite = FALSE;
    AddressDescriptor memaddrdesc;

    // Implementation may suppress NF load for any reason
    if ConstrainUnpredictableBool(Unpredictable\_NONFAULT) then
        return (bits(8*size) UNKNOWN, TRUE);

    // MMU or MPU
    memaddrdesc = AArch64.TranslateAddress(address, acctype, iswrite, wasaligned, size);

    // Non-fault load from Device memory must not be performed externally
    if memaddrdesc.memattrs.memtype == MemType\_Device then
        return (bits(8*size) UNKNOWN, TRUE);

    // Check for aborts or debug exceptions
    if IsFault(memaddrdesc) then
        return (bits(8*size) UNKNOWN, TRUE);

    // Memory array access
    if HaveTME() then
        transactional = TSTATE.depth > 0;
        accdesc = CreateAccessDescriptor(acctype, transactional);
    else
        accdesc = CreateAccessDescriptor(acctype);
    if HaveMTEExt() then
        if AArch64.AccessIsTagChecked(address, acctype) then
            bits(4) ptag = AArch64.PhysicalTag(address);
            if !AArch64.CheckTag(memaddrdesc, ptag, iswrite) then
                return (bits(8*size) UNKNOWN, TRUE);
    value = _Mem[memaddrdesc, size, accdesc];

    return (value, FALSE);
```

## Library pseudocode for aarch64/functions/sve/NoneActive

```
// NoneActive()
// =====

bit NoneActive(bits(N) mask, bits(N) x, integer esize)
    integer elements = N DIV (esize DIV 8);
    for e = 0 to elements-1
        if ElemP[mask, e, esize] == '1' && ElemP[x, e, esize] == '1' then return '0';
    return '1';
```

## Library pseudocode for aarch64/functions/sve/P

```
// P[] - non-assignment form
// =====

bits(width) P[integer n]
    assert n >= 0 && n <= 31;
    assert width == PL;
    return _P[n]<width-1:0>;

// P[] - assignment form
// =====

P[integer n] = bits(width) value
    assert n >= 0 && n <= 31;
    assert width == PL;
    if ConstrainUnpredictableBool(Unpredictable\_SVEZEROUPPER) then
        _P[n] = ZeroExtend(value);
    else
        _P[n]<width-1:0> = value;
```

## Library pseudocode for aarch64/functions/sve/PL

```
// PL - non-assignment form
// =====

integer PL
    return VL DIV 8;
```

## Library pseudocode for aarch64/functions/sve/PredTest

```
// PredTest()
// =====

bits(4) PredTest(bits(N) mask, bits(N) result, integer esize)
    bit n = FirstActive(mask, result, esize);
    bit z = NoneActive(mask, result, esize);
    bit c = NOT LastActive(mask, result, esize);
    bit v = '0';
    return n:z:c:v;
```

## Library pseudocode for aarch64/functions/sve/ReducePredicated

```
// ReducePredicated()
// =====

bits(esize) ReducePredicated(ReduceOp op, bits(N) input, bits(M) mask, bits(esize) identity)
    assert(N == M * 8);
    integer p2bits = CeilPow2(N);
    bits(p2bits) operand;
    integer elements = p2bits DIV esize;

    for e = 0 to elements-1
        if e * esize < N && ElemP[mask, e, esize] == '1' then
            Elem[operand, e, esize] = Elem[input, e, esize];
        else
            Elem[operand, e, esize] = identity;

    return Reduce(op, operand, esize);
```

## Library pseudocode for aarch64/functions/sve/Reverse

```
// Reverse()
// =====
// Reverse subwords of M bits in an N-bit word

bits(N) Reverse(bits(N) word, integer M)
    bits(N) result;
    integer sw = N DIV M;
    assert N == sw * M;
    for s = 0 to sw-1
        Elem[result, sw - 1 - s, M] = Elem[word, s, M];
    return result;
```

## Library pseudocode for aarch64/functions/sve/SVEAccessTrap

```
// SVEAccessTrap()
// =====
// Trapped access to SVE registers due to CPACR_EL1, CPTR_EL2, or CPTR_EL3.

SVEAccessTrap(bits(2) target_el)
    assert UInt(target_el) >= UInt(PSTATE.EL) && target_el != EL0 && HaveEL(target_el);
    route_to_el2 = target_el == EL1 && EL2Enabled() && HCR_EL2.TGE == '1';

    exception = ExceptionSyndrome(Exception_SVEAccessTrap);
    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x0;

    if route_to_el2 then
        AArch64.TakeException(EL2, exception, preferred_exception_return, vect_offset);
    else
        AArch64.TakeException(target_el, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/functions/sve/SVECmp

```
enumeration SVECmp { Cmp_EQ, Cmp_NE, Cmp_GE, Cmp_GT, Cmp_LT, Cmp_LE, Cmp_UN };
```



## Library pseudocode for aarch64/functions/sve/SVEMoveMaskPreferred

```
// SVEMoveMaskPreferred()
// =====
// Return FALSE if a bitmask immediate encoding would generate an immediate
// value that could also be represented by a single DUP instruction.
// Used as a condition for the preferred MOV<-DUPM alias.

boolean SVEMoveMaskPreferred(bits(13) imm13)
  bits(64) imm;
  (imm, -) = DecodeBitMasks(imm13<12>, imm13<5:0>, imm13<11:6>, TRUE);

  // Check for 8 bit immediates
  if !IsZero(imm<7:0>) then
    // Check for 'ffffffffffffxy' or '00000000000000xy'
    if IsZero(imm<63:7>) || IsOnes(imm<63:7>) then
      return FALSE;

    // Check for 'ffffffxyffffffxy' or '000000xy000000xy'
    if imm<63:32> == imm<31:0> && (IsZero(imm<31:7>) || IsOnes(imm<31:7>)) then
      return FALSE;

    // Check for 'ffxyffxyffxyffxy' or '00xy00xy00xy00xy'
    if imm<63:32> == imm<31:0> && imm<31:16> == imm<15:0> && (IsZero(imm<15:7>) || IsOnes(imm<15:7>)) then
      return FALSE;

    // Check for 'xyxyxyxyxyxyxyxy'
    if imm<63:32> == imm<31:0> && imm<31:16> == imm<15:0> && (imm<15:8> == imm<7:0>) then
      return FALSE;

  // Check for 16 bit immediates
  else
    // Check for 'ffffffffffffxy00' or '00000000000000xy00'
    if IsZero(imm<63:15>) || IsOnes(imm<63:15>) then
      return FALSE;

    // Check for 'ffffxy00ffffxy00' or '0000xy000000xy00'
    if imm<63:32> == imm<31:0> && (IsZero(imm<31:7>) || IsOnes(imm<31:7>)) then
      return FALSE;

    // Check for 'xy00xy00xy00xy00'
    if imm<63:32> == imm<31:0> && imm<31:16> == imm<15:0> then
      return FALSE;

  return TRUE;
```

## Library pseudocode for aarch64/functions/sve/ShiftSat

```
// ShiftSat()
// =====

integer ShiftSat(integer shift, integer esize)
  if shift > esize+1 then return esize+1;
  elsif shift < -(esize+1) then return -(esize+1);
  return shift;
```

## Library pseudocode for aarch64/functions/sve/System

```
array bits(MAX_VL) _Z[0..31];
array bits(MAX_PL) _P[0..15];
bits(MAX_PL) _FFR;
```

## Library pseudocode for aarch64/functions/sve/VL

```
// VL - non-assignment form
// =====

integer VL
integer vl;

if PSTATE.EL == EL1 || (PSTATE.EL == EL0 && !IsInHost()) then
    vl = UInt(ZCR_EL1.LEN);

if PSTATE.EL == EL2 || (PSTATE.EL == EL0 && IsInHost()) then
    vl = UInt(ZCR_EL2.LEN);
elseif PSTATE.EL IN {EL0, EL1} && EL2Enabled() then
    vl = Min(vl, UInt(ZCR_EL2.LEN));

if PSTATE.EL == EL3 then
    vl = UInt(ZCR_EL3.LEN);
elseif HaveEL(EL3) then
    vl = Min(vl, UInt(ZCR_EL3.LEN));

vl = (vl + 1) * 128;
vl = ImplementedSVEVectorLength(vl);

return vl;
```

## Library pseudocode for aarch64/functions/sve/Z

```
// Z[] - non-assignment form
// =====

bits(width) Z[integer n]
assert n >= 0 && n <= 31;
assert width == VL;
return _Z[n]<width-1:0>;

// Z[] - assignment form
// =====

Z[integer n] = bits(width) value
assert n >= 0 && n <= 31;
assert width == VL;
if ConstrainUnpredictableBool(Unpredictable_SVEZERoupper) then
    _Z[n] = ZeroExtend(value);
else
    _Z[n]<width-1:0> = value;
```

## Library pseudocode for aarch64/functions/sysregisters/CNTKCTL

```
// CNTKCTL[] - non-assignment form
// =====

CNTKCTLType CNTKCTL[]
bits(32) r;
if IsInHost() then
    r = CNTHCTL_EL2;
    return r;
r = CNTKCTL_EL1;
return r;
```

## Library pseudocode for aarch64/functions/sysregisters/CNTKCTLType

```
type CNTKCTLType;
```

## Library pseudocode for aarch64/functions/sysregisters/CPACR

```
// CPACR[] - non-assignment form
// =====

CPACRTYPE CPACR[]
  bits(32) r;
  if IsInHost() then
    r = CPTR_EL2;
    return r;
  r = CPACR_EL1;
  return r;
```

## Library pseudocode for aarch64/functions/sysregisters/CPACRTYPE

```
type CPACRTYPE;
```

## Library pseudocode for aarch64/functions/sysregisters/ELR

```
// ELR[] - non-assignment form
// =====

bits(64) ELR[bits(2) el]
  bits(64) r;
  case el of
    when EL1  r = ELR_EL1;
    when EL2  r = ELR_EL2;
    when EL3  r = ELR_EL3;
    otherwise Unreachable();
  return r;

// ELR[] - non-assignment form
// =====

bits(64) ELR[]
  assert PSTATE.EL != EL0;
  return ELR[PSTATE.EL];

// ELR[] - assignment form
// =====

ELR[bits(2) el] = bits(64) value
  bits(64) r = value;
  case el of
    when EL1  ELR_EL1 = r;
    when EL2  ELR_EL2 = r;
    when EL3  ELR_EL3 = r;
    otherwise Unreachable();
  return;

// ELR[] - assignment form
// =====

ELR[] = bits(64) value
  assert PSTATE.EL != EL0;
  ELR[PSTATE.EL] = value;
  return;
```

## Library pseudocode for aarch64/functions/sysregisters/ESR

```
// ESR[] - non-assignment form
// =====

ESRType ESR[bits(2) regime]
    bits(32) r;
    case regime of
        when EL1    r = ESR_EL1;
        when EL2    r = ESR_EL2;
        when EL3    r = ESR_EL3;
        otherwise Unreachable\(\);
    return r;

// ESR[] - non-assignment form
// =====

ESRType ESR[]
    return ESR\[S1TranslationRegime\\(\\)\];

// ESR[] - assignment form
// =====

ESR[bits(2) regime] = ESRType value
    bits(32) r = value;
    case regime of
        when EL1    ESR_EL1 = r;
        when EL2    ESR_EL2 = r;
        when EL3    ESR_EL3 = r;
        otherwise Unreachable\(\);
    return;

// ESR[] - assignment form
// =====

ESR[] = ESRType value
    ESR\[S1TranslationRegime\\(\\)\] = value;
```

## Library pseudocode for aarch64/functions/sysregisters/ESRType

```
type ESRType;
```

## Library pseudocode for aarch64/functions/sysregisters/FAR

```
// FAR[] - non-assignment form
// =====

bits(64) FAR[bits(2) regime]
  bits(64) r;
  case regime of
    when EL1   r = FAR_EL1;
    when EL2   r = FAR_EL2;
    when EL3   r = FAR_EL3;
    otherwise Unreachable\(\);
  return r;

// FAR[] - non-assignment form
// =====

bits(64) FAR[]
  return FAR\[S1TranslationRegime\(\)\];

// FAR[] - assignment form
// =====

FAR[bits(2) regime] = bits(64) value
  bits(64) r = value;
  case regime of
    when EL1   FAR_EL1 = r;
    when EL2   FAR_EL2 = r;
    when EL3   FAR_EL3 = r;
    otherwise Unreachable\(\);
  return;

// FAR[] - assignment form
// =====

FAR[] = bits(64) value
  FAR\[S1TranslationRegime\(\)\] = value;
  return;
```

## Library pseudocode for aarch64/functions/sysregisters/MAIR

```
// MAIR[] - non-assignment form
// =====

MAIRType MAIR[bits(2) regime]
  bits(64) r;
  case regime of
    when EL1   r = MAIR_EL1;
    when EL2   r = MAIR_EL2;
    when EL3   r = MAIR_EL3;
    otherwise Unreachable\(\);
  return r;

// MAIR[] - non-assignment form
// =====

MAIRType MAIR[]
  return MAIR\[S1TranslationRegime\(\)\];
```

## Library pseudocode for aarch64/functions/sysregisters/MAIRType

```
type MAIRType;
```

## Library pseudocode for aarch64/functions/sysregisters/SCTLR

```
// SCTLR[] - non-assignment form
// =====

SCTLRType SCTLR[bits(2) regime]
    bits(64) r;
    case regime of
        when EL1    r = SCTLR_EL1;
        when EL2    r = SCTLR_EL2;
        when EL3    r = SCTLR_EL3;
        otherwise Unreachable\(\);
    return r;

// SCTLR[] - non-assignment form
// =====

SCTLRType SCTLR[]
    return SCTLR\[S1TranslationRegime\(\)\];
```

## Library pseudocode for aarch64/functions/sysregisters/SCTLRType

```
type SCTLRType;
```

## Library pseudocode for aarch64/functions/sysregisters/VBAR

```
// VBAR[] - non-assignment form
// =====

bits(64) VBAR[bits(2) regime]
    bits(64) r;
    case regime of
        when EL1    r = VBAR_EL1;
        when EL2    r = VBAR_EL2;
        when EL3    r = VBAR_EL3;
        otherwise Unreachable\(\);
    return r;

// VBAR[] - non-assignment form
// =====

bits(64) VBAR[]
    return VBAR\[S1TranslationRegime\(\)\];
```

## Library pseudocode for aarch64/functions/system/AArch64.AllocationTagAccessIsEnabled

```
// AArch64.AllocationTagAccessIsEnabled()
// =====
// Check whether access to Allocation Tags is enabled.

boolean AArch64.AllocationTagAccessIsEnabled(AccType acctype)
    bits(2) el;
    if AArch64.AccessIsPrivileged(acctype) then
        el = PSTATE.EL;
    else
        el = EL0;

    if SCR_EL3.ATA == '0' && el IN {EL0, EL1, EL2} then
        return FALSE;
    elsif HCR_EL2.ATA == '0' && el IN {EL0, EL1} && EL2Enabled() && HCR_EL2.<E2H,TGE> != '11' then
        return FALSE;
    elsif SCTL_EL3.ATA == '0' && el == EL3 then
        return FALSE;
    elsif SCTL_EL2.ATA == '0' && el == EL2 then
        return FALSE;
    elsif SCTL_EL1.ATA == '0' && el == EL1 then
        return FALSE;
    elsif SCTL_EL2.ATA0 == '0' && el == EL0 && EL2Enabled() && HCR_EL2.<E2H,TGE> == '11' then
        return FALSE;
    elsif SCTL_EL1.ATA0 == '0' && el == EL0 && !(EL2Enabled() && HCR_EL2.<E2H,TGE> == '11') then
        return FALSE;
    else
        return TRUE;
```

## Library pseudocode for aarch64/functions/system/AArch64.CheckSystemAccess

```
// AArch64.CheckSystemAccess()
// =====
// Checks if an AArch64 MSR, MRS or SYS instruction is allowed from
// the current exception level and security state. Also checks for
// traps by TIDCP to IMPLEMENTATION DEFINED registers and for NV access.

AArch64.CheckSystemAccess(bits(2) op0, bits(3) op1, bits(4) crn,
                           bits(4) crm, bits(3) op2, bits(5) rt, bit read)
    need_secure = FALSE;
    if (HaveTME() && TSTATE.depth > 0 &&
        !CheckTransactionalSystemAccess(op0, op1, crn, crm, op2, read)) then
        FailTransaction(TMFailure_ERR, FALSE);

    case op1 of
        when '00x'
            min_EL = EL1;
        when '010'
            min_EL = EL1;
        when '011'
            min_EL = EL0;
        when '100'
            min_EL = EL2;
        when '101'
            if !HaveVirtHostExt() then
                UNDEFINED;
            min_EL = EL2;
        when '110'
            min_EL = EL3;
        when '111'
            min_EL = EL1;
            need_secure = TRUE;

    if UInt(PSTATE.EL) < UInt(min_EL) then
        UNDEFINED;
    elsif need_secure && !IsSecure() then
        UNDEFINED;
```

### Library pseudocode for aarch64/functions/system/AArch64.ChooseNonExcludedTag

```
// AArch64.ChooseNonExcludedTag()
// =====
// Return a tag derived from the start and the offset values, excluding
// any tags in the given mask.

bits(4) AArch64.ChooseNonExcludedTag(bits(4) tag, bits(4) offset, bits(16) exclude)
    if IsOnes(exclude) then
        return '0000';

    if offset == '0000' then
        while exclude<UInt(tag)> == '1' do
            tag = tag + '0001';

    while offset != '0000' do
        offset = offset - '0001';
        tag = tag + '0001';
        while exclude<UInt(tag)> == '1' do
            tag = tag + '0001';

    return tag;
```

### Library pseudocode for aarch64/functions/system/AArch64.ExecutingATS1xPInstr

```
// AArch64.ExecutingATS1xPInstr()
// =====
// Return TRUE if current instruction is AT S1E1R/WP

boolean AArch64.ExecutingATS1xPInstr()
    if !HavePrivATExt() then return FALSE;

    instr = ThisInstr();
    if instr<22+:10> == '1101010100' then
        op1 = instr<16+:3>;
        CRn = instr<12+:4>;
        CRm = instr<8+:4>;
        op2 = instr<5+:3>;
        return op1 == '000' && CRn == '0111' && CRm == '1001' && op2 IN {'000', '001'};
    else
        return FALSE;
```

### Library pseudocode for aarch64/functions/system/AArch64.ExecutingBR0rBLR0rRetInstr

```
// AArch64.ExecutingBR0rBLR0rRetInstr()
// =====
// Returns TRUE if current instruction is a BR, BLR, RET, B[L]RA[B][Z], or RETA[B].

boolean AArch64.ExecutingBR0rBLR0rRetInstr()
    if !HaveBTIExt() then return FALSE;

    instr = ThisInstr();
    if instr<31:25> == '1101011' && instr<20:16> == '11111' then
        opc = instr<24:21>;
        return opc != '0101';
    else
        return FALSE;
```



### Library pseudocode for aarch64/functions/system/AArch64.ExecutingBTIInstr

```
// AArch64.ExecutingBTIInstr()
// =====
// Returns TRUE if current instruction is a BTI.

boolean AArch64.ExecutingBTIInstr()
    if !HaveBTIExt() then return FALSE;

    instr = ThisInstr();
    if instr<31:22> == '1101010100' && instr<21:12> == '0000110010' && instr<4:0> == '11111' then
        CRm = instr<11:8>;
        op2 = instr<7:5>;
        return (CRm == '0100' && op2<0> == '0');
    else
        return FALSE;
```

### Library pseudocode for aarch64/functions/system/AArch64.ExecutingERETInstr

```
// AArch64.ExecutingERETInstr()
// =====
// Returns TRUE if current instruction is ERET.

boolean AArch64.ExecutingERETInstr()
    instr = ThisInstr();
    return instr<31:12> == '11010110100111110000';
```

### Library pseudocode for aarch64/functions/system/AArch64.NextRandomTagBit

```
// AArch64.NextRandomTagBit()
// =====
// Generate a random bit suitable for generating a random Allocation Tag.

bit AArch64.NextRandomTagBit()
    bits(16) lfsr = RGSr_EL1.SEED;
    bit top = lfsr<5> EOR lfsr<3> EOR lfsr<2> EOR lfsr<0>;
    RGSr_EL1.SEED = top:lfsr<15:1>;
    return top;
```

### Library pseudocode for aarch64/functions/system/AArch64.RandomTag

```
// AArch64.RandomTag()
// =====
// Generate a random Allocation Tag.

bits(4) AArch64.RandomTag()
    bits(4) tag;
    for i = 0 to 3
        tag<i> = AArch64.NextRandomTagBit();
    return tag;
```

### Library pseudocode for aarch64/functions/system/AArch64.SysInstr

```
// Execute a system instruction with write (source operand).
AArch64.SysInstr(integer op0, integer op1, integer crn, integer crm, integer op2, bits(64) val);
```

### Library pseudocode for aarch64/functions/system/AArch64.SysInstrWithResult

```
// Execute a system instruction with read (result operand).
// Returns the result of the instruction.
bits(64) AArch64.SysInstrWithResult(integer op0, integer op1, integer crn, integer crm, integer op2);
```

### Library pseudocode for aarch64/functions/system/AArch64.SysRegRead

```
// Read from a system register and return the contents of the register.  
bits(64) AArch64.SysRegRead(integer op0, integer op1, integer crn, integer crm, integer op2);
```

### Library pseudocode for aarch64/functions/system/AArch64.SysRegWrite

```
// Write to a system register.  
AArch64.SysRegWrite(integer op0, integer op1, integer crn, integer crm, integer op2, bits(64) val);
```

### Library pseudocode for aarch64/functions/system/BTypeCompatible

```
boolean BTypeCompatible;
```

### Library pseudocode for aarch64/functions/system/BTypeCompatible\_BTI

```
// BTypeCompatible_BTI  
// =====  
// This function determines whether a given hint encoding is compatible with the current value of  
// PSTATE.BTYPE. A value of TRUE here indicates a valid Branch Target Identification instruction.  
  
boolean BTypeCompatible_BTI(bits(2) hintcode)  
    case hintcode of  
        when '00'  
            return FALSE;  
        when '01'  
            return PSTATE.BTYPE != '11';  
        when '10'  
            return PSTATE.BTYPE != '10';  
        when '11'  
            return TRUE;
```

### Library pseudocode for aarch64/functions/system/BTypeCompatible\_PACIXSP

```
// BTypeCompatible_PACIXSP()  
// =====  
// Returns TRUE if PACIASP, PACIBSP instruction is implicit compatible with PSTATE.BTYPE,  
// FALSE otherwise.  
  
boolean BTypeCompatible_PACIXSP()  
    if PSTATE.BTYPE IN {'01', '10'} then  
        return TRUE;  
    elsif PSTATE.BTYPE == '11' then  
        index = if PSTATE.EL == EL0 then 35 else 36;  
        return SCTLR[]<index> == '0';  
    else  
        return FALSE;
```

### Library pseudocode for aarch64/functions/system/BTypeNext

```
bits(2) BTypeNext;
```

### Library pseudocode for aarch64/functions/system/InGuardedPage

```
boolean InGuardedPage;
```

### Library pseudocode for aarch64/functions/system/SetBTypeCompatible

```
// SetBTypeCompatible()  
// =====  
// Sets the value of BTypeCompatible global variable used by BTI  
  
SetBTypeCompatible(boolean x)  
    BTypeCompatible = x;
```

## Library pseudocode for aarch64/functions/system/SetBTypeNext

```
// SetBTypeNext()
// =====
// Set the value of BTypeNext global variable used by BTI

SetBTypeNext(bits(2) x)
    BTypeNext = x;
```

## Library pseudocode for aarch64/functions/system/\_ChooseRandomNonExcludedTag

```
// The _ChooseRandomNonExcludedTag function is used when GCR_EL1.RRND == '1' to generate random
// Allocation Tags.
//
// The resulting Allocation Tag is selected from the set [0,15], excluding any Allocation Tag where
// exclude[tag_value] == 1. If 'exclude' is all ones, the returned Allocation Tag is '0000'.
//
// This function is expected to generate a non-deterministic selection from the set of non-excluded
// Allocation Tags. A reasonable implementation is described by the Pseudocode used when
// GCR_EL1.RRND is 0, but with a non-deterministic implementation of NextRandomTagBit().
bits(4) _ChooseRandomNonExcludedTag(bits(16) exclude);
```

## Library pseudocode for aarch64/functions/tme/CheckTMEEnabled

```
// CheckTMEEnabled()
// =====
// Returns TRUE if access to TME instruction is enabled, FALSE otherwise.

CheckTMEEnabled()
    if PSTATE.EL IN {EL0, EL1, EL2} && HaveEL(EL3) then
        if SCR_EL3.TME == '0' then UNDEFINED;
    if PSTATE.EL IN {EL0, EL1} && EL2Enabled() then
        if HCR_EL2.TME == '0' then UNDEFINED;
    return;
```

## Library pseudocode for aarch64/functions/tme/CheckTransactionalSystemAccess

```
// CheckTransactionalSystemAccess()
// =====
// Returns TRUE if an AArch64 MSR, MRS, or SYS instruction is permitted in
// Transactional state, based on the opcode's encoding, and FALSE otherwise.

boolean CheckTransactionalSystemAccess(bits(2) op0, bits(3) op1, bits(4) crn, bits(4) crm, bits(3) op2, b
    case read:op0:op1:crn:crm:op2 of
        when '0 00 011 0100 xxxx 11x' return TRUE;           // MSR (imm): DAIFSet, DAIFClr
        when '0 01 011 0111 0100 001' return TRUE;           // DC ZVA
        when '0 11 011 0100 0010 00x' return TRUE;           // MSR: NZCV, DAIF
        when '0 11 011 0100 0100 00x' return TRUE;           // MSR: FPCR, FPSR
        when '0 11 000 0100 0110 000' return TRUE;           // MSR: ICC_PMR_EL1
        when '0 11 011 1001 1100 100' return TRUE;           // MRS: PMSWINC_EL0
        when '1 11 xxx 0xxx xxxx xxx' return TRUE;           // MRS: op1=3, CRn=0..7
        when '1 11 xxx 100x xxxx xxx' return TRUE;           // MRS: op1=3, CRn=8..9
        when '1 11 xxx 1010 xxxx xxx' return TRUE;           // MRS: op1=3, CRn=10
        when '1 11 000 1100 1x00 010' return TRUE;           // MRS: op1=3, CRn=12 - ICC_HPPIRx_EL1
        when '1 11 000 1100 1011 011' return TRUE;           // MRS: op1=3, CRn=12 - ICC_RPR_EL1
        when '1 11 xxx 1101 xxxx xxx' return TRUE;           // MRS: op1=3, CRn=13
        when '1 11 xxx 1110 xxxx xxx' return TRUE;           // MRS: op1=3, CRn=14
        when 'x 11 xxx 1x11 xxxx xxx' return boolean IMPLEMENTATION_DEFINED; // MRS: op1=3, CRn=11,15
        otherwise return FALSE;                               // all other SYS, SYSL, MRS, MSR
```

## Library pseudocode for aarch64/functions/tme/CommitTransactionalWrites

```
// Makes all transactional writes to memory observable by other PEs and reset
// the transactional read and write sets.
CommitTransactionalWrites();
```

## Library pseudocode for aarch64/functions/tme/DiscardTransactionalWrites

```
// Discards all transactional writes to memory and reset the transactional
// read and write sets.
DiscardTransactionalWrites();
```

## Library pseudocode for aarch64/functions/tme/FailTransaction

```
// FailTransaction()
// =====

FailTransaction(TMFailure cause, boolean retry)
    FailTransaction(cause, retry, FALSE, Zeros(15));
    return;

// FailTransaction()
// =====
// Exits Transactional state and discards transactional updates to registers
// and memory.

FailTransaction(TMFailure cause, boolean retry, boolean interrupt, bits(15) reason)
    assert !retry || !interrupt;

    DiscardTransactionalWrites();
    RestoreTransactionCheckpoint();
    ClearExclusiveLocal(ProcessorID());

    bits(64) result = Zeros();

    result<23> = if interrupt then '1' else '0';
    result<15> = if retry && !interrupt then '1' else '0';
    case cause of
        when TMFailure_DBG    result<22> = '1';
        when TMFailure_NEST   result<21> = '1';
        when TMFailure_SIZE   result<20> = '1';
        when TMFailure_ERR    result<19> = '1';
        when TMFailure_IMP    result<18> = '1';
        when TMFailure_MEM    result<17> = '1';
        when TMFailure_CNCL   result<16> = '1'; result<14:0> = reason;

    TSTATE.depth = 0;
    X[TSTATE.Rt] = result;
    BranchTo(TSTATE.nPC, BranchType_TMFAIL);
    EndOfInstruction();
    return;
```

## Library pseudocode for aarch64/functions/tme/RestoreTransactionCheckpoint

```
// RestoreTransactionCheckpoint()
// =====
// Restores part of the PE registers from the transaction checkpoint.

RestoreTransactionCheckpoint()
    SP[] = TSTATE.SP;
    ICC_PMR_EL1 = TSTATE.ICC_PMR_EL1;
    PSTATE.<N,Z,C,V> = TSTATE.nzcv;
    PSTATE.<D,A,I,F> = TSTATE.<D,A,I,F>;

    for n = 0 to 30
        X[n] = TSTATE.X[n];

    if IsFPEEnabled(PSTATE.EL) then
        if IsSVEEnabled(PSTATE.EL) then
            for n = 0 to 31
                Z[n] = TSTATE.Z[n]<VL-1:0>;
            for n = 0 to 15
                P[n] = TSTATE.P[n]<PL-1:0>;
            FFR[] = TSTATE.FFR<PL-1:0>;
        else
            for n = 0 to 31
                V[n] = TSTATE.Z[n]<127:0>;
            FPCR = TSTATE.FPCR;
            FPSR = TSTATE.FPSR;

    return;
```

## Library pseudocode for aarch64/functions/tme/StartTrackingTransactionalReadsWrites

```
// Starts tracking transactional reads and writes to memory.
StartTrackingTransactionalReadsWrites();
```

## Library pseudocode for aarch64/functions/tme/TMFailure

```
enumeration TMFailure {
    TMFailure_CNCL,    // Executed a TCANCEL instruction
    TMFailure_DBG,     // A debug event was generated
    TMFailure_ERR,     // A non-permissible operation was attempted
    TMFailure_NEST,    // The maximum transactional nesting level was exceeded
    TMFailure_SIZE,    // The transactional read or write set limit was exceeded
    TMFailure_MEM,     // A transactional conflict occurred
    TMFailure_TRIVIAL, // Only a TRIVIAL version of TM is available
    TMFailure_IMP      // Any other failure cause
};
```

## Library pseudocode for aarch64/functions/tme/TMState

```
type TMState is (
    integer    depth,           // Transaction nesting depth
    integer    Rt,             // TSTART destination register
    bits(64)   nPC,            // Fallback instruction address
    array[0..30] of bits(64)   X, // General purpose registers
    array[0..31] of bits(MAX_VL) Z, // Vector registers
    array[0..15] of bits(MAX_PL) P, // Predicate registers
    bits(MAX_PL) FFR,          // First Fault Register
    bits(64)   SP,             // Stack Pointer at current EL
    bits(32)   FPCR,           // Floating-point Control Register
    bits(32)   FPSR,           // Floating-point Status Register
    bits(32)   ICC_PMR_EL1,    // Interrupt Controller Interrupt Priority Mask Register
    bits(4)    nzcv,           // Condition flags
    bits(1)    D,              // Debug mask bit
    bits(1)    A,              // SError interrupt mask bit
    bits(1)    I,              // IRQ mask bit
    bits(1)    F               // FIQ mask bit
);
```

## Library pseudocode for aarch64/functions/tme/TSTATE

```
TMState TSTATE;
```

## Library pseudocode for aarch64/functions/tme/TakeTransactionCheckpoint

```
// TakeTransactionCheckpoint()
// =====
// Captures part of the PE registers into the transaction checkpoint.

TakeTransactionCheckpoint()
    TSTATE.SP = SP[];
    TSTATE.ICC_PMR_EL1 = ICC_PMR_EL1;
    TSTATE.nzcv = PSTATE.<N,Z,C,V>;
    TSTATE.<D,A,I,F> = PSTATE.<D,A,I,F>;

    for n = 0 to 30
        TSTATE.X[n] = X[n];

    if IsFPEEnabled(PSTATE.EL) then
        if IsSVEEnabled(PSTATE.EL) then
            for n = 0 to 31
                TSTATE.Z[n]<VL-1:0> = Z[n];
            for n = 0 to 15
                TSTATE.P[n]<PL-1:0> = P[n];
            TSTATE.FFR<PL-1:0> = FFR[];
        else
            for n = 0 to 31
                TSTATE.Z[n]<127:0> = V[n];
            TSTATE.FPCR = FPCR;
            TSTATE.FPSR = FPSR;

    return;
```

## Library pseudocode for aarch64/functions/tme/TransactionStartTrap

```
// TransactionStartTrap()
// =====
// Traps the execution of TSTART instruction.

TransactionStartTrap(integer dreg)
    bits(64) preferred_exception_return = ThisInstrAddr();
    vect_offset = 0x0;

    exception = ExceptionSyndrome(Exception_TSTARTAccessTrap);
    exception.syndrome<9:5> = dreg<4:0>;

    if UInt(PSTATE.EL) > UInt(EL1) then
        targetEL = PSTATE.EL;
    elsif EL2Enabled() && HCR_EL2.TGE == '1' then
        targetEL = EL2;
    else
        targetEL = EL1;
    AArch64.TakeException(targetEL, exception, preferred_exception_return, vect_offset);
```

## Library pseudocode for aarch64/instrs/branch/eret/AArch64.ExceptionReturn

```
// AArch64.ExceptionReturn()
// =====

AArch64.ExceptionReturn(bits(64) new_pc, bits(32) spsr)

    if HaveTME() && TSTATE.depth > 0 then
        FailTransaction(TMFailure_ERR, FALSE);

    SynchronizeContext();

    sync_errors = HaveIESB() && SCTLRL[0].IESB == '1';
    if HaveDoubleFaultExt() then
        sync_errors = sync_errors || (SCR_EL3.EA == '1' && SCR_EL3.NMEA == '1' && PSTATE.EL == EL3);
    if sync_errors then
        SynchronizeErrors();
        iesb_req = TRUE;
        TakeUnmaskedPhysicalSErrorInterrupts(iesb_req);
    // Attempts to change to an illegal state will invoke the Illegal Execution state mechanism
    SetPSTATEFromPSR(spsr);
    ClearExclusiveLocal(ProcessorID());
    SendEventLocal();

    if PSTATE.IL == '1' && spsr<4> == '1' && spsr<20> == '0' then
        // If the exception return is illegal, PC[63:32,1:0] are UNKNOWN
        new_pc<63:32> = bits(32) UNKNOWN;
        new_pc<1:0> = bits(2) UNKNOWN;
    elseif UsingAArch32() then // Return to AArch32
        // ELR_ElX[1:0] or ELR_ElX[0] are treated as being 0, depending on the target instruction set state
        if PSTATE.T == '1' then
            new_pc<0> = '0'; // T32
        else
            new_pc<1:0> = '00'; // A32
    else // Return to AArch64
        // ELR_ElX[63:56] might include a tag
        new_pc = AArch64.BranchAddr(new_pc);

    if UsingAArch32() then
        // 32 most significant bits are ignored.
        BranchTo(new_pc<31:0>, BranchType_ERET);
    else
        BranchToAddr(new_pc, BranchType_ERET);
```

## Library pseudocode for aarch64/instrs/countop/CountOp

```
enumeration CountOp {CountOp_CLZ, CountOp_CLS, CountOp_CNT};
```

## Library pseudocode for aarch64/instrs/extendreg/DecodeRegExtend

```
// DecodeRegExtend()
// =====
// Decode a register extension option

ExtendType DecodeRegExtend(bits(3) op)
    case op of
        when '000' return ExtendType_UXTB;
        when '001' return ExtendType_UXTH;
        when '010' return ExtendType_UXTW;
        when '011' return ExtendType_UXTX;
        when '100' return ExtendType_SXTB;
        when '101' return ExtendType_SXTH;
        when '110' return ExtendType_SXTW;
        when '111' return ExtendType_SXTX;
```

## Library pseudocode for aarch64/instrs/extendreg/ExtendReg

```
// ExtendReg()
// =====
// Perform a register extension and shift

bits(N) ExtendReg(integer reg, ExtendType exttype, integer shift)
    assert shift >= 0 && shift <= 4;
    bits(N) val = X[reg];
    boolean unsigned;
    integer len;

    case exttype of
        when ExtendType_SXTB unsigned = FALSE; len = 8;
        when ExtendType_SXTH unsigned = FALSE; len = 16;
        when ExtendType_SXTW unsigned = FALSE; len = 32;
        when ExtendType_SCTX unsigned = FALSE; len = 64;
        when ExtendType_UXTB unsigned = TRUE; len = 8;
        when ExtendType_UXTH unsigned = TRUE; len = 16;
        when ExtendType_UXTW unsigned = TRUE; len = 32;
        when ExtendType_UCTX unsigned = TRUE; len = 64;

    // Note the extended width of the intermediate value and
    // that sign extension occurs from bit <len+shift-1>, not
    // from bit <len-1>. This is equivalent to the instruction
    // [SU]BFIZ Rtmp, Rreg, #shift, #len
    // It may also be seen as a sign/zero extend followed by a shift:
    // LSL(Extend(val<len-1:0>, N, unsigned), shift);

    len = Min(len, N - shift);
    return Extend(val<len-1:0> : Zeros(shift), N, unsigned);
```

## Library pseudocode for aarch64/instrs/extendreg/ExtendType

```
enumeration ExtendType {ExtendType_SXTB, ExtendType_SXTH, ExtendType_SXTW, ExtendType_SCTX,
                        ExtendType_UXTB, ExtendType_UXTH, ExtendType_UXTW, ExtendType_UCTX};
```

## Library pseudocode for aarch64/instrs/float/arithmetic/max-min/fpmaxminop/FPMaxMinOp

```
enumeration FPMaxMinOp {FPMaxMinOp_MAX, FPMaxMinOp_MIN,
                        FPMaxMinOp_MAXNUM, FPMaxMinOp_MINNUM};
```

## Library pseudocode for aarch64/instrs/float/arithmetic/unary/fpunaryop/FPUnaryOp

```
enumeration FPUnaryOp {FPUnaryOp_ABS, FPUnaryOp_MOV,
                       FPUnaryOp_NEG, FPUnaryOp_SQRT};
```

## Library pseudocode for aarch64/instrs/float/convert/fpconvop/FPConvOp

```
enumeration FPConvOp {FPConvOp_CVT_FtoI, FPConvOp_CVT_ItoF,
                      FPConvOp_MOV_FtoI, FPConvOp_MOV_ItoF,
                      , FPConvOp_CVT_FtoI_JS
};
```



## Library pseudocode for aarch64/instrs/integer/bitfield/bfxpreferred/BFXPreferred

```
// BFXPreferred()
// =====
//
// Return TRUE if UBFX or SBFX is the preferred disassembly of a
// UBFM or SBFM bitfield instruction. Must exclude more specific
// aliases UBFIZ, SBFIZ, UXT[BH], SXT[BHW], LSL, LSR and ASR.

boolean BFXPreferred(bit sf, bit uns, bits(6) imms, bits(6) immr)
    integer S = UInt(imms);
    integer R = UInt(immr);

    // must not match UBFIZ/SBFIX alias
    if UInt(imms) < UInt(immr) then
        return FALSE;

    // must not match LSR/ASR/LSL alias (imms == 31 or 63)
    if imms == sf:'11111' then
        return FALSE;

    // must not match UXTx/SXTx alias
    if immr == '000000' then
        // must not match 32-bit UXT[BH] or SXT[BH]
        if sf == '0' && imms IN {'000111', '001111'} then
            return FALSE;
        // must not match 64-bit SXT[BHW]
        if sf:uns == '10' && imms IN {'000111', '001111', '011111'} then
            return FALSE;

    // must be UBFX/SBFX alias
    return TRUE;
```



```

// DecodeBitMasks()
// =====

// Decode AArch64 bitfield and logical immediate masks which use a similar encoding structure

(bits(M), bits(M)) DecodeBitMasks(bit immN, bits(6) imms, bits(6) immr, boolean immediate)
    bits(64) tmask, wmask;
    bits(6) tmask_and, wmask_and;
    bits(6) tmask_or, wmask_or;
    bits(6) levels;

    // Compute log2 of element size
    // 2^len must be in range [2, M]
    len = HighestSetBit(immN:NOT(imms));
    if len < 1 then UNDEFINED;
    assert M >= (1 << len);

    // Determine S, R and S - R parameters
    levels = ZeroExtend(Ones(len), 6);

    // For logical immediates an all-ones value of S is reserved
    // since it would generate a useless all-ones result (many times)
    if immediate && (imms AND levels) == levels then
        UNDEFINED;

    S = UInt(imms AND levels);
    R = UInt(immr AND levels);
    diff = S - R;    // 6-bit subtract with borrow

    // From a software perspective, the remaining code is equivalent to:
    //   esize = 1 << len;
    //   d = UInt(diff<len-1:0>);
    //   welem = ZeroExtend(Ones(S + 1), esize);
    //   telem = ZeroExtend(Ones(d + 1), esize);
    //   wmask = Replicate(ROR(welem, R));
    //   tmask = Replicate(telem);
    //   return (wmask, tmask);

    // Compute "top mask"
    tmask_and = diff<5:0> OR NOT(levels);
    tmask_or = diff<5:0> AND levels;

    tmask = Ones(64);
    tmask = ((tmask
        AND Replicate(Replicate(tmask_and<0>, 1) : Ones(1), 32))
        OR Replicate(Zeros(1) : Replicate(tmask_or<0>, 1), 32));
    // optimization of first step:
    // tmask = Replicate(tmask_and<0> : '1', 32);
    tmask = ((tmask
        AND Replicate(Replicate(tmask_and<1>, 2) : Ones(2), 16))
        OR Replicate(Zeros(2) : Replicate(tmask_or<1>, 2), 16));
    tmask = ((tmask
        AND Replicate(Replicate(tmask_and<2>, 4) : Ones(4), 8))
        OR Replicate(Zeros(4) : Replicate(tmask_or<2>, 4), 8));
    tmask = ((tmask
        AND Replicate(Replicate(tmask_and<3>, 8) : Ones(8), 4))
        OR Replicate(Zeros(8) : Replicate(tmask_or<3>, 8), 4));
    tmask = ((tmask
        AND Replicate(Replicate(tmask_and<4>, 16) : Ones(16), 2))
        OR Replicate(Zeros(16) : Replicate(tmask_or<4>, 16), 2));
    tmask = ((tmask
        AND Replicate(Replicate(tmask_and<5>, 32) : Ones(32), 1))
        OR Replicate(Zeros(32) : Replicate(tmask_or<5>, 32), 1));

    // Compute "wraparound mask"
    wmask_and = immr OR NOT(levels);
    wmask_or = immr AND levels;

    wmask = Zeros(64);
    wmask = ((wmask

```

```

        AND Replicate(Ones(1) : Replicate(wmask_and<0>, 1), 32))
        OR Replicate(Replicate(wmask_or<0>, 1) : Zeros(1), 32));
// optimization of first step:
// wmask = Replicate(wmask_or<0> : '0', 32);
wmask = ((wmask
        AND Replicate(Ones(2) : Replicate(wmask_and<1>, 2), 16))
        OR Replicate(Replicate(wmask_or<1>, 2) : Zeros(2), 16));
wmask = ((wmask
        AND Replicate(Ones(4) : Replicate(wmask_and<2>, 4), 8))
        OR Replicate(Replicate(wmask_or<2>, 4) : Zeros(4), 8));
wmask = ((wmask
        AND Replicate(Ones(8) : Replicate(wmask_and<3>, 8), 4))
        OR Replicate(Replicate(wmask_or<3>, 8) : Zeros(8), 4));
wmask = ((wmask
        AND Replicate(Ones(16) : Replicate(wmask_and<4>, 16), 2))
        OR Replicate(Replicate(wmask_or<4>, 16) : Zeros(16), 2));
wmask = ((wmask
        AND Replicate(Ones(32) : Replicate(wmask_and<5>, 32), 1))
        OR Replicate(Replicate(wmask_or<5>, 32) : Zeros(32), 1));

if diff<6> != '0' then // borrow from S - R
    wmask = wmask AND tmask;
else
    wmask = wmask OR tmask;

return (wmask<M-1:0>, tmask<M-1:0>);

```

### Library pseudocode for aarch64/instrs/integer/ins-ext/insert/movewide/movewideop/MoveWideOp

```

enumeration MoveWideOp {MoveWideOp_N, MoveWideOp_Z, MoveWideOp_K};

```

### Library pseudocode for aarch64/instrs/integer/logical/movwpreferred/MoveWidePreferred

```

// MoveWidePreferred()
// =====
//
// Return TRUE if a bitmask immediate encoding would generate an immediate
// value that could also be represented by a single MOVZ or MOVN instruction.
// Used as a condition for the preferred MOV<-ORR alias.

boolean MoveWidePreferred(bit sf, bit immN, bits(6) imms, bits(6) immr)
    integer S = UInt(imms);
    integer R = UInt(immr);
    integer width = if sf == '1' then 64 else 32;

    // element size must equal total immediate size
    if sf == '1' && immN:imms != 'lxxxxxx' then
        return FALSE;
    if sf == '0' && immN:imms != '00xxxxx' then
        return FALSE;

    // for MOVZ must contain no more than 16 ones
    if S < 16 then
        // ones must not span halfword boundary when rotated
        return (-R MOD 16) <= (15 - S);

    // for MOVN must contain no more than 16 zeros
    if S >= width - 15 then
        // zeros must not span halfword boundary when rotated
        return (R MOD 16) <= (S - (width - 15));

    return FALSE;

```

## Library pseudocode for aarch64/instrs/integer/shiftreg/DecodeShift

```
// DecodeShift()
// =====
// Decode shift encodings

ShiftType DecodeShift(bits(2) op)
    case op of
        when '00' return ShiftType_LSL;
        when '01' return ShiftType_LSR;
        when '10' return ShiftType_ASR;
        when '11' return ShiftType_ROR;
```

## Library pseudocode for aarch64/instrs/integer/shiftreg/ShiftReg

```
// ShiftReg()
// =====
// Perform shift of a register operand

bits(N) ShiftReg(integer reg, ShiftType shifttype, integer amount)
    bits(N) result = X[reg];
    case shifttype of
        when ShiftType_LSL result = LSL(result, amount);
        when ShiftType_LSR result = LSR(result, amount);
        when ShiftType_ASR result = ASR(result, amount);
        when ShiftType_ROR result = ROR(result, amount);
    return result;
```

## Library pseudocode for aarch64/instrs/integer/shiftreg/ShiftType

```
enumeration ShiftType {ShiftType_LSL, ShiftType_LSR, ShiftType_ASR, ShiftType_ROR};
```

## Library pseudocode for aarch64/instrs/logicalop/LogicalOp

```
enumeration LogicalOp {LogicalOp_AND, LogicalOp_EOR, LogicalOp_ORR};
```

## Library pseudocode for aarch64/instrs/memory/memop/MemAtomicOp

```
enumeration MemAtomicOp {MemAtomicOp_ADD,
                          MemAtomicOp_BIC,
                          MemAtomicOp_EOR,
                          MemAtomicOp_ORR,
                          MemAtomicOp_SMAX,
                          MemAtomicOp_SMIN,
                          MemAtomicOp_UMAX,
                          MemAtomicOp_UMIN,
                          MemAtomicOp_SWP};
```

## Library pseudocode for aarch64/instrs/memory/memop/MemOp

```
enumeration MemOp {MemOp_LOAD, MemOp_STORE, MemOp_PREFETCH};
```

## Library pseudocode for aarch64/instrs/memory/prefetch/Prefetch

```
// Prefetch()
// =====

// Decode and execute the prefetch hint on ADDRESS specified by PRFOP

Prefetch(bits(64) address, bits(5) prfop)
    PrefetchHint hint;
    integer target;
    boolean stream;

    case prfop<4:3> of
        when '00' hint = Prefetch_READ;           // PLD: prefetch for load
        when '01' hint = Prefetch_EXEC;           // PLI: preload instructions
        when '10' hint = Prefetch_WRITE;          // PST: prepare for store
        when '11' return;                          // unallocated hint
    target = UInt(prfop<2:1>);                      // target cache level
    stream = (prfop<0> != '0');                    // streaming (non-temporal)
    Hint_Prefetch(address, hint, target, stream);
    return;
```

## Library pseudocode for aarch64/instrs/system/barriers/barrierop/MemBarrierOp

```
enumeration MemBarrierOp { MemBarrierOp_DSB      // Data Synchronization Barrier
                           , MemBarrierOp_DMB      // Data Memory Barrier
                           , MemBarrierOp_ISB      // Instruction Synchronization Barrier
                           , MemBarrierOp_SSBB     // Speculative Synchronization Barrier to VA
                           , MemBarrierOp_PSSBB    // Speculative Synchronization Barrier to PA
                           , MemBarrierOp_SB       // Speculation Barrier
                           };
```

## Library pseudocode for aarch64/instrs/system/hints/syshintop/SystemHintOp

```
enumeration SystemHintOp {
    SystemHintOp_NOP,
    SystemHintOp_YIELD,
    SystemHintOp_WFE,
    SystemHintOp_WFI,
    SystemHintOp_SEV,
    SystemHintOp_SEVL,
    SystemHintOp_DGH,
    SystemHintOp_ESB,
    SystemHintOp_PSB,
    SystemHintOp_TSB,
    SystemHintOp_BTI,
    SystemHintOp_CSDB
};
```

## Library pseudocode for aarch64/instrs/system/register/cpsr/pstatefield/PSTATEField

```
enumeration PSTATEField {PSTATEField_DAIFFSet, PSTATEField_DAIFFClr,
                         PSTATEField_PAN, // Armv8.1
                         PSTATEField_UAO, // Armv8.2
                         PSTATEField_DIT, // Armv8.4
                         PSTATEField_SSBS,
                         PSTATEField_TCO, // Armv8.5
                         PSTATEField_SP
                         };
```

## Library pseudocode for aarch64/instrs/system/sysops/sysop/SysOp

```
// SysOp()
// =====

SystemOp SysOp(bits(3) op1, bits(4) CRn, bits(4) CRm, bits(3) op2)
  case op1:CRn:CRm:op2 of
    when '000 0111 1000 000' return Sys_AT; // S1E1R
    when '100 0111 1000 000' return Sys_AT; // S1E2R
    when '110 0111 1000 000' return Sys_AT; // S1E3R
    when '000 0111 1000 001' return Sys_AT; // S1E1W
    when '100 0111 1000 001' return Sys_AT; // S1E2W
    when '110 0111 1000 001' return Sys_AT; // S1E3W
    when '000 0111 1000 010' return Sys_AT; // S1E0R
    when '000 0111 1000 011' return Sys_AT; // S1E0W
    when '100 0111 1000 100' return Sys_AT; // S12E1R
    when '100 0111 1000 101' return Sys_AT; // S12E1W
    when '100 0111 1000 110' return Sys_AT; // S12E0R
    when '100 0111 1000 111' return Sys_AT; // S12E0W
    when '011 0111 0100 001' return Sys_DC; // ZVA
    when '000 0111 0110 001' return Sys_DC; // IVAC
    when '000 0111 0110 010' return Sys_DC; // ISW
    when '011 0111 1010 001' return Sys_DC; // CVAC
    when '000 0111 1010 010' return Sys_DC; // CSW
    when '011 0111 1011 001' return Sys_DC; // CVAU
    when '011 0111 1110 001' return Sys_DC; // CIVAC
    when '000 0111 1110 010' return Sys_DC; // CISW
    when '011 0111 1101 001' return Sys_DC; // CVADP
    when '000 0111 0001 000' return Sys_IC; // IALLUIS
    when '000 0111 0101 000' return Sys_IC; // IALLU
    when '011 0111 0101 001' return Sys_IC; // IVAU
    when '100 1000 0000 001' return Sys_TLBI; // IPAS2E1IS
    when '100 1000 0000 101' return Sys_TLBI; // IPAS2LE1IS
    when '000 1000 0011 000' return Sys_TLBI; // VMALLE1IS
    when '100 1000 0011 000' return Sys_TLBI; // ALLE2IS
    when '110 1000 0011 000' return Sys_TLBI; // ALLE3IS
    when '000 1000 0011 001' return Sys_TLBI; // VAE1IS
    when '100 1000 0011 001' return Sys_TLBI; // VAE2IS
    when '110 1000 0011 001' return Sys_TLBI; // VAE3IS
    when '000 1000 0011 010' return Sys_TLBI; // ASIDE1IS
    when '000 1000 0011 011' return Sys_TLBI; // VAAE1IS
    when '100 1000 0011 100' return Sys_TLBI; // ALLE1IS
    when '000 1000 0011 101' return Sys_TLBI; // VALE1IS
    when '100 1000 0011 101' return Sys_TLBI; // VALE2IS
    when '110 1000 0011 101' return Sys_TLBI; // VALE3IS
    when '100 1000 0011 110' return Sys_TLBI; // VMALLS12E1IS
    when '000 1000 0011 111' return Sys_TLBI; // VAALE1IS
    when '100 1000 0100 001' return Sys_TLBI; // IPAS2E1
    when '100 1000 0100 101' return Sys_TLBI; // IPAS2LE1
    when '000 1000 0111 000' return Sys_TLBI; // VMALLE1
    when '100 1000 0111 000' return Sys_TLBI; // ALLE2
    when '110 1000 0111 000' return Sys_TLBI; // ALLE3
    when '000 1000 0111 001' return Sys_TLBI; // VAE1
    when '100 1000 0111 001' return Sys_TLBI; // VAE2
    when '110 1000 0111 001' return Sys_TLBI; // VAE3
    when '000 1000 0111 010' return Sys_TLBI; // ASIDE1
    when '000 1000 0111 011' return Sys_TLBI; // VAAE1
    when '100 1000 0111 100' return Sys_TLBI; // ALLE1
    when '000 1000 0111 101' return Sys_TLBI; // VALE1
    when '100 1000 0111 101' return Sys_TLBI; // VALE2
    when '110 1000 0111 101' return Sys_TLBI; // VALE3
    when '100 1000 0111 110' return Sys_TLBI; // VMALLS12E1
    when '000 1000 0111 111' return Sys_TLBI; // VAALE1
  return Sys_SYS;
```

## Library pseudocode for aarch64/instrs/system/sysops/sysop/SystemOp

```
enumeration SystemOp {Sys_AT, Sys_DC, Sys_IC, Sys_TLBI, Sys_SYS};
```

## Library pseudocode for aarch64/instrs/vector/arithmetic/binary/uniform/logical/bsl-eor/vbitop/VBitOp

```
enumeration VBitOp {VBitOp_VBIF, VBitOp_VBIT, VBitOp_VBSL, VBitOp_VEOR};
```

## Library pseudocode for aarch64/instrs/vector/arithmetic/unary/cmp/compareop/CompareOp

```
enumeration CompareOp {CompareOp_GT, CompareOp_GE, CompareOp_EQ,  
                      CompareOp_LE, CompareOp_LT};
```

## Library pseudocode for aarch64/instrs/vector/logical/immediateop/ImmediateOp

```
enumeration ImmediateOp {ImmediateOp_MOVI, ImmediateOp_MVNI,  
                       ImmediateOp_ORR, ImmediateOp_BIC};
```

## Library pseudocode for aarch64/instrs/vector/reduce/reduceop/Reduce

```
// Reduce()  
// =====  
  
bits(esize) Reduce(ReduceOp op, bits(N) input, integer esize)  
{  
    integer half;  
    bits(esize) hi;  
    bits(esize) lo;  
    bits(esize) result;  
  
    if N == esize then  
        return input<esize-1:0>;  
  
    half = N DIV 2;  
    hi = Reduce(op, input<N-1:half>, esize);  
    lo = Reduce(op, input<half-1:0>, esize);  
  
    case op of  
        when ReduceOp_FMINNUM  
            result = FPMINum(lo, hi, FPCR);  
        when ReduceOp_FMAXNUM  
            result = FPMaxNum(lo, hi, FPCR);  
        when ReduceOp_FMIN  
            result = FPMIN(lo, hi, FPCR);  
        when ReduceOp_FMAX  
            result = FPMax(lo, hi, FPCR);  
        when ReduceOp_FADD  
            result = FPAdd(lo, hi, FPCR);  
        when ReduceOp_ADD  
            result = lo + hi;  
  
    return result;  
}
```

## Library pseudocode for aarch64/instrs/vector/reduce/reduceop/ReduceOp

```
enumeration ReduceOp {ReduceOp_FMINNUM, ReduceOp_FMAXNUM,  
                    ReduceOp_FMIN, ReduceOp_FMAX,  
                    ReduceOp_FADD, ReduceOp_ADD};
```



## Library pseudocode for aarch64/translation/attrs/AArch64.CombineS1S2Desc

```
// AArch64.CombineS1S2Desc()
// =====
// Combines the address descriptors from stage 1 and stage 2

AddressDescriptor AArch64.CombineS1S2Desc(AddressDescriptor s1desc, AddressDescriptor s2desc)

    AddressDescriptor result;

    result.paddress = s2desc.paddress;

    apply_force_writeback = HaveStage2MemAttrControl() && HCR_EL2.FWB == '1';
    if IsFault(s1desc) || IsFault(s2desc) then
        result = if IsFault(s1desc) then s1desc else s2desc;
    else
        result.fault = AArch64.NoFault();
        if s2desc.memattrs.memtype == MemType_Device || (
            (apply_force_writeback && s1desc.memattrs.memtype == MemType_Device && s2desc.memattrs.inner
            (!apply_force_writeback && s1desc.memattrs.memtype == MemType_Device) ) then
            result.memattrs.memtype = MemType_Device;
            if s1desc.memattrs.memtype == MemType_Normal then
                result.memattrs.device = s2desc.memattrs.device;
            elseif s2desc.memattrs.memtype == MemType_Normal then
                result.memattrs.device = s1desc.memattrs.device;
            else
                // Both Device
                result.memattrs.device = CombineS1S2Device(s1desc.memattrs.device,
                                                            s2desc.memattrs.device);

            result.memattrs.tagged = FALSE;
            // S1 can be either Normal or Device, S2 is Normal.
        else
            result.memattrs.memtype = MemType_Normal;
            result.memattrs.device = DeviceType UNKNOWN;
            result.memattrs.inner = CombineS1S2AttrHints(s1desc.memattrs.inner, s2desc.memattrs.inner);
            result.memattrs.outer = CombineS1S2AttrHints(s1desc.memattrs.outer, s2desc.memattrs.outer);
            result.memattrs.shareable = (s1desc.memattrs.shareable || s2desc.memattrs.shareable);
            result.memattrs.outershareable = (s1desc.memattrs.outershareable ||
                                                s2desc.memattrs.outershareable);

            result.memattrs.tagged = (s1desc.memattrs.tagged &&
                                     result.memattrs.inner.attrs == MemAttr_WB &&
                                     result.memattrs.inner.hints == MemHint_RWA &&
                                     result.memattrs.outer.attrs == MemAttr_WB &&
                                     result.memattrs.outer.hints == MemHint_RWA);

    result.memattrs = MemAttrDefaults(result.memattrs);

    return result;
```

## Library pseudocode for aarch64/translation/attrs/AArch64.InstructionDevice

```
// AArch64.InstructionDevice()
// =====
// Instruction fetches from memory marked as Device but not execute-never might generate a
// Permission Fault but are otherwise treated as if from Normal Non-cacheable memory.

AddressDescriptor AArch64.InstructionDevice(AddressDescriptor addrdesc, bits(64) vaddress,
                                             bits(52) ipaddress, integer level,
                                             AccType acctype, boolean iswrite, boolean secondstage,
                                             boolean s2fslwalk)

    c = ConstrainUnpredictable(Unpredictable_INSTRDEVICE);
    assert c IN {Constraint_NONE, Constraint_FAULT};

    if c == Constraint_FAULT then
        addrdesc.fault = AArch64.PermissionFault(ipaddress, boolean UNKNOWN, level, acctype, iswrite,
                                                  secondstage, s2fslwalk);
    else
        addrdesc.memattrs.memtype = MemType_Normal;
        addrdesc.memattrs.inner.attrs = MemAttr_NC;
        addrdesc.memattrs.inner.hints = MemHint_No;
        addrdesc.memattrs.outer = addrdesc.memattrs.inner;
        addrdesc.memattrs.tagged = FALSE;
        addrdesc.memattrs = MemAttrDefaults(addrdesc.memattrs);

    return addrdesc;
```

## Library pseudocode for aarch64/translation/attrs/AArch64.S1AttrDecode

```
// AArch64.S1AttrDecode()
// =====
// Converts the Stage 1 attribute fields, using the MAIR, to orthogonal
// attributes and hints.

MemoryAttributes AArch64.S1AttrDecode(bits(2) SH, bits(3) attr, AccType acctype)

    MemoryAttributes memattrs;

    mair = MAIR[];
    index = 8 * UInt(attr);
    attrfield = mair<index+7:index>;

    memattrs.tagged = FALSE;
    if ((attrfield<7:4> != '0000' && attrfield<7:4> != '1111' && attrfield<3:0> == '0000') ||
        (attrfield<7:4> == '0000' && attrfield<3:0> != 'xx00')) then
        // Reserved, maps to an allocated value
        (-, attrfield) = ConstrainUnpredictableBits(Unpredictable\_RESMAIR);
    if !HaveMTEExt() && attrfield<7:4> == '1111' && attrfield<3:0> == '0000' then
        // Reserved, maps to an allocated value
        (-, attrfield) = ConstrainUnpredictableBits(Unpredictable\_RESMAIR);

    if attrfield<7:4> == '0000' then // Device
        memattrs.memtype = MemType\_Device;
        case attrfield<3:0> of
            when '0000' memattrs.device = DeviceType\_nGnRnE;
            when '0100' memattrs.device = DeviceType\_nGnRE;
            when '1000' memattrs.device = DeviceType\_nGRE;
            when '1100' memattrs.device = DeviceType\_GRE;
            otherwise Unreachable(); // Reserved, handled above

    elseif attrfield<3:0> != '0000' then // Normal
        memattrs.memtype = MemType\_Normal;
        memattrs.outer = LongConvertAttrsHints(attrfield<7:4>, acctype);
        memattrs.inner = LongConvertAttrsHints(attrfield<3:0>, acctype);
        memattrs.shareable = SH<1> == '1';
        memattrs.outershareable = SH == '10';
    elseif HaveMTEExt() && attrfield == '11110000' then // Normal, Tagged WB-RWA
        memattrs.memtype = MemType\_Normal;
        memattrs.outer = LongConvertAttrsHints('1111', acctype); // WB_RWA
        memattrs.inner = LongConvertAttrsHints('1111', acctype); // WB_RWA
        memattrs.shareable = SH<1> == '1';
        memattrs.outershareable = SH == '10';
        memattrs.tagged = TRUE;
    else
        Unreachable(); // Reserved, handled above

    return MemAttrDefaults(memattrs);
```



```

// AArch64.TranslateAddressS10ff()
// =====
// Called for stage 1 translations when translation is disabled to supply a default translation.
// Note that there are additional constraints on instruction prefetching that are not described in
// this pseudocode.

TLBRecord AArch64.TranslateAddressS10ff(bits(64) vaddress, AccType acctype, boolean iswrite)
    assert !ELUsingAArch32\(S1TranslationRegime\(\)\);

    TLBRecord result;

    Top = AddrTop(vaddress, (acctype == AccType\_IFETCH), PSTATE.EL);
    if !IsZero(vaddress<Top:PAMax()>) then
        level = 0;
        ipaddress = bits(52) UNKNOWN;
        secondstage = FALSE;
        s2fslwalk = FALSE;
        result.addrdesc.fault = AArch64.AddressSizeFault(ipaddress,boolean UNKNOWN, level, acctype,
                                                    iswrite, secondstage, s2fslwalk);

        return result;

    default_cacheable = (HasS2Translation() && HCR_EL2.DC == '1');

    if default_cacheable then
        // Use default cacheable settings
        result.addrdesc.memattrs.memtype = MemType\_Normal;
        result.addrdesc.memattrs.inner.attrs = MemAttr\_WB; // Write-back
        result.addrdesc.memattrs.inner.hints = MemHint\_RWA;
        result.addrdesc.memattrs.shareable = FALSE;
        result.addrdesc.memattrs.outershareable = FALSE;
        result.addrdesc.memattrs.tagged = HCR_EL2.DCT == '1';
    elseif acctype != AccType\_IFETCH then
        // Treat data as Device
        result.addrdesc.memattrs.memtype = MemType\_Device;
        result.addrdesc.memattrs.device = DeviceType\_nGnRnE;
        result.addrdesc.memattrs.inner = MemAttrHints UNKNOWN;
        result.addrdesc.memattrs.tagged = FALSE;
    else
        // Instruction cacheability controlled by SCTLR_ELx.I
        cacheable = SCTLR[].I == '1';
        result.addrdesc.memattrs.memtype = MemType\_Normal;
        if cacheable then
            result.addrdesc.memattrs.inner.attrs = MemAttr\_WT;
            result.addrdesc.memattrs.inner.hints = MemHint\_RA;
        else
            result.addrdesc.memattrs.inner.attrs = MemAttr\_NC;
            result.addrdesc.memattrs.inner.hints = MemHint\_No;
            result.addrdesc.memattrs.shareable = TRUE;
            result.addrdesc.memattrs.outershareable = TRUE;
            result.addrdesc.memattrs.tagged = FALSE;

    result.addrdesc.memattrs.outer = result.addrdesc.memattrs.inner;

    result.addrdesc.memattrs = MemAttrDefaults(result.addrdesc.memattrs);

    result.perms.ap = bits(3) UNKNOWN;
    result.perms.xn = '0';
    result.perms.pxn = '0';

    result.nG = bit UNKNOWN;
    result.contiguous = boolean UNKNOWN;
    result.domain = bits(4) UNKNOWN;
    result.level = integer UNKNOWN;
    result.blocksize = integer UNKNOWN;
    result.addrdesc.paddress.address = vaddress<51:0>;
    result.addrdesc.paddress.NS = if IsSecure() then '0' else '1';
    result.addrdesc.fault = AArch64.NoFault();

    result.descupdate.AF = FALSE;
    result.descupdate.AP = FALSE;

```

```

    result.descupdate.descaddr = result.addrdesc;

    return result;

```

### Library pseudocode for aarch64/translation/checks/AArch64.AccessIsPrivileged

```

// AArch64.AccessIsPrivileged()
// =====

boolean AArch64.AccessIsPrivileged(AccType acctype)

    el = AArch64.AccessUsesEL(acctype);

    if el == EL0 then
        ispriv = FALSE;
    elsif el == EL3 then
        ispriv = TRUE;
    elsif el == EL2 && (!IsInHost() || HCR_EL2.TGE == '0') then
        ispriv = TRUE;
    elsif HaveUA0Ext() && PSTATE.UAO == '1' then
        ispriv = TRUE;
    else
        ispriv = (acctype != AccType_UNPRIV);

    return ispriv;

```

### Library pseudocode for aarch64/translation/checks/AArch64.AccessUsesEL

```

// AArch64.AccessUsesEL()
// =====
// Returns the Exception Level of the regime that will manage the translation for a given access type.

bits(2) AArch64.AccessUsesEL(AccType acctype)
    if acctype == AccType_UNPRIV then
        return EL0;
    elsif acctype == AccType_NV2REGISTER then
        return EL2;
    else
        return PSTATE.EL;

```



```

// AArch64.CheckPermission()
// =====
// Function used for permission checking from AArch64 stage 1 translations

FaultRecord AArch64.CheckPermission(Permissions perms, bits(64) vaddress, integer level,
                                     bit NS, AccType acctype, boolean iswrite)
    assert !ELUsingAArch32(S1TranslationRegime());

    wxn = SCTLRL[0].WXN == '1';

    if (PSTATE.EL == EL0 ||
        IsInHost() ||
        (PSTATE.EL == EL1 && !HaveNV2Ext()) ||
        (PSTATE.EL == EL1 && HaveNV2Ext() && (acctype != AccType_NV2REGISTER || !ELIsInHost(EL2)))) then
        priv_r = TRUE;
        priv_w = perms.ap<2> == '0';
        user_r = perms.ap<1> == '1';
        user_w = perms.ap<2:1> == '01';

        ispriv = AArch64.AccessIsPrivileged(acctype);

        pan = if HavePANExt() then PSTATE.PAN else '0';
        if (EL2Enabled() && ((PSTATE.EL == EL1 && HaveNVExt() && HCR_EL2.<NV, NV1> == '11') ||
            (HaveNV2Ext() && acctype == AccType_NV2REGISTER && HCR_EL2.NV2 == '1')))) then
            pan = '0';
        is_ldst = !(acctype IN {AccType_DC, AccType_DC_UNPRIV, AccType_AT, AccType_IFETCH});
        is_atslxp = (acctype == AccType_AT && AArch64.ExecutingATSLXPInstr());
        if pan == '1' && user_r && ispriv && (is_ldst || is_atslxp) then
            priv_r = FALSE;
            priv_w = FALSE;

        user_xn = perms.xn == '1' || (user_w && wxn);
        priv_xn = perms.pxn == '1' || (priv_w && wxn) || user_w;

        if ispriv then
            (r, w, xn) = (priv_r, priv_w, priv_xn);
        else
            (r, w, xn) = (user_r, user_w, user_xn);
    else
        // Access from EL2 or EL3
        r = TRUE;
        w = perms.ap<2> == '0';
        xn = perms.xn == '1' || (w && wxn);

        // Restriction on Secure instruction fetch
        if HaveEL(EL3) && IsSecure() && NS == '1' && SCR_EL3.SIF == '1' then
            xn = TRUE;

        if acctype == AccType_IFETCH then
            fail = xn;
            failedread = TRUE;
        elsif acctype IN { AccType_ATOMICRW, AccType_ORDEREDRW, AccType_ORDEREDATOMICRW } then
            fail = !r || !w;
            failedread = !r;
        elsif iswrite then
            fail = !w;
            failedread = FALSE;
        elsif acctype == AccType_DC && PSTATE.EL != EL0 then
            // DC maintenance instructions operating by VA, cannot fault from stage 1 translation,
            // other than DC IVAC, which requires write permission, and operations executed at EL0,
            // which require read permission.
            fail = FALSE;
        else
            fail = !r;
            failedread = TRUE;

        if fail then
            secondstage = FALSE;
            s2fslwalk = FALSE;
            ipaddress = bits(52) UNKNOWN;

```



```

        return AArch64.PermissionFault(ipaddress,boolean UNKNOWN, level, acctype,
                                         !failedread, secondstage, s2fslwalk);
    else
        return AArch64.NoFault();

```

## Library pseudocode for aarch64/translation/checks/AArch64.CheckS2Permission

```

// AArch64.CheckS2Permission()
// =====
// Function used for permission checking from AArch64 stage 2 translations

FaultRecord AArch64.CheckS2Permission(Permissions perms, bits(64) vaddress, bits(52) ipaddress,
                                       integer level, AccType acctype, boolean iswrite, boolean NS,
                                       boolean s2fslwalk, boolean hwupdatewalk)

    assert (IsSecureEL2Enabled() || (HaveEL(EL2) && !IsSecure() && !ELUsingAArch32(EL2))) && HasS2Translation

    r = perms.ap<1> == '1';
    w = perms.ap<2> == '1';
    if HaveExtendedExecuteNeverExt() then
        case perms.xn:perms.xxn of
            when '00' xn = FALSE;
            when '01' xn = PSTATE.EL == EL1;
            when '10' xn = TRUE;
            when '11' xn = PSTATE.EL == EL0;
    else
        xn = perms.xn == '1';
    // Stage 1 walk is checked as a read, regardless of the original type
    if acctype == AccType\_IFETCH && !s2fslwalk then
        fail = xn;
        failedread = TRUE;
    elsif (acctype IN { AccType\_ATOMICRW, AccType\_ORDEREDRW, AccType\_ORDEREDATOMICRW }) && !s2fslwalk then
        fail = !r || !w;
        failedread = !r;
    elsif iswrite && !s2fslwalk then
        fail = !w;
        failedread = FALSE;
    elsif acctype == AccType\_DC && PSTATE.EL != EL0 && !s2fslwalk then
        // DC maintenance instructions operating by VA, with the exception of DC IVAC, do
        // not generate Permission faults from stage 2 translation, other than when
        // performing a stage 1 translation table walk.
        fail = FALSE;
    elsif hwupdatewalk then
        fail = !w;
        failedread = !iswrite;
    else
        fail = !r;
        failedread = !iswrite;

    if fail then
        domain = bits(4) UNKNOWN;
        secondstage = TRUE;
        return AArch64.PermissionFault(ipaddress,NS, level, acctype,
                                         !failedread, secondstage, s2fslwalk);
    else
        return AArch64.NoFault();

```

## Library pseudocode for aarch64/translation/debug/AArch64.CheckBreakpoint

```
// AArch64.CheckBreakpoint()
// =====
// Called before executing the instruction of length "size" bytes at "vaddress" in an AArch64
// translation regime, when either debug exceptions are enabled, or halting debug is enabled
// and halting is allowed.

FaultRecord AArch64.CheckBreakpoint(bits(64) vaddress, AccType acctype, integer size)
    assert !ELUsingAArch32\(S1TranslationRegime\(\)\);
    assert (UsingAArch32\(\) && size IN {2,4}) || size == 4;

    match = FALSE;

    for i = 0 to UInt(ID_AA64DFR0_EL1.BRPs)
        match_i = AArch64.BreakpointMatch(i, vaddress, acctype, size);
        match = match || match_i;

    if match && HaltOnBreakpointOrWatchpoint\(\) then
        reason = DebugHalt\_Breakpoint;
        Halt(reason);
    elseif match then
        acctype = AccType\_IFETCH;
        iswrite = FALSE;
        return AArch64.DebugFault(acctype, iswrite);
    else
        return AArch64.NoFault();
```

## Library pseudocode for aarch64/translation/debug/AArch64.CheckDebug

```
// AArch64.CheckDebug()
// =====
// Called on each access to check for a debug exception or entry to Debug state.

FaultRecord AArch64.CheckDebug(bits(64) vaddress, AccType acctype, boolean iswrite, integer size)

    FaultRecord fault = AArch64.NoFault();

    d_side = (acctype != AccType\_IFETCH);
    if HaveNV2Ext\(\) && acctype == AccType\_NV2REGISTER then
        mask = '0';
        generate_exception = AArch64.GenerateDebugExceptionsFrom(EL2, IsSecure(), mask) && MDSCR_EL1.MDE
    else
        generate_exception = AArch64.GenerateDebugExceptions() && MDSCR_EL1.MDE == '1';
    halt = HaltOnBreakpointOrWatchpoint();

    if generate_exception || halt then
        if d_side then
            fault = AArch64.CheckWatchpoint(vaddress, acctype, iswrite, size);
        else
            fault = AArch64.CheckBreakpoint(vaddress, acctype, size);

    return fault;
```

## Library pseudocode for aarch64/translation/debug/AArch64.CheckWatchpoint

```
// AArch64.CheckWatchpoint()
// =====
// Called before accessing the memory location of "size" bytes at "address",
// when either debug exceptions are enabled for the access, or halting debug
// is enabled and halting is allowed.

FaultRecord AArch64.CheckWatchpoint(bits(64) vaddress, AccType acctype,
                                     boolean iswrite, integer size)
    assert !ELUsingAArch32\(S1TranslationRegime\(\)\);

    match = FALSE;
    ispriv = AArch64.AccessIsPrivileged(acctype);

    for i = 0 to UInt(ID_AA64DFR0_EL1.WRPs)
        match = match || AArch64.WatchpointMatch(i, vaddress, size, ispriv, acctype, iswrite);

    if match && HaltOnBreakpointOrWatchpoint() then
        if acctype != AccType\_NONFAULT && acctype != AccType\_CNOTFIRST then
            reason = DebugHalt\_Watchpoint;
            Halt(reason);
        else
            // Fault will be reported and cancelled
            return AArch64.DebugFault(acctype, iswrite);
    elseif match then
        return AArch64.DebugFault(acctype, iswrite);
    else
        return AArch64.NoFault();
```

## Library pseudocode for aarch64/translation/faults/AArch64.AccessFlagFault

```
// AArch64.AccessFlagFault()
// =====

FaultRecord AArch64.AccessFlagFault(bits(52) ipaddress, boolean NS, integer level,
                                     AccType acctype, boolean iswrite, boolean secondstage,
                                     boolean s2fslwalk)

    extflag = bit UNKNOWN;
    errortype = bits(2) UNKNOWN;
    return AArch64.CreateFaultRecord(Fault\_AccessFlag, ipaddress, NS, level, acctype, iswrite,
                                     extflag, errortype, secondstage, s2fslwalk);
```

## Library pseudocode for aarch64/translation/faults/AArch64.AddressSizeFault

```
// AArch64.AddressSizeFault()
// =====

FaultRecord AArch64.AddressSizeFault(bits(52) ipaddress, boolean NS, integer level,
                                     AccType acctype, boolean iswrite, boolean secondstage,
                                     boolean s2fslwalk)

    extflag = bit UNKNOWN;
    errortype = bits(2) UNKNOWN;
    return AArch64.CreateFaultRecord(Fault\_AddressSize, ipaddress, NS, level, acctype, iswrite,
                                     extflag, errortype, secondstage, s2fslwalk);
```

## Library pseudocode for aarch64/translation/faults/AArch64.AlignmentFault

```
// AArch64.AlignmentFault()
// =====

FaultRecord AArch64.AlignmentFault(AccType acctype, boolean iswrite, boolean secondstage)

    ipaddress = bits(52) UNKNOWN;
    level = integer UNKNOWN;
    extflag = bit UNKNOWN;
    errortype = bits(2) UNKNOWN;
    s2fslwalk = boolean UNKNOWN;

    return AArch64.CreateFaultRecord(Fault\_Alignment, ipaddress, boolean UNKNOWN, level, acctype, iswrite,
                                     extflag, errortype, secondstage, s2fslwalk);
```

## Library pseudocode for aarch64/translation/faults/AArch64.AsynchExternalAbort

```
// AArch64.AsynchExternalAbort()
// =====
// Wrapper function for asynchronous external aborts

FaultRecord AArch64.AsynchExternalAbort(boolean parity, bits(2) errortype, bit extflag)

    faulttype = if parity then Fault\_AsyncParity else Fault\_AsyncExternal;
    ipaddress = bits(52) UNKNOWN;
    level = integer UNKNOWN;
    acctype = AccType\_NORMAL;
    iswrite = boolean UNKNOWN;
    secondstage = FALSE;
    s2fslwalk = FALSE;

    return AArch64.CreateFaultRecord(faulttype, ipaddress, boolean UNKNOWN, level, acctype, iswrite, extflag,
                                     errortype, secondstage, s2fslwalk);
```

## Library pseudocode for aarch64/translation/faults/AArch64.DebugFault

```
// AArch64.DebugFault()
// =====

FaultRecord AArch64.DebugFault(AccType acctype, boolean iswrite)

    ipaddress = bits(52) UNKNOWN;
    errortype = bits(2) UNKNOWN;
    level = integer UNKNOWN;
    extflag = bit UNKNOWN;
    secondstage = FALSE;
    s2fslwalk = FALSE;

    return AArch64.CreateFaultRecord(Fault\_Debug, ipaddress, boolean UNKNOWN, level, acctype, iswrite,
                                     extflag, errortype, secondstage, s2fslwalk);
```

## Library pseudocode for aarch64/translation/faults/AArch64.NoFault

```
// AArch64.NoFault()
// =====

FaultRecord AArch64.NoFault()

    ipaddress = bits(52) UNKNOWN;
    level = integer UNKNOWN;
    acctype = AccType\_NORMAL;
    iswrite = boolean UNKNOWN;
    extflag = bit UNKNOWN;
    errortype = bits(2) UNKNOWN;
    secondstage = FALSE;
    s2fslwalk = FALSE;

    return AArch64.CreateFaultRecord(Fault\_None, ipaddress, boolean UNKNOWN, level, acctype, iswrite,
                                     extflag, errortype, secondstage, s2fslwalk);
```

## Library pseudocode for aarch64/translation/faults/AArch64.PermissionFault

```
// AArch64.PermissionFault()
// =====

FaultRecord AArch64.PermissionFault(bits(52) ipaddress, boolean NS, integer level,
                                     AccType acctype, boolean iswrite, boolean secondstage,
                                     boolean s2fslwalk)

    extflag = bit UNKNOWN;
    errortype = bits(2) UNKNOWN;
    return AArch64.CreateFaultRecord(Fault\_Permission, ipaddress, NS, level, acctype, iswrite,
                                     extflag, errortype, secondstage, s2fslwalk);
```

## Library pseudocode for aarch64/translation/faults/AArch64.TranslationFault

```
// AArch64.TranslationFault()
// =====

FaultRecord AArch64.TranslationFault(bits(52) ipaddress, boolean NS, integer level,
                                     AccType acctype, boolean iswrite, boolean secondstage,
                                     boolean s2fslwalk)

    extflag = bit UNKNOWN;
    errortype = bits(2) UNKNOWN;
    return AArch64.CreateFaultRecord(Fault\_Translation, ipaddress, NS, level, acctype, iswrite,
                                     extflag, errortype, secondstage, s2fslwalk);
```

## Library pseudocode for aarch64/translation/translation/AArch64.CheckAndUpdateDescriptor

```
// AArch64.CheckAndUpdateDescriptor()
// =====
// Check and update translation table descriptor if hardware update is configured

FaultRecord AArch64.CheckAndUpdateDescriptor(DescriptorUpdate result, FaultRecord fault,
                                              boolean secondstage, bits(64) vaddress, AccType acctype,
                                              boolean iswrite, boolean s2fslwalk, boolean hwupdatewalk)

    boolean hw_update_AF = FALSE;
    boolean hw_update_AP = FALSE;

    // Check if access flag can be updated
    // Address translation instructions are permitted to update AF but not required
    if result.AF then
        if fault.statuscode == Fault_None || ConstrainUnpredictable(Unpredictable_AFUPDATE) == ConstrainNone then
            hw_update_AF = TRUE;

    if result.AP && fault.statuscode == Fault_None then
        write_perm_req = (iswrite || acctype IN {AccType_ATOMICRW, AccType_ORDEREDRW, AccType_ORDEREDATOMICRW})
        hw_update_AP = (write_perm_req && !(acctype IN {AccType_AT, AccType_DC, AccType_DC_UNPRIV})) || hwupdatewalk

    if hw_update_AF || hw_update_AP then
        if secondstage || !HasS2Translation() then
            descaddr2 = result.descaddr;
        else
            hwupdatewalk = TRUE;
            descaddr2 = AArch64.SecondStageWalk(result.descaddr, vaddress, acctype, iswrite, 8, hwupdatewalk);
            if IsFault(descaddr2) then
                return descaddr2.fault;

        accdesc = CreateAccessDescriptor(AccType_ATOMICRW, FALSE);
        desc = _Mem[descaddr2, 8, accdesc];
        el = AArch64.AccessUsesEL(acctype);
        case el of
            when EL3
                reversedescriptors = SCTL_EL3.EE == '1';
            when EL2
                reversedescriptors = SCTL_EL2.EE == '1';
            otherwise
                reversedescriptors = SCTL_EL1.EE == '1';
        if reversedescriptors then
            desc = BigEndianReverse(desc);

        if hw_update_AF then
            desc<10> = '1';
        if hw_update_AP then
            desc<7> = (if secondstage then '1' else '0');

        _Mem[descaddr2, 8, accdesc] = if reversedescriptors then BigEndianReverse(desc) else desc;

    return fault;
```

## Library pseudocode for aarch64/translation/translation/AArch64.FirstStageTranslate

```
// AArch64.FirstStageTranslate()
// =====
// Perform a stage 1 translation walk. The function used by Address Translation operations is
// similar except it uses the translation regime specified for the instruction.

AddressDescriptor AArch64.FirstStageTranslate(bits(64) vaddress, AccType acctype, boolean iswrite,
                                             boolean wasaligned, integer size)

if HaveNV2Ext\(\) && acctype == AccType\_NV2REGISTER then
    s1_enabled = SCTLR_EL2.M == '1';
elseif HasS2Translation\(\) then
    s1_enabled = HCR_EL2.TGE == '0' && HCR_EL2.DC == '0' && SCTLR_EL1.M == '1';
else
    s1_enabled = SCTLR[].M == '1';

TLBRecord S1;
S1.addrdesc.fault = AArch64.NoFault\(\);
ipaddress = bits(52) UNKNOWN;
secondstage = FALSE;
s2fslwalk = FALSE;

if s1_enabled then                                // First stage enabled
    S1 = AArch64.TranslationTableWalk(ipaddress, TRUE, vaddress, acctype, iswrite, secondstage,
                                       s2fslwalk, size);

    permissioncheck = TRUE;
    if acctype == AccType\_IFETCH then
        InGuardedPage = S1.GP == '1';           // Global state updated on instruction fetch that denotes
                                                // if the fetched instruction is from a guarded page.
else
    S1 = AArch64.TranslateAddressS1off(vaddress, acctype, iswrite);
    permissioncheck = FALSE;
    InGuardedPage = FALSE;                        // No memory is guarded when stage 1 address translation is

if !IsFault(S1.addrdesc) && UsingAArch32\(\) && HaveTrapLoadStoreMultipleDeviceExt\(\) && AArch32.Executing
    if S1.addrdesc.memattrs.memtype == MemType\_Device && S1.addrdesc.memattrs.device != DeviceType\_GH
        nTLSMD = if S1TranslationRegime\(\) == EL2 then SCTLR_EL2.nTLSMD else SCTLR_EL1.nTLSMD;
        if nTLSMD == '0' then
            S1.addrdesc.fault = AArch64.AlignmentFault(acctype, iswrite, secondstage);

// Check for unaligned data accesses to Device memory
if ((!wasaligned && acctype != AccType\_IFETCH) || (acctype == AccType\_DCZVA))
    && !IsFault(S1.addrdesc) && S1.addrdesc.memattrs.memtype == MemType\_Device then
        S1.addrdesc.fault = AArch64.AlignmentFault(acctype, iswrite, secondstage);
if !IsFault(S1.addrdesc) && permissioncheck then
    S1.addrdesc.fault = AArch64.CheckPermission(S1.perms, vaddress, S1.level,
                                                S1.addrdesc.paddress.NS,
                                                acctype, iswrite);

// Check for instruction fetches from Device memory not marked as execute-never. If there has
// not been a Permission Fault then the memory is not marked execute-never.
if (!IsFault(S1.addrdesc) && S1.addrdesc.memattrs.memtype == MemType\_Device &&
    acctype == AccType\_IFETCH) then
    S1.addrdesc = AArch64.InstructionDevice(S1.addrdesc, vaddress, ipaddress, S1.level,
                                             acctype, iswrite,
                                             secondstage, s2fslwalk);

// Check and update translation table descriptor if required
hwupdatewalk = FALSE;
s2fslwalk = FALSE;
S1.addrdesc.fault = AArch64.CheckAndUpdateDescriptor(S1.descupdate, S1.addrdesc.fault,
                                                    secondstage, vaddress, acctype,
                                                    iswrite, s2fslwalk, hwupdatewalk);

return S1.addrdesc;
```

## Library pseudocode for aarch64/translation/translation/AArch64.FullTranslate

```
// AArch64.FullTranslate()
// =====
// Perform both stage 1 and stage 2 translation walks for the current translation regime. The
// function used by Address Translation operations is similar except it uses the translation
// regime specified for the instruction.

AddressDescriptor AArch64.FullTranslate(bits(64) vaddress, AccType acctype, boolean iswrite,
                                         boolean wasaligned, integer size)

    // First Stage Translation
    S1 = AArch64.FirstStageTranslate(vaddress, acctype, iswrite, wasaligned, size);
    if !IsFault(S1) && !\(HaveNV2Ext\(\)\) && acctype == AccType\_NV2REGISTER && HasS2Translation\(\) then
        s2fslwalk = FALSE;
        hwupdatewalk = FALSE;
        result = AArch64.SecondStageTranslate(S1, vaddress, acctype, iswrite, wasaligned, s2fslwalk,
                                                size, hwupdatewalk);
    else
        result = S1;

    return result;
```



## Library pseudocode for aarch64/translation/translation/AArch64.SecondStageTranslate

```
// AArch64.SecondStageTranslate()
// =====
// Perform a stage 2 translation walk. The function used by Address Translation operations is
// similar except it uses the translation regime specified for the instruction.

AddressDescriptor AArch64.SecondStageTranslate(AddressDescriptor S1, bits(64) vaddress,
                                              AccType acctype, boolean iswrite, boolean wasaligned,
                                              boolean s2fslwalk, integer size, boolean hwupdatewalk)

    assert HasS2Translation();

    s2_enabled = HCR_EL2.VM == '1' || HCR_EL2.DC == '1';
    secondstage = TRUE;

    if s2_enabled then // Second stage enabled
        ipaddress = S1.address.address<51:0>;
        NS = S1.address.NS == '1';
        S2 = AArch64.TranslationTableWalk(ipaddress, NS, vaddress, acctype, iswrite, secondstage,
                                           s2fslwalk, size);

        // Check for unaligned data accesses to Device memory
        if ((!wasaligned && acctype != AccType_IFETCH) || (acctype == AccType_DCZVA))
            && S2.addrdesc.memattrs.memtype == MemType_Device && !IsFault(S2.addrdesc) then
                S2.addrdesc.fault = AArch64.AlignmentFault(acctype, iswrite, secondstage);

        // Check for permissions on Stage2 translations
        if !IsFault(S2.addrdesc) then
            S2.addrdesc.fault = AArch64.CheckS2Permission(S2.perms, vaddress, ipaddress, S2.level,
                                                         acctype, iswrite, NS, s2fslwalk, hwupdatewalk);

        // Check for instruction fetches from Device memory not marked as execute-never. As there
        // has not been a Permission Fault then the memory is not marked execute-never.
        if (!s2fslwalk && !IsFault(S2.addrdesc) && S2.addrdesc.memattrs.memtype == MemType_Device &&
            acctype == AccType_IFETCH) then
            S2.addrdesc = AArch64.InstructionDevice(S2.addrdesc, vaddress, ipaddress, S2.level,
                                                    acctype, iswrite,
                                                    secondstage, s2fslwalk);

        if (s2fslwalk && !IsFault(S2.addrdesc) &&
            S2.addrdesc.memattrs.memtype == MemType_Device) then
            // Check for protected table walk.
            if HCR_EL2.PTW == '1' then
                S2.addrdesc.fault = AArch64.PermissionFault(ipaddress,
                                                            NS, S2.level,
                                                            acctype, iswrite, secondstage, s2fslwalk);
            else
                // Translation table walk occurs as Normal Non-cacheable memory.
                S2.addrdesc.memattrs.memtype = MemType_Normal;
                S2.addrdesc.memattrs.inner.attrs = MemAttr_NC;
                S2.addrdesc.memattrs.outer.attrs = MemAttr_NC;
                S2.addrdesc.memattrs.shareable = TRUE;
                S2.addrdesc.memattrs.outershareable = TRUE;

        // Check and update translation table descriptor if required
        S2.addrdesc.fault = AArch64.CheckAndUpdateDescriptor(S2.descupdate, S2.addrdesc.fault,
                                                            secondstage, vaddress, acctype,
                                                            iswrite, s2fslwalk, hwupdatewalk);

        result = AArch64.CombineS1S2Desc(S1, S2.addrdesc);
    else
        result = S1;

    return result;
```

## Library pseudocode for aarch64/translation/translation/AArch64.SecondStageWalk

```
// AArch64.SecondStageWalk()
// =====
// Perform a stage 2 translation on a stage 1 translation page table walk access.

AddressDescriptor AArch64.SecondStageWalk(AddressDescriptor S1, bits(64) vaddress, AccType acctype,
                                          boolean iswrite, integer size, boolean hwupdatewalk)

    assert HasS2Translation();

    s2fslwalk = TRUE;
    wasaligned = TRUE;
    return AArch64.SecondStageTranslate(S1, vaddress, acctype, iswrite, wasaligned, s2fslwalk,
                                         size, hwupdatewalk);
```

## Library pseudocode for aarch64/translation/translation/AArch64.TranslateAddress

```
// AArch64.TranslateAddress()
// =====
// Main entry point for translating an address

AddressDescriptor AArch64.TranslateAddress(bits(64) vaddress, AccType acctype, boolean iswrite,
                                          boolean wasaligned, integer size)

    result = AArch64.FullTranslate(vaddress, acctype, iswrite, wasaligned, size);

    if !(acctype IN {AccType_PTW, AccType_IC, AccType_AT}) && !IsFault(result) then
        result.fault = AArch64.CheckDebug(vaddress, acctype, iswrite, size);

    // Update virtual address for abort functions
    result.vaddress = ZeroExtend(vaddress);

    return result;
```



```

// AArch64.TranslationTableWalk()
// =====
// Returns a result of a translation table walk
//
// Implementations might cache information from memory in any number of non-coherent TLB
// caching structures, and so avoid memory accesses that have been expressed in this
// pseudocode. The use of such TLBs is not expressed in this pseudocode.

TLBRecord AArch64.TranslationTableWalk(bits(52) ipaddress, boolean s1_nonsecure, bits(64) vaddress,
                                         AccType acctype, boolean iswrite, boolean secondstage,
                                         boolean s2fslwalk, integer size)

if !secondstage then
    assert !ELUsingAArch32(S1TranslationRegime());
else
    assert (IsSecureEL2Enabled() || (HaveEL(EL2) && !IsSecure() && !ELUsingAArch32(EL2))) && HasS2Tr

TLBRecord result;
AddressDescriptor descaddr;
bits(64) baseregister;
bits(64) inputaddr;          // Input Address is 'vaddress' for stage 1, 'ipaddress' for stage 2
bit nswalk;                  // Stage 2 translation table walks are to Secure or to Non-secure PA

result.descupdate.AF = FALSE;
result.descupdate.AP = FALSE;

descaddr.memattrs.memtype = MemType_Normal;

// Derived parameters for the page table walk:
// grainsize = Log2(Size of Table)          - Size of Table is 4KB, 16KB or 64KB in AArch64
// stride = Log2(Address per Level)         - Bits of address consumed at each level
// firstblocklevel = First level where a block entry is allowed
// ps = Physical Address size as encoded in TCR_EL1.IPS or TCR_ELx/VTCCR_EL2.PS
// inputsize = Log2(Size of Input Address) - Input Address size in bits
// level = Level to start walk from
// This means that the number of levels after start level = 3-level

if !secondstage then
    // First stage translation
    inputaddr = ZeroExtend(vaddress);
    el = AArch64.AccessUsesEL(acctype);
    top = AddrTop(inputaddr, (acctype == AccType_IFETCH), el);
    if el == EL3 then
        largegrain = TCR_EL3.TG0 == '01';
        midgrain = TCR_EL3.TG0 == '10';
        inputsize = 64 - UInt(TCR_EL3.T0SZ);
        inputsize_max = if Have52BitVAExt() && largegrain then 52 else 48;
        inputsize_min = 64 - (if !HaveSmallPageTblExt() then 39 else if largegrain then 47 else 48);
        if inputsize < inputsize_min then
            c = ConstrainUnpredictable(Unpredictable_REStnSZ);
            assert c IN {Constraint_FORCE, Constraint_FAULT};
            if c == Constraint_FORCE then inputsize = inputsize_min;
        ps = TCR_EL3.PS;
        basefound = inputsize >= inputsize_min && inputsize <= inputsize_max && IsZero(inputaddr<top>);
        disabled = FALSE;
        baseregister = TTBR0_EL3;
        descaddr.memattrs = WalkAttrDecode(TCR_EL3.SH0, TCR_EL3.ORGNO, TCR_EL3.IRGNO, secondstage);
        reversedescriptors = SCTLRL_EL3.EE == '1';
        lookupsecure = TRUE;
        singlepriv = TRUE;
        update_AF = HaveAccessFlagUpdateExt() && TCR_EL3.HA == '1';
        update_AP = HaveDirtyBitModifierExt() && update_AF && TCR_EL3.HD == '1';
        hierattrsddisabled = AArch64.HaveHPDEExt() && TCR_EL3.HPD == '1';
    elseif ELIsInHost(el) then
        if inputaddr<top> == '0' then
            largegrain = TCR_EL2.TG0 == '01';
            midgrain = TCR_EL2.TG0 == '10';
            inputsize = 64 - UInt(TCR_EL2.T0SZ);
            inputsize_max = if Have52BitVAExt() && largegrain then 52 else 48;
            inputsize_min = 64 - (if !HaveSmallPageTblExt() then 39 else if largegrain then 47 else 48);
            if inputsize < inputsize_min then

```

```

        c = ConstrainUnpredictable(Unpredictable\_RESTnSZ);
        assert c IN {Constraint\_FORCE, Constraint\_FAULT};
        if c == Constraint\_FORCE then inputsize = inputsize_min;
        basefound = inputsize >= inputsize_min && inputsize <= inputsize_max && IsZero(inputaddr<top>);
        disabled = TCR_EL2.EPD0 == '1' || (el == EL0 && HaveE0PDEExt() && TCR_EL2.E0PD0 == '1');
        disabled = disabled || (el == EL0 && acctype == AccType\_NONFAULT && TCR_EL2.NFD0 == '1');
        baseregister = TTBR0_EL2;
        descaddr.memattrs = WalkAttrDecode(TCR_EL2.SH0, TCR_EL2.ORGNO, TCR_EL2.IRGNO, secondstage);
        hierattrsddisabled = AArch64.HaveHPDEExt() && TCR_EL2.HPD0 == '1';
    else
        inputsize = 64 - UInt(TCR_EL2.T1SZ);
        largegrain = TCR_EL2.TG1 == '11'; // TG1 and TG0 encodings differ
        midgrain = TCR_EL2.TG1 == '01';
        inputsize_max = if Have52BitVAExt() && largegrain then 52 else 48;
        inputsize_min = 64 - (if !HaveSmallPageTblExt() then 39 else if largegrain then 47 else 48);
        if inputsize < inputsize_min then
            c = ConstrainUnpredictable(Unpredictable\_RESTnSZ);
            assert c IN {Constraint\_FORCE, Constraint\_FAULT};
            if c == Constraint\_FORCE then inputsize = inputsize_min;
            basefound = inputsize >= inputsize_min && inputsize <= inputsize_max && IsOnes(inputaddr<top>);
            disabled = TCR_EL2.EPD1 == '1' || (el == EL0 && HaveE0PDEExt() && TCR_EL2.E0PD1 == '1');
            disabled = disabled || (el == EL0 && acctype == AccType\_NONFAULT && TCR_EL2.NFD1 == '1');
            baseregister = TTBR1_EL2;
            descaddr.memattrs = WalkAttrDecode(TCR_EL2.SH1, TCR_EL2.ORGNO, TCR_EL2.IRGNO, secondstage);
            hierattrsddisabled = AArch64.HaveHPDEExt() && TCR_EL2.HPD1 == '1';
        ps = TCR_EL2.IPS;
        reversedescriptors = SCTLR_EL2.EE == '1';
        lookupsecure = if IsSecureEL2Enabled() then IsSecure() else FALSE;
        singlepriv = FALSE;
        update_AF = HaveAccessFlagUpdateExt() && TCR_EL2.HA == '1';
        update_AP = HaveDirtyBitModifierExt() && update_AF && TCR_EL2.HD == '1';
    elseif el == EL2 then
        inputsize = 64 - UInt(TCR_EL2.T0SZ);
        largegrain = TCR_EL2.TG0 == '01';
        midgrain = TCR_EL2.TG0 == '10';
        inputsize_max = if Have52BitVAExt() && largegrain then 52 else 48;

        if !Have52BitVAExt() && inputsize > inputsize_max then
            c = ConstrainUnpredictable(Unpredictable\_RESTnSZ);
            assert c IN {Constraint\_FORCE, Constraint\_FAULT};
            if c == Constraint\_FORCE then inputsize = inputsize_max;

        inputsize_min = 64 - (if !HaveSmallPageTblExt() then 39 else if largegrain then 47 else 48);
        if inputsize < inputsize_min then
            c = ConstrainUnpredictable(Unpredictable\_RESTnSZ);
            assert c IN {Constraint\_FORCE, Constraint\_FAULT};
            if c == Constraint\_FORCE then inputsize = inputsize_min;
        ps = TCR_EL2.PS;
        basefound = inputsize >= inputsize_min && inputsize <= inputsize_max && IsZero(inputaddr<top>);
        disabled = FALSE;
        baseregister = TTBR0_EL2;
        descaddr.memattrs = WalkAttrDecode(TCR_EL2.SH0, TCR_EL2.ORGNO, TCR_EL2.IRGNO, secondstage);
        reversedescriptors = SCTLR_EL2.EE == '1';
        lookupsecure = if IsSecureEL2Enabled() then IsSecure() else FALSE;
        singlepriv = TRUE;
        update_AF = HaveAccessFlagUpdateExt() && TCR_EL2.HA == '1';
        update_AP = HaveDirtyBitModifierExt() && update_AF && TCR_EL2.HD == '1';
        hierattrsddisabled = AArch64.HaveHPDEExt() && TCR_EL2.HPD == '1';
    else
        if inputaddr<top> == '0' then
            inputsize = 64 - UInt(TCR_EL1.T0SZ);
            largegrain = TCR_EL1.TG0 == '01';
            midgrain = TCR_EL1.TG0 == '10';
            inputsize_max = if Have52BitVAExt() && largegrain then 52 else 48;

            if !Have52BitVAExt() && inputsize > inputsize_max then
                c = ConstrainUnpredictable(Unpredictable\_RESTnSZ);
                assert c IN {Constraint\_FORCE, Constraint\_FAULT};
                if c == Constraint\_FORCE then inputsize = inputsize_max;

```

```

inputsize_min = 64 - (if !HaveSmallPageTblExt() then 39 else if largegrain then 47 else 4
if inputsize < inputsize_min then
    c = ConstrainUnpredictable(Unpredictable_RESTnSZ);
    assert c IN {Constraint_FORCE, Constraint_FAULT};
    if c == Constraint_FORCE then inputsize = inputsize_min;
basefound = inputsize >= inputsize_min && inputsize <= inputsize_max && IsZero(inputaddr
disabled = TCR_EL1.EPD0 == '1' || (el == EL0 && HaveE0PDEExt() && TCR_EL1.E0PD0 == '1');
disabled = disabled || (el == EL0 && acctype == AccType_NONFAULT && TCR_EL1.NFD0 == '1');
baseregister = TTBR0_EL1;
descaddr.memattrs = WalkAttrDecode(TCR_EL1.SH0, TCR_EL1.ORGNO, TCR_EL1.IRGN0, secondstage
hierattrsdiscabled = AArch64.HaveHPDEExt() && TCR_EL1.HPD0 == '1';
else
    inputsize = 64 - UInt(TCR_EL1.T1SZ);
    largegrain = TCR_EL1.TG1 == '11';          // TG1 and TG0 encodings differ
    midgrain = TCR_EL1.TG1 == '01';
    inputsize_max = if Have52BitVAExt() && largegrain then 52 else 48;

    if !Have52BitVAExt() && inputsize > inputsize_max then
        c = ConstrainUnpredictable(Unpredictable_RESTnSZ);
        assert c IN {Constraint_FORCE, Constraint_FAULT};
        if c == Constraint_FORCE then inputsize = inputsize_max;

inputsize_min = 64 - (if !HaveSmallPageTblExt() then 39 else if largegrain then 47 else 4
if inputsize < inputsize_min then
    c = ConstrainUnpredictable(Unpredictable_RESTnSZ);
    assert c IN {Constraint_FORCE, Constraint_FAULT};
    if c == Constraint_FORCE then inputsize = inputsize_min;
basefound = inputsize >= inputsize_min && inputsize <= inputsize_max && IsOnes(inputaddr
disabled = TCR_EL1.EPD1 == '1' || (el == EL0 && HaveE0PDEExt() && TCR_EL1.E0PD1 == '1');
disabled = disabled || (el == EL0 && acctype == AccType_NONFAULT && TCR_EL1.NFD1 == '1');
baseregister = TTBR1_EL1;
descaddr.memattrs = WalkAttrDecode(TCR_EL1.SH1, TCR_EL1.ORGNO, TCR_EL1.IRGN1, secondstage
hierattrsdiscabled = AArch64.HaveHPDEExt() && TCR_EL1.HPD1 == '1';
ps = TCR_EL1.IPS;
reversedescriptors = SCTLR_EL1.EE == '1';
lookupsecure = IsSecure();
singlepriv = FALSE;
update_AF = HaveAccessFlagUpdateExt() && TCR_EL1.HA == '1';
update_AP = HaveDirtyBitModifierExt() && update_AF && TCR_EL1.HD == '1';
if largegrain then
    grainsize = 16;                                // Log2(64KB page size)
    firstblocklevel = (if Have52BitPAExt() then 1 else 2); // Largest block is 4TB (2^42 byt
// and 512MB (2^29 bytes) otherw

elseif midgrain then
    grainsize = 14;                                // Log2(16KB page size)
    firstblocklevel = 2;                            // Largest block is 32MB (2^25 by

else // Small grain
    grainsize = 12;                                // Log2(4KB page size)
    firstblocklevel = 1;                            // Largest block is 1GB (2^30 byt
stride = grainsize - 3;                            // Log2(page size / 8 bytes)
// The starting level is the number of strides needed to consume the input address
level = 4 - (1 + ((inputsize - grainsize - 1) DIV stride));

else
    // Second stage translation
    inputaddr = ZeroExtend(ipaddress);
    if IsSecureBelowEL3() then
        // Second stage for Secure translation regime
        if s1_nonsecure then // Non-secure IPA space
            t0size = VTCR_EL2.T0SZ;
            tg0 = VTCR_EL2.TG0;
            nswalk = VTCR_EL2.NSW;
        else // Secure IPA space
            t0size = VSTCR_EL2.T0SZ;
            tg0 = VSTCR_EL2.TG0;
            nswalk = VSTCR_EL2.SW;

    // Stage 2 translation accesses the Non-secure PA space or the Secure PA space
    if nswalk == '1' then
        // When walk is Non-secure, access must be to the Non-secure PA space

```

```

        nsaccess = '1';
    elseif !sl_nonsecure then
        // When walk is Secure and in the Secure IPA space,
        // access is specified by VSTCR_EL2.SA
        nsaccess = VSTCR_EL2.SA;
    elseif VSTCR_EL2.SW == '1' || VSTCR_EL2.SA == '1' then
        // When walk is Secure and in the Non-secure IPA space,
        // access is Non-secure when VSTCR_EL2.SA specifies the Non-secure PA space
        nsaccess = '1';
    else
        // When walk is Secure and in the Non-secure IPA space,
        // if VSTCR_EL2.SA specifies the Secure PA space, access is specified by VTCR_EL2.NSA
        nsaccess = VTCR_EL2.NSA;
    else
        // Second stage for Non-secure translation regime
        t0size = VTCR_EL2.T0SZ;
        tg0 = VTCR_EL2.TG0;
        nswalk = '1';
        nsaccess = '1';

    inputsize = 64 - UInt(t0size);
    largegrain = tg0 == '01';
    midgrain = tg0 == '10';

    inputsize_max = if Have52BitPAExt() && PAMax() == 52 && largegrain then 52 else 48;
    inputsize_min = 64 - (if !HaveSmallPageTblExt() then 39 else if largegrain then 47 else 48);
    if inputsize < inputsize_min then
        c = ConstrainUnpredictable(Unpredictable_RESTnSZ);
        assert c IN {Constraint_FORCE, Constraint_FAULT};
        if c == Constraint_FORCE then inputsize = inputsize_min;
    ps = VTCR_EL2.PS;
    basefound = inputsize >= inputsize_min && inputsize <= inputsize_max && IsZero(inputaddr<63:input
    disabled = FALSE;
    descaddr.memattrs = WalkAttrDecode(VTCR_EL2.SH0, VTCR_EL2.ORGNO, VTCR_EL2.IRGNO, secondstage);
    reversedescriptors = SCTLR_EL2.EE == '1';
    singlepriv = TRUE;
    update_AF = HaveAccessFlagUpdateExt() && VTCR_EL2.HA == '1';
    update_AP = HaveDirtyBitModifierExt() && update_AF && VTCR_EL2.HD == '1';

    if IsSecureEL2Enabled() then
        lookupsecure = !sl_nonsecure;
    else
        lookupsecure = FALSE;

    if lookupsecure then
        baseregister = VSTTBR_EL2;
        startlevel = UInt(VSTCR_EL2.SL0);
    else
        baseregister = VTTBR_EL2;
        startlevel = UInt(VTCR_EL2.SL0);
    if largegrain then
        grainsize = 16; // Log2(64KB page size)
        level = 3 - startlevel;
        firstblocklevel = (if Have52BitPAExt() then 1 else 2); // Largest block is 4TB (2^42 bytes)
        // and 512MB (2^29 bytes) otherwise
    elseif midgrain then
        grainsize = 14; // Log2(16KB page size)
        level = 3 - startlevel;
        firstblocklevel = 2; // Largest block is 32MB (2^25 bytes)
    else // Small grain
        grainsize = 12; // Log2(4KB page size)
        if HaveSmallPageTblExt() && startlevel == 3 then
            level = startlevel; // Startlevel 3 (VTCR_EL2.SL0 or VSTCR_EL2.SL0)
        else
            level = 2 - startlevel;
            firstblocklevel = 1; // Largest block is 1GB (2^30 bytes)
        stride = grainsize - 3; // Log2(page size / 8 bytes)

    // Limits on IPA controls based on implemented PA size. Level 0 is only
    // supported by small grain translations

```



```

if largegrain then // 64KB pages
    // Level 1 only supported if implemented PA size is greater than 2^42 bytes
    if level == 0 || (level == 1 && PAMax() <= 42) then basefound = FALSE;
elseif midgrain then // 16KB pages
    // Level 1 only supported if implemented PA size is greater than 2^40 bytes
    if level == 0 || (level == 1 && PAMax() <= 40) then basefound = FALSE;
else // Small grain, 4KB pages
    // Level 0 only supported if implemented PA size is greater than 2^42 bytes
    if level < 0 || (level == 0 && PAMax() <= 42) then basefound = FALSE;

// If the inputsize exceeds the PAMax value, the behavior is CONSTRAINED UNPREDICTABLE
inputsizecheck = inputsize;
if inputsize > PAMax() && (!ELUsingAArch32(EL1) || inputsize > 40) then
    case ConstrainUnpredictable(Unpredictable_LARGEIPA) of
        when Constraint_FORCE
            // Restrict the inputsize to the PAMax value
            inputsize = PAMax();
            inputsizecheck = PAMax();
        when Constraint_FORCENOSLCHECK
            // As FORCE, except use the configured inputsize in the size checks below
            inputsize = PAMax();
        when Constraint_FAULT
            // Generate a translation fault
            basefound = FALSE;
        otherwise
            Unreachable();

// Number of entries in the starting level table =
// (Size of Input Address)/((Address per level)^(Num levels remaining)*(Size of Table))
startsizecheck = inputsizecheck - ((3 - level)*stride + grainsize); // Log2(Num of entries)

// Check for starting level table with fewer than 2 entries or longer than 16 pages.
// Lower bound check is: startsizecheck < Log2(2 entries)
// Upper bound check is: startsizecheck > Log2(pagesize/8*16)
if startsizecheck < 1 || startsizecheck > stride + 4 then basefound = FALSE;
if !basefound || disabled then
    level = 0; // AArch32 reports this as a level 1 fault
    result.addrdesc.fault = AArch64.TranslationFault(ipaddress, sl_nonsecure, level, acctype, iswrite,
        secondstage, s2fslwalk);

    return result;

case ps of
    when '000' outputsiz = 32;
    when '001' outputsiz = 36;
    when '010' outputsiz = 40;
    when '011' outputsiz = 42;
    when '100' outputsiz = 44;
    when '101' outputsiz = 48;
    when '110' outputsiz = (if Have52BitPAExt() && largegrain then 52 else 48);
    otherwise outputsiz = integer IMPLEMENTATION_DEFINED "Reserved Intermediate Physical Address s

if outputsiz > PAMax() then outputsiz = PAMax();

if outputsiz < 48 && !IsZero(baseregister<47:outputsiz>) then
    level = 0;
    result.addrdesc.fault = AArch64.AddressSizeFault(ipaddress, sl_nonsecure, level, acctype, iswrite,
        secondstage, s2fslwalk);

    return result;

// Bottom bound of the Base address is:
// Log2(8 bytes per entry)+Log2(Number of entries in starting level table)
// Number of entries in starting level table =
// (Size of Input Address)/((Address per level)^(Num levels remaining)*(Size of Table))
baselowerbound = 3 + inputsize - ((3-level)*stride + grainsize); // Log2(Num of entries*8)
if outputsiz == 52 then
    z = (if baselowerbound < 6 then 6 else baselowerbound);
    baseaddress = baseregister<5:2>:baseregister<47:z>:Zeros(z);
else
    baseaddress = ZeroExtend(baseregister<47:baselowerbound>:Zeros(baselowerbound));

```



```

ns_table = if lookupsecure then '0' else '1';
ap_table = '00';
xn_table = '0';
pxn_table = '0';

addrselecttop = inputsizetop - 1;

apply_nvnv1_effect = HaveNVExt() && EL2Enabled() && HCR_EL2.<NV,NV1> == '11' && S1TranslationRegime(
repeat
    addrselectbottom = (3-level)*stride + grainsize;

    bits(52) index = ZeroExtend(inputaddr<addrselecttop:addrselectbottom>:'000');
    descaddr.paddress.address = baseaddress OR index;
    descaddr.paddress.NS = if secondstage then nswalk else ns_table;

    // If there are two stages of translation, then the first stage table walk addresses
    // are themselves subject to translation
    if secondstage || !HasS2Translation() || (HaveNV2Ext() && acctype == AccType_NV2REGISTER) then
        descaddr2 = descaddr;
    else
        hwupdatewalk = FALSE;
        descaddr2 = AArch64.SecondStageWalk(descaddr, vaddress, acctype, iswrite, 8, hwupdatewalk);
        // Check for a fault on the stage 2 walk
        if IsFault(descaddr2) then
            result.addrdesc.fault = descaddr2.fault;
            return result;

    // Update virtual address for abort functions
    descaddr2.vaddress = ZeroExtend(vaddress);

    accdesc = CreateAccessDescriptorPTW(acctype, secondstage, s2fslwalk, level);
    desc = _Mem[descaddr2, 8, accdesc];

    if reversedescriptors then desc = BigEndianReverse(desc);

    if desc<0> == '0' || (desc<1:0> == '01' && (level == 3 ||
        (HaveBlockBBM() && IsBlockDescriptorNTBitValid() && c
        // Fault (00), Reserved (10), Block (01) at level 3, or Block(01) with nT bit set.
        result.addrdesc.fault = AArch64.TranslationFault(ipaddress, s1_nonsecure, level, acctype,
            iswrite, secondstage, s2fslwalk);

        return result;

    // Valid Block, Page, or Table entry
    if desc<1:0> == '01' || level == 3 then // Block (01) or Page (11)
        blocktranslate = TRUE;
    else // Table (11)
        if (outputsize < 52 && largegrain && (PAMax() == 52 ||
            boolean IMPLEMENTATION_DEFINED "Address Size Fault on LPA descriptor bits [15:12]" &&
            !IsZero(desc<15:12>)) || (outputsize < 48 && !IsZero(desc<47:outputsize>)) then
            result.addrdesc.fault = AArch64.AddressSizeFault(ipaddress, s1_nonsecure, level, acctype,
                iswrite, secondstage, s2fslwalk);

            return result;

    if outputsize == 52 then
        baseaddress = desc<15:12>:desc<47:grainsize>:Zeros(grainsize);
    else
        baseaddress = ZeroExtend(desc<47:grainsize>:Zeros(grainsize));
    if !secondstage then
        // Unpack the upper and lower table attributes
        ns_table = ns_table OR desc<63>;
    if !secondstage && !hierattrsddisabled then
        ap_table<1> = ap_table<1> OR desc<62>; // read-only

        if apply_nvnv1_effect then
            pxn_table = pxn_table OR desc<60>;
        else
            xn_table = xn_table OR desc<60>;
        // pxn_table and ap_table[0] apply in EL1&0 or EL2&0 translation regimes
        if !singlepriv then
            if !apply_nvnv1_effect then

```

```

        pxn_table = pxn_table OR desc<59>;
        ap_table<0> = ap_table<0> OR desc<61>; // privileged

        level = level + 1;
        addrselecttop = addrselectbottom - 1;
        blocktranslate = FALSE;
until blocktranslate;

// Check block size is supported at this level
if level < firstblocklevel then
    result.addrdesc.fault = AArch64.TranslationFault(ipaddress, s1_nonsecure, level, acctype,
                                                    iswrite, secondstage, s2fslwalk);
    return result;

// Check for misprogramming of the contiguous bit
if largegrain then
    num_ch_entries = 5;
elseif midgrain then
    num_ch_entries = if level == 3 then 7 else 5;
else
    num_ch_entries = 4;

contiguousbitcheck = inputsize < (addrselectbottom + num_ch_entries);

if contiguousbitcheck && desc<52> == '1' then
    if boolean IMPLEMENTATION_DEFINED "Translation fault on misprogrammed contiguous bit" then
        result.addrdesc.fault = AArch64.TranslationFault(ipaddress, s1_nonsecure, level, acctype,
                                                    iswrite, secondstage, s2fslwalk);
        return result;

// Unpack the descriptor into address and upper and lower block attributes
if largegrain then
    outputaddress = desc<15:12>:desc<47:addrselectbottom>:inputaddr<addrselectbottom-1:0>;
else
    outputaddress = ZeroExtend(desc<47:addrselectbottom>:inputaddr<addrselectbottom-1:0>);

// When 52-bit PA is supported, for 64 Kbyte translation granule,
// block size might be larger than the supported output address size
if ((outputsize < 52 && !IsZero(outputaddress<51:48>) && largegrain && (PAMax() == 52 ||
boolean IMPLEMENTATION_DEFINED "Address Size Fault on LPA descriptor bits [15:12]")) ||
(outputsize < 48 && !IsZero(outputaddress<47:outputsize>))) then
    result.addrdesc.fault = AArch64.AddressSizeFault(ipaddress, s1_nonsecure, level, acctype,
                                                    iswrite, secondstage, s2fslwalk);
    return result;

// Check Access Flag
if desc<10> == '0' then
    if !update_AF then
        result.addrdesc.fault = AArch64.AccessFlagFault(ipaddress, s1_nonsecure, level, acctype,
                                                    iswrite, secondstage, s2fslwalk);
        return result;
    else
        result.descupdate.AF = TRUE;

if update_AP && desc<51> == '1' then
    // If hw update of access permission field is configured consider AP[2] as '0' / S2AP[2] as '1'
    if !secondstage && desc<7> == '1' then
        desc<7> = '0';
        result.descupdate.AP = TRUE;
    elseif secondstage && desc<7> == '0' then
        desc<7> = '1';
        result.descupdate.AP = TRUE;

// Required descriptor if AF or AP[2]/S2AP[2] needs update
result.descupdate.descaddr = descaddr;

if apply_nvnv1_effect then
    pxn = desc<54>; // Bit[54] of the block/page descriptor holds
    xn = '0'; // XN is '0'
    ap = desc<7>:'01'; // Bit[6] of the block/page descriptor is 1

```

```

else
    xn = desc<54>; // Bit[54] of the block/page descriptor ho
    pxn = desc<53>; // Bit[53] of the block/page descriptor ho
    ap = desc<7:6>:'1'; // Bits[7:6] of the block/page descriptor h
    contiguousbit = desc<52>;
    nG = desc<11>;
    sh = desc<9:8>;
    memattr = desc<5:2>; // AttrIndx and NS bit in stage 1

    result.domain = bits(4) UNKNOWN; // Domains not used
    result.level = level;
    result.blocksize = 2^((3-level)*stride + grainsize);

// Stage 1 translation regimes also inherit attributes from the tables
if !secondstage then
    result.perms.xn = xn OR xn_table;
    result.perms.ap<2> = ap<2> OR ap_table<1>; // Force read-only
    // PXN, nG and AP[1] apply in EL1&0 or EL2&0 stage 1 translation regimes
    if !singlepriv then
        result.perms.ap<1> = ap<1> AND NOT(ap_table<0>); // Force privileged only
        result.perms.pxn = pxn OR pxn_table;
        // Pages from Non-secure tables are marked non-global in Secure EL1&0
        if IsSecure() then
            result.nG = nG OR ns_table;
        else
            result.nG = nG;
    else
        result.perms.ap<1> = '1';
        result.perms.pxn = '0';
        result.nG = '0';
    result.GP = desc<50>; // Stage 1 block or pages might be guarded
    result.perms.ap<0> = '1';
    result.addrdesc.memattr = AArch64.S1AttrDecode(sh, memattr<2:0>, acctype);
    result.addrdesc.paddress.NS = memattr<3> OR ns_table;
else
    result.perms.ap<2:1> = ap<2:1>;
    result.perms.ap<0> = '1';
    result.perms.xn = xn;
    if HaveExtendedExecuteNeverExt() then result.perms.xxn = desc<53>;
    result.perms.pxn = '0';
    result.nG = '0';
    if s2fslwalk then
        result.addrdesc.memattr = S2AttrDecode(sh, memattr, AccType_PTW);
    else
        result.addrdesc.memattr = S2AttrDecode(sh, memattr, acctype);
    result.addrdesc.paddress.NS = nsaccess;

result.addrdesc.paddress.address = outputaddress;
result.addrdesc.fault = AArch64.NoFault();
result.contiguous = contiguousbit == '1';
if HaveCommonNotPrivateTransExt() then result.CnP = baseregister<0>;

return result;

```

## Library pseudocode for shared/debug/ClearStickyErrors/ClearStickyErrors

```
// ClearStickyErrors()
// =====

ClearStickyErrors()
    EDCR.TXU = '0';           // Clear TX underrun flag
    EDCR.RX0 = '0';           // Clear RX overrun flag

    if Halted() then           // in Debug state
        EDCR.IT0 = '0';       // Clear ITR overrun flag

    // If halted and the ITR is not empty then it is UNPREDICTABLE whether the EDCR.ERR is cleared.
    // The UNPREDICTABLE behavior also affects the instructions in flight, but this is not described
    // in the pseudocode.
    if Halted() && EDCR.ITE == '0' && ConstrainUnpredictableBool(Unpredictable_CLEARERRITEZERO) then
        return;
    EDCR.ERR = '0';           // Clear cumulative error flag

    return;
```

## Library pseudocode for shared/debug/DebugTarget/DebugTarget

```
// DebugTarget()
// =====
// Returns the debug exception target Exception level

bits(2) DebugTarget()
    secure = IsSecure();
    return DebugTargetFrom(secure);
```

## Library pseudocode for shared/debug/DebugTarget/DebugTargetFrom

```
// DebugTargetFrom()
// =====

bits(2) DebugTargetFrom(boolean secure)
    if HaveEL(EL2) && (!secure || (HaveSecureEL2Ext() && (!HaveEL(EL3) || SCR_EL3.EEL2 == '1'))) then
        if ELUsingAArch32(EL2) then
            route_to_el2 = (HDCR.TDE == '1' || HCR.TGE == '1');
        else
            route_to_el2 = (MDCR_EL2.TDE == '1' || HCR_EL2.TGE == '1');
    else
        route_to_el2 = FALSE;

    if route_to_el2 then
        target = EL2;
    elsif HaveEL(EL3) && HighestELUsingAArch32() && secure then
        target = EL3;
    else
        target = EL1;

    return target;
```

## Library pseudocode for shared/debug/DoubleLockStatus/DoubleLockStatus

```
// DoubleLockStatus()
// =====
// Returns the state of the OS Double Lock.
// FALSE if OSDLR_EL1.DLK == 0 or DBGPRCR_EL1.CORENPDRQ == 1 or the PE is in Debug state.
// TRUE if OSDLR_EL1.DLK == 1 and DBGPRCR_EL1.CORENPDRQ == 0 and the PE is in Non-debug state.

boolean DoubleLockStatus()
    if !HaveDoubleLock() then
        return FALSE;
    elseif ELUsingAArch32(EL1) then
        return DBGOSDLR.DLK == '1' && DBGPRCR.CORENPDRQ == '0' && !Halted();
    else
        return OSDLR_EL1.DLK == '1' && DBGPRCR_EL1.CORENPDRQ == '0' && !Halted();
```

## Library pseudocode for shared/debug/authentication/AllowExternalDebugAccess

```
// AllowExternalDebugAccess()
// =====
// Returns TRUE if an external debug interface access to the External debug registers
// is allowed, FALSE otherwise.

boolean AllowExternalDebugAccess()
    // The access may also be subject to OS Lock, power-down, etc.
    if HaveSecureExtDebugView() then
        return AllowExternalDebugAccess(IsAccessSecure());
    else
        return AllowExternalDebugAccess(ExternalSecureInvasiveDebugEnabled());

// AllowExternalDebugAccess()
// =====
// Returns TRUE if an external debug interface access to the External debug registers
// is allowed for the given Security state, FALSE otherwise.

boolean AllowExternalDebugAccess(boolean allow_secure)
    // The access may also be subject to OS Lock, power-down, etc.
    if HaveSecureExtDebugView() || ExternalInvasiveDebugEnabled() then
        if allow_secure then
            return TRUE;
        elseif HaveEL(EL3) then
            if ELUsingAArch32(EL3) then
                return SDCR.EDAD == '0';
            else
                return MDCR_EL3.EDAD == '0';
        else
            return !IsSecure();
    else
        return FALSE;
```

## Library pseudocode for shared/debug/authentication/AllowExternalPMUAccess

```
// AllowExternalPMUAccess()
// =====
// Returns TRUE if an external debug interface access to the PMU registers is allowed, FALSE otherwise.

boolean AllowExternalPMUAccess()
    // The access may also be subject to OS Lock, power-down, etc.
    if HaveSecureExtDebugView() then
        return AllowExternalPMUAccess(IsAccessSecure());
    else
        return AllowExternalPMUAccess(ExternalSecureNoninvasiveDebugEnabled());

// AllowExternalPMUAccess()
// =====
// Returns TRUE if an external debug interface access to the PMU registers is allowed for the given
// Security state, FALSE otherwise.

boolean AllowExternalPMUAccess(boolean allow_secure)
    // The access may also be subject to OS Lock, power-down, etc.
    if HaveSecureExtDebugView() || ExternalNoninvasiveDebugEnabled() then
        if allow_secure then
            return TRUE;
        elseif HaveEL(EL3) then
            if ELUsingAArch32(EL3) then
                return SDCR.EPMAD == '0';
            else
                return MDCR_EL3.EPMAD == '0';
        else
            return !IsSecure();
    else
        return FALSE;
```

## Library pseudocode for shared/debug/authentication/AllowExternalTraceAccess

```
// AllowExternalTraceAccess()
// =====
// Returns TRUE if an external Trace access to the Trace registers is allowed, FALSE otherwise.

boolean AllowExternalTraceAccess()
    if !HaveTraceBufferExtension() then
        return TRUE;
    else
        return AllowExternalTraceAccess(IsAccessSecure());

// AllowExternalTraceAccess()
// =====
// Returns TRUE if an external Trace access to the Trace registers is allowed for the
// given Security state, FALSE otherwise.

boolean AllowExternalTraceAccess(boolean access_is_secure)
    // The access may also be subject to OS lock, power-down, etc.
    if !HaveTraceBufferExtension() || access_is_secure then
        return TRUE;
    elseif HaveEL(EL3) then
        // External Trace access is not supported for EL3 using AArch32
        assert !ELUsingAArch32(EL3);

        return MDCR_EL3.ETAD == '0';
    else
        return !IsSecure();
```

## Library pseudocode for shared/debug/authentication/Debug\_authentication

```
signal DBGEN;
signal NIDEN;
signal SPIDEN;
signal SPNIDEN;
```

### Library pseudocode for shared/debug/authentication/ExternalInvasiveDebugEnabled

```
// ExternalInvasiveDebugEnabled()
// =====
// The definition of this function is IMPLEMENTATION DEFINED.
// In the recommended interface, this function returns the state of the DBGEN signal.

boolean ExternalInvasiveDebugEnabled()
    return DBGEN == HIGH;
```

### Library pseudocode for shared/debug/authentication/ExternalNoninvasiveDebugEnabled

```
// ExternalNoninvasiveDebugEnabled()
// =====
// Returns TRUE if Trace and PC Sample-based Profiling are allowed

boolean ExternalNoninvasiveDebugEnabled()
    return (ExternalNoninvasiveDebugEnabled() &&
        (!IsSecure() || ExternalSecureNoninvasiveDebugEnabled() ||
        (ELUsingAArch32(EL1) && PSTATE.EL == EL0 && SDER.SUNIDEN == '1')));
```

### Library pseudocode for shared/debug/authentication/ExternalNoninvasiveDebugEnabled

```
// ExternalNoninvasiveDebugEnabled()
// =====
// This function returns TRUE if the ARMv8.4-Debug is implemented, otherwise this
// function is IMPLEMENTATION DEFINED.
// In the recommended interface, ExternalNoninvasiveDebugEnabled returns the state of the (DBGEN
// OR NIDEN) signal.

boolean ExternalNoninvasiveDebugEnabled()
    return !HaveNoninvasiveDebugAuth() || ExternalInvasiveDebugEnabled() || NIDEN == HIGH;
```

### Library pseudocode for shared/debug/authentication/ExternalSecureInvasiveDebugEnabled

```
// ExternalSecureInvasiveDebugEnabled()
// =====
// The definition of this function is IMPLEMENTATION DEFINED.
// In the recommended interface, this function returns the state of the (DBGEN AND SPIDEN) signal.
// CoreSight allows asserting SPIDEN without also asserting DBGEN, but this is not recommended.

boolean ExternalSecureInvasiveDebugEnabled()
    if !HaveEL(EL3) && !IsSecure() then return FALSE;
    return ExternalInvasiveDebugEnabled() && SPIDEN == HIGH;
```

### Library pseudocode for shared/debug/authentication/ExternalSecureNoninvasiveDebugEnabled

```
// ExternalSecureNoninvasiveDebugEnabled()
// =====
// This function returns the value of ExternalSecureInvasiveDebugEnabled() when ARMv8.4-Debug
// is implemented. Otherwise, the definition of this function is IMPLEMENTATION DEFINED.
// In the recommended interface, this function returns the state of the (DBGEN OR NIDEN) AND
// (SPIDEN OR SPNIDEN) signal.

boolean ExternalSecureNoninvasiveDebugEnabled()
    if !HaveEL(EL3) && !IsSecure() then return FALSE;
    if HaveNoninvasiveDebugAuth() then
        return ExternalNoninvasiveDebugEnabled() && (SPIDEN == HIGH || SPNIDEN == HIGH);
    else
        return ExternalSecureInvasiveDebugEnabled();
```

### Library pseudocode for shared/debug/authentication/IsAccessSecure

```
// Returns TRUE when an access is Secure
boolean IsAccessSecure();
```

## Library pseudocode for shared/debug/authentication/IsCorePowered

```
// Returns TRUE if the Core power domain is powered on, FALSE otherwise.  
boolean IsCorePowered();
```

## Library pseudocode for shared/debug/breakpoint/CheckValidStateMatch

```
// CheckValidStateMatch()  
// =====  
// Checks for an invalid state match that will generate Constrained Unpredictable behaviour, otherwise  
// returns Constraint_NONE.  
  
(Constraint, bits(2), bit, bits(2)) CheckValidStateMatch(bits(2) SSC, bit HMC, bits(2) PxC, boolean isbreakpt, boolean reserved = FALSE;  
  
    // Match 'Usr/Sys/Svc' only valid for AArch32 breakpoints  
    if (!isbreakpt || !HaveAArch32EL(EL1)) && HMC:PxC == '000' && SSC != '11' then  
        reserved = TRUE;  
  
    // Both EL3 and EL2 are not implemented  
    if !HaveEL(EL3) && !HaveEL(EL2) && (HMC != '0' || SSC != '00') then  
        reserved = TRUE;  
  
    // EL3 is not implemented  
    if !HaveEL(EL3) && SSC IN {'01','10'} && HMC:SSC:PxC != '10100' then  
        reserved = TRUE;  
  
    // EL3 using AArch64 only  
    if (!HaveEL(EL3) || HighestELUsingAArch32()) && HMC:SSC:PxC == '11000' then  
        reserved = TRUE;  
  
    // EL2 is not implemented  
    if !HaveEL(EL2) && HMC:SSC:PxC == '11100' then  
        reserved = TRUE;  
  
    // Secure EL2 is not implemented  
    if !HaveSecureEL2Ext() && (HMC:SSC:PxC) IN {'01100','10100','x11x1'} then  
        reserved = TRUE;  
  
    // Values that are not allocated in any architecture version  
    if (HMC:SSC:PxC) IN {'01110','100x0','10110','11x10'} then  
        reserved = TRUE;  
  
    if reserved then  
        // If parameters are set to a reserved type, behaves as either disabled or a defined type  
        (c, <HMC,SSC,PxC>) = ConstrainUnpredictableBits(Unpredictable_RESBPWPCTRL);  
        assert c IN {Constraint_DISABLED, Constraint_UNKNOWN};  
        if c == Constraint_DISABLED then  
            return (c, bits(2) UNKNOWN, bit UNKNOWN, bits(2) UNKNOWN);  
        // Otherwise the value returned by ConstrainUnpredictableBits must be a not-reserved value  
  
    return (Constraint_NONE, SSC, HMC, PxC);
```

## Library pseudocode for shared/debug/cti/CTI\_SetEventLevel

```
// Set a Cross Trigger multi-cycle input event trigger to the specified level.  
CTI_SetEventLevel(CrossTriggerIn id, signal level);
```

## Library pseudocode for shared/debug/cti/CTI\_SignalEvent

```
// Signal a discrete event on a Cross Trigger input event trigger.  
CTI_SignalEvent(CrossTriggerIn id);
```



## Library pseudocode for shared/debug/cti/CrossTrigger

```
enumeration CrossTriggerOut {CrossTriggerOut_DebugRequest, CrossTriggerOut_RestartRequest,
                             CrossTriggerOut_IRQ,           CrossTriggerOut_RSVD3,
                             CrossTriggerOut_TraceExtIn0,    CrossTriggerOut_TraceExtIn1,
                             CrossTriggerOut_TraceExtIn2,    CrossTriggerOut_TraceExtIn3};

enumeration CrossTriggerIn {CrossTriggerIn_CrossHalt,       CrossTriggerIn_PMUOverflow,
                             CrossTriggerIn_RSVD2,          CrossTriggerIn_RSVD3,
                             CrossTriggerIn_TraceExtOut0,    CrossTriggerIn_TraceExtOut1,
                             CrossTriggerIn_TraceExtOut2,    CrossTriggerIn_TraceExtOut3};
```

## Library pseudocode for shared/debug/dccanditr/CheckForDCCInterrupts

```
// CheckForDCCInterrupts()
// =====

CheckForDCCInterrupts()
    commrx = (EDSCR.RXfull == '1');
    commtx = (EDSCR.TXfull == '0');

    // COMMRX and COMMTX support is optional and not recommended for new designs.
    // SetInterruptRequestLevel(InterruptID_COMMRX, if commrx then HIGH else LOW);
    // SetInterruptRequestLevel(InterruptID_COMMTX, if commtx then HIGH else LOW);

    // The value to be driven onto the common COMMIRQ signal.
    if ELUsingAArch32\(EL1\) then
        commirq = ((commrx && DBGDCCINT.RX == '1') ||
                   (commtx && DBGDCCINT.TX == '1'));
    else
        commirq = ((commrx && MDCCINT_EL1.RX == '1') ||
                   (commtx && MDCCINT_EL1.TX == '1'));
    SetInterruptRequestLevel(InterruptID\_COMMIRQ, if commirq then HIGH else LOW);

    return;
```

## Library pseudocode for shared/debug/dccanditr/DBGDTRRX\_EL0

```
// DBGDTRRX_EL0[] (external write)
// =====
// Called on writes to debug register 0x08C.

DBGDTRRX_EL0[boolean memory_mapped] = bits(32) value

if EDPRSR<6:5,0> != '001' then // Check DLK, OSLK and PU bits
    IMPLEMENTATION_DEFINED "signal slave-generated error";
    return;

if EDSCR.ERR == '1' then return; // Error flag set: ignore write

// The Software lock is OPTIONAL.
if memory_mapped && EDLSR.SLK == '1' then return; // Software lock locked: ignore write

if EDSCR.RXfull == '1' || (Halted() && EDSCR.MA == '1' && EDSCR.ITE == '0') then
    EDSCR.RX0 = '1'; EDSCR.ERR = '1'; // Overrun condition: ignore write
    return;

EDSCR.RXfull = '1';
DTRRX = value;

if Halted() && EDSCR.MA == '1' then
    EDSCR.ITE = '0'; // See comments in EDITR[] (external write)
    if !UsingAArch32() then
        ExecuteA64(0xD5330501<31:0>); // A64 "MRS X1,DBGDTRRX_EL0"
        ExecuteA64(0xB8004401<31:0>); // A64 "STR W1,[X0],#4"
        X[1] = bits(64) UNKNOWN;
    else
        ExecuteT32(0xEE10<15:0> /*hw1*/, 0x1E15<15:0> /*hw2*/); // T32 "MRS R1,DBGDTRRXint"
        ExecuteT32(0xF840<15:0> /*hw1*/, 0x1B04<15:0> /*hw2*/); // T32 "STR R1,[R0],#4"
        R[1] = bits(32) UNKNOWN;
    // If the store aborts, the Data Abort exception is taken and EDSCR.ERR is set to 1
    if EDSCR.ERR == '1' then
        EDSCR.RXfull = bit UNKNOWN;
        DBGDTRRX_EL0 = bits(32) UNKNOWN;
    else
        // "MRS X1,DBGDTRRX_EL0" calls DBGDTR_EL0[] (read) which clears RXfull.
        assert EDSCR.RXfull == '0';

    EDSCR.ITE = '1'; // See comments in EDITR[] (external write)
    return;

// DBGDTRRX_EL0[] (external read)
// =====

bits(32) DBGDTRRX_EL0[boolean memory_mapped]
return DTRRX;
```

## Library pseudocode for shared/debug/dccanditr/DBGDTRTX\_EL0

```
// DBGDTRTX_EL0[] (external read)
// =====
// Called on reads of debug register 0x080.

bits(32) DBGDTRTX_EL0[boolean memory_mapped]

    if EDPRSR<6:5,0> != '001' then // Check DLK, OSLK and PU bits
        IMPLEMENTATION_DEFINED "signal slave-generated error";
        return bits(32) UNKNOWN;

    underrun = EDSCR.TXfull == '0' || (Halted() && EDSCR.MA == '1' && EDSCR.ITE == '0');
    value = if underrun then bits(32) UNKNOWN else DTRTX;

    if EDSCR.ERR == '1' then return value; // Error flag set: no side-effects

    // The Software lock is OPTIONAL.
    if memory_mapped && EDLSR.SLK == '1' then // Software lock locked: no side-effects
        return value;

    if underrun then
        EDSCR.TXU = '1'; EDSCR.ERR = '1'; // Underrun condition: block side-effects
        return value; // Return UNKNOWN

    EDSCR.TXfull = '0';
    if Halted() && EDSCR.MA == '1' then
        EDSCR.ITE = '0'; // See comments in EDITR[] (external write)

    if !UsingAArch32() then
        ExecuteA64(0xB8404401<31:0>); // A64 "LDR W1,[X0],#4"
    else
        ExecuteT32(0xF850<15:0> /*hw1*/, 0x1B04<15:0> /*hw2*/); // T32 "LDR R1,[R0],#4"
    // If the load aborts, the Data Abort exception is taken and EDSCR.ERR is set to 1
    if EDSCR.ERR == '1' then
        EDSCR.TXfull = bit UNKNOWN;
        DBGDTRTX_EL0 = bits(32) UNKNOWN;
    else
        if !UsingAArch32() then
            ExecuteA64(0xD5130501<31:0>); // A64 "MSR DBGDTRTX_EL0,X1"
        else
            ExecuteT32(0xEE00<15:0> /*hw1*/, 0x1E15<15:0> /*hw2*/); // T32 "MSR DBGDTRTXint,R1"
            // "MSR DBGDTRTX_EL0,X1" calls DBGDTR_EL0[] (write) which sets TXfull.
            assert EDSCR.TXfull == '1';
        if !UsingAArch32() then
            X[1] = bits(64) UNKNOWN;
        else
            R[1] = bits(32) UNKNOWN;
        EDSCR.ITE = '1'; // See comments in EDITR[] (external write)

    return value;

// DBGDTRTX_EL0[] (external write)
// =====

DBGDTRTX_EL0[boolean memory_mapped] = bits(32) value
// The Software lock is OPTIONAL.
if memory_mapped && EDLSR.SLK == '1' then return; // Software lock locked: ignore write
DTRTX = value;
return;
```

## Library pseudocode for shared/debug/dccanditr/DBGDTR\_EL0

```
// DBGDTR_EL0[] (write)
// =====
// System register writes to DBGDTR_EL0, DBGDTRTX_EL0 (AArch64) and DBGDTRTXint (AArch32)

DBGDTR_EL0[] = bits(N) value
  // For MSR DBGDTRTX_EL0,<Rt>  N=32, value=X[t]<31:0>, X[t]<63:32> is ignored
  // For MSR DBGDTR_EL0,<Xt>    N=64, value=X[t]<63:0>
  assert N IN {32,64};
  if EDSCR.TXfull == '1' then
    value = bits(N) UNKNOWN;
  // On a 64-bit write, implement a half-duplex channel
  if N == 64 then DTRRX = value<63:32>;
  DTRTX = value<31:0>;          // 32-bit or 64-bit write
  EDSCR.TXfull = '1';
  return;

// DBGDTR_EL0[] (read)
// =====
// System register reads of DBGDTR_EL0, DBGDTRRX_EL0 (AArch64) and DBGDTRRXint (AArch32)

bits(N) DBGDTR_EL0[]
  // For MRS <Rt>,DBGDTRTX_EL0  N=32, X[t]=Zeros(32):result
  // For MRS <Xt>,DBGDTR_EL0    N=64, X[t]=result
  assert N IN {32,64};
  bits(N) result;
  if EDSCR.RXfull == '0' then
    result = bits(N) UNKNOWN;
  else
    // On a 64-bit read, implement a half-duplex channel
    // NOTE: the word order is reversed on reads with regards to writes
    if N == 64 then result<63:32> = DTRTX;
    result<31:0> = DTRRX;
  EDSCR.RXfull = '0';
  return result;
```

## Library pseudocode for shared/debug/dccanditr/DTR

```
bits(32) DTRRX;
bits(32) DTRTX;
```

## Library pseudocode for shared/debug/dccanditr/EDITR

```
// EDITR[] (external write)
// =====
// Called on writes to debug register 0x084.

EDITR[boolean memory_mapped] = bits(32) value
  if EDPRSR<6:5,0> != '001' then                                // Check DLK, OSLK and PU bits
    IMPLEMENTATION_DEFINED "signal slave-generated error";
    return;

  if EDSCR.ERR == '1' then return;                               // Error flag set: ignore write

  // The Software lock is OPTIONAL.
  if memory_mapped && EDLSR.SLK == '1' then return;             // Software lock locked: ignore write

  if !Halted() then return;                                     // Non-debug state: ignore write

  if EDSCR.ITE == '0' || EDSCR.MA == '1' then
    EDSCR.ITO = '1'; EDSCR.ERR = '1';                           // Overrun condition: block write
    return;

  // ITE indicates whether the processor is ready to accept another instruction; the processor
  // may support multiple outstanding instructions. Unlike the "InstrCompl" flag in [v7A] there
  // is no indication that the pipeline is empty (all instructions have completed). In this
  // pseudocode, the assumption is that only one instruction can be executed at a time,
  // meaning ITE acts like "InstrCompl".
  EDSCR.ITE = '0';

  if !UsingAArch32() then
    ExecuteA64(value);
  else
    ExecuteT32(value<15:0> /*hw1*/, value<31:16> /*hw2*/);

  EDSCR.ITE = '1';

return;
```



```

// DCPSInstruction()
// =====
// Operation of the DCPS instruction in Debug state

DCPSInstruction(bits(2) target_el)

    SynchronizeContext();

case target_el of
    when EL1
        if PSTATE.EL == EL2 || (PSTATE.EL == EL3 && !UsingAArch32()) then handle_el = PSTATE.EL;
        elsif EL2Enabled() && HCR_EL2.TGE == '1' then UNDEFINED;
        else handle_el = EL1;

    when EL2
        if !HaveEL(EL2) then UNDEFINED;
        elsif PSTATE.EL == EL3 && !UsingAArch32() then handle_el = EL3;
        elsif !IsSecureEL2Enabled() && IsSecure() then UNDEFINED;
        else handle_el = EL2;

    when EL3
        if EDSCR.SDD == '1' || !HaveEL(EL3) then UNDEFINED;
        handle_el = EL3;
    otherwise
        Unreachable();

from_secure = IsSecure();
if ELUsingAArch32(handle_el) then
    if PSTATE.M == M32_Monitor then SCR.NS = '0';
    assert UsingAArch32(); // Cannot move from AArch64 to AArch32
    case handle_el of
        when EL1
            AArch32.WriteMode(M32_Svc);
            if HavePANExt() && SCTL.R.SPAN == '0' then
                PSTATE.PAN = '1';
        when EL2 AArch32.WriteMode(M32_Hyp);
        when EL3
            AArch32.WriteMode(M32_Monitor);
            if HavePANExt() then
                if !from_secure then
                    PSTATE.PAN = '0';
                elsif SCTL.R.SPAN == '0' then
                    PSTATE.PAN = '1';
    if handle_el == EL2 then
        ELR_hyp = bits(32) UNKNOWN; HSR = bits(32) UNKNOWN;
    else
        LR = bits(32) UNKNOWN;
        SPSR[] = bits(32) UNKNOWN;
        PSTATE.E = SCTL.R.EE;
        DLR = bits(32) UNKNOWN; DSPSR = bits(32) UNKNOWN;

else // Targeting AArch64
    if UsingAArch32() then
        AArch64.MaybeZeroRegisterUppers();
        MaybeZeroSVEUppers(target_el);
        PSTATE.nRW = '0'; PSTATE.SP = '1'; PSTATE.EL = handle_el;
    if HavePANExt() && ((handle_el == EL1 && SCTL.R_EL1.SPAN == '0') ||
        (handle_el == EL2 && HCR_EL2.E2H == '1' &&
        HCR_EL2.TGE == '1' && SCTL.R_EL2.SPAN == '0')) then
        PSTATE.PAN = '1';
    ELR[] = bits(64) UNKNOWN; SPSR[] = bits(32) UNKNOWN; ESR[] = bits(32) UNKNOWN;
    DLR_EL0 = bits(64) UNKNOWN; DSPSR_EL0 = bits(32) UNKNOWN;
    if HaveUAOExt() then PSTATE.UAO = '0';
    if HaveMTEEExt() then PSTATE.TCO = '1';

UpdateEDSCRFields(); // Update EDSCR PE state flags
sync_errors = HaveIESB() && SCTL.R.IESB == '1';
if HaveDoubleFaultExt() && !UsingAArch32() then
    sync_errors = sync_errors || (SCR_EL3.EA == '1' && SCR_EL3.NMEA == '1' && PSTATE.EL == EL3);
// SCTL.R.IESB might be ignored in Debug state.
if !ConstrainUnpredictableBool(Unpredictable_IESBinDebug) then

```

```

    sync_errors = FALSE;
if sync_errors then
    SynchronizeErrors();
return;

```

## Library pseudocode for shared/debug/halting/DRPSInstruction

```

// DRPSInstruction()
// =====
// Operation of the A64 DRPS and T32 ERET instructions in Debug state

DRPSInstruction()

    SynchronizeContext();

    sync_errors = HaveIESB() && SCTLRL[IESB] == '1';
    if HaveDoubleFaultExt() && !UsingAArch32() then
        sync_errors = sync_errors || (SCR_EL3.EA == '1' && SCR_EL3.NMEA == '1' && PSTATE.EL == EL3);
    // SCTLRL[IESB] might be ignored in Debug state.
    if !ConstrainUnpredictableBool(Unpredictable_IESBinDebug) then
        sync_errors = FALSE;
    if sync_errors then
        SynchronizeErrors();

    SetPSTATEFromPSR(PSR[]);

    // PSTATE.{N,Z,C,V,Q,GE,SS,D,A,I,F} are not observable and ignored in Debug state, so
    // behave as if UNKNOWN.
    if UsingAArch32() then
        PSTATE.<N,Z,C,V,Q,GE,SS,A,I,F> = bits(13) UNKNOWN;
        // In AArch32, all instructions are T32 and unconditional.
        PSTATE.IT = '00000000'; PSTATE.T = '1'; // PSTATE.J is RES0
        DLR = bits(32) UNKNOWN; DSPSR = bits(32) UNKNOWN;
    else
        PSTATE.<N,Z,C,V,SS,D,A,I,F> = bits(9) UNKNOWN;
        DLR_EL0 = bits(64) UNKNOWN; DSPSR_EL0 = bits(32) UNKNOWN;

    UpdateEDSCRFields(); // Update EDSCR PE state flags

    return;

```

## Library pseudocode for shared/debug/halting/DebugHalt

```

constant bits(6) DebugHalt_Breakpoint      = '000111';
constant bits(6) DebugHalt_EDBGRQ         = '010011';
constant bits(6) DebugHalt_Step_Normal     = '011011';
constant bits(6) DebugHalt_Step_Exclusive = '011111';
constant bits(6) DebugHalt_OSUnlockCatch   = '100011';
constant bits(6) DebugHalt_ResetCatch      = '100111';
constant bits(6) DebugHalt_Watchpoint      = '101011';
constant bits(6) DebugHalt_HaltInstruction = '101111';
constant bits(6) DebugHalt_SoftwareAccess  = '110011';
constant bits(6) DebugHalt_ExceptionCatch  = '110111';
constant bits(6) DebugHalt_Step_NoSyndrome = '111011';

```

## Library pseudocode for shared/debug/halting/DisableITRAndResumeInstructionPrefetch

```

DisableITRAndResumeInstructionPrefetch();

```

## Library pseudocode for shared/debug/halting/ExecuteA64

```

// Execute an A64 instruction in Debug state.
ExecuteA64(bits(32) instr);

```



## Library pseudocode for shared/debug/halting/ExecuteT32

```
// Execute a T32 instruction in Debug state.  
ExecuteT32(bits(16) hw1, bits(16) hw2);
```

## Library pseudocode for shared/debug/halting/ExitDebugState

```
// ExitDebugState()  
// =====  
  
ExitDebugState()  
    assert Halted();  
    SynchronizeContext();  
  
    // Although EDSCR.STATUS signals that the PE is restarting, debuggers must use EDPRSR.SDR to  
    // detect that the PE has restarted.  
    EDSCR.STATUS = '000001'; // Signal restarting  
    EDESR<2:0> = '000'; // Clear any pending Halting debug events  
  
    bits(64) new_pc;  
    bits(32) spsr;  
  
    if UsingAArch32() then  
        new_pc = ZeroExtend(DLR);  
        spsr = DSPSR;  
    else  
        new_pc = DLR_EL0;  
        spsr = DSPSR_EL0;  
    // If this is an illegal return, SetPSTATEFromPSR() will set PSTATE.IL.  
    SetPSTATEFromPSR(spsr); // Can update privileged bits, even at EL0  
  
    if UsingAArch32() then  
        if ConstrainUnpredictableBool(Unpredictable_RESTARTALIGNPC) then new_pc<0> = '0';  
        BranchTo(new_pc<31:0>, BranchType_DBGEXIT); // AArch32 branch  
    else  
        // If targeting AArch32 then possibly zero the 32 most significant bits of the target PC  
        if spsr<4> == '1' && ConstrainUnpredictableBool(Unpredictable_RESTARTZEROUPPERPC) then  
            new_pc<63:32> = Zeros();  
            BranchTo(new_pc, BranchType_DBGEXIT); // A type of branch that is never predicted  
  
    (EDSCR.STATUS, EDPRSR.SDR) = ('000010', '1'); // Atomically signal restarted  
    UpdateEDSCRFields(); // Stop signalling PE state  
    DisableITRAndResumeInstructionPrefetch();  
  
    return;
```

## Library pseudocode for shared/debug/halting/Halt

```
// Halt()
// =====

Halt(bits(6) reason)

    CTI_SignalEvent(CrossTriggerIn_CrossHalt); // Trigger other cores to halt

    bits(64) preferred_restart_address = ThisInstrAddr();
    spsr = GetPSRFromPSTATE();

    if UsingAArch32() then
        // If entering from AArch32 state, spsr<21> is the DIT bit which has to be moved for DSPSR
        spsr<24> = spsr<21>;
        spsr<21> = PSTATE.SS; // Always save the SS bit

    if (HaveBTIExt() &&
        !(reason IN {DebugHalt_Step_Normal, DebugHalt_Step_Exclusive, DebugHalt_Step_NoSyndrome,
                    DebugHalt_Breakpoint, DebugHalt_HaltInstruction}) &&
        ConstrainUnpredictableBool(Unpredictable_ZEROBTYP)) then
        DSPSR<11:10> = '00';

    if UsingAArch32() then
        DLR = preferred_restart_address<31:0>;
        DSPSR = spsr;
    else
        DLR_EL0 = preferred_restart_address;
        DSPSR_EL0 = spsr;

    EDSCR.ITE = '1';
    EDSCR.IT0 = '0';
    if IsSecure() then
        EDSCR.SDD = '0'; // If entered in Secure state, allow debug
    elseif HaveEL(EL3) then
        EDSCR.SDD = if ExternalSecureInvasiveDebugEnabled() then '0' else '1';
    else
        assert EDSCR.SDD == '1'; // Otherwise EDSCR.SDD is RES1
    EDSCR.MA = '0';

    // PSTATE.{SS,SSBS,D,A,I,F} are not observable and ignored in Debug state,
    // so behave as if UNKNOWN. PSTATE.{IT,T} are ignored in Debug state and
    // behave as if UNKNOWN. PSTATE.{N,Z,C,V,Q,GE,E,M,nRW,EL,SP,PAN,UAO,DIT}
    // are also not observable, but since these are not changed on exception
    // entry, this function also leaves them unchanged. PSTATE.IL behaves as if 0.
    // PSTATE.TCO is ignored in Debug state and behaves as if 1.
    // PSTATE.BTYPE is ignored in Debug state and behaves as if 0.
    if UsingAArch32() then
        PSTATE.<IT,SSBS,SS,A,I,F,T> = bits(14) UNKNOWN;
    else
        PSTATE.<IT,SS,SSBS,D,A,I,F,T> = bits(15) UNKNOWN;
        PSTATE.TCO = '1';
        PSTATE.BTYPE = '00';
    PSTATE.IL = '0';

    StopInstructionPrefetchAndEnableITR();
    EDSCR.STATUS = reason; // Signal entered Debug state
    UpdateEDSCRFields(); // Update EDSCR PE state flags.

    return;
```

### Library pseudocode for shared/debug/halting/HaltOnBreakpointOrWatchpoint

```
// HaltOnBreakpointOrWatchpoint()
// =====
// Returns TRUE if the Breakpoint and Watchpoint debug events should be considered for Debug
// state entry, FALSE if they should be considered for a debug exception.

boolean HaltOnBreakpointOrWatchpoint()
    return HaltingAllowed() && EDSCR.HDE == '1' && OSLSR_EL1.OSLK == '0';
```

### Library pseudocode for shared/debug/halting/Halted

```
// Halted()
// =====

boolean Halted()
    return !(EDSCR.STATUS IN {'000001', '000010'}); // Halted
```

### Library pseudocode for shared/debug/halting/HaltingAllowed

```
// HaltingAllowed()
// =====
// Returns TRUE if halting is currently allowed, FALSE if halting is prohibited.

boolean HaltingAllowed()
    if Halted() || DoubleLockStatus() then
        return FALSE;
    elseif IsSecure() then
        return ExternalSecureInvasiveDebugEnabled();
    else
        return ExternalInvasiveDebugEnabled();
```

### Library pseudocode for shared/debug/halting/Restarting

```
// Restarting()
// =====

boolean Restarting()
    return EDSCR.STATUS == '000001'; // Restarting
```

### Library pseudocode for shared/debug/halting/StopInstructionPrefetchAndEnableITR

```
StopInstructionPrefetchAndEnableITR();
```

## Library pseudocode for shared/debug/halting/UpdateEDSCRFields

```
// UpdateEDSCRFields()
// =====
// Update EDSCR PE state fields

UpdateEDSCRFields()

    if !Halted() then
        EDSCR.EL = '00';
        EDSCR.NS = bit UNKNOWN;
        EDSCR.RW = '1111';
    else
        EDSCR.EL = PSTATE.EL;
        EDSCR.NS = if IsSecure() then '0' else '1';

        bits(4) RW;
        RW<1> = if ELUsingAArch32(EL1) then '0' else '1';
        if PSTATE.EL != EL0 then
            RW<0> = RW<1>;
        else
            RW<0> = if UsingAArch32() then '0' else '1';
        if !HaveEL(EL2) || (HaveEL(EL3) && SCR_GEN[].NS == '0' && !IsSecureEL2Enabled()) then
            RW<2> = RW<1>;
        else
            RW<2> = if ELUsingAArch32(EL2) then '0' else '1';
        if !HaveEL(EL3) then
            RW<3> = RW<2>;
        else
            RW<3> = if ELUsingAArch32(EL3) then '0' else '1';

        // The least-significant bits of EDSCR.RW are UNKNOWN if any higher EL is using AArch32.
        if RW<3> == '0' then RW<2:0> = bits(3) UNKNOWN;
        elsif RW<2> == '0' then RW<1:0> = bits(2) UNKNOWN;
        elsif RW<1> == '0' then RW<0> = bit UNKNOWN;
        EDSCR.RW = RW;
    return;
```

## Library pseudocode for shared/debug/haltingevents/CheckExceptionCatch

```
// CheckExceptionCatch()
// =====
// Check whether an Exception Catch debug event is set on the current Exception level

CheckExceptionCatch(boolean exception_entry)
    // Called after an exception entry or exit, that is, such that IsSecure() and PSTATE.EL are correct
    // for the exception target.
    base = if IsSecure() then 0 else 4;
    if HaltingAllowed() then
        if HaveExtendedECDebugEvents() then
            exception_exit = !exception_entry;
            ctrl = EDECCR<UInt>(PSTATE.EL) + base + 8>:EDECCR<UInt>(PSTATE.EL) + base>;
            case ctrl of
                when '00' halt = FALSE;
                when '01' halt = TRUE;
                when '10' halt = (exception_exit == TRUE);
                when '11' halt = (exception_entry == TRUE);
        else
            halt = (EDECCR<UInt>(PSTATE.EL) + base> == '1');
    if halt then Halt(DebugHalt_ExceptionCatch);
```

### Library pseudocode for shared/debug/haltingevents/CheckHaltingStep

```
// CheckHaltingStep()
// =====
// Check whether EDESR.SS has been set by Halting Step

CheckHaltingStep()
    if HaltingAllowed() && EDESR.SS == '1' then
        // The STATUS code depends on how we arrived at the state where EDESR.SS == 1.
        if HaltingStep_DidNotStep() then
            Halt(DebugHalt_Step_NoSyndrome);
        elseif HaltingStep_SteppedEX() then
            Halt(DebugHalt_Step_Exclusive);
        else
            Halt(DebugHalt_Step_Normal);
```

### Library pseudocode for shared/debug/haltingevents/CheckOSUnlockCatch

```
// CheckOSUnlockCatch()
// =====
// Called on unlocking the OS Lock to pend an OS Unlock Catch debug event

CheckOSUnlockCatch()

    if (HaveDoPD() && CTIDEVCTL.OSUCE == '1')
    || (!HaveDoPD() && EDECR.OSUCE == '1')
    then
        if !Halted() then EDESR.OSUC = '1';
```

### Library pseudocode for shared/debug/haltingevents/CheckPendingOSUnlockCatch

```
// CheckPendingOSUnlockCatch()
// =====
// Check whether EDESR.OSUC has been set by an OS Unlock Catch debug event

CheckPendingOSUnlockCatch()
    if HaltingAllowed() && EDESR.OSUC == '1' then
        Halt(DebugHalt_OSUnlockCatch);
```

### Library pseudocode for shared/debug/haltingevents/CheckPendingResetCatch

```
// CheckPendingResetCatch()
// =====
// Check whether EDESR.RC has been set by a Reset Catch debug event

CheckPendingResetCatch()
    if HaltingAllowed() && EDESR.RC == '1' then
        Halt(DebugHalt_ResetCatch);
```

### Library pseudocode for shared/debug/haltingevents/CheckResetCatch

```
// CheckResetCatch()
// =====
// Called after reset

CheckResetCatch()
    if (HaveDoPD() && CTIDEVCTL.RCE == '1') || (!HaveDoPD() && EDECR.RCE == '1') then
        EDESR.RC = '1';
        // If halting is allowed then halt immediately
        if HaltingAllowed() then Halt(DebugHalt_ResetCatch);
```

## Library pseudocode for shared/debug/haltingevents/CheckSoftwareAccessToDebugRegisters

```
// CheckSoftwareAccessToDebugRegisters()
// =====
// Check for access to Breakpoint and Watchpoint registers.

CheckSoftwareAccessToDebugRegisters()
    os_lock = (if ELUsingAArch32\(EL1\) then DBG0SLSR.OSLK else OSLSR_EL1.OSLK);
    if HaltingAllowed\(\) && EDCR.TDA == '1' && os_lock == '0' then
        Halt\(DebugHalt\_SoftwareAccess\);
```

## Library pseudocode for shared/debug/haltingevents/ExternalDebugRequest

```
// ExternalDebugRequest()
// =====

ExternalDebugRequest()
    if HaltingAllowed\(\) then
        Halt\(DebugHalt\_EDBGRQ\);
    // Otherwise the CTI continues to assert the debug request until it is taken.
```

## Library pseudocode for shared/debug/haltingevents/HaltingStep\_DidNotStep

```
// Returns TRUE if the previously executed instruction was executed in the inactive state, that is,
// if it was not itself stepped.
boolean HaltingStep_DidNotStep();
```

## Library pseudocode for shared/debug/haltingevents/HaltingStep\_SteppedEX

```
// Returns TRUE if the previously executed instruction was a Load-Exclusive class instruction
// executed in the active-not-pending state.
boolean HaltingStep_SteppedEX();
```

## Library pseudocode for shared/debug/haltingevents/RunHaltingStep

```
// RunHaltingStep()
// =====

RunHaltingStep(boolean exception_generated, bits(2) exception_target, boolean syscall,
               boolean reset)
    // "exception_generated" is TRUE if the previous instruction generated a synchronous exception
    // or was cancelled by an asynchronous exception.
    //
    // if "exception_generated" is TRUE then "exception_target" is the target of the exception, and
    // "syscall" is TRUE if the exception is a synchronous exception where the preferred return
    // address is the instruction following that which generated the exception.
    //
    // "reset" is TRUE if exiting reset state into the highest EL.

    if reset then assert !Halted\(\); // Cannot come out of reset halted
    active = EDCR.SS == '1' && !Halted\(\);

    if active && reset then // Coming out of reset with EDCR.SS set
        EDCR.SS = '1';
    elseif active && HaltingAllowed\(\) then
        if exception_generated && exception_target == EL3 then
            advance = syscall || ExternalSecureInvasiveDebugEnabled\(\);
        else
            advance = TRUE;
        if advance then EDCR.SS = '1';

    return;
```

## Library pseudocode for shared/debug/interrupts/ExternalDebugInterruptsDisabled

```
// ExternalDebugInterruptsDisabled()
// =====
// Determine whether EDSCR disables interrupts routed to 'target'

boolean ExternalDebugInterruptsDisabled(bits(2) target)
    case target of
        when EL3
            int_dis = EDSCR.INTdis == '11' && ExternalSecureInvasiveDebugEnabled\(\);
        when EL2
            int_dis = EDSCR.INTdis == '1x' && ExternalInvasiveDebugEnabled\(\);
        when EL1
            if IsSecure\(\) then
                int_dis = EDSCR.INTdis == '1x' && ExternalSecureInvasiveDebugEnabled\(\);
            else
                int_dis = EDSCR.INTdis != '00' && ExternalInvasiveDebugEnabled\(\);
    return int_dis;
```

## Library pseudocode for shared/debug/interrupts/InterruptID

```
enumeration InterruptID {InterruptID_PMUIRQ, InterruptID_COMMIRQ, InterruptID_CTIIRQ,
                          InterruptID_COMMRX, InterruptID_COMMTX};
```

## Library pseudocode for shared/debug/interrupts/SetInterruptRequestLevel

```
// Set a level-sensitive interrupt to the specified level.
SetInterruptRequestLevel(InterruptID id, signal level);
```

## Library pseudocode for shared/debug/samplebasedprofiling/CreatePCSample

```
// CreatePCSample()
// =====

CreatePCSample()
    // In a simple sequential execution of the program, CreatePCSample is executed each time the PE
    // executes an instruction that can be sampled. An implementation is not constrained such that
    // reads of EDPCSRlo return the current values of PC, etc.

    pc_sample.valid = ExternalNoninvasiveDebugAllowed\(\) && !Halted\(\);
    pc_sample.pc = ThisInstrAddr\(\);
    pc_sample.el = PSTATE.EL;
    pc_sample.rw = if UsingAArch32\(\) then '0' else '1';
    pc_sample.ns = if IsSecure\(\) then '0' else '1';
    pc_sample.contextidr = if ELUsingAArch32\(EL1\) then CONTEXTIDR else CONTEXTIDR_EL1;
    pc_sample.has_el2 = EL2Enabled\(\);

    if EL2Enabled\(\) then
        if ELUsingAArch32\(EL2\) then
            pc_sample.vmid = ZeroExtend(VTTBR.VMID, 16);
        elsif !Have16bitVMID\(\) || VTCR_EL2.VS == '0' then
            pc_sample.vmid = ZeroExtend(VTTBR_EL2.VMID<7:0>, 16);
        else
            pc_sample.vmid = VTTBR_EL2.VMID;
        if (HaveVirtHostExt\(\) || HaveV82Debug\(\)) && !ELUsingAArch32\(EL2\) then
            pc_sample.contextidr_el2 = CONTEXTIDR_EL2;
        else
            pc_sample.contextidr_el2 = bits(32) UNKNOWN;
        pc_sample.el0h = PSTATE.EL == EL0 && IsInHost\(\);
    return;
```

## Library pseudocode for shared/debug/samplebasedprofiling/EDPCSRlo

```
// EDPCSRlo[] (read)
// =====

bits(32) EDPCSRlo[boolean memory_mapped]

if EDPRSR<6:5,0> != '001' then // Check DLK, OSLK and PU bits
    IMPLEMENTATION_DEFINED "signal slave-generated error";
    return bits(32) UNKNOWN;

// The Software lock is OPTIONAL.
update = !memory_mapped || EDLSR.SLK == '0'; // Software locked: no side-effects

if pc_sample.valid then
    sample = pc_sample.pc<31:0>;
    if update then
        if HaveVirtHostExt() && EDSCR.SC2 == '1' then
            EDPCSRhi.PC = (if pc_sample.rw == '0' then Zeros(24) else pc_sample.pc<55:32>);
            EDPCSRhi.EL = pc_sample.el;
            EDPCSRhi.NS = pc_sample.ns;
        else
            EDPCSRhi = (if pc_sample.rw == '0' then Zeros(32) else pc_sample.pc<63:32>);
            EDCIDSR = pc_sample.contextidr;
            if (HaveVirtHostExt() || HaveV82Debug()) && EDSCR.SC2 == '1' then
                EDVIDSR = (if HaveEL(EL2) && pc_sample.ns == '1' then pc_sample.contextidr_el2
                    else bits(32) UNKNOWN);
            else
                if HaveEL(EL2) && pc_sample.ns == '1' && pc_sample.el IN {EL1,EL0} then
                    EDVIDSR.VMID = pc_sample.vmid;
                else
                    EDVIDSR.VMID = Zeros();
                    EDVIDSR.NS = pc_sample.ns;
                    EDVIDSR.E2 = (if pc_sample.el == EL2 then '1' else '0');
                    EDVIDSR.E3 = (if pc_sample.el == EL3 then '1' else '0') AND pc_sample.rw;
                    // The conditions for setting HV are not specified if PCSRhi is zero.
                    // An example implementation may be "pc_sample.rw".
                    EDVIDSR.HV = (if !IsZero(EDPCSRhi) then '1' else bit IMPLEMENTATION_DEFINED "0 or 1");
        else
            sample = Ones(32);
            if update then
                EDPCSRhi = bits(32) UNKNOWN;
                EDCIDSR = bits(32) UNKNOWN;
                EDVIDSR = bits(32) UNKNOWN;

    return sample;
```

## Library pseudocode for shared/debug/samplebasedprofiling/PCSample

```
type PCSample is (
    boolean valid,
    bits(64) pc,
    bits(2) el,
    bit rw,
    bit ns,
    boolean has_el2,
    bits(32) contextidr,
    bits(32) contextidr_el2,
    boolean el0h,
    bits(16) vmid
)

PCSample pc_sample;
```



## Library pseudocode for shared/debug/samplebasedprofiling/PMPCSR

```
// PMPCSR[] (read)
// =====

bits(32) PMPCSR[boolean memory_mapped]

    if EDPRSR<6:5,0> != '001' then // Check DLK, OSLK and PU bits
        IMPLEMENTATION_DEFINED "signal slave-generated error";
        return bits(32) UNKNOWN;

    // The Software lock is OPTIONAL.
    update = !memory_mapped || PMLSR.SLK == '0'; // Software locked: no side-effects

    if pc_sample.valid then
        sample = pc_sample.pc<31:0>;
        if update then
            PMPCSR<55:32> = (if pc_sample.rw == '0' then Zeros(24) else pc_sample.pc<55:32>);
            PMPCSR.EL = pc_sample.el;
            PMPCSR.NS = pc_sample.ns;

            PMCID1SR = pc_sample.contextidr;
            PMCID2SR = if pc_sample.has_el2 then pc_sample.contextidr_el2 else bits(32) UNKNOWN;

            PMVIDSR.VMID = (if pc_sample.has_el2 && pc_sample.el IN {EL1,EL0} && !pc_sample.el0h
                            then pc_sample.vmid else bits(16) UNKNOWN);
        else
            sample = Ones(32);
            if update then
                PMPCSR<55:32> = bits(24) UNKNOWN;
                PMPCSR.EL = bits(2) UNKNOWN;
                PMPCSR.NS = bit UNKNOWN;

                PMCID1SR = bits(32) UNKNOWN;
                PMCID2SR = bits(32) UNKNOWN;

                PMVIDSR.VMID = bits(16) UNKNOWN;

    return sample;
```

## Library pseudocode for shared/debug/softwarestep/CheckSoftwareStep

```
// CheckSoftwareStep()
// =====
// Take a Software Step exception if in the active-pending state

CheckSoftwareStep()

    // Other self-hosted debug functions will call AArch32.GenerateDebugExceptions() if called from
    // AArch32 state. However, because Software Step is only active when the debug target Exception
    // level is using AArch64, CheckSoftwareStep only calls AArch64.GenerateDebugExceptions().
    if !ELUsingAArch32(DebugTarget()) && AArch64.GenerateDebugExceptions() then
        if MDSCR_EL1.SS == '1' && PSTATE.SS == '0' then
            AArch64.SoftwareStepException();
```

## Library pseudocode for shared/debug/softwarestep/DebugExceptionReturnSS

```
// DebugExceptionReturnSS()
// =====
// Returns value to write to PSTATE.SS on an exception return or Debug state exit.

bit DebugExceptionReturnSS(bits(32) spsr)
    assert Halted() || Restarting() || PSTATE.EL != EL0;

    SS_bit = '0';

    if MDSCR_EL1.SS == '1' then
        if Restarting() then
            enabled_at_source = FALSE;
        elsif UsingAArch32() then
            enabled_at_source = AArch32.GenerateDebugExceptions();
        else
            enabled_at_source = AArch64.GenerateDebugExceptions();

        if IllegalExceptionReturn(spsr) then
            dest = PSTATE.EL;
        else
            (valid, dest) = ELFromSPSR(spsr); assert valid;

        secure = IsSecureBelowEL3() || dest == EL3;
        if ELUsingAArch32(dest) then
            enabled_at_dest = AArch32.GenerateDebugExceptionsFrom(dest, secure);
        else
            mask = spsr<9>;
            enabled_at_dest = AArch64.GenerateDebugExceptionsFrom(dest, secure, mask);
        ELd = DebugTargetFrom(secure);
        if !ELUsingAArch32(ELd) && !enabled_at_source && enabled_at_dest then
            SS_bit = spsr<21>;
    return SS_bit;
```

## Library pseudocode for shared/debug/softwarestep/SSAdvance

```
// SSAdvance()
// =====
// Advance the Software Step state machine.

SSAdvance()

    // A simpler implementation of this function just clears PSTATE.SS to zero regardless of the
    // current Software Step state machine. However, this check is made to illustrate that the
    // processor only needs to consider advancing the state machine from the active-not-pending
    // state.
    target = DebugTarget();
    step_enabled = !ELUsingAArch32(target) && MDSCR_EL1.SS == '1';
    active_not_pending = step_enabled && PSTATE.SS == '1';

    if active_not_pending then PSTATE.SS = '0';

    return;
```

## Library pseudocode for shared/debug/softwarestep/SoftwareStep\_DidNotStep

```
// Returns TRUE if the previously executed instruction was executed in the inactive state, that is,
// if it was not itself stepped.
// Might return TRUE or FALSE if the previously executed instruction was an ISB or ERET executed
// in the active-not-pending state, or if another exception was taken before the Software Step exception.
// Returns FALSE otherwise, indicating that the previously executed instruction was executed in the
// active-not-pending state, that is, the instruction was stepped.
boolean SoftwareStep_DidNotStep();
```

## Library pseudocode for shared/debug/softwarestep/SoftwareStep\_SteppedEX

```
// Returns a value that describes the previously executed instruction. The result is valid only if
// SoftwareStep_DidNotStep() returns FALSE.
// Might return TRUE or FALSE if the instruction was an AArch32 LDREX or LDAEX that failed its condition
// Otherwise returns TRUE if the instruction was a Load-Exclusive class instruction, and FALSE if the
// instruction was not a Load-Exclusive class instruction.
boolean SoftwareStep_SteppedEX();
```

## Library pseudocode for shared/exceptions/exceptions/ConditionSyndrome

```
// ConditionSyndrome()
// =====
// Return CV and COND fields of instruction syndrome

bits(5) ConditionSyndrome()

    bits(5) syndrome;

    if UsingAArch32() then
        cond = AArch32.CurrentCond();
        if PSTATE.T == '0' then // A32
            syndrome<4> = '1';
            // A conditional A32 instruction that is known to pass its condition code check
            // can be presented either with COND set to 0xE, the value for unconditional, or
            // the COND value held in the instruction.
            if ConditionHolds(cond) && ConstrainUnpredictableBool(Unpredictable_ESRCONDPASS) then
                syndrome<3:0> = '1110';
            else
                syndrome<3:0> = cond;
        else // T32
            // When a T32 instruction is trapped, it is IMPLEMENTATION DEFINED whether:
            // * CV set to 0 and COND is set to an UNKNOWN value
            // * CV set to 1 and COND is set to the condition code for the condition that
            // applied to the instruction.
            if boolean IMPLEMENTATION_DEFINED "Condition valid for trapped T32" then
                syndrome<4> = '1';
                syndrome<3:0> = cond;
            else
                syndrome<4> = '0';
                syndrome<3:0> = bits(4) UNKNOWN;
    else
        syndrome<4> = '1';
        syndrome<3:0> = '1110';

    return syndrome;
```

## Library pseudocode for shared/exceptions/exceptions/Exception

```
enumeration Exception {Exception_Uncategorized,    // Uncategorized or unknown reason
                        Exception_WFxTrap,         // Trapped WFI or WFE instruction
                        Exception_CP15RTTTrap,     // Trapped AArch32 MCR or MRC access to CP15
                        Exception_CP15RRTTrap,     // Trapped AArch32 MCRR or MRRC access to CP15
                        Exception_CP14RTTTrap,     // Trapped AArch32 MCR or MRC access to CP14
                        Exception_CP14DTTTrap,     // Trapped AArch32 LDC or STC access to CP14
                        Exception_AdvSIMDFPAccessTrap, // HCPTR-trapped access to SIMD or FP
                        Exception_FPIDTrap,        // Trapped access to SIMD or FP ID register
                        // Trapped BXJ instruction not supported in Armv8
                        Exception_PACTrap,         // Trapped invalid PAC use
                        Exception_CP14RRTTrap,     // Trapped MRRC access to CP14 from AArch32
                        Exception_IllegalState,    // Illegal Execution state
                        Exception_SupervisorCall,  // Supervisor Call
                        Exception_HypervisorCall,  // Hypervisor Call
                        Exception_MonitorCall,     // Monitor Call or Trapped SMC instruction
                        Exception_SystemRegisterTrap, // Trapped MRS or MSR system register access
                        Exception_ERetTrap,        // Trapped invalid ERET use
                        Exception_InstructionAbort, // Instruction Abort or Prefetch Abort
                        Exception_PCAAlignment,    // PC alignment fault
                        Exception_DataAbort,       // Data Abort
                        Exception_NV2DataAbort,    // Data abort at EL1 reported as being from EL2
                        Exception_PACFail,         // PAC Authentication failure
                        Exception_SPAlignment,     // SP alignment fault
                        Exception_FPTrappedException, // IEEE trapped FP exception
                        Exception_SError,         // SError interrupt
                        Exception_Breakpoint,      // (Hardware) Breakpoint
                        Exception_SoftwareStep,    // Software Step
                        Exception_Watchpoint,     // Watchpoint
                        Exception_NV2Watchpoint,   // Watchpoint at EL1 reported as being from EL2
                        Exception_SoftwareBreakpoint, // Software Breakpoint Instruction
                        Exception_VectorCatch,     // AArch32 Vector Catch
                        Exception_IRQ,            // IRQ interrupt
                        Exception_SVEAccessTrap,   // HCPTR trapped access to SVE
                        Exception_TSTARTAccessTrap, // Trapped TSTART access
                        Exception_BranchTarget,    // Branch Target Identification
                        Exception_FIQ};           // FIQ interrupt
```

## Library pseudocode for shared/exceptions/exceptions/ExceptionRecord

```
type ExceptionRecord is (Exception exceptype,    // Exception class
                        bits(25) syndrome,        // Syndrome record
                        bits(64) vaddress,        // Virtual fault address
                        boolean ipavalid,         // Physical fault address for second stage faults i
                        bits(1) NS,               // Physical fault address for second stage faults i
                        bits(52) ipaddress)       // Physical fault address for second stage faults
```

## Library pseudocode for shared/exceptions/exceptions/ExceptionSyndrome

```
// ExceptionSyndrome()
// =====
// Return a blank exception syndrome record for an exception of the given type.

ExceptionRecord ExceptionSyndrome(Exception exceptype)

    ExceptionRecord r;

    r.exceptype = exceptype;

    // Initialize all other fields
    r.syndrome = Zeros();
    r.vaddress = Zeros();
    r.ipavalid = FALSE;
    r.NS = '0';
    r.ipaddress = Zeros();

    return r;
```

## Library pseudocode for shared/exceptions/traps/ReservedValue

```
// ReservedValue()
// =====

ReservedValue()
  if UsingAArch32() && !AArch32.GeneralExceptionsToAArch64() then
    AArch32.TakeUndefInstrException();
  else
    AArch64.UndefinedFault();
```

## Library pseudocode for shared/exceptions/traps/UnallocatedEncoding

```
// UnallocatedEncoding()
// =====

UnallocatedEncoding()
  if UsingAArch32() && AArch32.ExecutingCP10or11Instr() then
    FPExc.DEX = '0';
  if UsingAArch32() && !AArch32.GeneralExceptionsToAArch64() then
    AArch32.TakeUndefInstrException();
  else
    AArch64.UndefinedFault();
```

## Library pseudocode for shared/functions/aborts/EncodeLDFSC

```
// EncodeLDFSC()
// =====
// Function that gives the Long-descriptor FSC code for types of Fault

bits(6) EncodeLDFSC(Fault statuscode, integer level)

  bits(6) result;
  case statuscode of
    when Fault_AddressSize      result = '0000':level<1:0>; assert level IN {0,1,2,3};
    when Fault_AccessFlag       result = '0010':level<1:0>; assert level IN {1,2,3};
    when Fault_Permission       result = '0011':level<1:0>; assert level IN {1,2,3};
    when Fault_Translation      result = '0001':level<1:0>; assert level IN {0,1,2,3};
    when Fault_SyncExternal     result = '010000';
    when Fault_SyncExternalOnWalk result = '0101':level<1:0>; assert level IN {0,1,2,3};
    when Fault_SyncParity       result = '011000';
    when Fault_SyncParityOnWalk result = '0111':level<1:0>; assert level IN {0,1,2,3};
    when Fault_AsyncParity      result = '011001';
    when Fault_AsyncExternal    result = '010001';
    when Fault_Alignment        result = '100001';
    when Fault_Debug            result = '100010';
    when Fault_TLBConflict      result = '110000';
    when Fault_HWUpdateAccessFlag result = '110001';
    when Fault_Lockdown         result = '110100'; // IMPLEMENTATION DEFINED
    when Fault_Exclusive        result = '110101'; // IMPLEMENTATION DEFINED
    otherwise                   Unreachable();

  return result;
```

## Library pseudocode for shared/functions/aborts/IPAValid

```
// IPAValid()
// =====
// Return TRUE if the IPA is reported for the abort

boolean IPAValid(FaultRecord fault)
    assert fault.statuscode != Fault_None;

    if fault.s2fslwalk then
        return fault.statuscode IN {Fault_AccessFlag, Fault_Permission, Fault_Translation,
                                     Fault_AddressSize};
    elseif fault.secondstage then
        return fault.statuscode IN {Fault_AccessFlag, Fault_Translation, Fault_AddressSize};
    else
        return FALSE;
```

## Library pseudocode for shared/functions/aborts/IsAsyncAbort

```
// IsAsyncAbort()
// =====
// Returns TRUE if the abort currently being processed is an asynchronous abort, and FALSE
// otherwise.

boolean IsAsyncAbort(Fault statuscode)
    assert statuscode != Fault_None;

    return (statuscode IN {Fault_AsyncExternal, Fault_AsyncParity});

// IsAsyncAbort()
// =====

boolean IsAsyncAbort(FaultRecord fault)
    return IsAsyncAbort(fault.statuscode);
```

## Library pseudocode for shared/functions/aborts/IsDebugException

```
// IsDebugException()
// =====

boolean IsDebugException(FaultRecord fault)
    assert fault.statuscode != Fault_None;
    return fault.statuscode == Fault_Debug;
```

## Library pseudocode for shared/functions/aborts/IsExternalAbort

```
// IsExternalAbort()
// =====
// Returns TRUE if the abort currently being processed is an external abort and FALSE otherwise.

boolean IsExternalAbort(Fault statuscode)
    assert statuscode != Fault_None;

    return (statuscode IN {Fault_SyncExternal, Fault_SyncParity, Fault_SyncExternalOnWalk, Fault_SyncParity,
                           Fault_AsyncExternal, Fault_AsyncParity });

// IsExternalAbort()
// =====

boolean IsExternalAbort(FaultRecord fault)
    return IsExternalAbort(fault.statuscode);
```

### Library pseudocode for shared/functions/aborts/IsExternalSyncAbort

```
// IsExternalSyncAbort()
// =====
// Returns TRUE if the abort currently being processed is an external synchronous abort and FALSE otherwise

boolean IsExternalSyncAbort(Fault statuscode)
    assert statuscode != Fault_None;

    return (statuscode IN {Fault_SyncExternal, Fault_SyncParity, Fault_SyncExternalOnWalk, Fault_SyncParity});

// IsExternalSyncAbort()
// =====

boolean IsExternalSyncAbort(FaultRecord fault)
    return IsExternalSyncAbort(fault.statuscode);
```

### Library pseudocode for shared/functions/aborts/IsFault

```
// IsFault()
// =====
// Return TRUE if a fault is associated with an address descriptor

boolean IsFault(AddressDescriptor addrdesc)
    return addrdesc.fault.statuscode != Fault_None;
```

### Library pseudocode for shared/functions/aborts/IsSErrorInterrupt

```
// IsSErrorInterrupt()
// =====
// Returns TRUE if the abort currently being processed is an SError interrupt, and FALSE
// otherwise.

boolean IsSErrorInterrupt(Fault statuscode)
    assert statuscode != Fault_None;

    return (statuscode IN {Fault_AsyncExternal, Fault_AsyncParity});

// IsSErrorInterrupt()
// =====

boolean IsSErrorInterrupt(FaultRecord fault)
    return IsSErrorInterrupt(fault.statuscode);
```

### Library pseudocode for shared/functions/aborts/IsSecondStage

```
// IsSecondStage()
// =====

boolean IsSecondStage(FaultRecord fault)
    assert fault.statuscode != Fault_None;

    return fault.secondstage;
```

### Library pseudocode for shared/functions/aborts/LSInstructionSyndrome

```
bits(11) LSInstructionSyndrome();
```

### Library pseudocode for shared/functions/common/ASR

```
// ASR()
// =====

bits(N) ASR(bits(N) x, integer shift)
    assert shift >= 0;
    if shift == 0 then
        result = x;
    else
        (result, -) = ASR\_C(x, shift);
    return result;
```

### Library pseudocode for shared/functions/common/ASR\_C

```
// ASR_C()
// =====

(bits(N), bit) ASR_C(bits(N) x, integer shift)
    assert shift > 0;
    extended_x = SignExtend(x, shift+N);
    result = extended_x<shift+N-1:shift>;
    carry_out = extended_x<shift-1>;
    return (result, carry_out);
```

### Library pseudocode for shared/functions/common/Abs

```
// Abs()
// =====

integer Abs(integer x)
    return if x >= 0 then x else -x;

// Abs()
// =====

real Abs(real x)
    return if x >= 0.0 then x else -x;
```

### Library pseudocode for shared/functions/common/Align

```
// Align()
// =====

integer Align(integer x, integer y)
    return y * (x DIV y);

// Align()
// =====

bits(N) Align(bits(N) x, integer y)
    return Align(UInt(x), y)<N-1:0>;
```

### Library pseudocode for shared/functions/common/BitCount

```
// BitCount()
// =====

integer BitCount(bits(N) x)
    integer result = 0;
    for i = 0 to N-1
        if x<i> == '1' then
            result = result + 1;
    return result;
```



## Library pseudocode for shared/functions/common/CountLeadingSignBits

```
// CountLeadingSignBits()
// =====

integer CountLeadingSignBits(bits(N) x)
    return CountLeadingZeroBits(x<N-1:1> EOR x<N-2:0>);
```

## Library pseudocode for shared/functions/common/CountLeadingZeroBits

```
// CountLeadingZeroBits()
// =====

integer CountLeadingZeroBits(bits(N) x)
    return N - (HighestSetBit(x) + 1);
```

## Library pseudocode for shared/functions/common/Elem

```
// Elem[] - non-assignment form
// =====

bits(size) Elem(bits(N) vector, integer e, integer size)
    assert e >= 0 && (e+1)*size <= N;
    return vector<e*size+size-1 : e*size>;

// Elem[] - non-assignment form
// =====

bits(size) Elem(bits(N) vector, integer e)
    return Elem[vector, e, size];

// Elem[] - assignment form
// =====

Elem(bits(N) &vector, integer e, integer size) = bits(size) value
    assert e >= 0 && (e+1)*size <= N;
    vector<(e+1)*size-1:e*size> = value;
    return;

// Elem[] - assignment form
// =====

Elem(bits(N) &vector, integer e) = bits(size) value
    Elem[vector, e, size] = value;
    return;
```

## Library pseudocode for shared/functions/common/Extend

```
// Extend()
// =====

bits(N) Extend(bits(M) x, integer N, boolean unsigned)
    return if unsigned then ZeroExtend(x, N) else SignExtend(x, N);

// Extend()
// =====

bits(N) Extend(bits(M) x, boolean unsigned)
    return Extend(x, N, unsigned);
```

### Library pseudocode for shared/functions/common/HighestSetBit

```
// HighestSetBit()
// =====

integer HighestSetBit(bits(N) x)
  for i = N-1 downto 0
    if x<i> == '1' then return i;
  return -1;
```

### Library pseudocode for shared/functions/common/Int

```
// Int()
// =====

integer Int(bits(N) x, boolean unsigned)
  result = if unsigned then UInt(x) else SInt(x);
  return result;
```

### Library pseudocode for shared/functions/common/IsOnes

```
// IsOnes()
// =====

boolean IsOnes(bits(N) x)
  return x == Ones(N);
```

### Library pseudocode for shared/functions/common/IsZero

```
// IsZero()
// =====

boolean IsZero(bits(N) x)
  return x == Zeros(N);
```

### Library pseudocode for shared/functions/common/IsZeroBit

```
// IsZeroBit()
// =====

bit IsZeroBit(bits(N) x)
  return if IsZero(x) then '1' else '0';
```

### Library pseudocode for shared/functions/common/LSL

```
// LSL()
// =====

bits(N) LSL(bits(N) x, integer shift)
  assert shift >= 0;
  if shift == 0 then
    result = x;
  else
    (result, -) = LSL\_C(x, shift);
  return result;
```

### Library pseudocode for shared/functions/common/LSL\_C

```
// LSL_C()
// =====

(bits(N), bit) LSL_C(bits(N) x, integer shift)
  assert shift > 0;
  extended_x = x : Zeros(shift);
  result = extended_x<N-1:0>;
  carry_out = extended_x<N>;
  return (result, carry_out);
```

### Library pseudocode for shared/functions/common/LSR

```
// LSR()
// =====

bits(N) LSR(bits(N) x, integer shift)
  assert shift >= 0;
  if shift == 0 then
    result = x;
  else
    (result, -) = LSR_C(x, shift);
  return result;
```

### Library pseudocode for shared/functions/common/LSR\_C

```
// LSR_C()
// =====

(bits(N), bit) LSR_C(bits(N) x, integer shift)
  assert shift > 0;
  extended_x = ZeroExtend(x, shift+N);
  result = extended_x<shift+N-1:shift>;
  carry_out = extended_x<shift-1>;
  return (result, carry_out);
```

### Library pseudocode for shared/functions/common/LeastSetBit

```
// LeastSetBit()
// =====

integer LeastSetBit(bits(N) x)
  for i = 0 to N-1
    if x<i> == '1' then return i;
  return N;
```

### Library pseudocode for shared/functions/common/Max

```
// Max()
// =====

integer Max(integer a, integer b)
  return if a >= b then a else b;

// Max()
// =====

real Max(real a, real b)
  return if a >= b then a else b;
```

### Library pseudocode for shared/functions/common/Min

```
// Min()
// =====

integer Min(integer a, integer b)
    return if a <= b then a else b;

// Min()
// =====

real Min(real a, real b)
    return if a <= b then a else b;
```

### Library pseudocode for shared/functions/common/Ones

```
// Ones()
// =====

bits(N) Ones(integer N)
    return Replicate('1',N);

// Ones()
// =====

bits(N) Ones()
    return Ones(N);
```

### Library pseudocode for shared/functions/common/ROR

```
// ROR()
// =====

bits(N) ROR(bits(N) x, integer shift)
    assert shift >= 0;
    if shift == 0 then
        result = x;
    else
        (result, -) = ROR_C(x, shift);
    return result;
```

### Library pseudocode for shared/functions/common/ROR\_C

```
// ROR_C()
// =====

(bits(N), bit) ROR_C(bits(N) x, integer shift)
    assert shift != 0;
    m = shift MOD N;
    result = LSR(x,m) OR LSL(x,N-m);
    carry_out = result<N-1>;
    return (result, carry_out);
```

### Library pseudocode for shared/functions/common/Replicate

```
// Replicate()
// =====

bits(N) Replicate(bits(M) x)
    assert N MOD M == 0;
    return Replicate(x, N DIV M);

bits(M*N) Replicate(bits(M) x, integer N);
```

### Library pseudocode for shared/functions/common/RoundDown

```
integer RoundDown(real x);
```

### Library pseudocode for shared/functions/common/RoundTowardsZero

```
// RoundTowardsZero()  
// =====  
  
integer RoundTowardsZero(real x)  
    return if x == 0.0 then 0 else if x >= 0.0 then RoundDown(x) else RoundUp(x);
```

### Library pseudocode for shared/functions/common/RoundUp

```
integer RoundUp(real x);
```

### Library pseudocode for shared/functions/common/SInt

```
// SInt()  
// =====  
  
integer SInt(bits(N) x)  
    result = 0;  
    for i = 0 to N-1  
        if x<i> == '1' then result = result + 2^i;  
    if x<N-1> == '1' then result = result - 2^N;  
    return result;
```

### Library pseudocode for shared/functions/common/SignExtend

```
// SignExtend()  
// =====  
  
bits(N) SignExtend(bits(M) x, integer N)  
    assert N >= M;  
    return Replicate(x<M-1>, N-M) : x;  
  
// SignExtend()  
// =====  
  
bits(N) SignExtend(bits(M) x)  
    return SignExtend(x, N);
```

### Library pseudocode for shared/functions/common/UInt

```
// UInt()  
// =====  
  
integer UInt(bits(N) x)  
    result = 0;  
    for i = 0 to N-1  
        if x<i> == '1' then result = result + 2^i;  
    return result;
```

## Library pseudocode for shared/functions/common/ZeroExtend

```
// ZeroExtend()
// =====

bits(N) ZeroExtend(bits(M) x, integer N)
    assert N >= M;
    return Zeros(N-M) : x;

// ZeroExtend()
// =====

bits(N) ZeroExtend(bits(M) x)
    return ZeroExtend(x, N);
```

## Library pseudocode for shared/functions/common/Zeros

```
// Zeros()
// =====

bits(N) Zeros(integer N)
    return Replicate('0',N);

// Zeros()
// =====

bits(N) Zeros()
    return Zeros(N);
```

## Library pseudocode for shared/functions/crc/BitReverse

```
// BitReverse()
// =====

bits(N) BitReverse(bits(N) data)
    bits(N) result;
    for i = 0 to N-1
        result<N-i-1> = data<i>;
    return result;
```

## Library pseudocode for shared/functions/crc/HaveCRCExt

```
// HaveCRCExt()
// =====

boolean HaveCRCExt()
    return HasArchVersion(ARMv8p1) || boolean IMPLEMENTATION_DEFINED "Have CRC extension";
```

## Library pseudocode for shared/functions/crc/Poly32Mod2

```
// Poly32Mod2()
// =====

// Poly32Mod2 on a bitstring does a polynomial Modulus over {0,1} operation

bits(32) Poly32Mod2(bits(N) data, bits(32) poly)
    assert N > 32;
    for i = N-1 downto 32
        if data<i> == '1' then
            data<i-1:0> = data<i-1:0> EOR (poly:Zeros(i-32));
    return data<31:0>;
```

## Library pseudocode for shared/functions/crypto/AESInvMixColumns

```
// AESInvMixColumns()
// =====
// Transformation in the Inverse Cipher that is the inverse of AESMixColumns.

bits(128) AESInvMixColumns(bits (128) op)
  bits(4*8) in0 = op< 96+:8> : op< 64+:8> : op< 32+:8> : op<  0+:8>;
  bits(4*8) in1 = op<104+:8> : op< 72+:8> : op< 40+:8> : op<  8+:8>;
  bits(4*8) in2 = op<112+:8> : op< 80+:8> : op< 48+:8> : op< 16+:8>;
  bits(4*8) in3 = op<120+:8> : op< 88+:8> : op< 56+:8> : op< 24+:8>;

  bits(4*8) out0;
  bits(4*8) out1;
  bits(4*8) out2;
  bits(4*8) out3;

  for c = 0 to 3
    out0<c*8+:8> = FFmul0E(in0<c*8+:8>) EOR FFmul0B(in1<c*8+:8>) EOR FFmul0D(in2<c*8+:8>) EOR FFmul09(in3<c*8+:8>)
    out1<c*8+:8> = FFmul09(in0<c*8+:8>) EOR FFmul0E(in1<c*8+:8>) EOR FFmul0B(in2<c*8+:8>) EOR FFmul0D(in3<c*8+:8>)
    out2<c*8+:8> = FFmul0D(in0<c*8+:8>) EOR FFmul09(in1<c*8+:8>) EOR FFmul0E(in2<c*8+:8>) EOR FFmul0B(in3<c*8+:8>)
    out3<c*8+:8> = FFmul0B(in0<c*8+:8>) EOR FFmul0D(in1<c*8+:8>) EOR FFmul09(in2<c*8+:8>) EOR FFmul0E(in3<c*8+:8>)

  return (
    out3<3*8+:8> : out2<3*8+:8> : out1<3*8+:8> : out0<3*8+:8> :
    out3<2*8+:8> : out2<2*8+:8> : out1<2*8+:8> : out0<2*8+:8> :
    out3<1*8+:8> : out2<1*8+:8> : out1<1*8+:8> : out0<1*8+:8> :
    out3<0*8+:8> : out2<0*8+:8> : out1<0*8+:8> : out0<0*8+:8>
  );
```

## Library pseudocode for shared/functions/crypto/AESInvShiftRows

```
// AESInvShiftRows()
// =====
// Transformation in the Inverse Cipher that is inverse of AESShiftRows.

bits(128) AESInvShiftRows(bits(128) op)
  return (
    op< 24+:8> : op< 48+:8> : op< 72+:8> : op< 96+:8> :
    op<120+:8> : op< 16+:8> : op< 40+:8> : op< 64+:8> :
    op< 88+:8> : op<112+:8> : op<  8+:8> : op< 32+:8> :
    op< 56+:8> : op< 80+:8> : op<104+:8> : op<  0+:8>
  );
```

## Library pseudocode for shared/functions/crypto/AESInvSubBytes

```
// AESInvSubBytes()
// =====
// Transformation in the Inverse Cipher that is the inverse of AESSubBytes.

bits(128) AESInvSubBytes(bits(128) op)
  // Inverse S-box values
  bits(16*16*8) GF2_inv = (
    /*      F E D C B A 9 8 7 6 5 4 3 2 1 0      */
    /*F*/ 0x7d0c2155631469e126d677ba7e042b17<127:0> :
    /*E*/ 0x619953833cbbefbc8b0f52aae4d3be0a0<127:0> :
    /*D*/ 0xef9cc9939f7ae52d0d4ab519a97f5160<127:0> :
    /*C*/ 0x5fec8027591012b131c7078833a8dd1f<127:0> :
    /*B*/ 0xf45acd78fec0db9a2079d2c64b3e56fc<127:0> :
    /*A*/ 0x1bbe18aa0e62b76f89c5291d711af147<127:0> :
    /*9*/ 0x6edf751ce837f9e28535ade72274ac96<127:0> :
    /*8*/ 0x73e6b4f0cecff297eadc674f4111913a<127:0> :
    /*7*/ 0x6b8a130103bdafc1020f3fca8f1e2cd0<127:0> :
    /*6*/ 0x0645b3b80558e4f70ad3bc8c00abd890<127:0> :
    /*5*/ 0x849d8da75746155edab9edfd5048706c<127:0> :
    /*4*/ 0x92b6655dcc5ca4d41698688664f6f872<127:0> :
    /*3*/ 0x25d18b6d49a25b76b224d92866a12e08<127:0> :
    /*2*/ 0x4ec3fa420b954cee3d23c2a632947b54<127:0> :
    /*1*/ 0xcbe9dec444438e3487ff2f9b8239e37c<127:0> :
    /*0*/ 0xfbd7f3819ea340bf38a53630d56a0952<127:0>
  );
  bits(128) out;
  for i = 0 to 15
    out<i*8+:8> = GF2_inv<UInt(op<i*8+:8>)*8+:8>;
  return out;
```

## Library pseudocode for shared/functions/crypto/AESMixColumns

```
// AESMixColumns()
// =====
// Transformation in the Cipher that takes all of the columns of the
// State and mixes their data (independently of one another) to
// produce new columns.

bits(128) AESMixColumns(bits (128) op)
  bits(4*8) in0 = op< 96+:8> : op< 64+:8> : op< 32+:8> : op<  0+:8>;
  bits(4*8) in1 = op<104+:8> : op< 72+:8> : op< 40+:8> : op<  8+:8>;
  bits(4*8) in2 = op<112+:8> : op< 80+:8> : op< 48+:8> : op< 16+:8>;
  bits(4*8) in3 = op<120+:8> : op< 88+:8> : op< 56+:8> : op< 24+:8>;

  bits(4*8) out0;
  bits(4*8) out1;
  bits(4*8) out2;
  bits(4*8) out3;

  for c = 0 to 3
    out0<c*8+:8> = FFmul02(in0<c*8+:8>) EOR FFmul03(in1<c*8+:8>) EOR          in2<c*8+:8> EOR
    out1<c*8+:8> =          in0<c*8+:8> EOR FFmul02(in1<c*8+:8>) EOR FFmul03(in2<c*8+:8>) EOR
    out2<c*8+:8> =          in0<c*8+:8> EOR          in1<c*8+:8> EOR FFmul02(in2<c*8+:8>) EOR FFmul03(in3<c*8+:8>)
    out3<c*8+:8> = FFmul03(in0<c*8+:8>) EOR          in1<c*8+:8> EOR          in2<c*8+:8> EOR FFmul02(in3<c*8+:8>)

  return (
    out3<3*8+:8> : out2<3*8+:8> : out1<3*8+:8> : out0<3*8+:8> :
    out3<2*8+:8> : out2<2*8+:8> : out1<2*8+:8> : out0<2*8+:8> :
    out3<1*8+:8> : out2<1*8+:8> : out1<1*8+:8> : out0<1*8+:8> :
    out3<0*8+:8> : out2<0*8+:8> : out1<0*8+:8> : out0<0*8+:8>
  );
```



## Library pseudocode for shared/functions/crypto/AESShiftRows

```
// AESShiftRows()
// =====
// Transformation in the Cipher that processes the State by cyclically
// shifting the last three rows of the State by different offsets.

bits(128) AESShiftRows(bits(128) op)
    return (
        op< 88+:8> : op< 48+:8> : op<  8+:8> : op< 96+:8> :
        op< 56+:8> : op< 16+:8> : op<104+:8> : op< 64+:8> :
        op< 24+:8> : op<112+:8> : op< 72+:8> : op< 32+:8> :
        op<120+:8> : op< 80+:8> : op< 40+:8> : op<  0+:8>
    );
```

## Library pseudocode for shared/functions/crypto/AESSubBytes

```
// AESSubBytes()
// =====
// Transformation in the Cipher that processes the State using a nonlinear
// byte substitution table (S-box) that operates on each of the State bytes
// independently.

bits(128) AESSubBytes(bits(128) op)
    // S-box values
    bits(16*16*8) GF2 = (
        /*      F E D C B A 9 8 7 6 5 4 3 2 1 0      */
        /*F*/ 0x16bb54b00f2d99416842e6bf0d89a18c<127:0> :
        /*E*/ 0xdf2855cee9871e9b948ed9691198f8e1<127:0> :
        /*D*/ 0x9e1dc186b95735610ef6034866b53e70<127:0> :
        /*C*/ 0x8a8bbd4b1f74dde8c6b4a61c2e2578ba<127:0> :
        /*B*/ 0x08ae7a65eaf4566ca94ed58d6d37c8e7<127:0> :
        /*A*/ 0x79e4959162acd3c25c2406490a3a32e0<127:0> :
        /*9*/ 0xdb0b5ede14b8ee4688902a22dc4f8160<127:0> :
        /*8*/ 0x73195d643d7ea7c41744975fec130ccd<127:0> :
        /*7*/ 0xd2f3ff1021dab6bcf5389d928f40a351<127:0> :
        /*6*/ 0xa89f3c507f02f94585334d43fbaefd0<127:0> :
        /*5*/ 0xcf584c4a39becb6a5bb1fc20ed00d153<127:0> :
        /*4*/ 0x842fe329b3d63b52a05a6e1b1a2c8309<127:0> :
        /*3*/ 0x75b227ebe28012079a059618c323c704<127:0> :
        /*2*/ 0x1531d871f1e5a534ccf73f362693fdb7<127:0> :
        /*1*/ 0xc072a49cafa2d4adf04759fa7dc982ca<127:0> :
        /*0*/ 0x76abd7fe2b670130c56f6bf27b777c63<127:0>
    );
    bits(128) out;
    for i = 0 to 15
        out<i*8+:8> = GF2<UInt>(op<i*8+:8>)*8+:8>;
    return out;
```

## Library pseudocode for shared/functions/crypto/FFmul02

```
// FFmul02()
// =====

bits(8) FFmul02(bits(8) b)
    bits(256*8) FFmul_02 = (
        /*      F E D C B A 9 8 7 6 5 4 3 2 1 0      */
        /*F*/ 0xE5E7E1E3EDEFE9EBF5F7F1F3FDFFF9FB<127:0> :
        /*E*/ 0xC5C7C1C3CDCFC9CBD5D7D1D3DDDFD9DB<127:0> :
        /*D*/ 0xA5A7A1A3ADAF9ABB5B7B1B3BDBFB9BB<127:0> :
        /*C*/ 0x858781838D8F898B959791939D9F999B<127:0> :
        /*B*/ 0x656761636D6F696B757771737D7F797B<127:0> :
        /*A*/ 0x454741434D4F494B555751535D5F595B<127:0> :
        /*9*/ 0x252721232D2F292B353731333D3F393B<127:0> :
        /*8*/ 0x050701030D0F090B151711131D1F191B<127:0> :
        /*7*/ 0xFEFCFAF8F6F4F2F0EEECEAE8E6E4E2E0<127:0> :
        /*6*/ 0xDEDCDAD8D6D4D2D0CECCAC8C6C4C2C0<127:0> :
        /*5*/ 0xBEBBCBAB8B6B4B2B0AEACAAA8A6A4A2A0<127:0> :
        /*4*/ 0x9E9C9A98969492908E8C8A8886848280<127:0> :
        /*3*/ 0x7E7C7A78767472706E6C6A6866646260<127:0> :
        /*2*/ 0x5E5C5A58565452504E4C4A4846444240<127:0> :
        /*1*/ 0x3E3C3A38363432302E2C2A2826242220<127:0> :
        /*0*/ 0x1E1C1A18161412100E0C0A0806040200<127:0>
    );
    return FFmul_02<UInt(b)*8+:8>;
```

## Library pseudocode for shared/functions/crypto/FFmul03

```
// FFmul03()
// =====

bits(8) FFmul03(bits(8) b)
    bits(256*8) FFmul_03 = (
        /*      F E D C B A 9 8 7 6 5 4 3 2 1 0      */
        /*F*/ 0x1A191C1F16151013020104070E0D080B<127:0> :
        /*E*/ 0x2A292C2F26252023323134373E3D383B<127:0> :
        /*D*/ 0x7A797C7F76757073626164676E6D686B<127:0> :
        /*C*/ 0x4A494C4F46454043525154575E5D585B<127:0> :
        /*B*/ 0xDAD9DCDFD6D5D0D3C2C1C4C7CECDC8CB<127:0> :
        /*A*/ 0xEAE9ECEFE6E5E0E3F2F1F4F7FEFDF8FB<127:0> :
        /*9*/ 0xBAB9BCBFB6B5B0B3A2A1A4A7AEADA8AB<127:0> :
        /*8*/ 0x8A898C8F86858083929194979E9D989B<127:0> :
        /*7*/ 0x818287848D8E8B88999A9F9C95969390<127:0> :
        /*6*/ 0xB1B2B7B4BDBEBBB8A9AAAFACA5A6A3A0<127:0> :
        /*5*/ 0xE1E2E7E4EDEEEBE8F9FAFFFCF5F6F3F0<127:0> :
        /*4*/ 0xD1D2D7D4DDDEDDBD8C9CACFCCC5C6C3C0<127:0> :
        /*3*/ 0x414247444D4E4B48595A5F5C55565350<127:0> :
        /*2*/ 0x717277747D7E7B78696A6F6C65666360<127:0> :
        /*1*/ 0x212227242D2E2B28393A3F3C35363330<127:0> :
        /*0*/ 0x111217141D1E1B18090A0F0C05060300<127:0>
    );
    return FFmul_03<UInt(b)*8+:8>;
```

## Library pseudocode for shared/functions/crypto/FFmul09

```
// FFmul09()
// =====

bits(8) FFmul09(bits(8) b)
  bits(256*8) FFmul_09 = (
    /*      F E D C B A 9 8 7 6 5 4 3 2 1 0      */
    /*F*/ 0x464F545D626B70790E071C152A233831<127:0> :
    /*E*/ 0xD6DFC4CDF2FBE0E99E978C85BAB3A8A1<127:0> :
    /*D*/ 0x7D746F6659504B42353C272E1118030A<127:0> :
    /*C*/ 0xEDE4FFF6C9C0DBD2A5ACB7BE8188939A<127:0> :
    /*B*/ 0x3039222B141D060F78716A635C554E47<127:0> :
    /*A*/ 0xA0A9B2BB848D969FE8E1FAF3CCC5DED7<127:0> :
    /*9*/ 0x0B0219102F263D34434A5158676E757C<127:0> :
    /*8*/ 0x9B928980BFB6ADA4D3DAC1C8F7FEE5EC<127:0> :
    /*7*/ 0xAAA3B8B18E879C95E2EBF0F9C6CFD4DD<127:0> :
    /*6*/ 0x3A3328211E170C05727B6069565F444D<127:0> :
    /*5*/ 0x9198838AB5BCA7AED9D0CBC2FDF4EFE6<127:0> :
    /*4*/ 0x0108131A252C373E49405B526D647F76<127:0> :
    /*3*/ 0xDCD5CEC7F8F1EAE3949D868FB0B9A2AB<127:0> :
    /*2*/ 0x4C455E5768617A73040D161F2029323B<127:0> :
    /*1*/ 0xE7EEF5FCC3CAD1D8AFA6BDB48B829990<127:0> :
    /*0*/ 0x777E656C535A41483F362D241B120900<127:0>
  );
  return FFmul_09<UInt(b)*8+:8>;
```

## Library pseudocode for shared/functions/crypto/FFmul0B

```
// FFmul0B()
// =====

bits(8) FFmul0B(bits(8) b)
  bits(256*8) FFmul_0B = (
    /*      F E D C B A 9 8 7 6 5 4 3 2 1 0      */
    /*F*/ 0xA3A8B5BE8F849992FBF0EDE6D7DCC1CA<127:0> :
    /*E*/ 0x1318050E3F3429224B405D56676C717A<127:0> :
    /*D*/ 0xD8D3CEC5F4FFE2E9808B969DACA7BAB1<127:0> :
    /*C*/ 0x68637E75444F5259303B262D1C170A01<127:0> :
    /*B*/ 0x555E434879726F640D061B10212A373C<127:0> :
    /*A*/ 0xE5EEF3F8C9C2DFD4BDB6ABA0919A878C<127:0> :
    /*9*/ 0x2E2538330209141F767D606B5A514C47<127:0> :
    /*8*/ 0x9E958883B2B9A4AFC6CDD0DBEAE1FCF7<127:0> :
    /*7*/ 0x545F424978736E650C071A11202B363D<127:0> :
    /*6*/ 0xE4EFF2F9C8C3DED5BCB7AAA1909B868D<127:0> :
    /*5*/ 0x2F2439320308151E777C616A5B504D46<127:0> :
    /*4*/ 0x9F948982B3B8A5AEC7CCD1DAEBE0FDF6<127:0> :
    /*3*/ 0xA2A9B4BF8E859893FAF1ECE7D6DDC0CB<127:0> :
    /*2*/ 0x1219040F3E3528234A415C57666D707B<127:0> :
    /*1*/ 0xD9D2CFC4F5FEE3E8818A979CADA6BBB0<127:0> :
    /*0*/ 0x69627F74454E5358313A272C1D160B00<127:0>
  );
  return FFmul_0B<UInt(b)*8+:8>;
```

## Library pseudocode for shared/functions/crypto/FFmul0D

```
// FFmul0D()
// =====

bits(8) FFmul0D(bits(8) b)
    bits(256*8) FFmul_0D = (
        /*      F E D C B A 9 8 7 6 5 4 3 2 1 0      */
        /*F*/ 0x979A8D80A3AEB9B4FFF2E5E8CBC6D1DC<127:0> :
        /*E*/ 0x474A5D50737E69642F2235381B16010C<127:0> :
        /*D*/ 0x2C21363B1815020F44495E53707D6A67<127:0> :
        /*C*/ 0xFCF1E6EBC8C5D2DF94998E83A0ADBAB7<127:0> :
        /*B*/ 0xFAF7E0EDCEC3D4D9929F8885A6ABBCB1<127:0> :
        /*A*/ 0x2A27303D1E130409424F5855767B6C61<127:0> :
        /*9*/ 0x414C5B5675786F622924333E1D10070A<127:0> :
        /*8*/ 0x919C8B86A5A8BFB2F9F4E3EECDC0D7DA<127:0> :
        /*7*/ 0x4D40575A7974636E25283F32111C0B06<127:0> :
        /*6*/ 0x9D90878AA9A4B3BEF5F8EFE2C1CCDBD6<127:0> :
        /*5*/ 0xF6FBCECE1C2CFD8D59E938489AAA7B0BD<127:0> :
        /*4*/ 0x262B3C31121F08054E4354597A77606D<127:0> :
        /*3*/ 0x202D3A3714190E034845525F7C71666B<127:0> :
        /*2*/ 0xF0FDEAE7C4C9DED39895828FACA1B6BB<127:0> :
        /*1*/ 0x9B96818CAFA2B5B8F3FEE9E4C7CADD00<127:0> :
        /*0*/ 0x4B46515C7F726568232E3934171A0D00<127:0>
    );
    return FFmul_0D<UInt(b)*8+:8>;
```

## Library pseudocode for shared/functions/crypto/FFmul0E

```
// FFmul0E()
// =====

bits(8) FFmul0E(bits(8) b)
    bits(256*8) FFmul_0E = (
        /*      F E D C B A 9 8 7 6 5 4 3 2 1 0      */
        /*F*/ 0x8D83919FB5BBA9A7FDF3E1EFC5CBD9D7<127:0> :
        /*E*/ 0x6D63717F555B49471D13010F252B3937<127:0> :
        /*D*/ 0x56584A446E60727C26283A341E10020C<127:0> :
        /*C*/ 0xB6B8AAA48E80929CC6C8DAD4FEF0E2EC<127:0> :
        /*B*/ 0x202E3C321816040A505E4C426866747A<127:0> :
        /*A*/ 0xC0CEDCD2F8F6E4EAB0BEACA28886949A<127:0> :
        /*9*/ 0xFBF5E7E9C3CDDFD18B859799B3BDFAFA1<127:0> :
        /*8*/ 0x1B150709232D3F316B657779535D4F41<127:0> :
        /*7*/ 0xCCC2D0DEF4FAE8E6BCB2A0AE848A9896<127:0> :
        /*6*/ 0x2C22303E141A08065C52404E646A7876<127:0> :
        /*5*/ 0x17190B052F21333D67697B755F51434D<127:0> :
        /*4*/ 0xF7F9EBE5CFC1D3DD87899B95BFB1A3AD<127:0> :
        /*3*/ 0x616F7D735957454B111F0D032927353B<127:0> :
        /*2*/ 0x818F9D93B9B7A5ABF1FFEDE3C9C7D5DB<127:0> :
        /*1*/ 0xBAB4A6A8828C9E90CAC4D6D8F2FCEEE0<127:0> :
        /*0*/ 0x5A544648626C7E702A243638121C0E00<127:0>
    );
    return FFmul_0E<UInt(b)*8+:8>;
```

## Library pseudocode for shared/functions/crypto/HaveAESExt

```
// HaveAESExt()
// =====
// TRUE if AES cryptographic instructions support is implemented,
// FALSE otherwise.

boolean HaveAESExt()
    return boolean IMPLEMENTATION_DEFINED "Has AES Crypto instructions";
```

### Library pseudocode for shared/functions/crypto/HaveBit128PMULLExt

```
// HaveBit128PMULLExt()
// =====
// TRUE if 128 bit form of PMULL instructions support is implemented,
// FALSE otherwise.

boolean HaveBit128PMULLExt()
    return boolean IMPLEMENTATION_DEFINED "Has 128-bit form of PMULL instructions";
```

### Library pseudocode for shared/functions/crypto/HaveSHA1Ext

```
// HaveSHA1Ext()
// =====
// TRUE if SHA1 cryptographic instructions support is implemented,
// FALSE otherwise.

boolean HaveSHA1Ext()
    return boolean IMPLEMENTATION_DEFINED "Has SHA1 Crypto instructions";
```

### Library pseudocode for shared/functions/crypto/HaveSHA256Ext

```
// HaveSHA256Ext()
// =====
// TRUE if SHA256 cryptographic instructions support is implemented,
// FALSE otherwise.

boolean HaveSHA256Ext()
    return boolean IMPLEMENTATION_DEFINED "Has SHA256 Crypto instructions";
```

### Library pseudocode for shared/functions/crypto/HaveSHA3Ext

```
// HaveSHA3Ext()
// =====
// TRUE if SHA3 cryptographic instructions support is implemented,
// and when SHA1 and SHA2 basic cryptographic instructions support is implemented,
// FALSE otherwise.

boolean HaveSHA3Ext()
    if !HasArchVersion\(ARMv8p2\) || !(HaveSHA1Ext\(\) && HaveSHA256Ext\(\)) then
        return FALSE;
    return boolean IMPLEMENTATION_DEFINED "Has SHA3 Crypto instructions";
```

### Library pseudocode for shared/functions/crypto/HaveSHA512Ext

```
// HaveSHA512Ext()
// =====
// TRUE if SHA512 cryptographic instructions support is implemented,
// and when SHA1 and SHA2 basic cryptographic instructions support is implemented,
// FALSE otherwise.

boolean HaveSHA512Ext()
    if !HasArchVersion\(ARMv8p2\) || !(HaveSHA1Ext\(\) && HaveSHA256Ext\(\)) then
        return FALSE;
    return boolean IMPLEMENTATION_DEFINED "Has SHA512 Crypto instructions";
```

### Library pseudocode for shared/functions/crypto/HaveSM3Ext

```
// HaveSM3Ext()
// =====
// TRUE if SM3 cryptographic instructions support is implemented,
// FALSE otherwise.

boolean HaveSM3Ext()
    if !HasArchVersion(ARMv8p2) then
        return FALSE;
    return boolean IMPLEMENTATION_DEFINED "Has SM3 Crypto instructions";
```

### Library pseudocode for shared/functions/crypto/HaveSM4Ext

```
// HaveSM4Ext()
// =====
// TRUE if SM4 cryptographic instructions support is implemented,
// FALSE otherwise.

boolean HaveSM4Ext()
    if !HasArchVersion(ARMv8p2) then
        return FALSE;
    return boolean IMPLEMENTATION_DEFINED "Has SM4 Crypto instructions";
```

### Library pseudocode for shared/functions/crypto/ROL

```
// ROL()
// =====

bits(N) ROL(bits(N) x, integer shift)
    assert shift >= 0 && shift <= N;
    if (shift == 0) then
        return x;
    return ROR(x, N-shift);
```

### Library pseudocode for shared/functions/crypto/SHA256hash

```
// SHA256hash()
// =====

bits(128) SHA256hash(bits (128) X, bits(128) Y, bits(128) W, boolean part1)
    bits(32) chs, maj, t;

    for e = 0 to 3
        chs = SHAchoose(Y<31:0>, Y<63:32>, Y<95:64>);
        maj = SHAmajority(X<31:0>, X<63:32>, X<95:64>);
        t = Y<127:96> + SHAhashSIGMA1(Y<31:0>) + chs + Elem[W, e, 32];
        X<127:96> = t + X<127:96>;
        Y<127:96> = t + SHAhashSIGMA0(X<31:0>) + maj;
        <Y, X> = ROL(Y : X, 32);
    return (if part1 then X else Y);
```

### Library pseudocode for shared/functions/crypto/SHAchoose

```
// SHAchoose()
// =====

bits(32) SHAchoose(bits(32) x, bits(32) y, bits(32) z)
    return ((y EOR z) AND x) EOR z;
```

### Library pseudocode for shared/functions/crypto/SHAhashSIGMA0

```
// SHAhashSIGMA0()
// =====

bits(32) SHAhashSIGMA0(bits(32) x)
    return ROR(x, 2) EOR ROR(x, 13) EOR ROR(x, 22);
```

### Library pseudocode for shared/functions/crypto/SHAhashSIGMA1

```
// SHAhashSIGMA1()
// =====

bits(32) SHAhashSIGMA1(bits(32) x)
    return ROR(x, 6) EOR ROR(x, 11) EOR ROR(x, 25);
```

### Library pseudocode for shared/functions/crypto/SHAmajority

```
// SHAmajority()
// =====

bits(32) SHAmajority(bits(32) x, bits(32) y, bits(32) z)
    return ((x AND y) OR ((x OR y) AND z));
```

### Library pseudocode for shared/functions/crypto/SHAparity

```
// SHAparity()
// =====

bits(32) SHAparity(bits(32) x, bits(32) y, bits(32) z)
    return (x EOR y EOR z);
```

### Library pseudocode for shared/functions/crypto/Sbox

```
// Sbox()
// =====
// Used in SM4E crypto instruction

bits(8) Sbox(bits(8) sboxin)
    bits(8) sboxout;
    bits(2048) sboxstring = 0xd690e9fecce13db716b614c228fb2c052b679a762abe04c3aa441326498606999c4250f491e
    sboxout = sboxstring<(255-UInt(sboxin))*8+7:(255-UInt(sboxin))*8>;
    return sboxout;
```

### Library pseudocode for shared/functions/exclusive/ClearExclusiveByAddress

```
// Clear the global Exclusives monitors for all PEs EXCEPT processorid if they
// record any part of the physical address region of size bytes starting at paddress.
// It is IMPLEMENTATION DEFINED whether the global Exclusives monitor for processorid
// is also cleared if it records any part of the address region.
ClearExclusiveByAddress(FullAddress paddress, integer processorid, integer size);
```

### Library pseudocode for shared/functions/exclusive/ClearExclusiveLocal

```
// Clear the local Exclusives monitor for the specified processorid.
ClearExclusiveLocal(integer processorid);
```

### Library pseudocode for shared/functions/exclusive/ClearExclusiveMonitors

```
// ClearExclusiveMonitors()
// =====

// Clear the local Exclusives monitor for the executing PE.

ClearExclusiveMonitors()
    ClearExclusiveLocal(ProcessorID());
```

### Library pseudocode for shared/functions/exclusive/ExclusiveMonitorsStatus

```
// Returns '0' to indicate success if the last memory write by this PE was to
// the same physical address region endorsed by ExclusiveMonitorsPass().
// Returns '1' to indicate failure if address translation resulted in a different
// physical address.
bit ExclusiveMonitorsStatus();
```

### Library pseudocode for shared/functions/exclusive/IsExclusiveGlobal

```
// Return TRUE if the global Exclusives monitor for processorid includes all of
// the physical address region of size bytes starting at address.
boolean IsExclusiveGlobal(FullAddress address, integer processorid, integer size);
```

### Library pseudocode for shared/functions/exclusive/IsExclusiveLocal

```
// Return TRUE if the local Exclusives monitor for processorid includes all of
// the physical address region of size bytes starting at address.
boolean IsExclusiveLocal(FullAddress address, integer processorid, integer size);
```

### Library pseudocode for shared/functions/exclusive/MarkExclusiveGlobal

```
// Record the physical address region of size bytes starting at address in
// the global Exclusives monitor for processorid.
MarkExclusiveGlobal(FullAddress address, integer processorid, integer size);
```

### Library pseudocode for shared/functions/exclusive/MarkExclusiveLocal

```
// Record the physical address region of size bytes starting at address in
// the local Exclusives monitor for processorid.
MarkExclusiveLocal(FullAddress address, integer processorid, integer size);
```

### Library pseudocode for shared/functions/exclusive/ProcessorID

```
// Return the ID of the currently executing PE.
integer ProcessorID();
```

### Library pseudocode for shared/functions/extension/AArch32.HaveHPDExt

```
// AArch32.HaveHPDExt()
// =====

boolean AArch32.HaveHPDExt()
    return HasArchVersion(ARMv8p2);
```

### Library pseudocode for shared/functions/extension/AArch64.HaveHPDExt

```
// AArch64.HaveHPDExt()
// =====

boolean AArch64.HaveHPDExt()
    return HasArchVersion(ARMv8p1);
```



### Library pseudocode for shared/functions/extension/Have52BitPAExt

```
// Have52BitPAExt()
// =====
// Returns TRUE if Large Physical Address extension
// support is implemented and FALSE otherwise.

boolean Have52BitPAExt()
    return HasArchVersion\(ARMv8p2\) && boolean IMPLEMENTATION_DEFINED "Has large 52-bit PA/IPA support";
```

### Library pseudocode for shared/functions/extension/Have52BitVAExt

```
// Have52BitVAExt()
// =====
// Returns TRUE if Large Virtual Address extension
// support is implemented and FALSE otherwise.

boolean Have52BitVAExt()
    return HasArchVersion\(ARMv8p2\) && boolean IMPLEMENTATION_DEFINED "Has large 52-bit VA support";
```

### Library pseudocode for shared/functions/extension/HaveAArch32BF16Ext

```
// HaveAArch32BF16Ext()
// =====
// Returns TRUE if AArch32 BFloat16 instruction support is implemented, and FALSE otherwise.

boolean HaveAArch32BF16Ext()
    return HasArchVersion\(ARMv8p2\) && boolean IMPLEMENTATION_DEFINED "Has AArch32 BFloat16 extension";
```

### Library pseudocode for shared/functions/extension/HaveAArch32Int8MatMulExt

```
// HaveAArch32Int8MatMulExt()
// =====
// Returns TRUE if AArch32 8-bit integer matrix multiply instruction support
// implemented, and FALSE otherwise.

boolean HaveAArch32Int8MatMulExt()
    return HasArchVersion\(ARMv8p2\) && boolean IMPLEMENTATION_DEFINED "Has AArch32 Int8 Mat Mul extension";
```

### Library pseudocode for shared/functions/extension/HaveAtomicExt

```
// HaveAtomicExt()
// =====

boolean HaveAtomicExt()
    return HasArchVersion\(ARMv8p1\);
```

### Library pseudocode for shared/functions/extension/HaveBF16Ext

```
// HaveBF16Ext()
// =====
// Returns TRUE if AArch64 BFloat16 instruction support is implemented, and FALSE otherwise.

boolean HaveBF16Ext()
    return HasArchVersion\(ARMv8p6\) || (HasArchVersion\(ARMv8p2\) && boolean IMPLEMENTATION_DEFINED "Has AArch64 BFloat16 extension");
```

### Library pseudocode for shared/functions/extension/HaveBTIExt

```
// HaveBTIExt()
// =====
// Returns TRUE if support for Branch Target Identification is implemented.

boolean HaveBTIExt()
    return HasArchVersion\(ARMv8p5\);
```

### Library pseudocode for shared/functions/extension/HaveBlockBBM

```
// HaveBlockBBM()
// =====
// Returns TRUE if support for changing block size without requiring break-before-make is implemented.

boolean HaveBlockBBM()
    return HasArchVersion\(ARMv8p4\);
```

### Library pseudocode for shared/functions/extension/HaveCommonNotPrivateTransExt

```
// HaveCommonNotPrivateTransExt()
// =====

boolean HaveCommonNotPrivateTransExt()
    return HasArchVersion\(ARMv8p2\);
```

### Library pseudocode for shared/functions/extension/HaveDGHExt

```
// HaveDGHExt()
// =====
// Returns TRUE if Data Gathering Hint instruction support is implemented, and FALSE otherwise.

boolean HaveDGHExt()
    return boolean IMPLEMENTATION_DEFINED "Has AArch64 DGH extension";
```

### Library pseudocode for shared/functions/extension/HaveDITExt

```
// HaveDITExt()
// =====

boolean HaveDITExt()
    return HasArchVersion\(ARMv8p4\);
```

### Library pseudocode for shared/functions/extension/HaveDOTPExt

```
// HaveDOTPExt()
// =====
// Returns TRUE if Dot Product feature support is implemented, and FALSE otherwise.

boolean HaveDOTPExt()
    return HasArchVersion\(ARMv8p4\) || (HasArchVersion\(ARMv8p2\) && boolean IMPLEMENTATION_DEFINED "Has Dot Product feature support");
```

### Library pseudocode for shared/functions/extension/HaveDoPD

```
// HaveDoPD()
// =====
// Returns TRUE if Debug Over Power Down extension support is implemented and FALSE otherwise.

boolean HaveDoPD()
    return HasArchVersion\(ARMv8p2\) && boolean IMPLEMENTATION_DEFINED "Has DoPD extension";
```

### Library pseudocode for shared/functions/extension/HaveDoubleFaultExt

```
// HaveDoubleFaultExt()
// =====

boolean HaveDoubleFaultExt()
    return (HasArchVersion\(ARMv8p4\) && HaveEL\(EL3\) && !ELUsingAArch32\(EL3\) && HaveIESB\(\));
```

### Library pseudocode for shared/functions/extension/HaveDoubleLock

```
// HaveDoubleLock()
// =====
// Returns TRUE if support for the OS Double Lock is implemented.

boolean HaveDoubleLock()
    return !HasArchVersion(ARMv8p4) || boolean IMPLEMENTATION_DEFINED "OS Double Lock is implemented";
```

### Library pseudocode for shared/functions/extension/HaveE0PDExt

```
// HaveE0PDExt()
// =====
// Returns TRUE if support for constant fault times for unprivileged accesses
// to the memory map is implemented.

boolean HaveE0PDExt()
    return HasArchVersion(ARMv8p5);
```

### Library pseudocode for shared/functions/extension/HaveECVExt

```
// HaveECVExt()
// =====
// Returns TRUE if Enhanced Counter Virtualization extension
// support is implemented, and FALSE otherwise.

boolean HaveECVExt()
    return HasArchVersion(ARMv8p6);
```

### Library pseudocode for shared/functions/extension/HaveEMPAMExt

```
// HaveEMPAMExt()
// =====
// Returns TRUE if Enhanced MPAM is implemented, and FALSE otherwise.

boolean HaveEMPAMExt()
    return (HasArchVersion(ARMv8p6) &&
            HaveMPAMExt() &&
            boolean IMPLEMENTATION_DEFINED "Has enhanced MPAM extension");
```

### Library pseudocode for shared/functions/extension/HaveExtendedCacheSets

```
// HaveExtendedCacheSets()
// =====

boolean HaveExtendedCacheSets()
    return HasArchVersion(ARMv8p3);
```

### Library pseudocode for shared/functions/extension/HaveExtendedECDebugEvents

```
// HaveExtendedECDebugEvents()
// =====

boolean HaveExtendedECDebugEvents()
    return HasArchVersion(ARMv8p2);
```

### Library pseudocode for shared/functions/extension/HaveExtendedExecuteNeverExt

```
// HaveExtendedExecuteNeverExt()
// =====

boolean HaveExtendedExecuteNeverExt()
    return HasArchVersion(ARMv8p2);
```

### Library pseudocode for shared/functions/extension/HaveFCADDExt

```
// HaveFCADDExt()
// =====

boolean HaveFCADDExt()
    return HasArchVersion\(ARMv8p3\);
```

### Library pseudocode for shared/functions/extension/HaveFGTExt

```
// HaveFGTExt()
// =====
// Returns TRUE if Fine Grained Trap is implemented, and FALSE otherwise.

boolean HaveFGTExt()
    return HasArchVersion\(ARMv8p6\) && !ELUsingAArch32\(EL2\);
```

### Library pseudocode for shared/functions/extension/HaveFJCVTZSExt

```
// HaveFJCVTZSExt()
// =====

boolean HaveFJCVTZSExt()
    return HasArchVersion\(ARMv8p3\);
```

### Library pseudocode for shared/functions/extension/HaveFP16MulNoRoundingToFP32Ext

```
// HaveFP16MulNoRoundingToFP32Ext()
// =====
// Returns TRUE if has FP16 multiply with no intermediate rounding accumulate to FP32 instructions,
// and FALSE otherwise

boolean HaveFP16MulNoRoundingToFP32Ext()
    if !HaveFP16Ext\(\) then return FALSE;
    if HasArchVersion\(ARMv8p4\) then return TRUE;
    return (HasArchVersion\(ARMv8p2\) &&
        boolean IMPLEMENTATION_DEFINED "Has accumulate FP16 product into FP32 extension");
```

### Library pseudocode for shared/functions/extension/HaveFlagFormatExt

```
// HaveFlagFormatExt()
// =====
// Returns TRUE if flag format conversion instructions implemented.

boolean HaveFlagFormatExt()
    return HasArchVersion\(ARMv8p5\);
```

### Library pseudocode for shared/functions/extension/HaveFlagManipulateExt

```
// HaveFlagManipulateExt()
// =====
// Returns TRUE if flag manipulate instructions are implemented.

boolean HaveFlagManipulateExt()
    return HasArchVersion\(ARMv8p4\);
```

### Library pseudocode for shared/functions/extension/HaveFrintExt

```
// HaveFrintExt()
// =====
// Returns TRUE if FRINT instructions are implemented.

boolean HaveFrintExt()
    return HasArchVersion\(ARMv8p5\);
```

### Library pseudocode for shared/functions/extension/HaveHPMDExt

```
// HaveHPMDExt()
// =====

boolean HaveHPMDExt()
    return HasArchVersion\(ARMv8p1\);
```

### Library pseudocode for shared/functions/extension/HaveIDSExt

```
// HaveIDSExt()
// =====
// Returns TRUE if ID register handling feature is implemented.

boolean HaveIDSExt()
    return HasArchVersion\(ARMv8p4\);
```

### Library pseudocode for shared/functions/extension/HaveIESB

```
// HaveIESB()
// =====

boolean HaveIESB()
    return (HaveRASExt\(\) &&
        boolean IMPLEMENTATION_DEFINED "Has Implicit Error Synchronization Barrier");
```

### Library pseudocode for shared/functions/extension/HaveInt8MatMulExt

```
// HaveInt8MatMulExt()
// =====
// Returns TRUE if AArch64 8-bit integer matrix multiply instruction support
// implemented, and FALSE otherwise.

boolean HaveInt8MatMulExt()
    return HasArchVersion\(ARMv8p6\) || (HasArchVersion\(ARMv8p2\) && boolean IMPLEMENTATION_DEFINED "Has AA
```

### Library pseudocode for shared/functions/extension/HaveMPAMExt

```
// HaveMPAMExt()
// =====
// Returns TRUE if MPAM is implemented, and FALSE otherwise.

boolean HaveMPAMExt()
    return (HasArchVersion\(ARMv8p2\) &&
        boolean IMPLEMENTATION_DEFINED "Has MPAM extension");
```

### Library pseudocode for shared/functions/extension/HaveMTEExt

```
// HaveMTEExt()
// =====
// Returns TRUE if MTE implemented, and FALSE otherwise.

boolean HaveMTEExt()
    if !HasArchVersion\(ARMv8p5\) then
        return FALSE;
    return boolean IMPLEMENTATION_DEFINED "Has MTE extension";
```

### Library pseudocode for shared/functions/extension/HaveNV2Ext

```
// HaveNV2Ext()  
// =====  
// Returns TRUE if Enhanced Nested Virtualization is implemented.  
  
boolean HaveNV2Ext()  
    return (HasArchVersion(ARMv8p4) && HaveNVExt()  
        && boolean IMPLEMENTATION_DEFINED "Has support for Enhanced Nested Virtualization");
```

### Library pseudocode for shared/functions/extension/HaveNVExt

```
// HaveNVExt()  
// =====  
// Returns TRUE if Nested Virtualization is implemented.  
  
boolean HaveNVExt()  
    return HasArchVersion(ARMv8p3) && boolean IMPLEMENTATION_DEFINED "Has Nested Virtualization";
```

### Library pseudocode for shared/functions/extension/HaveNoSecurePMUDisableOverride

```
// HaveNoSecurePMUDisableOverride()  
// =====  
  
boolean HaveNoSecurePMUDisableOverride()  
    return HasArchVersion(ARMv8p2);
```

### Library pseudocode for shared/functions/extension/HaveNoninvasiveDebugAuth

```
// HaveNoninvasiveDebugAuth()  
// =====  
// Returns TRUE if the Non-invasive debug controls are implemented.  
  
boolean HaveNoninvasiveDebugAuth()  
    return !HasArchVersion(ARMv8p4);
```

### Library pseudocode for shared/functions/extension/HavePANExt

```
// HavePANExt()  
// =====  
  
boolean HavePANExt()  
    return HasArchVersion(ARMv8p1);
```

### Library pseudocode for shared/functions/extension/HavePageBasedHardwareAttributes

```
// HavePageBasedHardwareAttributes()  
// =====  
  
boolean HavePageBasedHardwareAttributes()  
    return HasArchVersion(ARMv8p2);
```

### Library pseudocode for shared/functions/extension/HavePrivATExt

```
// HavePrivATExt()  
// =====  
  
boolean HavePrivATExt()  
    return HasArchVersion(ARMv8p2);
```

### Library pseudocode for shared/functions/extension/HaveQRDMLAExt

```
// HaveQRDMLAExt()
// =====

boolean HaveQRDMLAExt()
    return HasArchVersion\(ARMv8p1\);

boolean HaveAccessFlagUpdateExt()
    return HasArchVersion\(ARMv8p1\);

boolean HaveDirtyBitModifierExt()
    return HasArchVersion\(ARMv8p1\);
```

### Library pseudocode for shared/functions/extension/HaveRASExt

```
// HaveRASExt()
// =====

boolean HaveRASExt()
    return (HasArchVersion\(ARMv8p2\) ||
           boolean IMPLEMENTATION_DEFINED "Has RAS extension");
```

### Library pseudocode for shared/functions/extension/HaveRNG

```
// HaveRNG()
// =====
// Returns TRUE if Random Number Generator extension
// support is implemented and FALSE otherwise.

boolean HaveRNG()
    return HasArchVersion\(ARMv8p5\) && boolean IMPLEMENTATION_DEFINED "Has RNG extension";
```

### Library pseudocode for shared/functions/extension/HaveSBExt

```
// HaveSBExt()
// =====
// Returns TRUE if support for SB is implemented, and FALSE otherwise.

boolean HaveSBExt()
    return HasArchVersion\(ARMv8p5\) || boolean IMPLEMENTATION_DEFINED "Has SB extension";
```

### Library pseudocode for shared/functions/extension/HaveSSBSExt

```
// HaveSSBSExt()
// =====
// Returns TRUE if support for SSBS is implemented, and FALSE otherwise.

boolean HaveSSBSExt()
    return HasArchVersion\(ARMv8p5\) || boolean IMPLEMENTATION_DEFINED "Has SSBS extension";
```

### Library pseudocode for shared/functions/extension/HaveSecureEL2Ext

```
// HaveSecureEL2Ext()
// =====
// Returns TRUE if Secure EL2 is implemented.

boolean HaveSecureEL2Ext()
    return HasArchVersion\(ARMv8p4\);
```

### Library pseudocode for shared/functions/extension/HaveSecureExtDebugView

```
// HaveSecureExtDebugView()
// =====
// Returns TRUE if support for Secure and Non-secure views of debug peripherals is implemented.

boolean HaveSecureExtDebugView()
    return HasArchVersion(ARMv8p4);
```

### Library pseudocode for shared/functions/extension/HaveSelfHostedTrace

```
// HaveSelfHostedTrace()
// =====

boolean HaveSelfHostedTrace()
    return HasArchVersion(ARMv8p4);
```

### Library pseudocode for shared/functions/extension/HaveSmallPageTblExt

```
// HaveSmallPageTblExt()
// =====
// Returns TRUE if Small Page Table Support is implemented.

boolean HaveSmallPageTblExt()
    return HasArchVersion(ARMv8p4) && boolean IMPLEMENTATION_DEFINED "Has Small Page Table extension";
```

### Library pseudocode for shared/functions/extension/HaveStage2MemAttrControl

```
// HaveStage2MemAttrControl()
// =====
// Returns TRUE if support for Stage2 control of memory types and cacheability attributes is implemented.

boolean HaveStage2MemAttrControl()
    return HasArchVersion(ARMv8p4);
```

### Library pseudocode for shared/functions/extension/HaveStatisticalProfiling

```
// HaveStatisticalProfiling()
// =====

boolean HaveStatisticalProfiling()
    return HasArchVersion(ARMv8p2);
```

### Library pseudocode for shared/functions/extension/HaveTME

```
// HaveTME()
// =====

boolean HaveTME()
    return boolean IMPLEMENTATION_DEFINED "Has Transactional Memory extension";
```

### Library pseudocode for shared/functions/extension/HaveTWEDEExt

```
// HaveTWEDEExt()
// =====
// Returns TRUE if Delayed Trapping of WFE instruction support is implemented, and FALSE otherwise.

boolean HaveTWEDEExt()
    return boolean IMPLEMENTATION_DEFINED "Has TWED extension";
```



### Library pseudocode for shared/functions/extension/HaveTraceBufferExtension

```
// HaveTraceBufferExtension()
// =====
// Returns TRUE if support for the Trace Buffer Extension is implemented. This feature depends upon
// the Secure External Debug view feature being implemented. Returns FALSE otherwise.

boolean HaveTraceBufferExtension()
    return HaveSecureExtDebugView\(\) && boolean IMPLEMENTATION_DEFINED "Trace Buffer Extension implemented"
```

### Library pseudocode for shared/functions/extension/HaveTraceExt

```
// HaveTraceExt()
// =====
// Returns TRUE if Trace functionality as described by the Trace Architecture
// is implemented.

boolean HaveTraceExt()
    return boolean IMPLEMENTATION_DEFINED "Has Trace Architecture functionality";
```

### Library pseudocode for shared/functions/extension/HaveTrapLoadStoreMultipleDeviceExt

```
// HaveTrapLoadStoreMultipleDeviceExt()
// =====

boolean HaveTrapLoadStoreMultipleDeviceExt()
    return HasArchVersion\(ARMv8p2\);
```

### Library pseudocode for shared/functions/extension/HaveUA16Ext

```
// HaveUA16Ext()
// =====
// Returns TRUE if extended unaligned memory access support is implemented, and FALSE otherwise.

boolean HaveUA16Ext()
    return HasArchVersion\(ARMv8p4\);
```

### Library pseudocode for shared/functions/extension/HaveUAOExt

```
// HaveUAOExt()
// =====

boolean HaveUAOExt()
    return HasArchVersion\(ARMv8p2\);
```

### Library pseudocode for shared/functions/extension/HaveV82Debug

```
// HaveV82Debug()
// =====

boolean HaveV82Debug()
    return HasArchVersion\(ARMv8p2\);
```

### Library pseudocode for shared/functions/extension/HaveVirtHostExt

```
// HaveVirtHostExt()
// =====

boolean HaveVirtHostExt()
    return HasArchVersion\(ARMv8p1\);
```

## Library pseudocode for shared/functions/extension/InsertIESBBeforeException

```
// If SCTLR_ELx.IESB is 1 when an exception is generated to ELx, any pending Unrecoverable
// SError interrupt must be taken before executing any instructions in the exception handler.
// However, this can be before the branch to the exception handler is made.
boolean InsertIESBBeforeException(bits(2) el);
```

## Library pseudocode for shared/functions/float/bfloat/BFAdd

```
// BFAdd()
// =====
// Single-precision add following BFloat16 computation behaviors.

bits(32) BFAdd(bits(32) op1, bits(32) op2)
    bits(32) result;

    (type1,sign1,value1) = BFUnpack(op1);
    (type2,sign2,value2) = BFUnpack(op2);
    if type1 == FPType_QNaN || type2 == FPType_QNaN then
        result = FPDefaultNaN();
    else
        inf1 = (type1 == FPType_Infinity);
        inf2 = (type2 == FPType_Infinity);
        zero1 = (type1 == FPType_Zero);
        zero2 = (type2 == FPType_Zero);
        if inf1 && inf2 && sign1 == NOT(sign2) then
            result = FPDefaultNaN();
        elseif (inf1 && sign1 == '0') || (inf2 && sign2 == '0') then
            result = FPInfinity('0');
        elseif (inf1 && sign1 == '1') || (inf2 && sign2 == '1') then
            result = FPInfinity('1');
        elseif zero1 && zero2 && sign1 == sign2 then
            result = FPZero(sign1);
        else
            result_value = value1 + value2;
            if result_value == 0.0 then
                result = FPZero('0'); // Positive sign when Round to Odd
            else
                result = BFRound(result_value);

    return result;
```

## Library pseudocode for shared/functions/float/bfloat/BFMatMulAdd

```
// BFMatMulAdd()
// =====
// BFloat16 matrix multiply and add to single-precision matrix
// result[2, 2] = addend[2, 2] + (op1[2, 4] * op2[4, 2])

bits(N) BFMatMulAdd(bits(N) addend, bits(N) op1, bits(N) op2)
    assert N == 128;

    bits(N) result;
    bits(32) sum, prod0, prod1;

    for i = 0 to 1
        for j = 0 to 1
            sum = Elem[addend, 2*i + j, 32];
            for k = 0 to 1
                prod0 = BFMul(Elem[op1, 4*i + 2*k + 0, 16], Elem[op2, 4*j + 2*k + 0, 16]);
                prod1 = BFMul(Elem[op1, 4*i + 2*k + 1, 16], Elem[op2, 4*j + 2*k + 1, 16]);
                sum = BFAdd(sum, BFAdd(prod0, prod1));
            Elem[result, 2*i + j, 32] = sum;

    return result;
```

## Library pseudocode for shared/functions/float/bfloat/BFMul

```
// BFMul()
// =====
// BFloat16 widening multiply to single-precision following BFloat16
// computation behaviors.

bits(32) BFMul(bits(16) op1, bits(16) op2)
    bits(32) result;

    (type1,sign1,value1) = BFUnpack(op1);
    (type2,sign2,value2) = BFUnpack(op2);
    if type1 == FPType_QNaN || type2 == FPType_QNaN then
        result = FPDefaultNaN();
    else
        inf1 = (type1 == FPType_Infinity);
        inf2 = (type2 == FPType_Infinity);
        zero1 = (type1 == FPType_Zero);
        zero2 = (type2 == FPType_Zero);
        if (inf1 && zero2) || (zero1 && inf2) then
            result = FPDefaultNaN();
        elsif inf1 || inf2 then
            result = FPInfinity(sign1 EOR sign2);
        elsif zero1 || zero2 then
            result = FPZero(sign1 EOR sign2);
        else
            result = BFRound(value1*value2);

    return result;
```

## Library pseudocode for shared/functions/float/bfloat/BFRound

```
// BFRound()
// =====
// Converts a real number OP into a single-precision value using the
// Round to Odd rounding mode and following BFloat16 computation behaviors.

bits(32) BFRound(real op)
    assert op != 0.0;
    bits(32) result;

    // Format parameters - minimum exponent, numbers of exponent and fraction bits.
    minimum_exp = -126; E = 8; F = 23;

    // Split value into sign, unrounded mantissa and exponent.
    if op < 0.0 then
        sign = '1'; mantissa = -op;
    else
        sign = '0'; mantissa = op;
    exponent = 0;
    while mantissa < 1.0 do
        mantissa = mantissa * 2.0; exponent = exponent - 1;
    while mantissa >= 2.0 do
        mantissa = mantissa / 2.0; exponent = exponent + 1;

    // Fixed Flush-to-zero.
    if exponent < minimum_exp then
        return FPZero(sign);

    // Start creating the exponent value for the result. Start by biasing the actual exponent
    // so that the minimum exponent becomes 1, lower values 0 (indicating possible underflow).
    biased_exp = Max(exponent - minimum_exp + 1, 0);
    if biased_exp == 0 then mantissa = mantissa / 2.0^(minimum_exp - exponent);

    // Get the unrounded mantissa as an integer, and the "units in last place" rounding error.
    int_mant = RoundDown(mantissa * 2.0^F); // < 2.0^F if biased_exp == 0, >= 2.0^F if not
    error = mantissa * 2.0^F - Real(int_mant);

    // Round to Odd
    if error != 0.0 then
        int_mant<0> = '1';

    // Deal with overflow and generate result.
    if biased_exp >= 2^E - 1 then
        result = FPInfinity(sign); // Overflows generate appropriately-signed Infinity
    else
        result = sign : biased_exp<30-F:0> : int_mant<F-1:0>;

    return result;
```

## Library pseudocode for shared/functions/float/bfloat/BFUnpack

```
// BFUnpack()
// =====
// Unpacks a BFloat16 or single-precision value into its type,
// sign bit and real number that it represents.
// The real number result has the correct sign for numbers and infinities,
// is very large in magnitude for infinities, and is 0.0 for NaNs.
// (These values are chosen to simplify the description of
// comparisons and conversions.)

(FPType, bit, real) BFUnpack(bits(N) fpval)
  assert N IN {16,32};

  if N == 16 then
    sign  = fpval<15>;
    exp   = fpval<14:7>;
    frac  = fpval<6:0> : Zeros(16);
  else // N == 32
    sign  = fpval<31>;
    exp   = fpval<30:23>;
    frac  = fpval<22:0>;

  if IsZero(exp) then
    fptype = FPType_Zero; value = 0.0;    // Fixed Flush to Zero
  elseif IsOnes(exp) then
    if IsZero(frac) then
      fptype = FPType_Infinity; value = 2.0^1000000;
    else // no SNaN for BF16 arithmetic
      fptype = FPType_QNaN; value = 0.0;
  else
    fptype = FPType_Nonzero;
    value = 2.0^(UInt(exp)-127) * (1.0 + Real(UInt(frac)) * 2.0^-23);

  if sign == '1' then value = -value;

  return (fptype, sign, value);
```

## Library pseudocode for shared/functions/float/bfloat/FPConvertBF

```
// FPConvertBF()
// =====
// Converts a single-precision OP to BFloat16 value with rounding controlled by ROUNDING.

bits(16) FPConvertBF(bits(32) op, FPCRTType fpcr, FPRounding rounding)
    bits(32) result;    // BF16 value in top 16 bits

    // Unpack floating-point operand optionally with flush-to-zero.
    (fptype,sign,value) = FPUnpack(op, fpcr);

    if fptype == FPTType\_SNaN || fptype == FPTType\_QNaN then
        if fpcr.DN == '1' then
            result = FPDefaultNaN();
        else
            result = FPConvertNaN(op);
        if fptype == FPTType\_SNaN then
            FPProcessException(FPExc\_InvalidOp, fpcr);
    elseif fptype == FPTType\_Infinity then
        result = FPInfinity(sign);
    elseif fptype == FPTType\_Zero then
        result = FPZero(sign);
    else
        result = FPRoundCVBF(value, fpcr, rounding);

    // Returns correctly rounded BF16 value from top 16 bits
    return result<31:16>;

// FPConvertBF()
// =====
// Converts a single-precision operand to BFloat16 value.

bits(16) FPConvertBF(bits(32) op, FPCRTType fpcr)
    return FPConvertBF(op, fpcr, FPRoundingMode(fpcr));
```

## Library pseudocode for shared/functions/float/bfloat/FPRoundCVBF

```
// FPRoundCVBF()
// =====
// Converts a real number OP into a BFloat16 value using the supplied rounding mode RMODE.

bits(32) FPRoundCVBF(real op, FPCRTType fpcr, FPRounding rounding)
    boolean isbfloat = TRUE;
    return FPRoundBase(op, fpcr, rounding, isbfloat);
```

## Library pseudocode for shared/functions/float/fixedtofp/FixedToFP

```
// FixedToFP()
// =====

// Convert M-bit fixed point OP with FBITS fractional bits to
// N-bit precision floating point, controlled by UNSIGNED and ROUNDING.

bits(N) FixedToFP(bits(M) op, integer fbits, boolean unsigned, FPCRTType fpcr, FPRounding rounding)
    assert N IN {16,32,64};
    assert M IN {16,32,64};
    bits(N) result;
    assert fbits >= 0;
    assert rounding != FPRounding\_ODD;

    // Correct signed-ness
    int_operand = Int(op, unsigned);

    // Scale by fractional bits and generate a real value
    real_operand = Real(int_operand) / 2.0^fbits;

    if real_operand == 0.0 then
        result = FPZero('0');
    else
        result = FPRound(real_operand, fpcr, rounding);

    return result;
```

## Library pseudocode for shared/functions/float/fpabs/FPAbs

```
// FPAbs()
// =====

bits(N) FPAbs(bits(N) op)
    assert N IN {16,32,64};
    return '0' : op<N-2:0>;
```

## Library pseudocode for shared/functions/float/fpadd/FPAdd

```
// FPAdd()
// =====

bits(N) FPAdd(bits(N) op1, bits(N) op2, FPCRTType fpcr)
    assert N IN {16,32,64};
    rounding = FPRoundingMode(fpcr);
    (type1,sign1,value1) = FPUnpack(op1, fpcr);
    (type2,sign2,value2) = FPUnpack(op2, fpcr);
    (done,result) = FPProcessNaNs(type1, type2, op1, op2, fpcr);
    if !done then
        inf1 = (type1 == FPTYPE\_Infinity); inf2 = (type2 == FPTYPE\_Infinity);
        zero1 = (type1 == FPTYPE\_Zero); zero2 = (type2 == FPTYPE\_Zero);
        if inf1 && inf2 && sign1 == NOT(sign2) then
            result = FPDefaultNaN();
            FPProcessException(FPExc\_InvalidOp, fpcr);
        elsif (inf1 && sign1 == '0') || (inf2 && sign2 == '0') then
            result = FPInfinity('0');
        elsif (inf1 && sign1 == '1') || (inf2 && sign2 == '1') then
            result = FPInfinity('1');
        elsif zero1 && zero2 && sign1 == sign2 then
            result = FPZero(sign1);
        else
            result_value = value1 + value2;
            if result_value == 0.0 then // Sign of exact zero result depends on rounding mode
                result_sign = if rounding == FPRounding\_NEGINF then '1' else '0';
                result = FPZero(result_sign);
            else
                result = FPRound(result_value, fpcr, rounding);
    return result;
```

## Library pseudocode for shared/functions/float/fpcmpare/FPCompare

```
// FPCompare()
// =====

bits(4) FPCompare(bits(N) op1, bits(N) op2, boolean signal_nans, FPCRTType fpcr)
    assert N IN {16,32,64};
    (type1,sign1,value1) = FPUntpack(op1, fpcr);
    (type2,sign2,value2) = FPUntpack(op2, fpcr);
    if type1==FPTType\_SNaN || type1==FPTType\_QNaN || type2==FPTType\_SNaN || type2==FPTType\_QNaN then
        result = '0011';
        if type1==FPTType\_SNaN || type2==FPTType\_SNaN || signal_nans then
            FPProcessException(FPExc\_InvalidOp, fpcr);
    else
        // All non-NaN cases can be evaluated on the values produced by FPUntpack()
        if value1 == value2 then
            result = '0110';
        elsif value1 < value2 then
            result = '1000';
        else // value1 > value2
            result = '0010';
    return result;
```

## Library pseudocode for shared/functions/float/fpcmpareeq/FPCompareEQ

```
// FPCompareEQ()
// =====

boolean FPCompareEQ(bits(N) op1, bits(N) op2, FPCRTType fpcr)
    assert N IN {16,32,64};
    (type1,sign1,value1) = FPUntpack(op1, fpcr);
    (type2,sign2,value2) = FPUntpack(op2, fpcr);
    if type1==FPTType\_SNaN || type1==FPTType\_QNaN || type2==FPTType\_SNaN || type2==FPTType\_QNaN then
        result = FALSE;
        if type1==FPTType\_SNaN || type2==FPTType\_SNaN then
            FPProcessException(FPExc\_InvalidOp, fpcr);
    else
        // All non-NaN cases can be evaluated on the values produced by FPUntpack()
        result = (value1 == value2);
    return result;
```

## Library pseudocode for shared/functions/float/fpcmparege/FPCompareGE

```
// FPCompareGE()
// =====

boolean FPCompareGE(bits(N) op1, bits(N) op2, FPCRTType fpcr)
    assert N IN {16,32,64};
    (type1,sign1,value1) = FPUntpack(op1, fpcr);
    (type2,sign2,value2) = FPUntpack(op2, fpcr);
    if type1==FPTType\_SNaN || type1==FPTType\_QNaN || type2==FPTType\_SNaN || type2==FPTType\_QNaN then
        result = FALSE;
        FPProcessException(FPExc\_InvalidOp, fpcr);
    else
        // All non-NaN cases can be evaluated on the values produced by FPUntpack()
        result = (value1 >= value2);
    return result;
```



## Library pseudocode for shared/functions/float/fpcomparegt/FPCompareGT

```
// FPCompareGT()
// =====

boolean FPCompareGT(bits(N) op1, bits(N) op2, FPCRTType fpcr)
    assert N IN {16,32,64};
    (type1,sign1,value1) = FPUntpack(op1, fpcr);
    (type2,sign2,value2) = FPUntpack(op2, fpcr);
    if type1==FPTType\_SNaN || type1==FPTType\_QNaN || type2==FPTType\_SNaN || type2==FPTType\_QNaN then
        result = FALSE;
        FPProcessException(FPExc\_InvalidOp, fpcr);
    else
        // All non-NaN cases can be evaluated on the values produced by FPUntpack()
        result = (value1 > value2);
    return result;
```

## Library pseudocode for shared/functions/float/fpconvert/FPConvert

```
// FPConvert()
// =====

// Convert floating point OP with N-bit precision to M-bit precision,
// with rounding controlled by ROUNDING.
// This is used by the FP-to-FP conversion instructions and so for
// half-precision data ignores FZ16, but observes AHP.

bits(M) FPConvert(bits(N) op, FPCRTType fpcr, FPRounding rounding)
    assert M IN {16,32,64};
    assert N IN {16,32,64};
    bits(M) result;

    // Unpack floating-point operand optionally with flush-to-zero.
    (fptype,sign,value) = FPUntpackCV(op, fpcr);

    alt_hp = (M == 16) && (fpcr.AHP == '1');

    if fptype == FPTType\_SNaN || fptype == FPTType\_QNaN then
        if alt_hp then
            result = FPZero(sign);
        elsif fpcr.DN == '1' then
            result = FPDefaultNaN();
        else
            result = FPConvertNaN(op);
            if fptype == FPTType\_SNaN || alt_hp then
                FPProcessException(FPExc\_InvalidOp, fpcr);
    elsif fptype == FPTType\_Infinity then
        if alt_hp then
            result = sign:Ones(M-1);
            FPProcessException(FPExc\_InvalidOp, fpcr);
        else
            result = FPInfinity(sign);
    elsif fptype == FPTType\_Zero then
        result = FPZero(sign);
    else
        result = FPRoundCV(value, fpcr, rounding);
    return result;

// FPConvert()
// =====

bits(M) FPConvert(bits(N) op, FPCRTType fpcr)
    return FPConvert(op, fpcr, FPRoundingMode(fpcr));
```

## Library pseudocode for shared/functions/float/fpconvertnan/FPConvertNaN

```
// FPConvertNaN()
// =====
// Converts a NaN of one floating-point type to another

bits(M) FPConvertNaN(bits(N) op)
    assert N IN {16,32,64};
    assert M IN {16,32,64};
    bits(M) result;
    bits(51) frac;

    sign = op<N-1>;

    // Unpack payload from input NaN
    case N of
        when 64 frac = op<50:0>;
        when 32 frac = op<21:0>:Zeros(29);
        when 16 frac = op<8:0>:Zeros(42);

    // Repack payload into output NaN, while
    // converting an SNaN to a QNaN.
    case M of
        when 64 result = sign:Ones(M-52):frac;
        when 32 result = sign:Ones(M-23):frac<50:29>;
        when 16 result = sign:Ones(M-10):frac<50:42>;

    return result;
```

## Library pseudocode for shared/functions/float/fpcrtype/FPCRTType

```
type FPCRTType;
```

## Library pseudocode for shared/functions/float/fpdecoderm/FPDecodeRM

```
// FPDecoderM()
// =====
// Decode most common AArch32 floating-point rounding encoding.

FPRounding FPDecoderM(bits(2) rm)
    case rm of
        when '00' return FPRounding_TIEAWAY; // A
        when '01' return FPRounding_TIEEVEN; // N
        when '10' return FPRounding_POSINF; // P
        when '11' return FPRounding_NEGINF; // M
```

## Library pseudocode for shared/functions/float/fpdecoderounding/FPDecodeRounding

```
// FPDecodeRounding()
// =====
// Decode floating-point rounding mode and common AArch64 encoding.

FPRounding FPDecodeRounding(bits(2) rmode)
    case rmode of
        when '00' return FPRounding_TIEEVEN; // N
        when '01' return FPRounding_POSINF; // P
        when '10' return FPRounding_NEGINF; // M
        when '11' return FPRounding_ZERO; // Z
```

## Library pseudocode for shared/functions/float/fpdefaultnan/FPDefaultNaN

```
// FPDefaultNaN()
// =====

bits(N) FPDefaultNaN()
    assert N IN {16,32,64};
    constant integer E = (if N == 16 then 5 elsif N == 32 then 8 else 11);
    constant integer F = N - (E + 1);
    sign = '0';
    bits(E) exp = Ones(E);
    bits(F) frac = '1':Zeros(F-1);
    return sign : exp : frac;
```

## Library pseudocode for shared/functions/float/fpdiv/FPDiv

```
// FPDiv()
// =====

bits(N) FPDiv(bits(N) op1, bits(N) op2, FPCRTType fpcr)
    assert N IN {16,32,64};
    (type1,sign1,value1) = FPUnpack(op1, fpcr);
    (type2,sign2,value2) = FPUnpack(op2, fpcr);
    (done,result) = FPProcessNaNs(type1, type2, op1, op2, fpcr);
    if !done then
        inf1 = (type1 == FPType_Infinity);
        inf2 = (type2 == FPType_Infinity);
        zero1 = (type1 == FPType_Zero);
        zero2 = (type2 == FPType_Zero);
        if (inf1 && inf2) || (zero1 && zero2) then
            result = FPDefaultNaN();
            FPProcessException(FPExc_InvalidOp, fpcr);
        elsif inf1 || zero2 then
            result = FPInfinity(sign1 EOR sign2);
            if !inf1 then FPProcessException(FPExc_DivideByZero, fpcr);
        elsif zero1 || inf2 then
            result = FPZero(sign1 EOR sign2);
        else
            result = FPRound(value1/value2, fpcr);
    return result;
```

## Library pseudocode for shared/functions/float/fpexc/FPExc

```
enumeration FPExc
    {FPExc_InvalidOp, FPExc_DivideByZero, FPExc_Overflow,
     FPExc_Underflow, FPExc_Inexact, FPExc_InputDenorm};
```

## Library pseudocode for shared/functions/float/fpinfinity/FPInfinity

```
// FPInfinity()
// =====

bits(N) FPInfinity(bit sign)
    assert N IN {16,32,64};
    constant integer E = (if N == 16 then 5 elsif N == 32 then 8 else 11);
    constant integer F = N - (E + 1);
    bits(E) exp = Ones(E);
    bits(F) frac = Zeros(F);
    return sign : exp : frac;
```

## Library pseudocode for shared/functions/float/fpmatmul/FPMatMulAdd

```
// FPMatMulAdd()
// =====
//
// Floating point matrix multiply and add to same precision matrix
// result[2, 2] = addend[2, 2] + (op1[2, 2] * op2[2, 2])

bits(N) FPMatMulAdd(bits(N) addend, bits(N) op1, bits(N) op2, integer esize, FPCRTType fpcr)
    assert N == esize * 2 * 2;
    bits(N) result;
    bits(esize) prod0, prod1, sum;

    for i = 0 to 1
        for j = 0 to 1
            sum = Elem[addend, 2*i + j, esize];
            prod0 = FPMul(Elem[op1, 2*i + 0, esize],
                        Elem[op2, 2*j + 0, esize], fpcr);
            prod1 = FPMul(Elem[op1, 2*i + 1, esize],
                        Elem[op2, 2*j + 1, esize], fpcr);
            sum = FPAAdd(sum, FPAAdd(prod0, prod1, fpcr), fpcr);
            Elem[result, 2*i + j, esize] = sum;

    return result;
```

## Library pseudocode for shared/functions/float/fpmax/FPMax

```
// FPMax()
// =====

bits(N) FPMax(bits(N) op1, bits(N) op2, FPCRTType fpcr)
    assert N IN {16,32,64};
    (type1,sign1,value1) = FPUnpack(op1, fpcr);
    (type2,sign2,value2) = FPUnpack(op2, fpcr);
    (done,result) = FPProcessNaNs(type1, type2, op1, op2, fpcr);
    if !done then
        if value1 > value2 then
            (fptype,sign,value) = (type1,sign1,value1);
        else
            (fptype,sign,value) = (type2,sign2,value2);
        if fptype == FPType\_Infinity then
            result = FPIInfinity(sign);
        elsif fptype == FPType\_Zero then
            sign = sign1 AND sign2; // Use most positive sign
            result = FPZero(sign);
        else
            // The use of FPRound() covers the case where there is a trapped underflow exception
            // for a denormalized number even though the result is exact.
            result = FPRound(value, fpcr);
    return result;
```

## Library pseudocode for shared/functions/float/fpmaxnormal/FPMaxNormal

```
// FPMaxNormal()
// =====

bits(N) FPMaxNormal(bit sign)
    assert N IN {16,32,64};
    constant integer E = (if N == 16 then 5 elsif N == 32 then 8 else 11);
    constant integer F = N - (E + 1);
    exp = Ones(E-1):'0';
    frac = Ones(F);
    return sign : exp : frac;
```

## Library pseudocode for shared/functions/float/fpmaxnum/FPMaxNum

```
// FPMaxNum()
// =====

bits(N) FPMaxNum(bits(N) op1, bits(N) op2, FPCRTType fpcr)
    assert N IN {16,32,64};
    (type1,-,-) = FPUnpack(op1, fpcr);
    (type2,-,-) = FPUnpack(op2, fpcr);

    // treat a single quiet-NaN as -Infinity
    if type1 == FPTYPE\_QNaN && type2 != FPTYPE\_QNaN then
        op1 = FPInfinity('1');
    elsif type1 != FPTYPE\_QNaN && type2 == FPTYPE\_QNaN then
        op2 = FPInfinity('1');

    return FPMax(op1, op2, fpcr);
```

## Library pseudocode for shared/functions/float/fpmin/FPMin

```
// FPMin()
// =====

bits(N) FPMin(bits(N) op1, bits(N) op2, FPCRTType fpcr)
    assert N IN {16,32,64};
    (type1,sign1,value1) = FPUnpack(op1, fpcr);
    (type2,sign2,value2) = FPUnpack(op2, fpcr);
    (done,result) = FPProcessNaNs(type1, type2, op1, op2, fpcr);
    if !done then
        if value1 < value2 then
            (ftype,sign,value) = (type1,sign1,value1);
        else
            (ftype,sign,value) = (type2,sign2,value2);
        if ftype == FPTYPE\_Infinity then
            result = FPInfinity(sign);
        elsif ftype == FPTYPE\_Zero then
            sign = sign1 OR sign2; // Use most negative sign
            result = FPZero(sign);
        else
            // The use of FPRound() covers the case where there is a trapped underflow exception
            // for a denormalized number even though the result is exact.
            result = FPRound(value, fpcr);
    return result;
```

## Library pseudocode for shared/functions/float/fpminnum/FPMinNum

```
// FPMinNum()
// =====

bits(N) FPMinNum(bits(N) op1, bits(N) op2, FPCRTType fpcr)
    assert N IN {16,32,64};
    (type1,-,-) = FPUnpack(op1, fpcr);
    (type2,-,-) = FPUnpack(op2, fpcr);

    // Treat a single quiet-NaN as +Infinity
    if type1 == FPTYPE\_QNaN && type2 != FPTYPE\_QNaN then
        op1 = FPInfinity('0');
    elsif type1 != FPTYPE\_QNaN && type2 == FPTYPE\_QNaN then
        op2 = FPInfinity('0');

    return FPMin(op1, op2, fpcr);
```

## Library pseudocode for shared/functions/float/fpmul/FPMul

```
// FPMul()
// =====

bits(N) FPMul(bits(N) op1, bits(N) op2, FPCRTType fpcr)
  assert N IN {16,32,64};
  (type1,sign1,value1) = FPUnpack(op1, fpcr);
  (type2,sign2,value2) = FPUnpack(op2, fpcr);
  (done,result) = FPProcessNaNs(type1, type2, op1, op2, fpcr);
  if !done then
    inf1 = (type1 == FPTType\_Infinity);
    inf2 = (type2 == FPTType\_Infinity);
    zero1 = (type1 == FPTType\_Zero);
    zero2 = (type2 == FPTType\_Zero);
    if (inf1 && zero2) || (zero1 && inf2) then
      result = FPDefaultNaN();
      FPProcessException(FPExc\_InvalidOp, fpcr);
    elsif inf1 || inf2 then
      result = FPInfinity(sign1 EOR sign2);
    elsif zero1 || zero2 then
      result = FPZero(sign1 EOR sign2);
    else
      result = FPRound(value1*value2, fpcr);
  return result;
```

## Library pseudocode for shared/functions/float/fpmuladd/FPMulAdd

```
// FPMulAdd()
// =====
//
// Calculates addend + op1*op2 with a single rounding.

bits(N) FPMulAdd(bits(N) addend, bits(N) op1, bits(N) op2, FPCRType fpcr)
    assert N IN {16,32,64};
    rounding = FPRoundingMode(fpcr);
    (typeA,signA,valueA) = FPUnpack(addend, fpcr);
    (type1,sign1,value1) = FPUnpack(op1, fpcr);
    (type2,sign2,value2) = FPUnpack(op2, fpcr);
    inf1 = (type1 == FPTYPE\_Infinity); zero1 = (type1 == FPTYPE\_Zero);
    inf2 = (type2 == FPTYPE\_Infinity); zero2 = (type2 == FPTYPE\_Zero);
    (done,result) = FPProcessNaNs3(typeA, type1, type2, addend, op1, op2, fpcr);

    if typeA == FPTYPE\_QNaN && ((inf1 && zero2) || (zero1 && inf2)) then
        result = FPDefaultNaN();
        FPProcessException(FPExc\_InvalidOp, fpcr);

    if !done then
        infA = (typeA == FPTYPE\_Infinity); zeroA = (typeA == FPTYPE\_Zero);

        // Determine sign and type product will have if it does not cause an Invalid
        // Operation.
        signP = sign1 EOR sign2;
        infP = inf1 || inf2;
        zeroP = zero1 || zero2;

        // Non SNaN-generated Invalid Operation cases are multiplies of zero by infinity and
        // additions of opposite-signed infinities.
        if (inf1 && zero2) || (zero1 && inf2) || (infA && infP && signA != signP) then
            result = FPDefaultNaN();
            FPProcessException(FPExc\_InvalidOp, fpcr);

        // Other cases involving infinities produce an infinity of the same sign.
        elsif (infA && signA == '0') || (infP && signP == '0') then
            result = FPInfinity('0');
        elsif (infA && signA == '1') || (infP && signP == '1') then
            result = FPInfinity('1');

        // Cases where the result is exactly zero and its sign is not determined by the
        // rounding mode are additions of same-signed zeros.
        elsif zeroA && zeroP && signA == signP then
            result = FPZero(signA);

        // Otherwise calculate numerical result and round it.
        else
            result_value = valueA + (value1 * value2);
            if result_value == 0.0 then // Sign of exact zero result depends on rounding mode
                result_sign = if rounding == FPRounding\_NEGINF then '1' else '0';
                result = FPZero(result_sign);
            else
                result = FPRound(result_value, fpcr);

    return result;
```

## Library pseudocode for shared/functions/float/fpmuladdh/FPMulAddH

```
// FPMulAddH()
// =====

bits(N) FPMulAddH(bits(N) addend, bits(N DIV 2) op1, bits(N DIV 2) op2, FPCRType fpcr)
    assert N IN {32,64};
    rounding = FPRoundingMode(fpcr);
    (typeA,signA,valueA) = FPUnpack(addend, fpcr);
    (type1,sign1,value1) = FPUnpack(op1, fpcr);
    (type2,sign2,value2) = FPUnpack(op2, fpcr);
    inf1 = (type1 == FPTYPE\_Infinity); zero1 = (type1 == FPTYPE\_Zero);
    inf2 = (type2 == FPTYPE\_Infinity); zero2 = (type2 == FPTYPE\_Zero);
    (done,result) = FPProcessNaNs3H(typeA, type1, type2, addend, op1, op2, fpcr);
    if typeA == FPTYPE\_QNaN && ((inf1 && zero2) || (zero1 && inf2)) then
        result = FPDefaultNaN();
        FPProcessException(FPExc\_InvalidOp, fpcr);
    if !done then
        infA = (typeA == FPTYPE\_Infinity); zeroA = (typeA == FPTYPE\_Zero);
        // Determine sign and type product will have if it does not cause an Invalid
        // Operation.
        signP = sign1 EOR sign2;
        infP = inf1 || inf2;
        zeroP = zero1 || zero2;
        // Non SNaN-generated Invalid Operation cases are multiplies of zero by infinity and
        // additions of opposite-signed infinities.
        if (inf1 && zero2) || (zero1 && inf2) || (infA && infP && signA != signP) then
            result = FPDefaultNaN();
            FPProcessException(FPExc\_InvalidOp, fpcr);
        // Other cases involving infinities produce an infinity of the same sign.
        elsif (infA && signA == '0') || (infP && signP == '0') then
            result = FPInfinity('0');
        elsif (infA && signA == '1') || (infP && signP == '1') then
            result = FPInfinity('1');
        // Cases where the result is exactly zero and its sign is not determined by the
        // rounding mode are additions of same-signed zeros.
        elsif zeroA && zeroP && signA == signP then
            result = FPZero(signA);
        // Otherwise calculate numerical result and round it.
        else
            result_value = valueA + (value1 * value2);
            if result_value == 0.0 then // Sign of exact zero result depends on rounding mode
                result_sign = if rounding == FPRounding\_NEGINF then '1' else '0';
                result = FPZero(result_sign);
            else
                result = FPRound(result_value, fpcr);
    return result;
```



## Library pseudocode for shared/functions/float/fpmuladdh/FPPProcessNaNs3H

```
// FPPProcessNaNs3H()
// =====

(boolean, bits(N)) FPPProcessNaNs3H(FPType type1, FPType type2, FPType type3, bits(N) op1, bits(N DIV 2) op2, bits(N DIV 2) op3)
    assert N IN {32,64};
    bits(N) result;
    if type1 == FPType_SNaN then
        done = TRUE; result = FPPProcessNaN(type1, op1, fpcr);
    elsif type2 == FPType_SNaN then
        done = TRUE; result = FPConvertNaN(FPPProcessNaN(type2, op2, fpcr));
    elsif type3 == FPType_SNaN then
        done = TRUE; result = FPConvertNaN(FPPProcessNaN(type3, op3, fpcr));
    elsif type1 == FPType_QNaN then
        done = TRUE; result = FPPProcessNaN(type1, op1, fpcr);
    elsif type2 == FPType_QNaN then
        done = TRUE; result = FPConvertNaN(FPPProcessNaN(type2, op2, fpcr));
    elsif type3 == FPType_QNaN then
        done = TRUE; result = FPConvertNaN(FPPProcessNaN(type3, op3, fpcr));
    else
        done = FALSE; result = Zeros(); // 'Don't care' result
    return (done, result);
```

## Library pseudocode for shared/functions/float/fpmulx/FPMulX

```
// FPMulX()
// =====

bits(N) FPMulX(bits(N) op1, bits(N) op2, FPCRTYPE fpcr)
    assert N IN {16,32,64};
    bits(N) result;
    (type1,sign1,value1) = FPUnpack(op1, fpcr);
    (type2,sign2,value2) = FPUnpack(op2, fpcr);
    (done,result) = FPPProcessNaNs(type1, type2, op1, op2, fpcr);
    if !done then
        inf1 = (type1 == FPType_Infinity);
        inf2 = (type2 == FPType_Infinity);
        zero1 = (type1 == FPType_Zero);
        zero2 = (type2 == FPType_Zero);
        if (inf1 && zero2) || (zero1 && inf2) then
            result = FPTwo(sign1 EOR sign2);
        elsif inf1 || inf2 then
            result = FPInfinity(sign1 EOR sign2);
        elsif zero1 || zero2 then
            result = FPZero(sign1 EOR sign2);
        else
            result = FPRound(value1*value2, fpcr);
    return result;
```

## Library pseudocode for shared/functions/float/fpneg/FPNeg

```
// FPNeg()
// =====

bits(N) FPNeg(bits(N) op)
    assert N IN {16,32,64};
    return NOT(op<N-1>) : op<N-2:0>;
```

## Library pseudocode for shared/functions/float/fponepointfive/FPOnePointFive

```
// FPOnePointFive()
// =====

bits(N) FPOnePointFive(bit sign)
    assert N IN {16,32,64};
    constant integer E = (if N == 16 then 5 elsif N == 32 then 8 else 11);
    constant integer F = N - (E + 1);
    exp = '0':Ones(E-1);
    frac = '1':Zeros(F-1);
    return sign : exp : frac;
```

## Library pseudocode for shared/functions/float/fpprocessexception/FPPProcessException

```
// FPPProcessException()
// =====
//
// The 'fpcr' argument supplies FPCR control bits. Status information is
// updated directly in the FPSR where appropriate.

FPPProcessException(FPExc exception, FPCRTYPE fpcr)
    // Determine the cumulative exception bit number
    case exception of
        when FPExc_InvalidOp      cumul = 0;
        when FPExc_DivideByZero    cumul = 1;
        when FPExc_Overflow        cumul = 2;
        when FPExc_Underflow       cumul = 3;
        when FPExc_Inexact         cumul = 4;
        when FPExc_InputDenorm     cumul = 7;
    enable = cumul + 8;
    if fpcr<enable> == '1' then
        // Trapping of the exception enabled.
        // It is IMPLEMENTATION DEFINED whether the enable bit may be set at all, and
        // if so then how exceptions may be accumulated before calling FPTrappedException()
        IMPLEMENTATION_DEFINED "floating-point trap handling";
    elsif UsingAArch32() then
        // Set the cumulative exception bit
        FPSCR<cumul> = '1';
    else
        // Set the cumulative exception bit
        FPSR<cumul> = '1';
    return;
```

## Library pseudocode for shared/functions/float/fpprocessnan/FPProcessNaN

```
// FPProcessNaN()
// =====

bits(N) FPProcessNaN(FPTYPE fptype, bits(N) op, FPCRTYPE fpcr)
    assert N IN {16,32,64};
    assert fptype IN {FPTYPE_QNaN, FPTYPE_SNaN};

    case N of
        when 16 topfrac = 9;
        when 32 topfrac = 22;
        when 64 topfrac = 51;

    result = op;
    if fptype == FPTYPE_SNaN then
        result<topfrac> = '1';
        FPPProcessException(FPExc_InvalidOp, fpcr);
    if fpcr.DN == '1' then // DefaultNaN requested
        result = FPDefaultNaN();
    return result;
```

## Library pseudocode for shared/functions/float/fpprocessnans/FPPProcessNaNs

```
// FPPProcessNaNs()
// =====
//
// The boolean part of the return value says whether a NaN has been found and
// processed. The bits(N) part is only relevant if it has and supplies the
// result of the operation.
//
// The 'fpcr' argument supplies FPCR control bits. Status information is
// updated directly in the FPSR where appropriate.

(boolean, bits(N)) FPPProcessNaNs(FPType type1, FPType type2,
                                   bits(N) op1, bits(N) op2,
                                   FPCRTYPE fpcr)

    assert N IN {16,32,64};
    if type1 == FPType_SNaN then
        done = TRUE; result = FPPProcessNaN(type1, op1, fpcr);
    elsif type2 == FPType_SNaN then
        done = TRUE; result = FPPProcessNaN(type2, op2, fpcr);
    elsif type1 == FPType_QNaN then
        done = TRUE; result = FPPProcessNaN(type1, op1, fpcr);
    elsif type2 == FPType_QNaN then
        done = TRUE; result = FPPProcessNaN(type2, op2, fpcr);
    else
        done = FALSE; result = Zeros(); // 'Don't care' result
    return (done, result);
```

## Library pseudocode for shared/functions/float/fpprocessnans3/FPPProcessNaNs3

```
// FPPProcessNaNs3()
// =====
//
// The boolean part of the return value says whether a NaN has been found and
// processed. The bits(N) part is only relevant if it has and supplies the
// result of the operation.
//
// The 'fpcr' argument supplies FPCR control bits. Status information is
// updated directly in the FPSR where appropriate.

(boolean, bits(N)) FPPProcessNaNs3(FPType type1, FPType type2, FPType type3,
                                    bits(N) op1, bits(N) op2, bits(N) op3,
                                    FPCRTYPE fpcr)

    assert N IN {16,32,64};
    if type1 == FPType_SNaN then
        done = TRUE; result = FPPProcessNaN(type1, op1, fpcr);
    elsif type2 == FPType_SNaN then
        done = TRUE; result = FPPProcessNaN(type2, op2, fpcr);
    elsif type3 == FPType_SNaN then
        done = TRUE; result = FPPProcessNaN(type3, op3, fpcr);
    elsif type1 == FPType_QNaN then
        done = TRUE; result = FPPProcessNaN(type1, op1, fpcr);
    elsif type2 == FPType_QNaN then
        done = TRUE; result = FPPProcessNaN(type2, op2, fpcr);
    elsif type3 == FPType_QNaN then
        done = TRUE; result = FPPProcessNaN(type3, op3, fpcr);
    else
        done = FALSE; result = Zeros(); // 'Don't care' result
    return (done, result);
```



```

// FPrecipEstimate()
// =====

bits(N) FPrecipEstimate(bits(N) operand, FPCRTType fpcr)
  assert N IN {16,32,64};
  (fptype,sign,value) = FPUntpack(operand, fpcr);
  if fptype == FPTType\_SNaN || fptype == FPTType\_0NaN then
    result = FPProcessNaN(fptype, operand, fpcr);
  elsif fptype == FPTType\_Infinity then
    result = FPZero(sign);
  elsif fptype == FPTType\_Zero then
    result = FPIfinity(sign);
    FPProcessException(FPExc\_DivideByZero, fpcr);
  elsif (
    (N == 16 && Abs(value) < 2.0^-16) ||
    (N == 32 && Abs(value) < 2.0^-128) ||
    (N == 64 && Abs(value) < 2.0^-1024)
  ) then
    case FPRoundingMode(fpcr) of
      when FPRounding\_TIEEVEN
        overflow_to_inf = TRUE;
      when FPRounding\_POSINF
        overflow_to_inf = (sign == '0');
      when FPRounding\_NEGINF
        overflow_to_inf = (sign == '1');
      when FPRounding\_ZERO
        overflow_to_inf = FALSE;
    result = if overflow_to_inf then FPIfinity(sign) else FPMMaxNormal(sign);
    FPProcessException(FPExc\_Overflow, fpcr);
    FPProcessException(FPExc\_Inexact, fpcr);
  elsif ((fpcr.FZ == '1' && N != 16) || (fpcr.FZ16 == '1' && N == 16))
    && (
      (N == 16 && Abs(value) >= 2.0^14) ||
      (N == 32 && Abs(value) >= 2.0^126) ||
      (N == 64 && Abs(value) >= 2.0^1022)
    ) then
      // Result flushed to zero of correct sign
      result = FPZero(sign);
      if UsingAArch32() then
        FPSR.UFC = '1';
      else
        FPSR.UFC = '1';
    else
      // Scale to a fixed point value in the range 0.5 <= x < 1.0 in steps of 1/512, and
      // calculate result exponent. Scaled value has copied sign bit,
      // exponent = 1022 = double-precision biased version of -1,
      // fraction = original fraction
      case N of
        when 16
          fraction = operand<9:0> : Zeros(42);
          exp = UInt(operand<14:10>);
        when 32
          fraction = operand<22:0> : Zeros(29);
          exp = UInt(operand<30:23>);
        when 64
          fraction = operand<51:0>;
          exp = UInt(operand<62:52>);

      if exp == 0 then
        if fraction<51> == '0' then
          exp = -1;
          fraction = fraction<49:0>:'00';
        else
          fraction = fraction<50:0>:'0';

      integer scaled = UInt('1':fraction<51:44>);

      case N of
        when 16 result_exp = 29 - exp; // In range 29-30 = -1 to 29+1 = 30
        when 32 result_exp = 253 - exp; // In range 253-254 = -1 to 253+1 = 254

```

```

        when 64 result_exp = 2045 - exp; // In range 2045-2046 = -1 to 2045+1 = 2046

// scaled is in range 256..511 representing a fixed-point number in range [0.5..1.0)
estimate = RecipEstimate(scaled);

// estimate is in the range 256..511 representing a fixed point result in the range [1.0..2.0)
// Convert to scaled floating point result with copied sign bit,
// high-order bits from estimate, and exponent calculated above.

fraction = estimate<7:0> : Zeros(44);
if result_exp == 0 then
    fraction = '1' : fraction<51:1>;
elsif result_exp == -1 then
    fraction = '01' : fraction<51:2>;
    result_exp = 0;

case N of
    when 16 result = sign : result_exp<N-12:0> : fraction<51:42>;
    when 32 result = sign : result_exp<N-25:0> : fraction<51:29>;
    when 64 result = sign : result_exp<N-54:0> : fraction<51:0>;

return result;

```

### Library pseudocode for shared/functions/float/fprecipestimate/RecipEstimate

```

// Compute estimate of reciprocal of 9-bit fixed-point number
//
// a is in range 256 .. 511 representing a number in the range 0.5 <= x < 1.0.
// result is in the range 256 .. 511 representing a number in the range in the range 1.0 to 511/256.

integer RecipEstimate(integer a)
    assert 256 <= a && a < 512;
    a = a*2+1; // round to nearest
    integer b = (2 ^ 19) DIV a;
    r = (b+1) DIV 2; // round to nearest
    assert 256 <= r && r < 512;
    return r;

```

## Library pseudocode for shared/functions/float/fprecpX/FPRecpX

```
// FPRecpX()
// =====

bits(N) FPRecpX(bits(N) op, FPCRTType fpcr)
    assert N IN {16,32,64};

    case N of
        when 16 esize = 5;
        when 32 esize = 8;
        when 64 esize = 11;

    bits(N)          result;
    bits(esize)      exp;
    bits(esize)      max_exp;
    bits(N-(esize+1)) frac = Zeros\(\);

    case N of
        when 16 exp = op<10+esize-1:10>;
        when 32 exp = op<23+esize-1:23>;
        when 64 exp = op<52+esize-1:52>;

    max_exp = Ones(esize) - 1;

    (fptype,sign,value) = FPUntpack(op, fpcr);
    if fptype == FPTType\_SNaN || fptype == FPTType\_QNaN then
        result = FPProcessNaN(fptype, op, fpcr);
    else
        if IsZero(exp) then // Zero and denormals
            result = sign:max_exp:frac;
        else // Infinities and normals
            result = sign:NOT(exp):frac;

    return result;
```





```

// FPRound()
// =====
// Used by data processing and int/fixed <-> FP conversion instructions.
// For half-precision data it ignores AHP, and observes FZ16.

bits(N) FPRound(real op, FPCRTType fpcr, FPRounding rounding)
    fpcr.AHP = '0';
    boolean isbfloat = FALSE;
    return FPRoundBase(op, fpcr, rounding, isbfloat);

// Convert a real number OP into an N-bit floating-point value using the
// supplied rounding mode RMODE.

bits(N) FPRoundBase(real op, FPCRTType fpcr, FPRounding rounding, boolean isbfloat)
    assert N IN {16,32,64};
    assert op != 0.0;
    assert rounding != FPRounding\_TIEAWAY;
    bits(N) result;

    // Obtain format parameters - minimum exponent, numbers of exponent and fraction bits.
    if N == 16 then
        minimum_exp = -14; E = 5; F = 10;
    elsif N == 32 && isbfloat then
        minimum_exp = -126; E = 8; F = 7;
    elsif N == 32 then
        minimum_exp = -126; E = 8; F = 23;
    else // N == 64
        minimum_exp = -1022; E = 11; F = 52;

    // Split value into sign, unrounded mantissa and exponent.
    if op < 0.0 then
        sign = '1'; mantissa = -op;
    else
        sign = '0'; mantissa = op;
    exponent = 0;
    while mantissa < 1.0 do
        mantissa = mantissa * 2.0; exponent = exponent - 1;
    while mantissa >= 2.0 do
        mantissa = mantissa / 2.0; exponent = exponent + 1;

    // Deal with flush-to-zero.
    if ((fpcr.FZ == '1' && N != 16) || (fpcr.FZ16 == '1' && N == 16)) && exponent < minimum_exp then
        // Flush-to-zero never generates a trapped exception
        if UsingAArch32() then
            FPSCR.UFC = '1';
        else
            FPSR.UFC = '1';
        return FPZero(sign);

    // Start creating the exponent value for the result. Start by biasing the actual exponent
    // so that the minimum exponent becomes 1, lower values 0 (indicating possible underflow).
    biased_exp = Max(exponent - minimum_exp + 1, 0);
    if biased_exp == 0 then mantissa = mantissa / 2.0^(minimum_exp - exponent);

    // Get the unrounded mantissa as an integer, and the "units in last place" rounding error.
    int_mant = RoundDown(mantissa * 2.0^F); // < 2.0^F if biased_exp == 0, >= 2.0^F if not
    error = mantissa * 2.0^F - Real(int_mant);

    // Underflow occurs if exponent is too small before rounding, and result is inexact or
    // the Underflow exception is trapped.
    if biased_exp == 0 && (error != 0.0 || fpcr.UFE == '1') then
        FPProcessException(FPExc\_Underflow, fpcr);

    // Round result according to rounding mode.
    case rounding of
        when FPRounding\_TIEEVEN
            round_up = (error > 0.5 || (error == 0.5 && int_mant<0> == '1'));
            overflow_to_inf = TRUE;
        when FPRounding\_POSINF
            round_up = (error != 0.0 && sign == '0');

```

```

        overflow_to_inf = (sign == '0');
when FPRounding\_NEGINF
    round_up = (error != 0.0 && sign == '1');
    overflow_to_inf = (sign == '1');
when FPRounding\_ZERO, FPRounding\_ODD
    round_up = FALSE;
    overflow_to_inf = FALSE;

if round_up then
    int_mant = int_mant + 1;
    if int_mant == 2^F then // Rounded up from denormalized to normalized
        biased_exp = 1;
    if int_mant == 2^(F+1) then // Rounded up to next exponent
        biased_exp = biased_exp + 1; int_mant = int_mant DIV 2;

// Handle rounding to odd aka Von Neumann rounding
if error != 0.0 && rounding == FPRounding\_ODD then
    int_mant<0> = '1';

// Deal with overflow and generate result.
if N != 16 || fpcr.AHP == '0' then // Single, double or IEEE half precision
    if biased_exp >= 2^E - 1 then
        result = if overflow_to_inf then FPInfinity(sign) else FPMMaxNormal(sign);
        FPPProcessException(FPExc\_Overflow, fpcr);
        error = 1.0; // Ensure that an Inexact exception occurs
    else
        result = sign : biased_exp<E-1:0> : int_mant<F-1:0> : Zeros(N-(E+F+1));
else // Alternative half precision
    if biased_exp >= 2^E then
        result = sign : Ones(N-1);
        FPPProcessException(FPExc\_InvalidOp, fpcr);
        error = 0.0; // Ensure that an Inexact exception does not occur
    else
        result = sign : biased_exp<E-1:0> : int_mant<F-1:0> : Zeros(N-(E+F+1));

// Deal with Inexact exception.
if error != 0.0 then
    FPPProcessException(FPExc\_Inexact, fpcr);

return result;

// FPRound()
// =====

bits(N) FPRound(real op, FPCRTType fpcr)
    return FPRound(op, fpcr, FPRoundingMode(fpcr));

```

### Library pseudocode for shared/functions/float/fpround/FPRoundCV

```

// FPRoundCV()
// =====
// Used for FP <-> FP conversion instructions.
// For half-precision data ignores FZ16 and observes AHP.

bits(N) FPRoundCV(real op, FPCRTType fpcr, FPRounding rounding)
    fpcr.FZ16 = '0';
    boolean isbfloat = FALSE;
    return FPRoundBase(op, fpcr, rounding, isbfloat);

```

### Library pseudocode for shared/functions/float/fprounding/FPRounding

```

enumeration FPRounding {FPRounding\_TIEEVEN, FPRounding\_POSINF,
    FPRounding\_NEGINF, FPRounding\_ZERO,
    FPRounding\_TIEAWAY, FPRounding\_ODD};

```

## Library pseudocode for shared/functions/float/fproundingmode/FPRoundingMode

```
// FPRoundingMode()
// =====

// Return the current floating-point rounding mode.

FPRounding FPRoundingMode(FPCRTYPE fpcr)
    return FPDecodeRounding(fpcr.RMode);
```

## Library pseudocode for shared/functions/float/fproundint/FPRoundInt

```
// FPRoundInt()
// =====

// Round OP to nearest integral floating point value using rounding mode ROUNDING.
// If EXACT is TRUE, set FPSR.IXC if result is not numerically equal to OP.

bits(N) FPRoundInt(bits(N) op, FPCRTYPE fpcr, FPRounding rounding, boolean exact)
    assert rounding != FPRounding_ODD;
    assert N IN {16,32,64};

    // Unpack using FPCR to determine if subnormals are flushed-to-zero
    (fptype,sign,value) = FPUnpack(op, fpcr);

    if fptype == FPTYPE_SNaN || fptype == FPTYPE_0NaN then
        result = FPProcessNaN(fptype, op, fpcr);
    elsif fptype == FPTYPE_Infinity then
        result = FPInfinity(sign);
    elsif fptype == FPTYPE_Zero then
        result = FPZero(sign);
    else
        // extract integer component
        int_result = RoundDown(value);
        error = value - Real(int_result);

        // Determine whether supplied rounding mode requires an increment
        case rounding of
            when FPRounding_TIEEVEN
                round_up = (error > 0.5 || (error == 0.5 && int_result<0> == '1'));
            when FPRounding_POSINF
                round_up = (error != 0.0);
            when FPRounding_NEGINF
                round_up = FALSE;
            when FPRounding_ZERO
                round_up = (error != 0.0 && int_result < 0);
            when FPRounding_TIEAWAY
                round_up = (error > 0.5 || (error == 0.5 && int_result >= 0));

        if round_up then int_result = int_result + 1;

        // Convert integer value into an equivalent real value
        real_result = Real(int_result);

        // Re-encode as a floating-point value, result is always exact
        if real_result == 0.0 then
            result = FPZero(sign);
        else
            result = FPRound(real_result, fpcr, FPRounding_ZERO);

        // Generate inexact exceptions
        if error != 0.0 && exact then
            FPProcessException(FPExc_Inexact, fpcr);

    return result;
```



```

// FPRoundIntN()
// =====

bits(N) FPRoundIntN(bits(N) op, FPCRTType fpcr, FPRounding rounding, integer intsize)
    assert rounding != FPRounding\_ODD;
    assert N IN {32,64};
    assert intsize IN {32, 64};
    integer exp;
    constant integer E = (if N == 32 then 8 else 11);
    constant integer F = N - (E + 1);

    // Unpack using FPCR to determine if subnormals are flushed-to-zero
    (fptype,sign,value) = FPUnpack(op, fpcr);

    if fptype IN {FPTType\_SNaN, FPTType\_0NaN, FPTType\_Infinity} then
        if N == 32 then
            exp = 126 + intsize;
            result = '1':exp<(E-1):0>:Zeros(F);
        else
            exp = 1022+intsize;
            result = '1':exp<(E-1):0>:Zeros(F);
            FPProcessException(FPExc\_InvalidOp, fpcr);
    elsif fptype == FPTType\_Zero then
        result = FPZero(sign);
    else
        // Extract integer component
        int_result = RoundDown(value);
        error = value - Real(int_result);

        // Determine whether supplied rounding mode requires an increment
        case rounding of
            when FPRounding\_TIEEVEN
                round_up = error > 0.5 || (error == 0.5 && int_result<0> == '1');
            when FPRounding\_POSINF
                round_up = error != 0.0;
            when FPRounding\_NEGINF
                round_up = FALSE;
            when FPRounding\_ZERO
                round_up = error != 0.0 && int_result < 0;
            when FPRounding\_TIEAWAY
                round_up = error > 0.5 || (error == 0.5 && int_result >= 0);

        if round_up then int_result = int_result + 1;

        if int_result > 2^(intsize-1)-1 || int_result < -1*2^(intsize-1) then
            if N == 32 then
                exp = 126 + intsize;
                result = '1':exp<(E-1):0>:Zeros(F);
            else
                exp = 1022 + intsize;
                result = '1':exp<(E-1):0>:Zeros(F);
                FPProcessException(FPExc\_InvalidOp, fpcr);
                // this case shouldn't set Inexact
                error = 0.0;

        else
            // Convert integer value into an equivalent real value
            real_result = Real(int_result);

            // Re-encode as a floating-point value, result is always exact
            if real_result == 0.0 then
                result = FPZero(sign);
            else
                result = FPRound(real_result, fpcr, FPRounding\_ZERO);

        // Generate inexact exceptions
        if error != 0.0 then
            FPProcessException(FPExc\_Inexact, fpcr);

    return result;

```

## Library pseudocode for shared/functions/float/fprsqrtestimate/FPRSqrtEstimate

```
// FPRSqrtEstimate()
// =====

bits(N) FPRSqrtEstimate(bits(N) operand, FPCRTType fpcr)
  assert N IN {16,32,64};
  (fptype,sign,value) = FPUnpack(operand, fpcr);
  if fptype == FPTType\_SNaN || fptype == FPTType\_0NaN then
    result = FPProcessNaN(fptype, operand, fpcr);
  elsif fptype == FPTType\_Zero then
    result = FPInfinity(sign);
    FPProcessException(FPExc\_DivideByZero, fpcr);
  elsif sign == '1' then
    result = FPDefaultNaN();
    FPProcessException(FPExc\_InvalidOp, fpcr);
  elsif fptype == FPTType\_Infinity then
    result = FPZero('0');
  else
    // Scale to a fixed-point value in the range 0.25 <= x < 1.0 in steps of 512, with the
    // evenness or oddness of the exponent unchanged, and calculate result exponent.
    // Scaled value has copied sign bit, exponent = 1022 or 1021 = double-precision
    // biased version of -1 or -2, fraction = original fraction extended with zeros.

    case N of
      when 16
        fraction = operand<9:0> : Zeros(42);
        exp = UInt(operand<14:10>);
      when 32
        fraction = operand<22:0> : Zeros(29);
        exp = UInt(operand<30:23>);
      when 64
        fraction = operand<51:0>;
        exp = UInt(operand<62:52>);

    if exp == 0 then
      while fraction<51> == '0' do
        fraction = fraction<50:0> : '0';
        exp = exp - 1;
      fraction = fraction<50:0> : '0';

    if exp<0> == '0' then
      scaled = UInt('1':fraction<51:44>);
    else
      scaled = UInt('01':fraction<51:45>);

    case N of
      when 16 result_exp = ( 44 - exp) DIV 2;
      when 32 result_exp = ( 380 - exp) DIV 2;
      when 64 result_exp = (3068 - exp) DIV 2;

    estimate = RecipSqrtEstimate(scaled);

    // estimate is in the range 256..511 representing a fixed point result in the range [1.0..2.0)
    // Convert to scaled floating point result with copied sign bit and high-order
    // fraction bits, and exponent calculated above.
    case N of
      when 16 result = '0' : result_exp<N-12:0> : estimate<7:0>:Zeros( 2);
      when 32 result = '0' : result_exp<N-25:0> : estimate<7:0>:Zeros(15);
      when 64 result = '0' : result_exp<N-54:0> : estimate<7:0>:Zeros(44);
  return result;
```

## Library pseudocode for shared/functions/float/fpsqrtestimate/RecipSqrtEstimate

```
// Compute estimate of reciprocal square root of 9-bit fixed-point number
//
// a is in range 128 .. 511 representing a number in the range 0.25 <= x < 1.0.
// result is in the range 256 .. 511 representing a number in the range 1.0 to 511/256.

integer RecipSqrtEstimate(integer a)
  assert 128 <= a && a < 512;
  if a < 256 then // 0.25 .. 0.5
    a = a*2+1;    // a in units of 1/512 rounded to nearest
  else // 0.5 .. 1.0
    a = (a >> 1) << 1; // discard bottom bit
    a = (a+1)*2; // a in units of 1/256 rounded to nearest
  integer b = 512;
  while a*(b+1)*(b+1) < 2^28 do
    b = b+1;
  // b = largest b such that b < 2^14 / sqrt(a) do
  r = (b+1) DIV 2; // round to nearest
  assert 256 <= r && r < 512;
  return r;
```

## Library pseudocode for shared/functions/float/fpsqrt/FPSqrt

```
// FPSqrt()
// =====

bits(N) FPSqrt(bits(N) op, FPCRTType fpcr)
  assert N IN {16,32,64};
  (fptype,sign,value) = FPUnpack(op, fpcr);
  if fptype == FPTType\_SNaN || fptype == FPTType\_QNaN then
    result = FPProcessNaN(fptype, op, fpcr);
  elsif fptype == FPTType\_Zero then
    result = FPZero(sign);
  elsif fptype == FPTType\_Infinity && sign == '0' then
    result = FPInfinity(sign);
  elsif sign == '1' then
    result = FPDefaultNaN();
    FPProcessException(FPExc\_InvalidOp, fpcr);
  else
    result = FPRound(Sqrt(value), fpcr);
  return result;
```

## Library pseudocode for shared/functions/float/fpsub/FPSub

```
// FPSub()
// =====

bits(N) FPSub(bits(N) op1, bits(N) op2, FPCRTType fpcr)
    assert N IN {16,32,64};
    rounding = FPRoundingMode(fpcr);
    (type1,sign1,value1) = FPUnpack(op1, fpcr);
    (type2,sign2,value2) = FPUnpack(op2, fpcr);
    (done,result) = FPProcessNaNs(type1, type2, op1, op2, fpcr);
    if !done then
        inf1 = (type1 == FPType\_Infinity);
        inf2 = (type2 == FPType\_Infinity);
        zero1 = (type1 == FPType\_Zero);
        zero2 = (type2 == FPType\_Zero);
        if inf1 && inf2 && sign1 == sign2 then
            result = FPDefaultNaN();
            FPProcessException(FPExc\_InvalidOp, fpcr);
        elsif (inf1 && sign1 == '0') || (inf2 && sign2 == '1') then
            result = FPInfinity('0');
        elsif (inf1 && sign1 == '1') || (inf2 && sign2 == '0') then
            result = FPInfinity('1');
        elsif zero1 && zero2 && sign1 == NOT(sign2) then
            result = FPZero(sign1);
        else
            result_value = value1 - value2;
            if result_value == 0.0 then // Sign of exact zero result depends on rounding mode
                result_sign = if rounding == FPRounding\_NEGINF then '1' else '0';
                result = FPZero(result_sign);
            else
                result = FPRound(result_value, fpcr, rounding);
    return result;
```

## Library pseudocode for shared/functions/float/fpthree/FPThree

```
// FPThree()
// =====

bits(N) FPThree(bit sign)
    assert N IN {16,32,64};
    constant integer E = (if N == 16 then 5 elsif N == 32 then 8 else 11);
    constant integer F = N - (E + 1);
    exp = '1':Zeros(E-1);
    frac = '1':Zeros(F-1);
    return sign : exp : frac;
```



## Library pseudocode for shared/functions/float/fptofixed/FPToFixed

```
// FPToFixed()
// =====

// Convert N-bit precision floating point OP to M-bit fixed point with
// FBITS fractional bits, controlled by UNSIGNED and ROUNDING.

bits(M) FPToFixed(bits(N) op, integer fbits, boolean unsigned, FPCRTYPE fpcr, FPRounding rounding)
    assert N IN {16,32,64};
    assert M IN {16,32,64};
    assert fbits >= 0;
    assert rounding != FPRounding\_ODD;

    // Unpack using fpcr to determine if subnormals are flushed-to-zero
    (fptype,sign,value) = FPUntpack(op, fpcr);

    // If NaN, set cumulative flag or take exception
    if fptype == FPTYPE\_SNaN || fptype == FPTYPE\_QNaN then
        FPProcessException(FPExc\_InvalidOp, fpcr);

    // Scale by fractional bits and produce integer rounded towards minus-infinity
    value = value * 2.0^fbits;
    int_result = RoundDown(value);
    error = value - Real(int_result);

    // Determine whether supplied rounding mode requires an increment
    case rounding of
        when FPRounding\_TIEEVEN
            round_up = (error > 0.5 || (error == 0.5 && int_result<0> == '1'));
        when FPRounding\_POSINF
            round_up = (error != 0.0);
        when FPRounding\_NEGINF
            round_up = FALSE;
        when FPRounding\_ZERO
            round_up = (error != 0.0 && int_result < 0);
        when FPRounding\_TIEAWAY
            round_up = (error > 0.5 || (error == 0.5 && int_result >= 0));

    if round_up then int_result = int_result + 1;

    // Generate saturated result and exceptions
    (result, overflow) = SatQ(int_result, M, unsigned);
    if overflow then
        FPProcessException(FPExc\_InvalidOp, fpcr);
    elsif error != 0.0 then
        FPProcessException(FPExc\_Inexact, fpcr);

    return result;
```

## Library pseudocode for shared/functions/float/fptofixedjs/FPToFixedJS

```
// FPToFixedJS()
// =====

// Converts a double precision floating point input value
// to a signed integer, with rounding to zero.

(bits(N), bit) FPToFixedJS(bits(M) op, FPCRTType fpcr, boolean Is64)

    assert M == 64 && N == 32;

    // Unpack using fpcr to determine if subnormals are flushed-to-zero
    (fptype,sign,value) = FPUntpack(op, fpcr);

    Z = '1';
    // If NaN, set cumulative flag or take exception
    if fptype == FPTType\_SNaN || fptype == FPTType\_QNaN then
        FPProcessException(FPExc\_InvalidOp, fpcr);
        Z = '0';

    int_result = RoundDown(value);
    error = value - Real(int_result);

    // Determine whether supplied rounding mode requires an increment

    round_it_up = (error != 0.0 && int_result < 0);
    if round_it_up then int_result = int_result + 1;

    if int_result < 0 then
        result = int_result - 2^32*RoundUp(Real(int_result)/Real(2^32));
    else
        result = int_result - 2^32*RoundDown(Real(int_result)/Real(2^32));

    // Generate exceptions
    if int_result < -(2^31) || int_result > (2^31)-1 then
        FPProcessException(FPExc\_InvalidOp, fpcr);
        Z = '0';
    elsif error != 0.0 then
        FPProcessException(FPExc\_Inexact, fpcr);
        Z = '0';
    elsif sign == '1' && value == 0.0 then
        Z = '0';
    elsif sign == '0' && value == 0.0 && !IsZero(op<51:0>) then
        Z = '0';

    if fptype == FPTType\_Infinity then result = 0;

    return (result<N-1:0>, Z);
```

## Library pseudocode for shared/functions/float/fptwo/FPTwo

```
// FPTwo()
// =====

bits(N) FPTwo(bit sign)
    assert N IN {16,32,64};
    constant integer E = (if N == 16 then 5 elsif N == 32 then 8 else 11);
    constant integer F = N - (E + 1);
    exp = '1':Zeros(E-1);
    frac = Zeros(F);
    return sign : exp : frac;
```

## Library pseudocode for shared/functions/float/fptype/FPTType

```
enumeration FPType    {FPTType_Nonzero, FPTType_Zero, FPTType_Infinity,
                       FPTType_QNaN, FPTType_SNaN};
```

## Library pseudocode for shared/functions/float/fpunpack/FPUnpack

```
// FPUnpack()
// =====
//
// Used by data processing and int/fixed <-> FP conversion instructions.
// For half-precision data it ignores AHP, and observes FZ16.

(FPType, bit, real) FPUnpack(bits(N) fpval, FPCRTType fpcr)
    fpcr.AHP = '0';
    (fp_type, sign, value) = FPUnpackBase(fpval, fpcr);
    return (fp_type, sign, value);
```



```

// FPUUnpackBase()
// =====
//
// Unpack a floating-point number into its type, sign bit and the real number
// that it represents. The real number result has the correct sign for numbers
// and infinities, is very large in magnitude for infinities, and is 0.0 for
// NaNs. (These values are chosen to simplify the description of comparisons
// and conversions.)
//
// The 'fpcr' argument supplies FPCR control bits. Status information is
// updated directly in the FPSR where appropriate.

(FPType, bit, real) FPUUnpackBase(bits(N) fpval, FPCRTType fpcr)
    assert N IN {16,32,64};

    if N == 16 then
        sign    = fpval<15>;
        exp16   = fpval<14:10>;
        frac16  = fpval<9:0>;
        if IsZero(exp16) then
            // Produce zero if value is zero or flush-to-zero is selected
            if IsZero(frac16) || fpcr.FZ16 == '1' then
                fptype = FPType\_Zero; value = 0.0;
            else
                fptype = FPType\_Nonzero; value = 2.0^-14 * (Real(UInt(frac16)) * 2.0^-10);
        elsif IsOnes(exp16) && fpcr.AHP == '0' then // Infinity or NaN in IEEE format
            if IsZero(frac16) then
                fptype = FPType\_Infinity; value = 2.0^1000000;
            else
                fptype = if frac16<9> == '1' then FPType\_QNaN else FPType\_SNaN;
                value = 0.0;
        else
            fptype = FPType\_Nonzero;
            value = 2.0^(UInt(exp16)-15) * (1.0 + Real(UInt(frac16)) * 2.0^-10);

    elsif N == 32 then

        sign    = fpval<31>;
        exp32   = fpval<30:23>;
        frac32  = fpval<22:0>;
        if IsZero(exp32) then
            // Produce zero if value is zero or flush-to-zero is selected.
            if IsZero(frac32) || fpcr.FZ == '1' then
                fptype = FPType\_Zero; value = 0.0;
                if !IsZero(frac32) then // Denormalized input flushed to zero
                    FPProcessException(FPExc\_InputDenorm, fpcr);
            else
                fptype = FPType\_Nonzero; value = 2.0^-126 * (Real(UInt(frac32)) * 2.0^-23);
        elsif IsOnes(exp32) then
            if IsZero(frac32) then
                fptype = FPType\_Infinity; value = 2.0^1000000;
            else
                fptype = if frac32<22> == '1' then FPType\_QNaN else FPType\_SNaN;
                value = 0.0;
        else
            fptype = FPType\_Nonzero;
            value = 2.0^(UInt(exp32)-127) * (1.0 + Real(UInt(frac32)) * 2.0^-23);

    else // N == 64

        sign    = fpval<63>;
        exp64   = fpval<62:52>;
        frac64  = fpval<51:0>;
        if IsZero(exp64) then
            // Produce zero if value is zero or flush-to-zero is selected.
            if IsZero(frac64) || fpcr.FZ == '1' then
                fptype = FPType\_Zero; value = 0.0;
                if !IsZero(frac64) then // Denormalized input flushed to zero
                    FPProcessException(FPExc\_InputDenorm, fpcr);
            else

```

```

        fptype = FPTYPE\_Nonzero; value = 2.0^-1022 * (Real(UInt(frac64)) * 2.0^-52);
    elsif IsOnes(exp64) then
        if IsZero(frac64) then
            fptype = FPTYPE\_Infinity; value = 2.0^1000000;
        else
            fptype = if frac64<51> == '1' then FPTYPE\_QNaN else FPTYPE\_SNaN;
            value = 0.0;
        else
            fptype = FPTYPE\_Nonzero;
            value = 2.0^(UInt(exp64)-1023) * (1.0 + Real(UInt(frac64)) * 2.0^-52);

    if sign == '1' then value = -value;
    return (fptype, sign, value);

```

### Library pseudocode for shared/functions/float/fpunpack/FPUnpackCV

```

// FPUnpackCV()
// =====
//
// Used for FP <-> FP conversion instructions.
// For half-precision data ignores FZ16 and observes AHP.

(FType, bit, real) FPUnpackCV(bits(N) fpval, FPCRTYPE fpcr)
    fpcr.FZ16 = '0';
    (fp_type, sign, value) = FPUnpackBase(fpval, fpcr);
    return (fp_type, sign, value);

```

### Library pseudocode for shared/functions/float/fpzero/FPZero

```

// FPZero()
// =====

bits(N) FPZero(bit sign)
    assert N IN {16,32,64};
    constant integer E = (if N == 16 then 5 elsif N == 32 then 8 else 11);
    constant integer F = N - (E + 1);
    exp = Zeros(E);
    frac = Zeros(F);
    return sign : exp : frac;

```

### Library pseudocode for shared/functions/float/vfpexpandimm/VFPEExpandImm

```

// VFPEExpandImm()
// =====

bits(N) VFPEExpandImm(bits(8) imm8)
    assert N IN {16,32,64};
    constant integer E = (if N == 16 then 5 elsif N == 32 then 8 else 11);
    constant integer F = N - E - 1;
    sign = imm8<7>;
    exp = NOT(imm8<6>):Replicate(imm8<6>,E-3):imm8<5:4>;
    frac = imm8<3:0>:Zeros(F-4);
    return sign : exp : frac;

```

## Library pseudocode for shared/functions/integer/AddWithCarry

```
// AddWithCarry()
// =====
// Integer addition with carry input, returning result and NZCV flags

(bits(N), bits(4)) AddWithCarry(bits(N) x, bits(N) y, bit carry_in)
    integer unsigned_sum = UInt(x) + UInt(y) + UInt(carry_in);
    integer signed_sum = SInt(x) + SInt(y) + UInt(carry_in);
    bits(N) result = unsigned_sum<N-1:0>; // same value as signed_sum<N-1:0>
    bit n = result<N-1>;
    bit z = if IsZero(result) then '1' else '0';
    bit c = if UInt(result) == unsigned_sum then '0' else '1';
    bit v = if SInt(result) == signed_sum then '0' else '1';
    return (result, n:z:c:v);
```

## Library pseudocode for shared/functions/memory/AArch64.BranchAddr

```
// AArch64.BranchAddr()
// =====
// Return the virtual address with tag bits removed for storing to the program counter.

bits(64) AArch64.BranchAddr(bits(64) vaddress)
    assert !UsingAArch32();
    msbit = AddrTop(vaddress, TRUE, PSTATE.EL);
    if msbit == 63 then
        return vaddress;
    elsif (PSTATE.EL IN {EL0, EL1} || IsInHost()) && vaddress<msbit> == '1' then
        return SignExtend(vaddress<msbit:0>);
    else
        return ZeroExtend(vaddress<msbit:0>);
```

## Library pseudocode for shared/functions/memory/AccType

```
enumeration AccType {AccType_NORMAL, AccType_VEC, // Normal loads and stores
    AccType_STREAM, AccType_VECSTREAM, // Streaming loads and stores
    AccType_ATOMIC, AccType_ATOMICRW, // Atomic loads and stores
    AccType_ORDERED, AccType_ORDEREDRW, // Load-Acquire and Store-Release
    AccType_ORDEREDATOMIC, // Load-Acquire and Store-Release with atomic access
    AccType_ORDEREDATOMICRW,
    AccType_LIMITEDORDERED, // Load-LOAcquire and Store-LORelease
    AccType_UNPRIV, // Load and store unprivileged
    AccType_IFETCH, // Instruction fetch
    AccType_PTW, // Page table walk
    AccType_NONFAULT, // Non-faulting loads
    AccType_CNOTFIRST, // Contiguous FF load, not first element
    AccType_NV2REGISTER, // MRS/MSR instruction used at EL1 and which is
    // to a memory access that uses the EL2 translation
    // Other operations
    AccType_DC, // Data cache maintenance
    AccType_DC_UNPRIV, // Data cache maintenance instruction used at EL1
    AccType_IC, // Instruction cache maintenance
    AccType_DCZVA, // DC ZVA instructions
    AccType_AT}; // Address translation
```

## Library pseudocode for shared/functions/memory/AccessDescriptor

```
type AccessDescriptor is (
    AccType acctype,
    boolean transactional,
    MPAMInfo mpam,
    boolean page_table_walk,
    boolean secondstage,
    boolean s2fslwalk,
    integer level
)
```

## Library pseudocode for shared/functions/memory/AddrTop

```
// AddrTop()
// =====
// Return the MSB number of a virtual address in the stage 1 translation regime for "el".
// If EL1 is using AArch64 then addresses from EL0 using AArch32 are zero-extended to 64 bits.

integer AddrTop(bits(64) address, boolean IsInstr, bits(2) el)
    assert HaveEL(el);
    regime = S1TranslationRegime(el);
    if ELUsingAArch32(regime) then
        // AArch32 translation regime.
        return 31;
    else
        if EffectiveTBI(address, IsInstr, el) == '1' then
            return 55;
        else
            return 63;
```

## Library pseudocode for shared/functions/memory/AddressDescriptor

```
type AddressDescriptor is (
    FaultRecord    fault,    // fault.statuscode indicates whether the address is valid
    MemoryAttributes memattrs,
    FullAddress    paddress,
    bits(64)       vaddress
)
```

## Library pseudocode for shared/functions/memory/Allocation

```
constant bits(2) MemHint_No = '00';    // No Read-Allocate, No Write-Allocate
constant bits(2) MemHint_WA = '01';    // No Read-Allocate, Write-Allocate
constant bits(2) MemHint_RA = '10';    // Read-Allocate, No Write-Allocate
constant bits(2) MemHint_RWA = '11';   // Read-Allocate, Write-Allocate
```

## Library pseudocode for shared/functions/memory/BigEndian

```
// BigEndian()
// =====

boolean BigEndian()
    boolean bigend;
    if UsingAArch32() then
        bigend = (PSTATE.E != '0');
    elsif PSTATE.EL == EL0 then
        bigend = (SCTLR[].E0E != '0');
    else
        bigend = (SCTLR[].EE != '0');
    return bigend;
```

## Library pseudocode for shared/functions/memory/BigEndianReverse

```
// BigEndianReverse()
// =====

bits(width) BigEndianReverse (bits(width) value)
    assert width IN {8, 16, 32, 64, 128};
    integer half = width DIV 2;
    if width == 8 then return value;
    return BigEndianReverse(value<half-1:0>) : BigEndianReverse(value<width-1:half>);
```

## Library pseudocode for shared/functions/memory/Cacheability

```
constant bits(2) MemAttr_NC = '00';    // Non-cacheable
constant bits(2) MemAttr_WT = '10';    // Write-through
constant bits(2) MemAttr_WB = '11';    // Write-back
```



## Library pseudocode for shared/functions/memory/CreateAccessDescriptor

```
// CreateAccessDescriptor()
// =====

AccessDescriptor CreateAccessDescriptor(AccType acctype, boolean transactional)
    AccessDescriptor accdesc;
    accdesc.acctype = acctype;
    accdesc.transactional = transactional;
    accdesc.mpam = GenMPAMcurEL(acctype IN {AccType\_IFETCH, AccType\_IC});
    accdesc.page_table_walk = FALSE;
    return accdesc;

// CreateAccessDescriptor()
// =====

AccessDescriptor CreateAccessDescriptor(AccType acctype)
    transactional = FALSE;
    return CreateAccessDescriptor(acctype, transactional);
```

## Library pseudocode for shared/functions/memory/CreateAccessDescriptorPTW

```
// CreateAccessDescriptorPTW()
// =====

AccessDescriptor CreateAccessDescriptorPTW(AccType acctype, boolean secondstage,
                                           boolean s2fslwalk, integer level)
    AccessDescriptor accdesc;
    accdesc.acctype = acctype;
    accdesc.transactional = FALSE;
    accdesc.mpam = GenMPAMcurEL(acctype IN {AccType\_IFETCH, AccType\_IC});
    accdesc.page_table_walk = TRUE;
    accdesc.s2fslwalk = s2fslwalk;
    accdesc.secondstage = secondstage;
    accdesc.level = level;
    return accdesc;
```

## Library pseudocode for shared/functions/memory/DataMemoryBarrier

```
DataMemoryBarrier(MBReqDomain domain, MBReqTypes types);
```

## Library pseudocode for shared/functions/memory/DataSynchronizationBarrier

```
DataSynchronizationBarrier(MBReqDomain domain, MBReqTypes types);
```

## Library pseudocode for shared/functions/memory/DescriptorUpdate

```
type DescriptorUpdate is (
    boolean AF,           // AF needs to be set
    boolean AP,           // AP[2] / S2AP[2] will be modified
    AddressDescriptor descaddr // Descriptor to be updated
)
```

## Library pseudocode for shared/functions/memory/DeviceType

```
enumeration DeviceType {DeviceType\_GRE, DeviceType\_nGRE, DeviceType\_nGnRE, DeviceType\_nGnRnE};
```

## Library pseudocode for shared/functions/memory/EffectiveTBI

```
// EffectiveTBI()
// =====
// Returns the effective TBI in the AArch64 stage 1 translation regime for "el".

bit EffectiveTBI(bits(64) address, boolean IsInstr, bits(2) el)
  assert HaveEL(el);
  regime = S1TranslationRegime(el);
  assert(!ELUsingAArch32(regime));

  case regime of
    when EL1
      tbi = if address<55> == '1' then TCR_EL1.TBI1 else TCR_EL1.TBI0;
      if HavePACExt() then
        tbid = if address<55> == '1' then TCR_EL1.TBID1 else TCR_EL1.TBID0;
    when EL2
      if HaveVirtHostExt() && ELIsInHost(el) then
        tbi = if address<55> == '1' then TCR_EL2.TBI1 else TCR_EL2.TBI0;
        if HavePACExt() then
          tbid = if address<55> == '1' then TCR_EL2.TBID1 else TCR_EL2.TBID0;
        else
          tbi = TCR_EL2.TBI;
          if HavePACExt() then tbid = TCR_EL2.TBID;
      when EL3
        tbi = TCR_EL3.TBI;
        if HavePACExt() then tbid = TCR_EL3.TBID;

  return (if tbi == '1' && (!HavePACExt() || tbid == '0' || !IsInstr) then '1' else '0');
```

## Library pseudocode for shared/functions/memory/EffectiveTCMA

```
// EffectiveTCMA()
// =====
// Returns the effective TCMA of a virtual address in the stage 1 translation regime for "el".

bit EffectiveTCMA(bits(64) address, bits(2) el)
  assert HaveEL(el);
  regime = S1TranslationRegime(el);
  assert(!ELUsingAArch32(regime));

  case regime of
    when EL1
      tcma = if address<55> == '1' then TCR_EL1.TCMA1 else TCR_EL1.TCMA0;
    when EL2
      if HaveVirtHostExt() && ELIsInHost(el) then
        tcma = if address<55> == '1' then TCR_EL2.TCMA1 else TCR_EL2.TCMA0;
      else
        tcma = TCR_EL2.TCMA;
    when EL3
      tcma = TCR_EL3.TCMA;

  return tcma;
```

## Library pseudocode for shared/functions/memory/Fault

```
enumeration Fault {Fault_None,
    Fault_AccessFlag,
    Fault_Alignment,
    Fault_Background,
    Fault_Domain,
    Fault_Permission,
    Fault_Translation,
    Fault_AddressSize,
    Fault_SyncExternal,
    Fault_SyncExternalOnWalk,
    Fault_SyncParity,
    Fault_SyncParityOnWalk,
    Fault_AsyncParity,
    Fault_AsyncExternal,
    Fault_Debug,
    Fault_TLBConflict,
    Fault_BranchTarget,
    Fault_HWUpdateAccessFlag,
    Fault_Lockdown,
    Fault_Exclusive,
    Fault_ICacheMaint};
```

## Library pseudocode for shared/functions/memory/FaultRecord

```
type FaultRecord is (Fault    statuscode, // Fault Status
    AccType acctype, // Type of access that faulted
    FullAddress ipaddress, // Intermediate physical address
    boolean s2fslwalk, // Is on a Stage 1 page table walk
    boolean write, // TRUE for a write, FALSE for a read
    integer level, // For translation, access flag and permission faults
    bit extflag, // IMPLEMENTATION DEFINED syndrome for external aborts
    boolean secondstage, // Is a Stage 2 abort
    bits(4) domain, // Domain number, AArch32 only
    bits(2) errortype, // [Armv8.2 RAS] AArch32 AET or AArch64 SET
    bits(4) debugmoe) // Debug method of entry, from AArch32 only

type PARTIDtype = bits(16);
type PMGtype = bits(8);

type MPAMinfo is (
    bit mpam_ns,
    PARTIDtype partid,
    PMGtype pmg
)
```

## Library pseudocode for shared/functions/memory/FullAddress

```
type FullAddress is (
    bits(52) address,
    bit NS // '0' = Secure, '1' = Non-secure
)
```

## Library pseudocode for shared/functions/memory/Hint\_Prefetch

```
// Signals the memory system that memory accesses of type HINT to or from the specified address are
// likely in the near future. The memory system may take some action to speed up the memory
// accesses when they do occur, such as pre-loading the the specified address into one or more
// caches as indicated by the innermost cache level target (0=L1, 1=L2, etc) and non-temporal hint
// stream. Any or all prefetch hints may be treated as a NOP. A prefetch hint must not cause a
// synchronous abort due to Alignment or Translation faults and the like. Its only effect on
// software-visible state should be on caches and TLBs associated with address, which must be
// accessible by reads, writes or execution, as defined in the translation regime of the current
// Exception level. It is guaranteed not to access Device memory.
// A Prefetch_EXEC hint must not result in an access that could not be performed by a speculative
// instruction fetch, therefore if all associated MMUs are disabled, then it cannot access any
// memory location that cannot be accessed by instruction fetches.
Hint_Prefetch(bits(64) address, PrefetchHint hint, integer target, boolean stream);
```

## Library pseudocode for shared/functions/memory/MBReqDomain

```
enumeration MBReqDomain      {MBReqDomain_Nonshareable, MBReqDomain_InnerShareable,
                              MBReqDomain_OuterShareable, MBReqDomain_FullSystem};
```

## Library pseudocode for shared/functions/memory/MBReqTypes

```
enumeration MBReqTypes      {MBReqTypes_Reads, MBReqTypes_Writes, MBReqTypes_All};
```

## Library pseudocode for shared/functions/memory/MemAttrHints

```
type MemAttrHints is (
    bits(2) attrs, // See MemAttr_*, Cacheability attributes
    bits(2) hints, // See MemHint_*, Allocation hints
    boolean transient
)
```

## Library pseudocode for shared/functions/memory/MemType

```
enumeration MemType {MemType_Normal, MemType_Device};
```

## Library pseudocode for shared/functions/memory/MemoryAttributes

```
type MemoryAttributes is (
    MemType      memtype,

    DeviceType   device,      // For Device memory types
    MemAttrHints inner,      // Inner hints and attributes
    MemAttrHints outer,      // Outer hints and attributes
    boolean     tagged,      // Tagged access
    boolean     shareable,
    boolean     outershareable
)
```

## Library pseudocode for shared/functions/memory/Permissions

```
type Permissions is (
    bits(3) ap, // Access permission bits
    bit     xn, // Execute-never bit
    bit     xxn, // [ArmV8.2] Extended execute-never bit for stage 2
    bit     pxn // Privileged execute-never bit
)
```

## Library pseudocode for shared/functions/memory/PrefetchHint

```
enumeration PrefetchHint {Prefetch_READ, Prefetch_WRITE, Prefetch_EXEC};
```

## Library pseudocode for shared/functions/memory/SpeculativeStoreBypassBarrierToPA

```
SpeculativeStoreBypassBarrierToPA();
```

## Library pseudocode for shared/functions/memory/SpeculativeStoreBypassBarrierToVA

```
SpeculativeStoreBypassBarrierToVA();
```

## Library pseudocode for shared/functions/memory/TLBRecord

```
type TLBRecord is (  
    Permissions      perms,  
    bit              nG,                // '0' = Global, '1' = not Global  
    bits(4)          domain,            // AArch32 only  
    bit              GP,                // Guarded Page  
    boolean          contiguous,        // Contiguous bit from page table  
    integer          level,             // AArch32 Short-descriptor format: Indicates Section/Page  
    integer          blocksize,         // Describes size of memory translated in KBytes  
    DescriptorUpdate descupdate,        // [ArmV8.1] Context for h/w update of table descriptor  
    bit              CnP,               // [ArmV8.2] TLB entry can be shared between different PEs  
    AddressDescriptor addrdesc  
)
```

## Library pseudocode for shared/functions/memory/Tag

```
constant integer LOG2_TAG_GRANULE = 4;  
  
constant integer TAG_GRANULE = 1 << LOG2\_TAG\_GRANULE;
```

## Library pseudocode for shared/functions/memory/\_Mem

```
// These two _Mem[] accessors are the hardware operations which perform single-copy atomic,  
// aligned, little-endian memory accesses of size bytes from/to the underlying physical  
// memory array of bytes.  
//  
// The functions address the array using desc.paddress which supplies:  
// * A 52-bit physical address  
// * A single NS bit to select between Secure and Non-secure parts of the array.  
//  
// The accdesc descriptor describes the access type: normal, exclusive, ordered, streaming,  
// etc and other parameters required to access the physical memory or for setting syndrome  
// register in the event of an external abort.  
bits(8*size) _Mem[AddressDescriptor desc, integer size, AccessDescriptor accdesc];  
  
_Mem[AddressDescriptor desc, integer size, AccessDescriptor accdesc] = bits(8*size) value;
```

## Library pseudocode for shared/functions/mpam/DefaultMPAMInfo

```
// DefaultMPAMInfo  
// =====  
// Returns default MPAM info. If secure is TRUE return default Secure  
// MPAMInfo, otherwise return default Non-secure MPAMInfo.  
  
MPAMInfo DefaultMPAMInfo(boolean secure)  
    MPAMInfo DefaultInfo;  
    DefaultInfo.mpam_ns = if secure then '0' else '1';  
    DefaultInfo.partid = DefaultPARTID;  
    DefaultInfo.pmg = DefaultPMG;  
    return DefaultInfo;
```

## Library pseudocode for shared/functions/mpam/DefaultPARTID

```
constant PARTIDtype DefaultPARTID = 0<15:0>;
```

## Library pseudocode for shared/functions/mpam/DefaultPMG

```
constant PMGtype    DefaultPMG = 0<7:0>;
```

## Library pseudocode for shared/functions/mpam/GenMPAMcurEL

```
// GenMPAMcurEL
// =====
// Returns MPAMinfo for the current EL and security state.
// InD is TRUE instruction access and FALSE otherwise.
// May be called if MPAM is not implemented (but in an version that supports
// MPAM), MPAM is disabled, or in AArch32. In AArch32, convert the mode to
// EL if can and use that to drive MPAM information generation. If mode
// cannot be converted, MPAM is not implemented, or MPAM is disabled return
// default MPAM information for the current security state.

MPAMinfo GenMPAMcurEL(boolean InD)
    bits(2) mpamel;
    boolean validEL;
    boolean securempam;
    if HaveEMPAMExt() then
        boolean secure = IsSecure();
        securempam = MPAM3_EL3.FORCE_NS == '0' && secure;
        if MPAMisEnabled() && (!secure || MPAM3_EL3.SDEFLT == '0') then
            if UsingAArch32() then
                (validEL, mpamel) = ELFromM32(PSTATE.M);
            else
                validEL = TRUE;
                mpamel = PSTATE.EL;
            if validEL then
                return genMPAM(UInt(mpamel), InD, securempam);
    else
        securempam = IsSecure();
        if HaveMPAMExt() && MPAMisEnabled() then
            if UsingAArch32() then
                (validEL, mpamel) = ELFromM32(PSTATE.M);
            else
                validEL = TRUE;
                mpamel = PSTATE.EL;
            if validEL then
                return genMPAM(UInt(mpamel), InD, securempam);
    return DefaultMPAMinfo(securempam);
```

## Library pseudocode for shared/functions/mpam/MAP\_vPARTID

```
// MAP_vPARTID
// =====
// Performs conversion of virtual PARTID into physical PARTID
// Contains all of the error checking and implementation
// choices for the conversion.

(PARTIDtype, boolean) MAP_vPARTID(PARTIDtype vpartid)
    // should not ever be called if EL2 is not implemented
    // or is implemented but not enabled in the current
    // security state.
    PARTIDtype ret;
    boolean err;
    integer virt    = UInt( vpartid );
    integer vpmrmax = UInt( MPAMIDR_EL1.VPMR_MAX );

    // vpartid_max is largest vpartid supported
    integer vpartid_max = (4 * vpmrmax) + 3;

    // One of many ways to reduce vpartid to value less than vpartid_max.
    if virt > vpartid_max then
        virt = virt MOD (vpartid_max+1);

    // Check for valid mapping entry.
    if MPAMVPMV_EL2<virt> == '1' then
        // vpartid has a valid mapping so access the map.
        ret = mapvpmw(virt);
        err = FALSE;

    // Is the default virtual PARTID valid?
    elsif MPAMVPMV_EL2<0> == '1' then
        // Yes, so use default mapping for vpartid == 0.
        ret = MPAMVPM0_EL2<0 +: 16>;
        err = FALSE;

    // Neither is valid so use default physical PARTID.
    else
        ret = DefaultPARTID;
        err = TRUE;

    // Check that the physical PARTID is in-range.
    // This physical PARTID came from a virtual mapping entry.
    integer partid_max = UInt( MPAMIDR_EL1.PARTID_MAX );
    if UInt(ret) > partid_max then
        // Out of range, so return default physical PARTID
        ret = DefaultPARTID;
        err = TRUE;
    return (ret, err);
```

## Library pseudocode for shared/functions/mpam/MPAMisEnabled

```
// MPAMisEnabled
// =====
// Returns TRUE if MPAMisEnabled.

boolean MPAMisEnabled()
    el = HighestEL();
    case el of
        when EL3 return MPAM3_EL3.MPAMEN == '1';
        when EL2 return MPAM2_EL2.MPAMEN == '1';
        when EL1 return MPAM1_EL1.MPAMEN == '1';
```

## Library pseudocode for shared/functions/mpam/MPAMisVirtual

```
// MPAMisVirtual
// =====
// Returns TRUE if MPAM is configured to be virtual at EL.

boolean MPAMisVirtual(integer el)
    return ( MPAMIDR_EL1.HAS_HCR == '1' && EL2Enabled() &&
        (( el == 0 && MPAMHCR_EL2.EL0_VPMEN == '1' &&
            ( HCR_EL2.E2H == '0' || HCR_EL2.TGE == '0' )) ||
            ( el == 1 && MPAMHCR_EL2.EL1_VPMEN == '1')));
```

## Library pseudocode for shared/functions/mpam/genMPAM

```
// genMPAM
// =====
// Returns MPAMinfo for exception level el.
// If InD is TRUE returns MPAM information using PARTID_I and PMG_I fields
// of MPAMEl_ELx register and otherwise using PARTID_D and PMG_D fields.
// Produces a Secure PARTID if Secure is TRUE and a Non-secure PARTID otherwise.

MPAMinfo genMPAM(integer el, boolean InD, boolean secure)
    MPAMinfo returnInfo;
    PARTIDtype partidel;
    boolean perr;
    boolean gstplk = (el == 0 && EL2Enabled() &&
        MPAMHCR_EL2.GSTAPP_PLK == '1' && HCR_EL2.TGE == '0');
    integer eff_el = if gstplk then 1 else el;
    (partidel, perr) = genPARTID(eff_el, InD);
    PMGtype groupel = genPMG(eff_el, InD, perr);
    returnInfo.mpam_ns = if secure then '0' else '1';
    returnInfo.partid = partidel;
    returnInfo.pmg = groupel;
    return returnInfo;
```

## Library pseudocode for shared/functions/mpam/genMPAMEl

```
// genMPAMEl
// =====
// Returns MPAMinfo for specified EL in the current security state.
// InD is TRUE for instruction access and FALSE otherwise.

MPAMinfo genMPAMEl(bits(2) el, boolean InD)
    boolean secure = IsSecure();
    boolean securempam = secure;
    if HaveEMPAMExt() then
        securempam = MPAM3_EL3.FORCE_NS == '0' && secure;
        if HaveMPAMExt() && MPAMisEnabled() && (!secure || MPAM3_EL3.SDEFLT == '0') then
            return genMPAM(UInt(el), InD, securempam);
    else
        if HaveMPAMExt() && MPAMisEnabled() then
            return genMPAM(UInt(el), InD, securempam);
    return DefaultMPAMinfo(securempam);
```



## Library pseudocode for shared/functions/mpam/genPARTID

```
// genPARTID
// =====
// Returns physical PARTID and error boolean for exception level el.
// If InD is TRUE then PARTID is from MPAMel_ELx.PARTID_I and
// otherwise from MPAMel_ELx.PARTID_D.

(PARTIDtype, boolean) genPARTID(integer el, boolean InD)
    PARTIDtype partidel = getMPAM_PARTID(el, InD);

    integer partid_max = UInt(MPAMIDR_EL1.PARTID_MAX);
    if UInt(partidel) > partid_max then
        return (DefaultPARTID, TRUE);

    if MPAMisVirtual(el) then
        return MAP_vPARTID(partidel);
    else
        return (partidel, FALSE);
```

## Library pseudocode for shared/functions/mpam/genPMG

```
// genPMG
// =====
// Returns PMG for exception level el and I- or D-side (InD).
// If PARTID generation (genPARTID) encountered an error, genPMG() should be
// called with partid_err as TRUE.

PMGtype genPMG(integer el, boolean InD, boolean partid_err)
    integer pmg_max = UInt(MPAMIDR_EL1.PMG_MAX);

    // It is CONSTRAINED UNPREDICTABLE whether partid_err forces PMG to
    // use the default or if it uses the PMG from getMPAM_PMG.
    if partid_err then
        return DefaultPMG;
    PMGtype groupe1 = getMPAM_PMG(el, InD);
    if UInt(groupe1) <= pmg_max then
        return groupe1;
    return DefaultPMG;
```

## Library pseudocode for shared/functions/mpam/getMPAM\_PARTID

```
// getMPAM_PARTID
// =====
// Returns a PARTID from one of the MPAMn_ELx registers.
// MPAMn selects the MPAMn_ELx register used.
// If InD is TRUE, selects the PARTID_I field of that
// register. Otherwise, selects the PARTID_D field.

PARTIDtype getMPAM_PARTID(integer MPAMn, boolean InD)
    PARTIDtype partid;
    boolean el2avail = EL2Enabled();

    if InD then
        case MPAMn of
            when 3 partid = MPAM3_EL3.PARTID_I;
            when 2 partid = if el2avail then MPAM2_EL2.PARTID_I else Zeros();
            when 1 partid = MPAM1_EL1.PARTID_I;
            when 0 partid = MPAM0_EL1.PARTID_I;
            otherwise partid = PARTIDtype UNKNOWN;
    else
        case MPAMn of
            when 3 partid = MPAM3_EL3.PARTID_D;
            when 2 partid = if el2avail then MPAM2_EL2.PARTID_D else Zeros();
            when 1 partid = MPAM1_EL1.PARTID_D;
            when 0 partid = MPAM0_EL1.PARTID_D;
            otherwise partid = PARTIDtype UNKNOWN;
    return partid;
```

## Library pseudocode for shared/functions/mpam/getMPAM\_PMG

```
// getMPAM_PMG
// =====
// Returns a PMG from one of the MPAMn_ELx registers.
// MPAMn selects the MPAMn_ELx register used.
// If InD is TRUE, selects the PMG_I field of that
// register. Otherwise, selects the PMG_D field.

PMGtype getMPAM_PMG(integer MPAMn, boolean InD)
    PMGtype pmg;
    boolean el2avail = EL2Enabled();

    if InD then
        case MPAMn of
            when 3 pmg = MPAM3_EL3.PMG_I;
            when 2 pmg = if el2avail then MPAM2_EL2.PMG_I else Zeros();
            when 1 pmg = MPAM1_EL1.PMG_I;
            when 0 pmg = MPAM0_EL1.PMG_I;
            otherwise pmg = PMGtype UNKNOWN;
    else
        case MPAMn of
            when 3 pmg = MPAM3_EL3.PMG_D;
            when 2 pmg = if el2avail then MPAM2_EL2.PMG_D else Zeros();
            when 1 pmg = MPAM1_EL1.PMG_D;
            when 0 pmg = MPAM0_EL1.PMG_D;
            otherwise pmg = PMGtype UNKNOWN;
    return pmg;
```

## Library pseudocode for shared/functions/mpam/mapvpmw

```
// mapvpmw
// =====
// Map a virtual PARTID into a physical PARTID using
// the MPAMVPMn_EL2 registers.
// vpartid is now assumed in-range and valid (checked by caller)
// returns physical PARTID from mapping entry.

PARTIDtype mapvpmw(integer vpartid)
    bits(64) vpmw;
    integer wd = vpartid DIV 4;
    case wd of
        when 0 vpmw = MPAMVPM0_EL2;
        when 1 vpmw = MPAMVPM1_EL2;
        when 2 vpmw = MPAMVPM2_EL2;
        when 3 vpmw = MPAMVPM3_EL2;
        when 4 vpmw = MPAMVPM4_EL2;
        when 5 vpmw = MPAMVPM5_EL2;
        when 6 vpmw = MPAMVPM6_EL2;
        when 7 vpmw = MPAMVPM7_EL2;
        otherwise vpmw = Zeros(64);
    // vpme_lsb selects LSB of field within register
    integer vpme_lsb = (vpartid MOD 4) * 16;
    return vpmw<vpme_lsb +: 16>;
```

## Library pseudocode for shared/functions/registers/BranchTo

```
// BranchTo()
// =====

// Set program counter to a new address, with a branch type
// In AArch64 state the address might include a tag in the top eight bits.

BranchTo(bits(N) target, BranchType branch_type)
    Hint_Branch(branch_type);
    if N == 32 then
        assert UsingAArch32();
        _PC = ZeroExtend(target);
    else
        assert N == 64 && !UsingAArch32();
        _PC = AArch64.BranchAddr(target<63:0>);
    return;
```

## Library pseudocode for shared/functions/registers/BranchToAddr

```
// BranchToAddr()
// =====

// Set program counter to a new address, with a branch type
// In AArch64 state the address does not include a tag in the top eight bits.

BranchToAddr(bits(N) target, BranchType branch_type)
    Hint_Branch(branch_type);
    if N == 32 then
        assert UsingAArch32();
        _PC = ZeroExtend(target);
    else
        assert N == 64 && !UsingAArch32();
        _PC = target<63:0>;
    return;
```

## Library pseudocode for shared/functions/registers/BranchType

```
enumeration BranchType {
    BranchType_DIRCALL,    // Direct Branch with link
    BranchType_INDCALL,    // Indirect Branch with link
    BranchType_ERET,       // Exception return (indirect)
    BranchType_DBGEXIT,    // Exit from Debug state
    BranchType_RET,        // Indirect branch with function return hint
    BranchType_DIR,        // Direct branch
    BranchType_INDIR,      // Indirect branch
    BranchType_EXCEPTION,  // Exception entry
    BranchType_TMFAIL,     // Transaction failure
    BranchType_RESET,      // Reset
    BranchType_UNKNOWN};   // Other
```

## Library pseudocode for shared/functions/registers/Hint\_Branch

```
// Report the hint passed to BranchTo() and BranchToAddr(), for consideration when processing
// the next instruction.
Hint_Branch(BranchType hint);
```

## Library pseudocode for shared/functions/registers/NextInstrAddr

```
// Return address of the sequentially next instruction.
bits(N) NextInstrAddr();
```

## Library pseudocode for shared/functions/registers/ResetExternalDebugRegisters

```
// Reset the External Debug registers in the Core power domain.
ResetExternalDebugRegisters(boolean cold_reset);
```

## Library pseudocode for shared/functions/registers/ThisInstrAddr

```
// ThisInstrAddr()
// =====
// Return address of the current instruction.

bits(N) ThisInstrAddr()
  assert N == 64 || (N == 32 && UsingAArch32());
  return _PC<N-1:0>;
```

## Library pseudocode for shared/functions/registers/\_PC

```
bits(64) _PC;
```

## Library pseudocode for shared/functions/registers/\_R

```
array bits(64) _R[0..30];
```

## Library pseudocode for shared/functions/sysregisters/SPSR

```
// SPSR[] - non-assignment form
// =====

bits(32) SPSR[]
  bits(32) result;
  if UsingAArch32() then
    case PSTATE.M of
      when M32_FIQ      result = SPSR_fiq;
      when M32_IRQ      result = SPSR_irq;
      when M32_Svc      result = SPSR_svc;
      when M32_Monitor  result = SPSR_mon;
      when M32_Abort    result = SPSR_abt;
      when M32_Hyp      result = SPSR_hyp;
      when M32_Undef    result = SPSR_und;
      otherwise         Unreachable();
  else
    case PSTATE.EL of
      when EL1          result = SPSR_EL1;
      when EL2          result = SPSR_EL2;
      when EL3          result = SPSR_EL3;
      otherwise         Unreachable();
  return result;

// SPSR[] - assignment form
// =====

SPSR[] = bits(32) value
  if UsingAArch32() then
    case PSTATE.M of
      when M32_FIQ      SPSR_fiq = value;
      when M32_IRQ      SPSR_irq = value;
      when M32_Svc      SPSR_svc = value;
      when M32_Monitor  SPSR_mon = value;
      when M32_Abort    SPSR_abt = value;
      when M32_Hyp      SPSR_hyp = value;
      when M32_Undef    SPSR_und = value;
      otherwise         Unreachable();
  else
    case PSTATE.EL of
      when EL1          SPSR_EL1 = value;
      when EL2          SPSR_EL2 = value;
      when EL3          SPSR_EL3 = value;
      otherwise         Unreachable();
  return;
```

## Library pseudocode for shared/functions/system/ArchVersion

```
enumeration ArchVersion {
    ARMv8p0
    , ARMv8p1
    , ARMv8p2
    , ARMv8p3
    , ARMv8p4
    , ARMv8p5
    , ARMv8p6
};
```

## Library pseudocode for shared/functions/system/BranchTargetCheck

```
// BranchTargetCheck()
// =====
// This function is executed checks if the current instruction is a valid target for a branch
// taken into, or inside, a guarded page. It is executed on every cycle once the current
// instruction has been decoded and the values of InGuardedPage and BTypeCompatible have been
// determined for the current instruction.

BranchTargetCheck()
    assert HaveBTIExt() && !UsingAArch32();

    // The branch target check considers two state variables:
    // * InGuardedPage, which is evaluated during instruction fetch.
    // * BTypeCompatible, which is evaluated during instruction decode.
    if InGuardedPage && PSTATE.BTYPE != '00' && !BTypeCompatible && !Halted() then
        bits(64) pc = ThisInstrAddr();
        AArch64.BranchTargetException(pc<51:0>);

    boolean branch_instr = AArch64.ExecutingBR0rBLR0rRetInstr();
    boolean bti_instr    = AArch64.ExecutingBTIInstr();

    // PSTATE.BTYPE defaults to 00 for instructions that do not explicitly set BTYPE.
    if !(branch_instr || bti_instr) then
        BTypeNext = '00';
```

## Library pseudocode for shared/functions/system/ClearEventRegister

```
// ClearEventRegister()
// =====
// Clear the Event Register of this PE

ClearEventRegister()
    EventRegister = '0';
    return;
```

## Library pseudocode for shared/functions/system/ClearPendingPhysicalSError

```
// Clear a pending physical SError interrupt
ClearPendingPhysicalSError();
```

## Library pseudocode for shared/functions/system/ClearPendingVirtualSError

```
// Clear a pending virtual SError interrupt
ClearPendingVirtualSError();
```

## Library pseudocode for shared/functions/system/ConditionHolds

```
// ConditionHolds()
// =====
// Return TRUE iff COND currently holds

boolean ConditionHolds(bits(4) cond)
// Evaluate base condition.
case cond<3:1> of
  when '000' result = (PSTATE.Z == '1');           // EQ or NE
  when '001' result = (PSTATE.C == '1');           // CS or CC
  when '010' result = (PSTATE.N == '1');           // MI or PL
  when '011' result = (PSTATE.V == '1');           // VS or VC
  when '100' result = (PSTATE.C == '1' && PSTATE.Z == '0'); // HI or LS
  when '101' result = (PSTATE.N == PSTATE.V);       // GE or LT
  when '110' result = (PSTATE.N == PSTATE.V && PSTATE.Z == '0'); // GT or LE
  when '111' result = TRUE;                         // AL

// Condition flag values in the set '111x' indicate always true
// Otherwise, invert condition if necessary.
if cond<0> == '1' && cond != '1111' then
  result = !result;

return result;
```

## Library pseudocode for shared/functions/system/ConsumptionOfSpeculativeDataBarrier

```
ConsumptionOfSpeculativeDataBarrier();
```

## Library pseudocode for shared/functions/system/CurrentInstrSet

```
// CurrentInstrSet()
// =====

InstrSet CurrentInstrSet()

if UsingAArch32\(\) then
  result = if PSTATE.T == '0' then InstrSet\_A32 else InstrSet\_T32;
  // PSTATE.J is RES0. Implementation of T32EE or Jazelle state not permitted.
else
  result = InstrSet\_A64;
return result;
```

## Library pseudocode for shared/functions/system/CurrentPL

```
// CurrentPL()
// =====

PrivilegeLevel CurrentPL()
  return PLOfEL(PSTATE.EL);
```

## Library pseudocode for shared/functions/system/DelayForWFETrap

```
// Causes the PE to stall for 'n' cycles.
DelayForWFETrap(integer n);
```

## Library pseudocode for shared/functions/system/EL0

```
constant bits(2) EL3 = '11';
constant bits(2) EL2 = '10';
constant bits(2) EL1 = '01';
constant bits(2) EL0 = '00';
```

## Library pseudocode for shared/functions/system/EL2Enabled

```
// EL2Enabled()
// =====
// Returns TRUE if EL2 is present and executing
// - with SCR_EL3.NS==1 when Non-secure EL2 is implemented, or
// - with SCR_EL3.NS==0 when Secure EL2 is implemented and enabled, or
// - when EL3 is not implemented.

boolean EL2Enabled()
    return HaveEL(EL2) && (!HaveEL(EL3) || SCR_EL3.NS == '1' || IsSecureEL2Enabled());
```

## Library pseudocode for shared/functions/system/ELFromM32

```
// ELFromM32()
// =====

(boolean, bits(2)) ELFromM32(bits(5) mode)
    // Convert an AArch32 mode encoding to an Exception level.
    // Returns (valid, EL):
    //   'valid' is TRUE if 'mode<4:0>' encodes a mode that is both valid for this implementation
    //           and the current value of SCR.NS/SCR_EL3.NS.
    //   'EL'    is the Exception level decoded from 'mode'.
    bits(2) el;
    boolean valid = !BadMode(mode); // Check for modes that are not valid for this implementation
    case mode of
        when M32_Monitor
            el = EL3;
        when M32_Hyp
            el = EL2;
            valid = valid && (!HaveEL(EL3) || SCR_GEN[].NS == '1');
        when M32_FIQ, M32_IRQ, M32_Svc, M32_Abort, M32_Undef, M32_System
            // If EL3 is implemented and using AArch32, then these modes are EL3 modes in Secure
            // state, and EL1 modes in Non-secure state. If EL3 is not implemented or is using
            // AArch64, then these modes are EL1 modes.
            el = (if HaveEL(EL3) && HighestELUsingAArch32() && SCR.NS == '0' then EL3 else EL1);
        when M32_User
            el = EL0;
        otherwise
            valid = FALSE; // Passed an illegal mode value
    if !valid then el = bits(2) UNKNOWN;
    return (valid, el);
```

## Library pseudocode for shared/functions/system/ELFromSPSR

```
// ELFromSPSR()
// =====

// Convert an SPSR value encoding to an Exception level.
// Returns (valid,EL):
// 'valid' is TRUE if 'spsr<4:0>' encodes a valid mode for the current state.
// 'EL' is the Exception level decoded from 'spsr'.

(boolean, bits(2)) ELFromSPSR(bits(32) spsr)
    if spsr<4> == '0' then // AArch64 state
        el = spsr<3:2>;
        if HighestELUsingAArch32() then // No AArch64 support
            valid = FALSE;
        elseif !HaveEL(el) then // Exception level not implemented
            valid = FALSE;
        elseif spsr<1> == '1' then // M[1] must be 0
            valid = FALSE;
        elseif el == EL0 && spsr<0> == '1' then // for EL0, M[0] must be 0
            valid = FALSE;
        elseif el == EL2 && HaveEL(EL3) && !IsSecureEL2Enabled() && SCR_EL3.NS == '0' then
            valid = FALSE; // Unless Secure EL2 is enabled, EL2 only valid in Non-secure state
        else
            valid = TRUE;
    elseif HaveAnyAArch32() then // AArch32 state
        (valid, el) = ELFromM32(spsr<4:0>);
    else
        valid = FALSE;

    if !valid then el = bits(2) UNKNOWN;
    return (valid, el);
```

## Library pseudocode for shared/functions/system/ELIsInHost

```
// ELIsInHost()
// =====

boolean ELIsInHost(bits(2) el)
    return ((IsSecureEL2Enabled() || !IsSecureBelowEL3()) && HaveVirtHostExt() && !ELUsingAArch32(EL2) &&
        HCR_EL2.E2H == '1' && (el == EL2 || (el == EL0 && HCR_EL2.TGE == '1')));
```

## Library pseudocode for shared/functions/system/ELStateUsingAArch32

```
// ELStateUsingAArch32()
// =====

boolean ELStateUsingAArch32(bits(2) el, boolean secure)
    // See ELStateUsingAArch32K() for description. Must only be called in circumstances where
    // result is valid (typically, that means 'el IN {EL1, EL2, EL3}').
    (known, aarch32) = ELStateUsingAArch32K(el, secure);
    assert known;
    return aarch32;
```



## Library pseudocode for shared/functions/system/ELStateUsingAArch32K

```
// ELStateUsingAArch32K()
// =====

(boolean,boolean) ELStateUsingAArch32K(bits(2) el, boolean secure)
// Returns (known, aarch32):
// 'known' is FALSE for EL0 if the current Exception level is not EL0 and EL1 is
// using AArch64, since it cannot determine the state of EL0; TRUE otherwise.
// 'aarch32' is TRUE if the specified Exception level is using AArch32; FALSE otherwise.
if !HaveAArch32EL(el) then
    return (TRUE, FALSE); // Exception level is using AArch64
elseif secure && el == EL2 then
    return (TRUE, FALSE); // Secure EL2 is using AArch64
elseif HighestELUsingAArch32() then
    return (TRUE, TRUE); // Highest Exception level, and therefore all levels are using AArch32
elseif el == HighestEL() then
    return (TRUE, FALSE); // This is highest Exception level, so is using AArch32

// Remainder of function deals with the interprocessing cases when highest Exception level is using AArch64

boolean aarch32 = boolean UNKNOWN;
boolean known = TRUE;

aarch32_below_el3 = HaveEL(EL3) && SCR_EL3.RW == '0' && (!secure || !HaveSecureEL2Ext() || SCR_EL3.EEL2 == '1')
aarch32_at_el1 = (aarch32_below_el3 || (HaveEL(EL2) && ((HaveSecureEL2Ext() && SCR_EL3.EEL2 == '1') || !secure) && HCR_EL2.E2H == '1' && HCR_EL2.TGE == '1' && HaveVirtHostExt()))
// Only know if EL0 using AArch32 from PSTATE
if el == EL0 && !aarch32_at_el1 then
    if PSTATE.EL == EL0 then
        aarch32 = PSTATE.nRW == '1'; // EL0 controlled by PSTATE
    else
        known = FALSE; // EL0 state is UNKNOWN
else
    aarch32 = (aarch32_below_el3 && el != EL3) || (aarch32_at_el1 && el IN {EL1, EL0});

if !known then aarch32 = boolean UNKNOWN;
return (known, aarch32);
```

## Library pseudocode for shared/functions/system/ELUsingAArch32

```
// ELUsingAArch32()
// =====

boolean ELUsingAArch32(bits(2) el)
    return ELStateUsingAArch32(el, IsSecureBelowEL3());
```

## Library pseudocode for shared/functions/system/ELUsingAArch32K

```
// ELUsingAArch32K()
// =====

(boolean,boolean) ELUsingAArch32K(bits(2) el)
    return ELStateUsingAArch32K(el, IsSecureBelowEL3());
```

## Library pseudocode for shared/functions/system/EndOfInstruction

```
// Terminate processing of the current instruction.
EndOfInstruction();
```

## Library pseudocode for shared/functions/system/EnterLowPowerState

```
// PE enters a low-power state
EnterLowPowerState();
```

## Library pseudocode for shared/functions/system/EventRegister

```
bits(1) EventRegister;
```

## Library pseudocode for shared/functions/system/GetPSRFromPSTATE

```
// GetPSRFromPSTATE()
// =====
// Return a PSR value which represents the current PSTATE

bits(32) GetPSRFromPSTATE()
  bits(32) spsr = Zeros();
  spsr<31:28> = PSTATE.<N,Z,C,V>;
  if HavePANExt() then spsr<22> = PSTATE.PAN;
  spsr<20> = PSTATE.IL;
  if PSTATE.nRW == '1' then // AArch32 state
    spsr<27> = PSTATE.Q;
    spsr<26:25> = PSTATE.IT<1:0>;
    if HaveSSBSExt() then spsr<23> = PSTATE.SSBS;
    if HaveDITExt() then spsr<21> = PSTATE.DIT;
    spsr<19:16> = PSTATE.GE;
    spsr<15:10> = PSTATE.IT<7:2>;
    spsr<9> = PSTATE.E;
    spsr<8:6> = PSTATE.<A,I,F>; // No PSTATE.D in AArch32 state
    spsr<5> = PSTATE.T;
    assert PSTATE.M<4> == PSTATE.nRW; // bit [4] is the discriminator
    spsr<4:0> = PSTATE.M;
  else // AArch64 state
    if HaveMTEExt() then spsr<25> = PSTATE.TC0;
    if HaveDITExt() then spsr<24> = PSTATE.DIT;
    if HaveUA0Ext() then spsr<23> = PSTATE.UA0;
    spsr<21> = PSTATE.SS;
    if HaveSSBSExt() then spsr<12> = PSTATE.SSBS;
    if HaveBTIExt() then spsr<11:10> = PSTATE.BTYPE;
    spsr<9:6> = PSTATE.<D,A,I,F>;
    spsr<4> = PSTATE.nRW;
    spsr<3:2> = PSTATE.EL;
    spsr<0> = PSTATE.SP;
  return spsr;
```

## Library pseudocode for shared/functions/system/HasArchVersion

```
// HasArchVersion()
// =====
// Return TRUE if the implemented architecture includes the extensions defined in the specified
// architecture version.

boolean HasArchVersion(ArchVersion version)
  return version == ARMv8p0 || boolean IMPLEMENTATION_DEFINED;
```

## Library pseudocode for shared/functions/system/HaveAArch32EL

```
// HaveAArch32EL()
// =====

boolean HaveAArch32EL(bits(2) el)
  // Return TRUE if Exception level 'el' supports AArch32 in this implementation
  if !HaveEL(el) then // The Exception level is not implemented
    return FALSE;
  elseif !HaveAnyAArch32() then // No Exception level can use AArch32
    return FALSE;
  elseif HighestELUsingAArch32() then // All Exception levels are using AArch32
    return TRUE;
  elseif el == HighestEL() then // The highest Exception level is using AArch64
    return FALSE;
  elseif el == EL0 then // EL0 must support using AArch32 if any AArch32
    return TRUE;
  return boolean IMPLEMENTATION_DEFINED;
```

### Library pseudocode for shared/functions/system/HaveAnyAArch32

```
// HaveAnyAArch32()
// =====
// Return TRUE if AArch32 state is supported at any Exception level

boolean HaveAnyAArch32()
    return boolean IMPLEMENTATION_DEFINED;
```

### Library pseudocode for shared/functions/system/HaveAnyAArch64

```
// HaveAnyAArch64()
// =====
// Return TRUE if AArch64 state is supported at any Exception level

boolean HaveAnyAArch64()
    return !HighestELUsingAArch32();
```

### Library pseudocode for shared/functions/system/HaveEL

```
// HaveEL()
// =====
// Return TRUE if Exception level 'el' is supported

boolean HaveEL(bits(2) el)
    if el IN {EL1, EL0} then
        return TRUE; // EL1 and EL0 must exist
    return boolean IMPLEMENTATION_DEFINED;
```

### Library pseudocode for shared/functions/system/HaveELUsingSecurityState

```
// HaveELUsingSecurityState()
// =====
// Returns TRUE if Exception level 'el' with Security state 'secure' is supported,
// FALSE otherwise.

boolean HaveELUsingSecurityState(bits(2) el, boolean secure)

    case el of
        when EL3
            assert secure;
            return HaveEL(EL3);
        when EL2
            if secure then
                return HaveEL(EL2) && HaveSecureEL2Ext();
            else
                return HaveEL(EL2);
        otherwise
            return (HaveEL(EL3) ||
                (secure == boolean IMPLEMENTATION_DEFINED "Secure-only implementation"));
```

### Library pseudocode for shared/functions/system/HaveFP16Ext

```
// HaveFP16Ext()
// =====
// Return TRUE if FP16 extension is supported

boolean HaveFP16Ext()
    return boolean IMPLEMENTATION_DEFINED;
```

### Library pseudocode for shared/functions/system/HighestEL

```
// HighestEL()
// =====
// Returns the highest implemented Exception level.

bits(2) HighestEL()
    if HaveEL(EL3) then
        return EL3;
    elsif HaveEL(EL2) then
        return EL2;
    else
        return EL1;
```

### Library pseudocode for shared/functions/system/HighestELUsingAArch32

```
// HighestELUsingAArch32()
// =====
// Return TRUE if configured to boot into AArch32 operation

boolean HighestELUsingAArch32()
    if !HaveAnyAArch32() then return FALSE;
    return boolean IMPLEMENTATION_DEFINED;    // e.g. CFG32SIGNAL == HIGH
```

### Library pseudocode for shared/functions/system/Hint\_DGH

```
// Provides a hint to close any gathering occurring within the micro-architecture.
Hint_DGH();
```

### Library pseudocode for shared/functions/system/Hint\_Yield

```
// Provides a hint that the task performed by a thread is of low
// importance so that it could yield to improve overall performance.
Hint_Yield();
```

## Library pseudocode for shared/functions/system/IllegalExceptionReturn

```
// IllegalExceptionReturn()
// =====

boolean IllegalExceptionReturn(bits(32) spsr)

    // Check for illegal return:
    // * To an unimplemented Exception level.
    // * To EL2 in Secure state, when SecureEL2 is not enabled.
    // * To EL0 using AArch64 state, with SPSR.M[0]==1.
    // * To AArch64 state with SPSR.M[1]==1.
    // * To AArch32 state with an illegal value of SPSR.M.
    (valid, target) = ELFromSPSR(spsr);
    if !valid then return TRUE;

    // Check for return to higher Exception level
    if UInt(target) > UInt(PSTATE.EL) then return TRUE;

    spsr_mode_is_aarch32 = (spsr<4> == '1');

    // Check for illegal return:
    // * To EL1, EL2 or EL3 with register width specified in the SPSR different from the
    //   Execution state used in the Exception level being returned to, as determined by
    //   the SCR_EL3.RW or HCR_EL2.RW bits, or as configured from reset.
    // * To EL0 using AArch64 state when EL1 is using AArch32 state as determined by the
    //   SCR_EL3.RW or HCR_EL2.RW bits or as configured from reset.
    // * To AArch64 state from AArch32 state (should be caught by above)
    (known, target_el_is_aarch32) = ELUsingAArch32K(target);
    assert known || (target == EL0 && !ELUsingAArch32(EL1));
    if known && spsr_mode_is_aarch32 != target_el_is_aarch32 then return TRUE;

    // Check for illegal return from AArch32 to AArch64
    if UsingAArch32() && !spsr_mode_is_aarch32 then return TRUE;

    // Check for illegal return to EL1 when HCR.TGE is set and when either of
    // * SecureEL2 is enabled.
    // * SecureEL2 is not enabled and EL1 is in Non-secure state.
    if HaveEL(EL2) && target == EL1 && HCR_EL2.TGE == '1' then
        if (!IsSecureBelowEL3() || IsSecureEL2Enabled()) then return TRUE;
    return FALSE;
```

## Library pseudocode for shared/functions/system/InstrSet

```
enumeration InstrSet {InstrSet_A64, InstrSet_A32, InstrSet_T32};
```

## Library pseudocode for shared/functions/system/InstructionSynchronizationBarrier

```
InstructionSynchronizationBarrier();
```

## Library pseudocode for shared/functions/system/InterruptPending

```
// InterruptPending()
// =====
// Return TRUE if there are any pending physical or virtual
// interrupts, and FALSE otherwise.

boolean InterruptPending()
    pending_physical_interrupt = (IRQPending() || FIQPending() ||
        IsPhysicalSErrorPending());
    pending_virtual_interrupt = !IsInHost() && ((HCR_EL2.<VSE,VI,VF> AND
        HCR_EL2.<AMO,IMO,FMO>) != '000');
    return pending_physical_interrupt || pending_virtual_interrupt;
```

## Library pseudocode for shared/functions/system/IsEventRegisterSet

```
// IsEventRegisterSet()
// =====
// Return TRUE if the Event Register of this PE is set, and FALSE otherwise

boolean IsEventRegisterSet()
    return EventRegister == '1';
```

## Library pseudocode for shared/functions/system/IsHighestEL

```
// IsHighestEL()
// =====
// Returns TRUE if given exception level is the highest exception level implemented

boolean IsHighestEL(bits(2) el)
    return HighestEL\(\) == el;
```

## Library pseudocode for shared/functions/system/IsInHost

```
// IsInHost()
// =====

boolean IsInHost()
    return ELIsInHost(PSTATE.EL);
```

## Library pseudocode for shared/functions/system/IsPhysicalSErrorPending

```
// Return TRUE if a physical SError interrupt is pending
boolean IsPhysicalSErrorPending();
```

## Library pseudocode for shared/functions/system/IsSecure

```
// IsSecure()
// =====
// Returns TRUE if current Exception level is in Secure state.

boolean IsSecure()
    if HaveEL(EL3) && !UsingAArch32() && PSTATE.EL == EL3 then
        return TRUE;
    elseif HaveEL(EL3) && UsingAArch32() && PSTATE.M == M32\_Monitor then
        return TRUE;
    return IsSecureBelowEL3();
```

## Library pseudocode for shared/functions/system/IsSecureBelowEL3

```
// IsSecureBelowEL3()
// =====
// Return TRUE if an Exception level below EL3 is in Secure state
// or would be following an exception return to that level.
//
// Differs from IsSecure in that it ignores the current EL or Mode
// in considering security state.
// That is, if at AArch64 EL3 or in AArch32 Monitor mode, whether an
// exception return would pass to Secure or Non-secure state.

boolean IsSecureBelowEL3()
    if HaveEL(EL3) then
        return SCR\_GEN[][NS] == '0';
    elseif HaveEL(EL2) && (!HaveSecureEL2Ext() || HighestELUsingAArch32()) then
        // If Secure EL2 is not an architecture option then we must be Non-secure.
        return FALSE;
    else
        // TRUE if processor is Secure or FALSE if Non-secure.
        return boolean IMPLEMENTATION_DEFINED "Secure-only implementation";
```

## Library pseudocode for shared/functions/system/IsSecureEL2Enabled

```
// IsSecureEL2Enabled()
// =====
// Returns TRUE if Secure EL2 is enabled, FALSE otherwise.

boolean IsSecureEL2Enabled()
  if HaveEL(EL2) && HaveSecureEL2Ext() then
    if HaveEL(EL3) then
      if !ELUsingAArch32(EL3) && SCR_EL3.EEL2 == '1' then
        return TRUE;
      else
        return FALSE;
    else
      return IsSecure();
  else
    return FALSE;
```

## Library pseudocode for shared/functions/system/IsSynchronizablePhysicalErrorPending

```
// Return TRUE if a synchronizable physical SError interrupt is pending
boolean IsSynchronizablePhysicalErrorPending();
```

## Library pseudocode for shared/functions/system/IsVirtualSErrorPending

```
// Return TRUE if a virtual SError interrupt is pending
boolean IsVirtualSErrorPending();
```

## Library pseudocode for shared/functions/system/Mode\_Bits

```
constant bits(5) M32_User      = '10000';
constant bits(5) M32_FIQ      = '10001';
constant bits(5) M32_IRQ      = '10010';
constant bits(5) M32_Svc      = '10011';
constant bits(5) M32_Monitor = '10110';
constant bits(5) M32_Abort    = '10111';
constant bits(5) M32_Hyp      = '11010';
constant bits(5) M32_Undef    = '11011';
constant bits(5) M32_System   = '11111';
```

## Library pseudocode for shared/functions/system/PL0fEL

```
// PL0fEL()
// =====

PrivilegeLevel PL0fEL(bits(2) el)
  case el of
    when EL3 return if HighestELUsingAArch32() then PL1 else PL3;
    when EL2 return PL2;
    when EL1 return PL1;
    when EL0 return PL0;
```

## Library pseudocode for shared/functions/system/PSTATE

```
ProcState PSTATE;
```

## Library pseudocode for shared/functions/system/PrivilegeLevel

```
enumeration PrivilegeLevel {PL3, PL2, PL1, PL0};
```

## Library pseudocode for shared/functions/system/ProcState

```
type ProcState is (  
    bits (1) N,          // Negative condition flag  
    bits (1) Z,          // Zero condition flag  
    bits (1) C,          // Carry condition flag  
    bits (1) V,          // oVerflow condition flag  
    bits (1) D,          // Debug mask bit [AArch64 only]  
    bits (1) A,          // SError interrupt mask bit  
    bits (1) I,          // IRQ mask bit  
    bits (1) F,          // FIQ mask bit  
    bits (1) PAN,        // Privileged Access Never Bit [v8.1]  
    bits (1) UAO,        // User Access Override [v8.2]  
    bits (1) DIT,        // Data Independent Timing [v8.4]  
    bits (1) TCO,        // Tag Check Override [v8.5, AArch64 only]  
    bits (2) BTYPE,      // Branch Type [v8.5]  
    bits (1) SS,         // Software step bit  
    bits (1) IL,         // Illegal Execution state bit  
    bits (2) EL,         // Exception Level  
    bits (1) nRW,        // not Register Width: 0=64, 1=32  
    bits (1) SP,         // Stack pointer select: 0=SP0, 1=SPx [AArch64 only]  
    bits (1) Q,          // Cumulative saturation flag [AArch32 only]  
    bits (4) GE,         // Greater than or Equal flags [AArch32 only]  
    bits (1) SSBS,       // Speculative Store Bypass Safe  
    bits (8) IT,         // If-then bits, RES0 in CPSR [AArch32 only]  
    bits (1) J,          // J bit, RES0 [AArch32 only, RES0 in SPSR and CPSR]  
    bits (1) T,          // T32 bit, RES0 in CPSR [AArch32 only]  
    bits (1) E,          // Endianness bit [AArch32 only]  
    bits (5) M           // Mode field [AArch32 only]  
)
```

## Library pseudocode for shared/functions/system/RestoredITBits

```
// RestoredITBits()  
// =====  
// Get the value of PSTATE.IT to be restored on this exception return.  
  
bits(8) RestoredITBits(bits(32) spsr)  
    it = spsr<15:10,26:25>;  
  
    // When PSTATE.IL is set, it is CONSTRAINED UNPREDICTABLE whether the IT bits are each set  
    // to zero or copied from the SPSR.  
    if PSTATE.IL == '1' then  
        if ConstrainUnpredictableBool(Unpredictable\_ILZEROIT) then return '00000000';  
        else return it;  
  
    // The IT bits are forced to zero when they are set to a reserved value.  
    if !IsZero(it<7:4>) && IsZero(it<3:0>) then  
        return '00000000';  
  
    // The IT bits are forced to zero when returning to A32 state, or when returning to an EL  
    // with the ITD bit set to 1, and the IT bits are describing a multi-instruction block.  
    itd = if PSTATE.EL == EL2 then HSCTLR.ITD else SCTL.R.ITD;  
    if (spsr<5> == '0' && !IsZero(it)) || (itd == '1' && !IsZero(it<2:0>)) then  
        return '00000000';  
    else  
        return it;
```

## Library pseudocode for shared/functions/system/SCRTType

```
type SCRTType;
```



## Library pseudocode for shared/functions/system/SCR\_GEN

```
// SCR_GEN[]
// =====

SCRType SCR_GEN[]
// AArch32 secure & AArch64 EL3 registers are not architecturally mapped
assert HaveEL(EL3);
bits(64) r;
if HighestELUsingAArch32() then
    r = ZeroExtend(SCR);
else
    r = ZeroExtend(SCR_EL3);
return r;
```

## Library pseudocode for shared/functions/system/SendEvent

```
// Signal an event to all PEs in a multiprocessor system to set their Event Registers.
// When a PE executes the SEV instruction, it causes this function to be executed
SendEvent();
```

## Library pseudocode for shared/functions/system/SendEventLocal

```
// SendEventLocal()
// =====
// Set the local Event Register of this PE.
// When a PE executes the SEVL instruction, it causes this function to be executed

SendEventLocal()
    EventRegister = '1';
    return;
```

## Library pseudocode for shared/functions/system/SetPSTATEFromPSR

```
// SetPSTATEFromPSR()
// =====
// Set PSTATE based on a PSR value

SetPSTATEFromPSR(bits(32) spsr)
    PSTATE.SS = DebugExceptionReturnSS(spsr);
    if IllegalExceptionReturn(spsr) then
        PSTATE.IL = '1';
        if HaveSSBSExt() then PSTATE.SSBS = bit UNKNOWN;
    else
        // State that is reinstated only on a legal exception return
        PSTATE.IL = spsr<20>;
        if spsr<4> == '1' then // AArch32 state
            AArch32.WriteMode(spsr<4:0>); // Sets PSTATE.EL correctly
            if HaveSSBSExt() then PSTATE.SSBS = spsr<23>;
        else // AArch64 state
            PSTATE.nRW = '0';
            PSTATE.EL = spsr<3:2>;
            PSTATE.SP = spsr<0>;
            if HaveSSBSExt() then PSTATE.SSBS = spsr<12>;

    // If PSTATE.IL is set and returning to AArch32 state, it is CONSTRAINED UNPREDICTABLE whether
    // the T bit is set to zero or copied from SPSR.
    if PSTATE.IL == '1' && PSTATE.nRW == '1' then
        if ConstrainUnpredictableBool(Unpredictable\_ILZEROT) then spsr<5> = '0';

    // State that is reinstated regardless of illegal exception return
    PSTATE.<N,Z,C,V> = spsr<31:28>;
    if HavePANExt() then PSTATE.PAN = spsr<22>;
    if PSTATE.nRW == '1' then // AArch32 state
        PSTATE.Q = spsr<27>;
        PSTATE.IT = RestoredITBits(spsr);
        ShouldAdvanceIT = FALSE;
        if HaveDITExt() then PSTATE.DIT = (if Restarting() then spsr<24> else spsr<21>);
        PSTATE.GE = spsr<19:16>;
        PSTATE.E = spsr<9>;
        PSTATE.<A,I,F> = spsr<8:6>; // No PSTATE.D in AArch32 state
        PSTATE.T = spsr<5>; // PSTATE.J is RES0
    else // AArch64 state
        if HaveMTEExt() then PSTATE.TCO = spsr<25>;
        if HaveDITExt() then PSTATE.DIT = spsr<24>;
        if HaveUA0Ext() then PSTATE.UA0 = spsr<23>;
        if HaveBTIExt() then PSTATE.BTYPE = spsr<11:10>;
        PSTATE.<D,A,I,F> = spsr<9:6>; // No PSTATE.<Q,IT,GE,E,T> in AArch64 state
    return;
```

## Library pseudocode for shared/functions/system/ShouldAdvanceIT

```
boolean ShouldAdvanceIT;
```

## Library pseudocode for shared/functions/system/SpeculationBarrier

```
SpeculationBarrier();
```

## Library pseudocode for shared/functions/system/SynchronizeContext

```
SynchronizeContext();
```

## Library pseudocode for shared/functions/system/SynchronizeErrors

```
// Implements the error synchronization event.
SynchronizeErrors();
```

### Library pseudocode for shared/functions/system/TakeUnmaskedPhysicalSErrorInterrupts

```
// Take any pending unmasked physical SError interrupt
TakeUnmaskedPhysicalSErrorInterrupts(boolean iesb_req);
```

### Library pseudocode for shared/functions/system/TakeUnmaskedSErrorInterrupts

```
// Take any pending unmasked physical SError interrupt or unmasked virtual SError
// interrupt.
TakeUnmaskedSErrorInterrupts();
```

### Library pseudocode for shared/functions/system/ThisInstr

```
bits(32) ThisInstr();
```

### Library pseudocode for shared/functions/system/ThisInstrLength

```
integer ThisInstrLength();
```

### Library pseudocode for shared/functions/system/Unreachable

```
Unreachable()
    assert FALSE;
```

### Library pseudocode for shared/functions/system/UsingAArch32

```
// UsingAArch32()
// =====
// Return TRUE if the current Exception level is using AArch32, FALSE if using AArch64.

boolean UsingAArch32()
    boolean aarch32 = (PSTATE.nRW == '1');
    if !HaveAnyAArch32() then assert !aarch32;
    if HighestELUsingAArch32() then assert aarch32;
    return aarch32;
```

### Library pseudocode for shared/functions/system/WaitForEvent

```
// WaitForEvent()
// =====
// PE suspends its operation and enters a low-power state
// if the Event Register is clear when the WFE is executed

WaitForEvent()
    if EventRegister == '0' then
        EnterLowPowerState();
    return;
```

### Library pseudocode for shared/functions/system/WaitForInterrupt

```
// WaitForInterrupt()
// =====
// PE suspends its operation to enter a low-power state
// until a WFI wake-up event occurs or the PE is reset

WaitForInterrupt()
    EnterLowPowerState();
    return;
```



```
// ConstrainUnpredictable()
// =====
// Return the appropriate Constraint result to control the caller's behavior. The return value
// is IMPLEMENTATION DEFINED within a permitted list for each UNPREDICTABLE case.
// (The permitted list is determined by an assert or case statement at the call site.)

// NOTE: This version of the function uses an Unpredictable argument to define the call site.
// This argument does not appear in the version used in the Armv8 Architecture Reference Manual.
// The extra argument is used here to allow this example definition. This is an example only and
// does not imply a fixed implementation of these behaviors. Indeed the intention is that it should
// be defined by each implementation, according to its implementation choices.
```

```
Constraint ConstrainUnpredictable(Unpredictable which)
    case which of
        when Unpredictable\_VMSR
            return Constraint\_UNDEF;
        when Unpredictable\_WBOVERLAPLD
            return Constraint\_WBSUPPRESS; // return loaded value
        when Unpredictable\_WBOVERLAPST
            return Constraint\_NONE; // store pre-writeback value
        when Unpredictable\_LDPOVERLAP
            return Constraint\_UNDEF; // instruction is UNDEFINED
        when Unpredictable\_BASEOVERLAP
            return Constraint\_NONE; // use original address
        when Unpredictable\_DATAOVERLAP
            return Constraint\_NONE; // store original value
        when Unpredictable\_DEVPAGE2
            return Constraint\_FAULT; // take an alignment fault
        when Unpredictable\_INSTRDEVICE
            return Constraint\_NONE; // Do not take a fault
        when Unpredictable\_RESCPACR
            return Constraint\_TRUE; // Map to UNKNOWN value
        when Unpredictable\_RESMAIR
            return Constraint\_UNKNOWN; // Map to UNKNOWN value
        when Unpredictable\_RESTEXCB
            return Constraint\_UNKNOWN; // Map to UNKNOWN value
        when Unpredictable\_RESDACR
            return Constraint\_UNKNOWN; // Map to UNKNOWN value
        when Unpredictable\_RESPRRR
            return Constraint\_UNKNOWN; // Map to UNKNOWN value
        when Unpredictable\_RESVTCRS
            return Constraint\_UNKNOWN; // Map to UNKNOWN value
        when Unpredictable\_RESTnSZ
            return Constraint\_FORCE; // Map to the limit value
        when Unpredictable\_OORTnSZ
            return Constraint\_FORCE; // Map to the limit value
        when Unpredictable\_LARGEIPA
            return Constraint\_FORCE; // Restrict the inputsize to the PAMax value
        when Unpredictable\_ESRCONDPASS
            return Constraint\_FALSE; // Report as "AL"
        when Unpredictable\_ILZEROIT
            return Constraint\_FALSE; // Do not zero PSTATE.IT
        when Unpredictable\_ILZEROT
            return Constraint\_FALSE; // Do not zero PSTATE.T
        when Unpredictable\_BPVECTORCATCHPRI
            return Constraint\_TRUE; // Debug Vector Catch: match on 2nd halfword
        when Unpredictable\_VCMATCHHALF
            return Constraint\_FALSE; // No match
        when Unpredictable\_VCMATCHDAPA
            return Constraint\_FALSE; // No match on Data Abort or Prefetch abort
        when Unpredictable\_WPMASKANDBAS
            return Constraint\_FALSE; // Watchpoint disabled
        when Unpredictable\_WPBASCONTIGUOUS
            return Constraint\_FALSE; // Watchpoint disabled
        when Unpredictable\_RESWPMASK
            return Constraint\_DISABLED; // Watchpoint disabled
        when Unpredictable\_WPMASKEDBITS
            return Constraint\_FALSE; // Watchpoint disabled
        when Unpredictable\_RESBPWPCtrl
            return Constraint\_DISABLED; // Breakpoint/watchpoint disabled
```

```

when Unpredictable\_BPNOTIMPL
    return Constraint\_DISABLED; // Breakpoint disabled
when Unpredictable\_RESBPTYPE
    return Constraint\_DISABLED; // Breakpoint disabled
when Unpredictable\_BPNOTCTXCMP
    return Constraint\_DISABLED; // Breakpoint disabled
when Unpredictable\_BPMATCHHALF
    return Constraint\_FALSE; // No match
when Unpredictable\_BPMISMATCHHALF
    return Constraint\_FALSE; // No match
when Unpredictable\_RESTARTALIGNPC
    return Constraint\_FALSE; // Do not force alignment
when Unpredictable\_RESTARTZEROUPPERPC
    return Constraint\_TRUE; // Force zero extension
when Unpredictable\_ZEROUPPER
    return Constraint\_TRUE; // zero top halves of X registers
when Unpredictable\_ERETZEROUPPERPC
    return Constraint\_TRUE; // zero top half of PC
when Unpredictable\_A32FORCEALIGNPC
    return Constraint\_FALSE; // Do not force alignment
when Unpredictable\_SMD
    return Constraint\_UNDEF; // disabled SMC is Unallocated
when Unpredictable\_NONFAULT
    return Constraint\_FALSE; // Speculation enabled
when Unpredictable\_SVEZEROUPPER
    return Constraint\_TRUE; // zero top bits of Z registers
when Unpredictable\_SVELDNFDATA
    return Constraint\_TRUE; // Load mem data in NF loads
when Unpredictable\_SVELDNFZERO
    return Constraint\_TRUE; // Write zeros in NF loads
when Unpredictable\_CHECKSPNONEACTIVE
    return Constraint\_TRUE; // Check SP alignment
when Unpredictable\_AFUPDATE
    return Constraint\_TRUE; // AF update for alignment or permission fault
when Unpredictable\_IESBinDebug // Use SCTLR[].IESB in Debug state
    return Constraint\_TRUE;
when Unpredictable\_BADPMSFCR // Bad settings for PMSFCR_EL1/PMSEVFR_EL1/PMSLATFR_EL1
    return Constraint\_TRUE;
when Unpredictable\_ZEROBTYP
    return Constraint\_TRUE; // Save BTYP in SPSR_ELx/DPSR_EL0 as '00'
when Unpredictable\_CLEARERRITEZERO // Clearing sticky errors when instruction in flight
    return Constraint\_FALSE;

```

## Library pseudocode for shared/functions/unpredictable/ConstrainUnpredictableBits

```

// ConstrainUnpredictableBits()
// =====

// This is a variant of ConstrainUnpredictable for when the result can be Constraint_UNKNOWN.
// If the result is Constraint_UNKNOWN then the function also returns UNKNOWN value, but that
// value is always an allocated value; that is, one for which the behavior is not itself
// CONSTRAINED.

// NOTE: This version of the function uses an Unpredictable argument to define the call site.
// This argument does not appear in the version used in the Armv8 Architecture Reference Manual.
// See the NOTE on ConstrainUnpredictable() for more information.

// This is an example placeholder only and does not imply a fixed implementation of the bits part
// of the result, and may not be applicable in all cases.

(Constraint, bits(width)) ConstrainUnpredictableBits(Unpredictable which)

    c = ConstrainUnpredictable(which);

    if c == Constraint\_UNKNOWN then
        return (c, Zeros(width)); // See notes; this is an example implementation only
    else
        return (c, bits(width) UNKNOWN); // bits result not used

```

## Library pseudocode for shared/functions/unpredictable/ConstrainUnpredictableBool

```
// ConstrainUnpredictableBool()
// =====

// This is a simple wrapper function for cases where the constrained result is either TRUE or FALSE.

// NOTE: This version of the function uses an Unpredictable argument to define the call site.
// This argument does not appear in the version used in the Armv8 Architecture Reference Manual.
// See the NOTE on ConstrainUnpredictable() for more information.

boolean ConstrainUnpredictableBool(Unpredictable which)

    c = ConstrainUnpredictable(which);
    assert c IN {Constraint\_TRUE, Constraint\_FALSE};
    return (c == Constraint\_TRUE);
```

## Library pseudocode for shared/functions/unpredictable/ConstrainUnpredictableInteger

```
// ConstrainUnpredictableInteger()
// =====

// This is a variant of ConstrainUnpredictable for when the result can be Constraint_UNKNOWN. If
// the result is Constraint_UNKNOWN then the function also returns an UNKNOWN value in the range
// low to high, inclusive.

// NOTE: This version of the function uses an Unpredictable argument to define the call site.
// This argument does not appear in the version used in the Armv8 Architecture Reference Manual.
// See the NOTE on ConstrainUnpredictable() for more information.

// This is an example placeholder only and does not imply a fixed implementation of the integer part
// of the result.

(Constraint, integer) ConstrainUnpredictableInteger(integer low, integer high, Unpredictable which)

    c = ConstrainUnpredictable(which);

    if c == Constraint\_UNKNOWN then
        return (c, low); // See notes; this is an example implementation only
    else
        return (c, integer UNKNOWN); // integer result not used
```

## Library pseudocode for shared/functions/unpredictable/Constraint

```
enumeration Constraint    { // General
    Constraint_NONE,        // Instruction executes with
                           // no change or side-effect to its described b
    Constraint_UNKNOWN,    // Destination register has UNKNOWN value
    Constraint_UNDEF,      // Instruction is UNDEFINED
    Constraint_UNDEFEL0,   // Instruction is UNDEFINED at EL0 only
    Constraint_NOP,        // Instruction executes as NOP
    Constraint_TRUE,
    Constraint_FALSE,
    Constraint_DISABLED,
    Constraint_UNCOND,     // Instruction executes unconditionally
    Constraint_COND,       // Instruction executes conditionally
    Constraint_ADDITIONAL_DECODE, // Instruction executes with additional decode
    // Load-store
    Constraint_WBSUPPRESS, Constraint_FAULT,
    // IPA too large
    Constraint_FORCE, Constraint_FORCENOSLCHECK};
```





```

enumeration Unpredictable { // VMSR on MVFR
    Unpredictable_VMSR,
    // Writeback/transfer register overlap (load)
    Unpredictable_WBOVERLAPLD,
    // Writeback/transfer register overlap (store)
    Unpredictable_WBOVERLAPST,
    // Load Pair transfer register overlap
    Unpredictable_LDPOVERLAP,
    // Store-exclusive base/status register overlap
    Unpredictable_BASEOVERLAP,
    // Store-exclusive data/status register overlap
    Unpredictable_DATAOVERLAP,
    // Load-store alignment checks
    Unpredictable_DEVPAGE2,
    // Instruction fetch from Device memory
    Unpredictable_INSTRDEVICE,
    // Reserved CPACR value
    Unpredictable_RESCPACR,
    // Reserved MAIR value
    Unpredictable_RESMAIR,
    // Reserved TEX:C:B value
    Unpredictable_RESTEXCB,
    // Reserved PRRR value
    Unpredictable_RESPRRR,
    // Reserved DACR field
    Unpredictable_RESDACR,
    // Reserved VTCR.S value
    Unpredictable_RESVTCRS,
    // Reserved TCR.TnSZ value
    Unpredictable_RESTnSZ,
    // Reserved SCTLR_ELx.TCF value
    Unpredictable_RESTCF,
    // Out-of-range TCR.TnSZ value
    Unpredictable_OORTnSZ,
    // IPA size exceeds PA size
    Unpredictable_LARGEIPA,
    // Syndrome for a known-passing conditional A32 instruction
    Unpredictable_ESRCONDPASS,
    // Illegal State exception: zero PSTATE.IT
    Unpredictable_ILZEROIT,
    // Illegal State exception: zero PSTATE.T
    Unpredictable_ILZEROT,
    // Debug: prioritization of Vector Catch
    Unpredictable_BPVECTORCATCHPRI,
    // Debug Vector Catch: match on 2nd halfword
    Unpredictable_VCMATCHHALF,
    // Debug Vector Catch: match on Data Abort or Prefetch abort
    Unpredictable_VCMATCHDAPA,
    // Debug watchpoints: non-zero MASK and non-ones BAS
    Unpredictable_WPMASKANDBAS,
    // Debug watchpoints: non-contiguous BAS
    Unpredictable_WPBASCONTIGUOUS,
    // Debug watchpoints: reserved MASK
    Unpredictable_RESWPMASK,
    // Debug watchpoints: non-zero MASKed bits of address
    Unpredictable_WPMASKEDBITS,
    // Debug breakpoints and watchpoints: reserved control bits
    Unpredictable_RESBPWPCTRL,
    // Debug breakpoints: not implemented
    Unpredictable_BPNOTIMPL,
    // Debug breakpoints: reserved type
    Unpredictable_RESBPTYPE,
    // Debug breakpoints: not-context-aware breakpoint
    Unpredictable_BPNOTCTXCMP,
    // Debug breakpoints: match on 2nd halfword of instruction
    Unpredictable_BPMATCHHALF,
    // Debug breakpoints: mismatch on 2nd halfword of instruction
    Unpredictable_BPMISMATCHHALF,
    // Debug: restart to a misaligned AArch32 PC value
    Unpredictable_RESTARTALIGNPC,

```

```

// Debug: restart to a not-zero-extended AArch32 PC value
Unpredictable_RESTARTZEROUPPERPC,
// Zero top 32 bits of X registers in AArch32 state
Unpredictable_ZEROUPPER,
// Zero top 32 bits of PC on illegal return to AArch32 state
Unpredictable_ERETZEROUPPERPC,
// Force address to be aligned when interworking branch to A32 state
Unpredictable_A32FORCEALIGNPC,
// SMC disabled
Unpredictable_SMD,
// FF speculation
Unpredictable_NONFAULT,
// Zero top bits of Z registers in EL change
Unpredictable_SVEZEROUPPER,
// Load mem data in NF loads
Unpredictable_SVELDNFDATA,
// Write zeros in NF loads
Unpredictable_SVELDNFZERO,
// SP alignment fault when predicate is all zero
Unpredictable_CHECKSPNONEACTIVE,
// Access Flag Update by HW
Unpredictable_AFUPDATE,
// Consider SCTLR[].IESB in Debug state
Unpredictable_IESBinDebug,
// Bad settings for PMSFCR_EL1/PMSEVFR_EL1/PMSLATFR_EL1
Unpredictable_BADPMSFCR,
// Zero saved BType value in SPSR_ELx/DPSR_EL0
Unpredictable_ZEROBTYPE,
// Timestamp constrained to virtual or physical
Unpredictable_EL2TIMESTAMP,
Unpredictable_EL1TIMESTAMP,
// Clearing DCC/ITR sticky flags when instruction is in flight
Unpredictable_CLEARERRITEZERO};

```

## Library pseudocode for shared/functions/vector/AdvSIMDEExpandImm

```
// AdvSIMDEExpandImm()
// =====

bits(64) AdvSIMDEExpandImm(bit op, bits(4) cmode, bits(8) imm8)
  case cmode<3:1> of
    when '000'
      imm64 = Replicate(Zeros(24):imm8, 2);
    when '001'
      imm64 = Replicate(Zeros(16):imm8:Zeros(8), 2);
    when '010'
      imm64 = Replicate(Zeros(8):imm8:Zeros(16), 2);
    when '011'
      imm64 = Replicate(imm8:Zeros(24), 2);
    when '100'
      imm64 = Replicate(Zeros(8):imm8, 4);
    when '101'
      imm64 = Replicate(imm8:Zeros(8), 4);
    when '110'
      if cmode<0> == '0' then
        imm64 = Replicate(Zeros(16):imm8:Ones(8), 2);
      else
        imm64 = Replicate(Zeros(8):imm8:Ones(16), 2);
    when '111'
      if cmode<0> == '0' && op == '0' then
        imm64 = Replicate(imm8, 8);
      if cmode<0> == '0' && op == '1' then
        imm8a = Replicate(imm8<7>, 8); imm8b = Replicate(imm8<6>, 8);
        imm8c = Replicate(imm8<5>, 8); imm8d = Replicate(imm8<4>, 8);
        imm8e = Replicate(imm8<3>, 8); imm8f = Replicate(imm8<2>, 8);
        imm8g = Replicate(imm8<1>, 8); imm8h = Replicate(imm8<0>, 8);
        imm64 = imm8a:imm8b:imm8c:imm8d:imm8e:imm8f:imm8g:imm8h;
      if cmode<0> == '1' && op == '0' then
        imm32 = imm8<7>:NOT(imm8<6>):Replicate(imm8<6>,5):imm8<5>:0>:Zeros(19);
        imm64 = Replicate(imm32, 2);
      if cmode<0> == '1' && op == '1' then
        if UsingAArch32() then ReservedEncoding();
        imm64 = imm8<7>:NOT(imm8<6>):Replicate(imm8<6>,8):imm8<5>:0>:Zeros(48);

  return imm64;
```

## Library pseudocode for shared/functions/vector/MatMulAdd

```
// MatMulAdd()
// =====
//
// Signed or unsigned 8-bit integer matrix multiply and add to 32-bit integer matrix
// result[2, 2] = addend[2, 2] + (op1[2, 8] * op2[8, 2])

bits(N) MatMulAdd(bits(N) addend, bits(N) op1, bits(N) op2, boolean op1_unsigned, boolean op2_unsigned)
  assert N == 128;

  bits(N) result;
  bits(32) sum;
  integer prod;

  for i = 0 to 1
    for j = 0 to 1
      sum = Elem[addend, 2*i + j, 32];
      for k = 0 to 7
        prod = Int(Elem[op1, 8*i + k, 8], op1_unsigned) * Int(Elem[op2, 8*j + k, 8], op2_unsigned)
        sum = sum + prod;
      Elem[result, 2*i + j, 32] = sum;

  return result;
```

## Library pseudocode for shared/functions/vector/PolynomialMult

```
// PolynomialMult()
// =====

bits(M+N) PolynomialMult(bits(M) op1, bits(N) op2)
    result = Zeros(M+N);
    extended_op2 = ZeroExtend(op2, M+N);
    for i=0 to M-1
        if op1<i> == '1' then
            result = result EOR LSL(extended_op2, i);
    return result;
```

## Library pseudocode for shared/functions/vector/SatQ

```
// SatQ()
// =====

(bits(N), boolean) SatQ(integer i, integer N, boolean unsigned)
    (result, sat) = if unsigned then UnsignedSatQ(i, N) else SignedSatQ(i, N);
    return (result, sat);
```

## Library pseudocode for shared/functions/vector/SignedSatQ

```
// SignedSatQ()
// =====

(bits(N), boolean) SignedSatQ(integer i, integer N)
    if i > 2^(N-1) - 1 then
        result = 2^(N-1) - 1; saturated = TRUE;
    elsif i < -(2^(N-1)) then
        result = -(2^(N-1)); saturated = TRUE;
    else
        result = i; saturated = FALSE;
    return (result<N-1:0>, saturated);
```

## Library pseudocode for shared/functions/vector/UnsignedRSqrtEstimate

```
// UnsignedRSqrtEstimate()
// =====

bits(N) UnsignedRSqrtEstimate(bits(N) operand)
    assert N IN {16,32};
    if operand<N-1:N-2> == '00' then // Operands <= 0x3FFFFFFF produce 0xFFFFFFFF
        result = Ones(N);
    else
        // input is in the range 0x40000000 .. 0xffffffff representing [0.25 .. 1.0)

        // estimate is in the range 256 .. 511 representing [1.0 .. 2.0)
        case N of
            when 16 estimate = RecipSqrtEstimate(UInt(operand<15:7>));
            when 32 estimate = RecipSqrtEstimate(UInt(operand<31:23>));

        // result is in the range 0x80000000 .. 0xff800000 representing [1.0 .. 2.0)
        result = estimate<8:0> : Zeros(N-9);

    return result;
```

## Library pseudocode for shared/functions/vector/UnsignedRecipEstimate

```
// UnsignedRecipEstimate()
// =====

bits(N) UnsignedRecipEstimate(bits(N) operand)
    assert N IN {16,32};
    if operand<N-1> == '0' then // Operands <= 0x7FFFFFFF produce 0xFFFFFFFF
        result = Ones(N);
    else
        // input is in the range 0x80000000 .. 0xffffffff representing [0.5 .. 1.0)

        // estimate is in the range 256 to 511 representing [1.0 .. 2.0)
        case N of
            when 16 estimate = RecipEstimate(UInt(operand<15:7>));
            when 32 estimate = RecipEstimate(UInt(operand<31:23>));

        // result is in the range 0x80000000 .. 0xff800000 representing [1.0 .. 2.0)
        result = estimate<8:0> : Zeros(N-9);

    return result;
```

## Library pseudocode for shared/functions/vector/UnsignedSatQ

```
// UnsignedSatQ()
// =====

(bits(N), boolean) UnsignedSatQ(integer i, integer N)
    if i > 2^N - 1 then
        result = 2^N - 1; saturated = TRUE;
    elsif i < 0 then
        result = 0; saturated = TRUE;
    else
        result = i; saturated = FALSE;
    return (result<N-1:0>, saturated);
```

## Library pseudocode for shared/trace/selfhosted/SelfHostedTraceEnabled

```
// SelfHostedTraceEnabled()
// =====
// Returns TRUE if Self-hosted Trace is enabled.

boolean SelfHostedTraceEnabled()
    if !HaveTraceExt() || !HaveSelfHostedTrace() then return FALSE;
    if HaveEL(EL3) then
        secure_trace_enable = (if ELUsingAArch32(EL3) then SDCR.STE else MDCR_EL3.STE);
        niden = (secure_trace_enable == '0' || ExternalSecureNoninvasiveDebugEnabled());
    else
        // If no EL3, IsSecure() returns the Effective value of (SCR_EL3.NS == '0')
        niden = (!IsSecure() || ExternalSecureNoninvasiveDebugEnabled());
    return (EDSCR.TF0 == '0' || !niden);
```

## Library pseudocode for shared/trace/selfhosted/TraceAllowed

```
// TraceAllowed()
// =====
// Returns TRUE if Self-hosted Trace is allowed in the current Security state and Exception Level

boolean TraceAllowed()
    if !HaveTraceExt() then return FALSE;
    if SelfHostedTraceEnabled() then
        if IsSecure() && HaveEL(EL3) then
            secure_trace_enable = (if ELUsingAArch32(EL3) then SDCR.STE else MDCR_EL3.STE);
            if secure_trace_enable == '0' then return FALSE;
            TGE_bit = if EL2Enabled() then HCR_EL2.TGE else '0';
            case PSTATE.EL of
                when EL3 TRE_bit = if HighestELUsingAArch32() then TRFCR_EL3.TRE else '0';
                when EL2 TRE_bit = TRFCR_EL2.E2TRE;
                when EL1 TRE_bit = TRFCR_EL1.E1TRE;
                when EL0 TRE_bit = if TGE_bit == '1' then TRFCR_EL2.E0HTRE else TRFCR_EL1.E0TRE;
            return TRE_bit == '1';
        else
            return (!IsSecure() || ExternalSecureNoninvasiveDebugEnabled());
```

## Library pseudocode for shared/trace/selfhosted/TraceContextIDR2

```
// TraceContextIDR2()
// =====

boolean TraceContextIDR2()
    if !TraceAllowed() || !HaveEL(EL2) then return FALSE;
    return (!SelfHostedTraceEnabled() || TRFCR_EL2.CX == '1');
```

## Library pseudocode for shared/trace/selfhosted/TraceSynchronizationBarrier

```
// Memory barrier instruction that preserves the relative order of memory accesses to System
// registers due to trace operations and other memory accesses to the same registers
TraceSynchronizationBarrier();
```

## Library pseudocode for shared/trace/selfhosted/TraceTimeStamp

```
// TraceTimeStamp()
// =====

TimeStamp TraceTimeStamp()
    if SelfHostedTraceEnabled() then
        if HaveEL(EL2) then
            TS_el2 = TRFCR_EL2.TS;
            if TS_el2 == '10' then (-, TS_el2) = ConstrainUnpredictableBits(Unpredictable_EL2TIMESTAMP);
            case TS_el2 of
                when '00' /* falls through to check TRFCR_EL1.TS */
                when '01' return TimeStamp_Virtual;
                when '10' if HaveECVExt() then return TimeStamp_OffsetPhysical;
                when '11' return TimeStamp_Physical;
                otherwise Unreachable(); // ConstrainUnpredictableBits removes this case
            TS_el1 = TRFCR_EL1.TS;
            if TS_el1 == 'x0' then (-, TS_el1) = ConstrainUnpredictableBits(Unpredictable_EL1TIMESTAMP);
            case TS_el1 of
                when '01' return TimeStamp_Virtual;
                when '10' if HaveECVExt() then return TimeStamp_OffsetPhysical;
                when '11' return TimeStamp_Physical;
                otherwise Unreachable(); // ConstrainUnpredictableBits removes this case
        else
            return TimeStamp_CoreSight;
```

## Library pseudocode for shared/trace/system/IsTraceCorePowered

```
// Returns TRUE if the Trace Core Power Domain is powered up
boolean IsTraceCorePowered();
```

## Library pseudocode for shared/translation/attrs/CombineS1S2AttrHints

```
// CombineS1S2AttrHints()
// =====
// Combines cacheability attributes and allocation hints from stage 1 and stage 2

MemAttrHints CombineS1S2AttrHints(MemAttrHints s1desc, MemAttrHints s2desc)

    MemAttrHints result;

    apply_force_writeback = HaveStage2MemAttrControl() && HCR_EL2.FWB == '1';
    if apply_force_writeback then
        if HCR_EL2.CD == '1' then
            result.attrs = MemAttr_NC;    // force Non-cacheable
        elseif s2desc.attrs == '11' then
            result.attrs = s1desc.attrs;
        elseif s2desc.attrs == '10' then
            result.attrs = MemAttr_WB;    // force Write-back
        else
            result.attrs = MemAttr_NC;
    else
        if s2desc.attrs == '01' || s1desc.attrs == '01' then
            result.attrs = bits(2) UNKNOWN;    // Reserved
        elseif s2desc.attrs == MemAttr_NC || s1desc.attrs == MemAttr_NC then
            result.attrs = MemAttr_NC;    // Non-cacheable
        elseif s2desc.attrs == MemAttr_WT || s1desc.attrs == MemAttr_WT then
            result.attrs = MemAttr_WT;    // Write-through
        else
            result.attrs = MemAttr_WB;    // Write-back

    if result.attrs == MemAttr_NC then
        result.hints = MemHint_No;
    elseif apply_force_writeback then
        if s1desc.attrs != MemAttr_NC then
            result.hints = s1desc.hints;
        else
            result.hints = MemHint_RWA;
    else
        result.hints = s1desc.hints;
    result.transient = s1desc.transient;

    return result;
```

## Library pseudocode for shared/translation/attrs/CombineS1S2Device

```
// CombineS1S2Device()
// =====
// Combines device types from stage 1 and stage 2

DeviceType CombineS1S2Device(DeviceType s1device, DeviceType s2device)

    if s2device == DeviceType_nGnRnE || s1device == DeviceType_nGnRnE then
        result = DeviceType_nGnRnE;
    elseif s2device == DeviceType_nGnRE || s1device == DeviceType_nGnRE then
        result = DeviceType_nGnRE;
    elseif s2device == DeviceType_nGRE || s1device == DeviceType_nGRE then
        result = DeviceType_nGRE;
    else
        result = DeviceType_GRE;

    return result;
```

## Library pseudocode for shared/translation/attrs/LongConvertAttrsHints

```
// LongConvertAttrsHints()
// =====
// Convert the long attribute fields for Normal memory as used in the MAIR fields
// to orthogonal attributes and hints

MemAttrHints LongConvertAttrsHints(bits(4) attrfield, AccType acctype)
    assert !IsZero(attrfield);
    MemAttrHints result;
    if S1CacheDisabled(acctype) then                // Force Non-cacheable
        result.attrs = MemAttr_NC;
        result.hints = MemHint_No;
    else
        if attrfield<3:2> == '00' then              // Write-through transient
            result.attrs = MemAttr_WT;
            result.hints = attrfield<1:0>;
            result.transient = TRUE;
        elsif attrfield<3:0> == '0100' then        // Non-cacheable (no allocate)
            result.attrs = MemAttr_NC;
            result.hints = MemHint_No;
            result.transient = FALSE;
        elsif attrfield<3:2> == '01' then          // Write-back transient
            result.attrs = MemAttr_WB;
            result.hints = attrfield<1:0>;
            result.transient = TRUE;
        else                                        // Write-through/Write-back non-transient
            result.attrs = attrfield<3:2>;
            result.hints = attrfield<1:0>;
            result.transient = FALSE;

    return result;
```

## Library pseudocode for shared/translation/attrs/MemAttrDefaults

```
// MemAttrDefaults()
// =====
// Supply default values for memory attributes, including overriding the shareability attributes
// for Device and Non-cacheable memory types.

MemoryAttributes MemAttrDefaults(MemoryAttributes memattrs)

    if memattrs.memtype == MemType_Device then
        memattrs.inner = MemAttrHints UNKNOWN;
        memattrs.outer = MemAttrHints UNKNOWN;
        memattrs.shareable = TRUE;
        memattrs.outershareable = TRUE;
    else
        memattrs.device = DeviceType UNKNOWN;
        if memattrs.inner.attrs == MemAttr_NC && memattrs.outer.attrs == MemAttr_NC then
            memattrs.shareable = TRUE;
            memattrs.outershareable = TRUE;

    return memattrs;
```



## Library pseudocode for shared/translation/attrs/S1CacheDisabled

```
// S1CacheDisabled()
// =====

boolean S1CacheDisabled(AccType acctype)
  if ELUsingAArch32(S1TranslationRegime()) then
    if PSTATE.EL == EL2 then
      enable = if acctype == AccType_IFETCH then HSCTLR.I else HSCTLR.C;
    else
      enable = if acctype == AccType_IFETCH then SCTLR.I else SCTLR.C;
  else
    enable = if acctype == AccType_IFETCH then SCTLR[].I else SCTLR[].C;
  return enable == '0';
```

## Library pseudocode for shared/translation/attrs/S2AttrDecode

```
// S2AttrDecode()
// =====
// Converts the Stage 2 attribute fields into orthogonal attributes and hints

MemoryAttributes S2AttrDecode(bits(2) SH, bits(4) attr, AccType acctype)

  MemoryAttributes memattrs;

  apply_force_writeback = HaveStage2MemAttrControl() && HCR_EL2.FWB == '1';

  // Device memory
  if (apply_force_writeback && attr<2> == '0') || attr<3:2> == '00' then
    memattrs.memtype = MemType_Device;
    case attr<1:0> of
      when '00' memattrs.device = DeviceType_nGnRnE;
      when '01' memattrs.device = DeviceType_nGnRE;
      when '10' memattrs.device = DeviceType_nGRE;
      when '11' memattrs.device = DeviceType_GRE;

  // Normal memory
  elseif apply_force_writeback then
    if attr<2> == '1' then
      memattrs.memtype = MemType_Normal;
      memattrs.inner.attrs = attr<1:0>;
      memattrs.outer.attrs = attr<1:0>;
      memattrs.shareable = SH<1> == '1';
      memattrs.outershareable = SH == '10';
    elseif attr<1:0> != '00' then
      memattrs.memtype = MemType_Normal;
      memattrs.outer = S2ConvertAttrsHints(attr<3:2>, acctype);
      memattrs.inner = S2ConvertAttrsHints(attr<1:0>, acctype);
      memattrs.shareable = SH<1> == '1';
      memattrs.outershareable = SH == '10';
    else
      memattrs = MemoryAttributes UNKNOWN; // Reserved

  return MemAttrDefaults(memattrs);
```

## Library pseudocode for shared/translation/attrs/S2CacheDisabled

```
// S2CacheDisabled()
// =====

boolean S2CacheDisabled(AccType acctype)
  if ELUsingAArch32(EL2) then
    disable = if acctype == AccType_IFETCH then HCR2.ID else HCR2.CD;
  else
    disable = if acctype == AccType_IFETCH then HCR_EL2.ID else HCR_EL2.CD;
  return disable == '1';
```

## Library pseudocode for shared/translation/attrs/S2ConvertAttrsHints

```
// S2ConvertAttrsHints()
// =====
// Converts the attribute fields for Normal memory as used in stage 2
// descriptors to orthogonal attributes and hints

MemAttrHints S2ConvertAttrsHints(bits(2) attr, AccType acctype)
    assert !IsZero(attr);

    MemAttrHints result;

    if S2CacheDisabled(acctype) then                                // Force Non-cacheable
        result.attrs = MemAttr\_NC;
        result.hints = MemHint\_No;
    else
        case attr of
            when '01'                                              // Non-cacheable (no allocate)
                result.attrs = MemAttr\_NC;
                result.hints = MemHint\_No;
            when '10'                                              // Write-through
                result.attrs = MemAttr\_WT;
                result.hints = MemHint\_RWA;
            when '11'                                              // Write-back
                result.attrs = MemAttr\_WB;
                result.hints = MemHint\_RWA;

    result.transient = FALSE;

    return result;
```

## Library pseudocode for shared/translation/attrs/ShortConvertAttrsHints

```
// ShortConvertAttrsHints()
// =====
// Converts the short attribute fields for Normal memory as used in the TTBR and
// TEX fields to orthogonal attributes and hints

MemAttrHints ShortConvertAttrsHints(bits(2) RGN, AccType acctype, boolean secondstage)

    MemAttrHints result;

    if (!secondstage && S1CacheDisabled(acctype)) || (secondstage && S2CacheDisabled(acctype)) then
        // Force Non-cacheable
        result.attrs = MemAttr\_NC;
        result.hints = MemHint\_No;
    else
        case RGN of
            when '00'                                              // Non-cacheable (no allocate)
                result.attrs = MemAttr\_NC;
                result.hints = MemHint\_No;
            when '01'                                              // Write-back, Read and Write allocate
                result.attrs = MemAttr\_WB;
                result.hints = MemHint\_RWA;
            when '10'                                              // Write-through, Read allocate
                result.attrs = MemAttr\_WT;
                result.hints = MemHint\_RA;
            when '11'                                              // Write-back, Read allocate
                result.attrs = MemAttr\_WB;
                result.hints = MemHint\_RA;

    result.transient = FALSE;

    return result;
```

## Library pseudocode for shared/translation/attrs/WalkAttrDecode

```
// WalkAttrDecode()
// =====

MemoryAttributes WalkAttrDecode(bits(2) SH, bits(2) ORGN, bits(2) IRGN, boolean secondstage)

    MemoryAttributes memattrs;

    AccType acctype = AccType_NORMAL;

    memattrs.memtype = MemType_Normal;
    memattrs.inner = ShortConvertAttrsHints(IRGN, acctype, secondstage);
    memattrs.outer = ShortConvertAttrsHints(ORGN, acctype, secondstage);
    memattrs.shareable = SH<1> == '1';
    memattrs.outershareable = SH == '10';
    memattrs.tagged = FALSE;

    return MemAttrDefaults(memattrs);
```

## Library pseudocode for shared/translation/translation/HasS2Translation

```
// HasS2Translation()
// =====
// Returns TRUE if stage 2 translation is present for the current translation regime

boolean HasS2Translation()
    return (EL2Enabled() && !IsInHost()) && PSTATE.EL IN {EL0, EL1});
```

## Library pseudocode for shared/translation/translation/Have16bitVMID

```
// Have16bitVMID()
// =====
// Returns TRUE if EL2 and support for a 16-bit VMID are implemented.

boolean Have16bitVMID()
    return HaveEL(EL2) && boolean IMPLEMENTATION_DEFINED;
```

## Library pseudocode for shared/translation/translation/PAMax

```
// PAMax()
// =====
// Returns the IMPLEMENTATION_DEFINED upper limit on the physical address
// size for this processor, as log2().

integer PAMax()
    return integer IMPLEMENTATION_DEFINED "Maximum Physical Address Size";
```

## Library pseudocode for shared/translation/translation/S1TranslationRegime

```
// S1TranslationRegime()
// =====
// Stage 1 translation regime for the given Exception level

bits(2) S1TranslationRegime(bits(2) el)
    if el != EL0 then
        return el;
    elsif HaveEL(EL3) && ELUsingAArch32(EL3) && SCR.NS == '0' then
        return EL3;
    elsif HaveVirtHostExt() && ELIsInHost(el) then
        return EL2;
    else
        return EL1;

// S1TranslationRegime()
// =====
// Returns the Exception level controlling the current Stage 1 translation regime. For the most
// part this is unused in code because the system register accessors (SCTLR[], etc.) implicitly
// return the correct value.

bits(2) S1TranslationRegime()
    return S1TranslationRegime(PSTATE.EL);
```

## Library pseudocode for shared/translation/translation/VAMax

```
// VAMax()
// =====
// Returns the IMPLEMENTATION DEFINED upper limit on the virtual address
// size for this processor, as log2().

integer VAMax()
    return integer IMPLEMENTATION_DEFINED "Maximum Virtual Address Size";
```

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