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# **ST10 FAMILY PROGRAMMING MANUAL**



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# Introduction

This programming manual details the instruction set for the ST10 family of products. The manual is arranged in two sections. *Section 1* details the standard instruction set and includes all of the basic instructions. *Section 2* details the extension to the instruction set provided by the MAC. The MAC instructions are only available to devices containing the MAC, refer to the datasheet for device-specific information.

In the standard instruction set, addressing modes, instruction execution times, minimum state times and the causes of additional state times are defined. Cross reference tables of instruction mnemonics, hexadecimal opcode, address modes and number of bytes, are provided for the optimization of instruction sequences. Instruction set tables ordered by functional group, can be used to identify the best instruction for a given application. Instruction set tables ordered by hexadecimal opcode can be used to identify specific instructions when reading executable code i.e. during the de-bugging phase. Finally, each instruction is described individually on a page of standard format, using the conventions defined in this manual. For ease of use, the instructions are listed alphabetically.

The MAC instruction set is divided into its 5 functional groups: Multiply and Multiply-Accumulate, 32-Bit Arithmetic, Shift, Compare and Transfer Instructions. Two new addressing modes supply the MAC with up to 2 new operands per instruction. Cross reference tables of MAC instruction mnemonics by address mode, and MAC instruction mnemonic by functional code can be used for quick reference. As for the standard instruction set, each instruction has been described individually in a standard format according to defined conventions. For convenience, the instructions are described in alphabetical order.

# 1 Standard Instruction Set

## 1.1 Addressing modes

### 1.1.1 Short addressing modes

The ST10 family of devices use several powerful addressing modes for access to word, byte and bit data. This section describes short, long and indirect address modes, constants and branch target addressing modes.

Short addressing modes use an implicit base offset address to specify the 24-bit physical address.

Short addressing modes give access to the GPR, SFR or bit-addressable memory space

$$\text{PhysicalAddress} = \text{BaseAddress} + \Delta \times \text{ShortAddress}$$

Note:  $\Delta = 1$  for byte GPRs,  $\Delta = 2$  for word GPRs.

Mnemo	Physical Address	Short Address Range	Scope of Access
Rw	(CP) + 2*Rw	Rw = 0...15	GPRs (Word) 16 values
Rb	(CP) + 1*Rb	Rb = 0...15	GPRs (Byte) 16 values
reg	00'FE00h + 2*reg	reg = 00h...EFh	SFRs (Word, Low byte)
	00'F000h + 2*reg	reg = 00h...EFh	ESFRs (Word, Low byte)
	(CP) + 2*(reg^0Fh)	reg = F0h...FFh	GPRs (Word) 16 values
	(CP) + 1*(reg^0Fh)	reg = F0h...FFh	GPRs (Bytes) 16 values
bitoff	00'FD00h + 2*bitoff	bitoff = 00h...7Fh	RAM Bit word offset 128 values
	00'FF00h + 2*(bitoff^FFh)	bitoff = 80h...EFh	SFR Bit word offset 128 values
	(CP) + 2*(bitoff^0Fh)	bitoff = F0h...FFh	GPR Bit word offset 16 values
bitaddr	Word offset as with bitoff.	bitoff = 00h...FFh	Any single bit
	Immediate bit position.	bitpos = 0...15	

Table 1 Short addressing mode summary

- Rw, Rb: Specifies direct access to any GPR in the currently active context (register bank). Both 'Rw' and 'Rb' require four bits in the instruction format. The base address of the current register bank is determined by the content of register CP. 'Rw' specifies a 4-bit word GPR address relative to the base address (CP), while 'Rb' specifies a 4 bit byte GPR address relative to the base address (CP).
- reg: Specifies direct access to any (E)SFR or GPR in the currently active context (register bank). 'reg' requires eight bits in the instruction format. Short 'reg' addresses from 00h to EFh always specify (E)SFRs. In this case, the factor 'Δ' equals 2 and the base address is 00'F000h for the standard SFR area, or 00'FE00h for the extended ESFR area. 'reg' accesses to the ESFR area require a preceding EXT\*R instruction to switch the base address. Depending on the opcode of an instruction, either the total word (for word operations), or the low byte (for byte operations) of an SFR can be addressed via 'reg'. Note that the high byte of an SFR cannot be accessed by the 'reg' addressing mode. Short 'reg' addresses from F0h to FFh always specify GPRs. In this case, only the lower four bits of 'reg' are significant for physical address generation, therefore it can be regarded as identical to the address generation described for the 'Rb' and 'Rw' addressing modes.
- bitoff: Specifies direct access to any word in the bit-addressable memory space. 'bitoff' requires eight bits in the instruction format. Depending on the specified 'bitoff' range, different base addresses are used to generate physical addresses: Short 'bitoff' addresses from 00h to 7Fh use 00'FD00h as a base address, therefore they specify the 128 highest internal RAM word locations (00'FD00h to 00'FDFEh). Short 'bitoff' addresses from 80h to EFh use 00'FF00h as a base address to specify the highest internal SFR word locations (00'FF00h to 00'FFDEh) or use 00'F100h as a base address to specify the highest internal ESFR word locations (00'F100h to 00'F1DEh). 'bitoff' accesses to the ESFR area require a preceding EXT\*R instruction to switch the base address. For short 'bitoff' addresses from F0h to FFh, only the lowest four bits and the contents of the CP register are used to generate the physical address of the selected word GPR.
- bitaddr: Any bit address is specified by a word address within the bit-addressable memory space (see 'bitoff'), and by a bit position ('bitpos') within that word. Thus, 'bitaddr' requires twelve bits in the instruction format.

## 1.1.2 Long addressing mode

Long addressing mode uses one of the four DPP registers to specify a physical 18-bit or 24-bit address. Any word or byte data within the entire address space can be accessed in this mode. All devices support an override mechanism for the DPP addressing scheme (see section 1.1.3).

*Note Word accesses on odd byte addresses are not executed, but rather trigger a hardware trap. After reset, the DPP registers are initialized so that all long addresses are directly mapped onto the identical physical addresses, within segment 0.*

Long addresses (16-bit) are treated in two parts. Bits 13...0 specify a 14-bit data page offset, and bits 15...14 specify the Data Page Pointer (1 of 4). The DPP is used to generate the physical 24-bit address (see figure below).

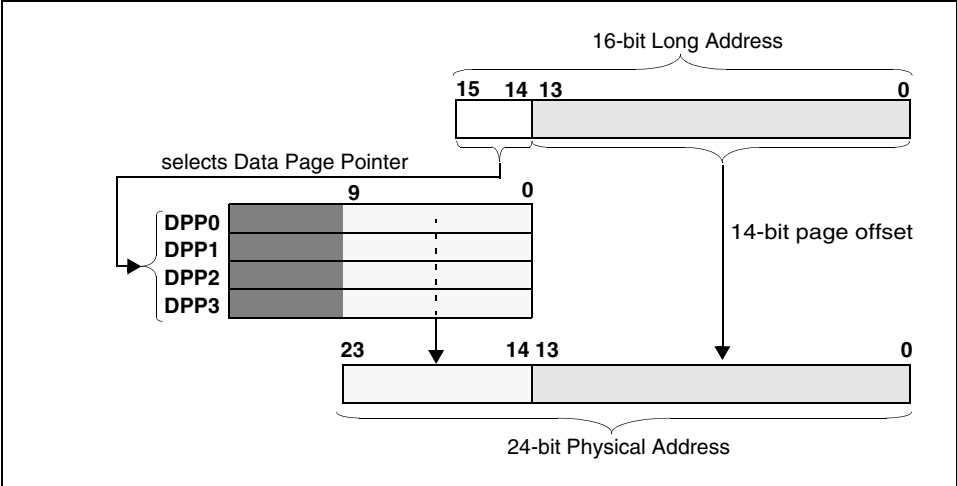


Figure 1 Interpretation of a 16-bit long address

All ST10 devices support an address space of up to 16 MByte, so only the lower ten bits of the selected DPP register content are concatenated with the 14-bit data page offset to build the physical address.

The long addressing mode is referred to by the mnemonic “mem”.

Mnemo	Physical Address		Long Address Range	Scope of Access
mem	(DPP0)	mem^3FFFh	0000h...3FFFh	Any Word or Byte
	(DPP1)	mem^3FFFh	4000h...7FFFh	
	(DPP2)	mem^3FFFh	8000h...BFFFh	
	(DPP3)	mem^3FFFh	C000h...FFFFh	
mem	pag	mem^3FFFh	0000h...FFFFh (14-bit)	Any Word or Byte
mem	seg	mem	0000h...FFFFh (16-bit)	Any Word or Byte

Table 2 Summary of long address modes

1.1.3 DPP override mechanism

The DPP override mechanism temporarily bypasses the DPP addressing scheme.

The EXTP(R) and EXTS(R) instructions override this addressing mechanism. Instruction EXTP(R) replaces the content of the respective DPP register, while instruction EXTS(R) concatenates the complete 16-bit long address with the specified segment base address. The overriding page or segment may be specified directly as a constant (#pag, #seg) or by a word GPR (Rw).

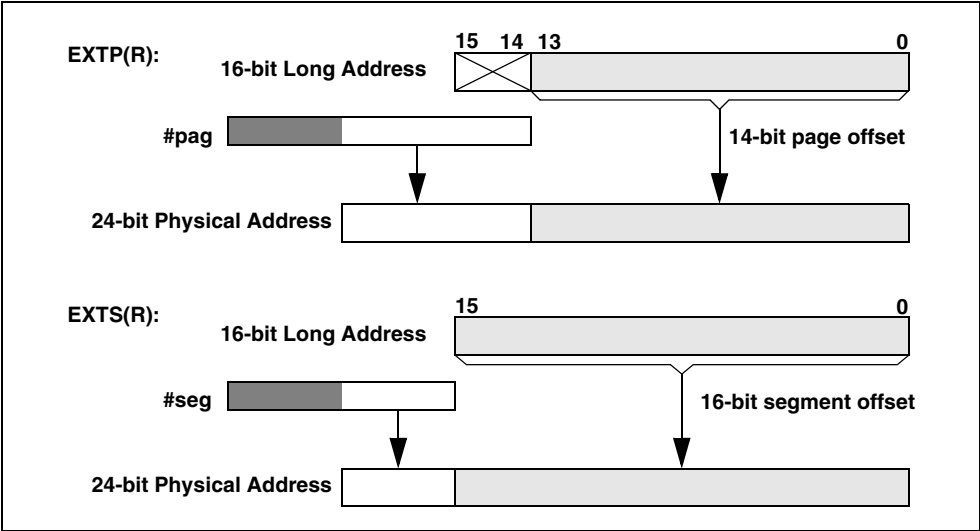


Figure 2 Overriding the DPP mechanism



### 1.1.4 Indirect addressing modes

Indirect addressing modes can be considered as a combination of short and long addressing modes. In this mode, long 16-bit addresses are specified indirectly by the contents of a word GPR, which is specified directly by a short 4-bit address ('Rw'=0 to 15). Some indirect addressing modes add a constant value to the GPR contents before the long 16-bit address is calculated. Other indirect addressing modes allow decrementing or incrementing of the indirect address pointers (GPR content) by 2 or 1 (referring to words or bytes).

In each case, one of the four DPP registers is used to specify the physical 18-bit or 24-bit addresses. Any word or byte data within the entire memory space can be addressed indirectly. Note that EXTP(R) and EXT(S) instructions override the DPP mechanism.

Instructions using the lowest four word GPRs (R3...R0) as indirect address pointers are specified by short 2-bit addresses.

Word accesses on odd byte addresses are not executed, but rather trigger a hardware trap. After reset, the DPP registers are initialized in a way that all indirect long addresses are directly mapped onto the identical physical addresses.

Physical addresses are generated from indirect address pointers by the following algorithm:

- 1 Calculate the physical address of the word GPR which is used as indirect address pointer, by using the specified short address ('Rw') and the current register bank base address (CP).

$$\text{GPRAddress} = (\text{CP}) + 2 \times \text{ShortAddress} - \Delta; [\text{optionalstep!}]$$

- 2 Pre-decremented indirect address pointers ('-Rw') are decremented by a data-type-dependent value ( $\Delta = 1$  for byte operations,  $\Delta = 2$  for word operations), before the long 16-bit address is generated:

$$(\text{GPRAddress}) = (\text{GPRAddress}) - \Delta; [\text{optionalstep!}]$$

- 3 Calculate the long 16-bit address by adding a constant value (if selected) to the content of the indirect address pointer:

$$\text{Long Address} = (\text{GPR Pointer}) + \text{Constant}$$

- 4 Calculate the physical 18-bit or 24-bit address using the resulting long address and the corresponding DPP register content (see long 'mem' addressing modes).

$$\text{Physical Address} = (\text{DPPi}) + \text{Page offset}$$

- 5 Post-Incremented indirect address pointers ('Rw+') are incremented by a data-type-dependent value ( $\Delta = 1$  for byte operations,  $\Delta = 2$  for word operations):

$$(\text{GPRPointer}) = (\text{GPRPointer}) + \Delta; [\text{optionalstep!}]$$

The following indirect addressing modes are provided:

Mnemonic	Notes
[Rw]	Most instructions accept any GPR (R15...R0) as indirect address pointer. Some instructions, however, only accept the lower four GPRs (R3...R0).
[Rw+]	The specified indirect address pointer is automatically incremented by 2 or 1 (for word or byte data operations) after the access.
[-Rw]	The specified indirect address pointer is automatically decremented by 2 or 1 (for word or byte data operations) before the access.
[Rw+#data <sub>16</sub> ]	A 16-bit constant and the contents of the indirect address pointer are added before the long 16-bit address is calculated.

Table 3 Table of indirect address modes

1.1.5 Constants

The ST10 Family instruction set supports the use of wordwide or bytewise immediate constants. For optimum utilization of the available code storage, these constants are represented in the instruction formats by either 3, 4, 8 or 16 bits. Therefore, short constants are always zero-extended, while long constants can be truncated to match the data format required for the operation (see table below):

Mnemonic	Word operation	Byte operation
#data <sub>3</sub>	0000 <sub>h</sub> + data <sub>3</sub>	00 <sub>h</sub> + data <sub>3</sub>
#data <sub>4</sub>	0000 <sub>h</sub> + data <sub>4</sub>	00 <sub>h</sub> + data <sub>4</sub>
#data <sub>8</sub>	0000 <sub>h</sub> + data <sub>8</sub>	data <sub>8</sub>
#data <sub>16</sub>	data <sub>16</sub>	data <sub>16</sub> ^ FF <sub>h</sub>
#mask	0000 <sub>h</sub> + mask	mask

Table 4 Table of constants

*Note* Immediate constants are always signified by a leading number sign “#”.

## 1.1.6 Branch target addressing modes

Jump and Call instructions use different addressing modes to specify the target address and segment. Relative, absolute and indirect modes can be used to update the Instruction Pointer register (IP), while the Code Segment Pointer register (CSP) can only be updated with an absolute value. A special mode is provided to address the interrupt and trap jump vector table situated in the lowest portion of code segment 0.

Mnemo	Target Address		Target Segment	Valid Address Range	
caddr	(IP)	= caddr	-	caddr	= 0000h...FFFEh
rel	(IP)	= (IP) + 2*rel	-	rel	= 00h...7Fh
	(IP)	= (IP) + 2*(~rel+1)	-	rel	= 80h...FFh
[Rw]	(IP)	= ((CP) + 2*Rw)	-	Rw	= 0...15
seg	-		(CSP) = seg	seg	= 0...255
#trap <sub>7</sub>	(IP)	= 0000h + 4*trap <sub>7</sub>	(CSP) = 0000h	trap <sub>7</sub>	= 00h...7Fh

**Table 5 Branch target address summary**

- caddr:** Specifies an absolute 16-bit code address within the current segment. Branches MAY NOT be taken to odd code addresses. Therefore, the least significant bit of 'caddr' must always contain a '0', otherwise a hardware trap would occur.
- rel:** Represents an 8-bit signed word offset address relative to the current Instruction Pointer contents which points to the instruction after the branch instruction. Depending on the offset address range, either forward ('rel' = 00h to 7Fh) or backward ('rel' = 80h to FFh) branches are possible. The branch instruction itself is repeatedly executed, when 'rel' = '-1' (FF<sub>h</sub>) for a word-sized branch instruction, or 'rel' = '-2' (FEh) for a double-word-sized branch instruction.
- [Rw]:** The 16-bit branch target instruction address is determined indirectly by the content of a word GPR. In contrast to indirect data addresses, indirectly specified code addresses are NOT calculated by additional pointer registers (e.g. DPP registers). Branches MAY NOT be taken to odd code addresses. Therefore, to prevent a hardware trap, the least significant bit of the address pointer GPR must always contain a '0'.
- seg:** Specifies an absolute code segment number. All devices support 256 different code segments, so only the eight lower bits of the 'seg' operand value are used for updating the CSP register.
- #trap<sub>7</sub>:** Specifies a particular interrupt or trap number for branching to the corresponding interrupt or trap service routine by a jump vector table. Trap numbers from 00h to 7Fh can be specified, which allows access to any double word code location within the address range 00'0000h...00'01FCh in code segment 0 (i.e. the interrupt jump vector table). For further information on the relation between trap numbers and interrupt or trap sources, refer to the device user manual section on "Interrupt and Trap Functions".

## 1.2 Instruction execution times

The instruction execution time depends on where the instruction is fetched from, and where the operands are read from or written to. The fastest processing mode is to execute a program fetched from the internal ROM. In this case most of the instructions can be processed in just one machine cycle.

All external memory accesses are performed by the on-chip External Bus Controller (EBC) which works in parallel with the CPU. Instructions from external memory cannot be processed as fast as instructions from the internal ROM, because it is necessary to perform data transfers sequentially via the external interface. In contrast to internal ROM program execution, the time required to process an external program additionally depends on the length of the instructions and operands, on the selected bus mode, and on the duration of an external memory cycle.

Processing a program from the internal RAM space is not as fast as execution from the internal ROM area, but it is flexible (i.e. for loading temporary programs into the internal RAM via the chip's serial interface, or end-of-line programming via the bootstrap loader).

The following description evaluates the minimum and maximum program execution times, which is sufficient for most requirements. For an exact determination of the instructions' state times, the facilities provided by simulators or emulators should be used.

This section defines measurement units, summarizes the minimum (standard) state times of the 16-bit microcontroller instructions, and describes the exceptions from the standard timing.

### 1.2.1 Definition of measurement units

The following measurement units are used to define instruction processing times:

[ $f_{CPU}$ ]: CPU operating frequency (may vary from 1 MHz to 50 MHz).

[State]: One state time is specified by one CPU clock period. Therefore, one State is used as the basic time unit, because it represents the shortest period of time which has to be considered for instruction timing evaluations.

$$1 \text{ [State]} = 1/f_{CPU}[\text{s}] \quad ; \text{ for } f_{CPU} = \text{variable}$$

$$= 50[\text{ns}] \quad ; \text{ for } f_{CPU} = 20 \text{ MHz}$$

[ $f_{\text{CPU}}$ ]: CPU operating frequency (may vary from 1 MHz to 50 MHz).

[ACT]: ALE (Address Latch Enable) Cycle Time specifies the time required to perform one external memory access. One ALE Cycle Time consists of either two (for demultiplexed external bus modes) or three (for multiplexed external bus modes) state times plus a number of state times, which is determined by the number of waitstates programmed in the MCTC (Memory Cycle Time Control) and MTTC (Memory Tristate Time Control) bit fields of the SYSCON/ BUSCONx registers.

For demultiplexed external bus modes:

$$\begin{aligned} 1 \cdot \text{ACT} &= (2 + (15 - \text{MCTC}) + (1 - \text{MTTC})) \cdot \text{States} \\ &= 100 \text{ n... } 900 \text{ ns ; for } f_{\text{CPU}} = 20 \text{ MHz} \end{aligned}$$

For multiplexed external bus modes:

$$\begin{aligned} 1 \cdot \text{ACT} &= (3 + (15 - \text{MCTC}) + (1 - \text{MTTC})) \cdot \text{States} \\ &= 150 \text{ ns ... } 950 \text{ ns ; for } f_{\text{CPU}} = 20 \text{ MHz} \end{aligned}$$

$T_{\text{tot}}$  The total time ( $T_{\text{tot}}$ ) taken to process a particular part of a program can be calculated by the sum of the single instruction processing times ( $T_{\text{In}}$ ) of the considered instructions plus an offset value of 6 state times which takes into account the solitary filling of the pipeline:

$$T_{\text{tot}} = T_{\text{I1}} + T_{\text{I2}} + \dots + T_{\text{In}} + 6 \cdot \text{States}$$

$T_{\text{In}}$  The time ( $T_{\text{In}}$ ) taken to process a single instruction, consists of a minimum number ( $T_{\text{Imin}}$ ) plus an additional number ( $T_{\text{Iadd}}$ ) of instruction state times and/or ALE Cycle Times:

$$T_{\text{In}} = T_{\text{Imin}} + T_{\text{Iadd}}$$

### 1.2.2 Minimum state times

The table below shows the minimum number of state times required to process an instruction fetched from the internal ROM ( $T_{Imin} (ROM)$ ). This table can also be used to calculate the minimum number of state times for instructions fetched from the internal RAM ( $T_{Imin} (RAM)$ ), or ALE Cycle Times for instructions fetched from the external memory ( $T_{Imin} (ext)$ ).

Most of the 16-bit microcontroller instructions (except some branch, multiplication, division and a special move instructions) require a minimum of two state times. For internal ROM program execution, execution time has no dependence on instruction length, except for some special branch situations.

To evaluate the execution time for the injected target instruction of a cache jump instruction, it can be considered as if it was executed from the internal ROM, regardless of which memory area the rest of the current program is really fetched from.

For some of the branch instructions the table below represents both the standard number of state times (i.e. the corresponding branch is taken) and an additional  $T_{Imin}$  value in parentheses, which refers to the case where, either the branch condition is not met, or a cache jump is taken.

Instruction	$T_{Imin} (ROM)$ [States]	$T_{Imin} (ROM)$ (20MHz CPU clk)
CALLI, CALLA	4 (2)	200 (100)
CALLS, CALLR, PCALL	4	200
JB, JBC, JNB, JNBS	4 (2)	200 (100)
JMPS	4	200
JMPA, JMPI, JMPR	4 (2)	200 (100)
MUL, MULU	10	500
DIV, DIVL, DIVU, DIVLU	20	1000
MOV[B] Rn, [Rm + #data <sub>16</sub> ]	4	200
RET, RETI, RETP, RETS	4	200
TRAP	4	200
All other instructions	2	100

Table 6 Minimum instruction state times [Unit = ns]

Instructions executed from the internal RAM require the same minimum time as they would if they were fetched from the internal ROM, plus an instruction-length dependent number of state times, as follows:

- For 2-byte instructions:  $T_{lmin}(RAM) = T_{lmin}(ROM) + 4 * States$
- For 4-byte instructions:  $T_{lmin}(RAM) = T_{lmin}(ROM) + 6 * States$

Unlike internal ROM program execution, the minimum time  $T_{lmin}(ext)$  to process an external instruction also depends on instruction length.  $T_{lmin}(ext)$  is either 1 ALE Cycle Time for most of the 2-byte instructions, or 2 ALE Cycle Times for most of the 4-byte instructions. The following formula represents the minimum execution time of instructions fetched from an external memory via a 16-bit wide data bus:

- For 2-byte instructions:  $T_{lmin}(ext) = 1 * ACT + (T_{lmin}(ROM) - 2) * States$
- For 4-byte instructions:  $T_{lmin}(ext) = 2 * ACTs + (T_{lmin}(ROM) - 2) * States$

*Note For instructions fetched from an external memory via an 8-bit wide data bus, the minimum number of required ALE Cycle Times is twice the number for those of a 16-bit wide bus.*

### 1.2.3 Additional state times

Some operand accesses can extend the execution time of an instruction  $T_{ln}$ . Since the additional time  $T_{ladd}$  is generally caused by internal instruction pipelining, it may be possible to minimize the effect by rearranging the instruction sequences. Simulators and emulators offer a high level of programmer support for program optimization.

The following operands require additional state times:

**Internal ROM operand reads:**  $T_{ladd} = 2 * States$

Both byte and word operand reads always require 2 additional state times.

**Internal RAM operand reads via indirect addressing modes:**  $T_{ladd} = 0$  or  $1 * State$

Reading a GPR or any other directly addressed operand within the internal RAM space does NOT cause additional state times. However, reading an indirectly addressed internal RAM operand will extend the processing time by 1 state time, if the preceding instruction auto-increments or auto-decrements a GPR, as shown in the following example:

$I_n$	: MOV R1, [R0+]	; auto-increment R0
$I_{n+1}$	: MOV [R3], [R2]	; if R2 points into the internal RAM space:
		; $T_{ladd} = 1 * State$

In this case, the additional time can be avoided by putting another suitable instruction before the instruction  $I_{n+1}$  indirectly reading the internal RAM.

**Internal SFR operand reads:**  $T_{Iadd} = 0, 1 * \text{State}$  or  $2 * \text{States}$ 

SFR read accesses do NOT usually require additional processing time. In some rare cases, however, either one or two additional state times will be caused by particular SFR operations:

- Reading an SFR immediately after an instruction, which writes to the internal SFR space, as shown in the following example:

```

In           : MOV    T0, #1000h    ; write to Timer 0
In+1         : ADD    R3, T1         ; read from Timer 1: TIadd = 1 * State

```

- Reading the PSW register immediately after an instruction which implicitly updates the flags as shown in the following example:

```

In           : ADD    R0, #1000h    ; implicit modification of PSW flags
In+1         : BAND   C, Z          ; read from PSW: TIadd = 2 * States

```

- Implicitly incrementing or decrementing the SP register immediately after an instruction which explicitly writes to the SP register, as shown in the following example:

```

In           : MOV    SP, #0FB00h ; explicit update of the stack pointer
In+1         : SCXT   R1, #1000h   ; implicit decrement of the stack pointer:
                                   ; TIadd = 2 * States

```

In each of these above cases, the extra state times can be avoided by putting other suitable instructions before the instruction  $I_{n+1}$  reading the SFR.

**External operand reads:**  $T_{Iadd} = 1 * \text{ACT}$ 

Any external operand reading via a 16-bit wide data bus requires one additional ALE Cycle Time. Reading word operands via an 8-bit wide data bus takes twice as much time (2 ALE Cycle Times) as the reading of byte operands.

**External operand writes:**  $T_{Iadd} = 0 * \text{State} \dots 1 * \text{ACT}$ 

Writing an external operand via a 16-bit wide data bus takes one additional ALE Cycle Time. For timing calculations of external program parts, this extra time must always be considered. The value of  $T_{Iadd}$  which must be considered for timing evaluations of internal program parts, may fluctuate between 0 state times and 1 ALE Cycle Time. This is because external writes are normally performed in parallel to other CPU operations. Thus,  $T_{Iadd}$  could already have been considered in the standard processing time of another instruction. Writing a word operand via an 8-bit wide data bus requires twice as much time (2 ALE Cycle Times) as the writing of a byte operand.



**Jumps into the internal ROM space:**  $T_{\text{Iadd}} = 0$  or  $2 * \text{States}$ 

The minimum time of 4 state times for standard jumps into the internal ROM space will be extended by 2 additional state times, if the branch target instruction is a double word instruction at a non-aligned double word location (xxx2h, xxx6h, xxxAh, xxxEh), as shown in the following example:

```
label      : ....                ; any non-aligned double word instruction
                                   ; (e.g. at location 0FFEh)

....       : ....

In+1      : JMPA cc_UC, label    ; if a standard branch is taken:
                                   ; TIadd = 2 * States (TIn = 6 * States)
```

A cache jump, which normally requires just 2 state times, will be extended by 2 additional state times, if both the cached jump target instruction and the following instruction are non-aligned double word instructions, as shown in the following example:

```
label      : ....                ; any non-aligned double word instruction
                                   ; (e.g. at location 12FAh)

In+1      : ....                ; any non-aligned double word instruction
                                   ; (e.g. at location 12FEh)

In+1      : JMPR cc_UC, label    ; provided that a cache jump is taken:
                                   ; TIadd = 2 * States (TIn = 4 * States)
```

If necessary, these extra state times can be avoided by allocating double word jump target instructions to aligned double word addresses (xxx0h, xxx4h, xxx8h, xxxCh).

**Testing Branch Conditions:**  $T_{\text{Iadd}} = 0$  or  $1 * \text{States}$ 

NO extra time is usually required for a conditional branch instructions to decide whether a branch condition is met or not. However, an additional state time is required if the preceding instruction writes to the PSW register, as shown in the following example:

```
In        : BSET USR0          ; implicit modification of PSW flags

In+1      : JMPR cc_Z, label    ; test condition flag in PSW: TIadd = 1 * State
```

In this case, the extra state time can be intercepted by putting another suitable instruction before the conditional branch instruction.

## 1.3 Instruction set summary

The following table lists the instruction mnemonic by hex-code with operand.

**Table 7 Instruction mnemonic by hex-code with operand**

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Table 8 lists the instructions by their mnemonic and identifies the addressing modes that may be used with a specific instruction and the instruction length, depending on the selected addressing mode (in bytes).

Mnemonic	Addressing modes	Bytes	Mnemonic	Addressing modes	Bytes
ADD[B]	$Rw_n^{-1}, Rw_m^{-1}$	2	CPL[B]	$Rw_n^{-1}$	2
ADDC[B]	$Rw_n^{-1}, [Rw_i]$	2	NEG[B]		
AND[B]	$Rw_n^{-1}, [Rw_i+]$	2	DIV	$Rw_n$	2
OR[B]	$Rw_n^{-1}, \#data_3$	2	DIVL		
SUB[B]	reg, $\#data_{16}$	4	DIVLU		
SUBC[B]	reg, mem	4	DIVU		
XOR[B]	mem, reg	4	MUL	$Rw_n, Rw_m$	2
			MULU		
ASHR	$Rw_n, Rw_m$	2	CMPD1/2	$Rw_n, \#data_4$	2
ROL / ROR	$Rw_n, \#data_4$	2	CMPI1/2	$Rw_n, \#data_{16}$	4
SHL / SHR				$Rw_n, \text{mem}$	4
BAND	bitaddr <sub>Z,z</sub> , bitaddr <sub>Q,q</sub>	4	CMP[B]	$Rw_n, Rw_m^{-1}$	
BCMP				$Rw_n, [Rw_i]^{-1}$	2
BMOV				$Rw_n, [Rw_i+]$	2
BMOVN				$Rw_n, \#data_3^{-1}$	2
BOR / BXOR				reg, $\#data_{16}$	4
				reg, mem	4
BCLR	bitaddr <sub>Q,q</sub>	2	CALLA	cc, caddr	4
BSET			JMPA		
BFLDH	bitoff <sub>Q</sub> , $\#mask_8, \#data_8$	4	CALLI	cc, $[Rw_n]$	2
BFLDL			JMPI		

**Table 8 Mnemonic vs address mode & number of bytes**

Mnemonic	Addressing modes	Bytes	Mnemonic	Addressing modes	Bytes
MOV[B]	$Rw_n^1, Rw_m^1$	2	CALLS	seg, caddr	4
	$Rw_n^1, \#data_4$	2	JMPS		
	$Rw_n^1, [Rw_m]$	2	CALLR	rel	2
	$Rw_n^1, [Rw_m+]$	2	JMPR	cc, rel	2
	$[Rw_m], Rw_n^1$	2	JB	bitaddr <sub>Q,q</sub> , rel	4
	$[-Rw_m], Rw_n^1$	2	JBC		
	$[Rw_n], [Rw_m]$	2	JNB		
	$[Rw_n+], [Rw_m]$	2	JNBS		
	$[Rw_n], [Rw_m+]$	2	PCALL	reg, caddr	4
	reg, #data <sub>16</sub>	4	POP	reg	2
	$Rw_n, [Rw_m+\#data_{16}]^1$	4	PUSH		
	$[Rw_m+\#data_{16}], Rw_n^1$	4	RETP		
	$[Rw_n], mem$	4	SCXT	reg, #data <sub>16</sub>	4
	mem, $[Rw_n]$	4		reg, mem	4
	reg, mem	4	PRIOR	$Rw_n, Rw_m$	2
	mem, reg	4			
MOVBS	$Rw_n, Rb_m$	2	TRAP	#trap7	2
MOVBZ	reg, mem	4	ATOMIC	#data <sub>2</sub>	2
	mem, reg	4	EXTR		
EXTS	$Rw_m, \#data_2$	2	EXTP	$Rw_m, \#data_2$	2
EXTSR	#seg, #data <sub>2</sub>	4	EXTPR	#pag, #data <sub>2</sub>	4
NOP	-	2	SRST/IDLE	-	4
RET			PWRDN		
RETI			SRVWDT		
RETS			DISWDT		
			EINIT		

**Table 8 Mnemonic vs address mode & number of bytes (Continued)**

1. Byte oriented instructions (suffix 'B') use Rb instead of Rw (not with  $[Rw_i]!$ ).

## 1.4 Instruction set ordered by functional group

The minimum number of state times required for instruction execution are given for the following configurations: internal ROM, internal RAM, external memory with a 16-bit demultiplexed and multiplexed bus or an 8-bit demultiplexed and multiplexed bus. These state time figures do not take into account possible wait states on external busses or possible additional state times induced by operand fetches. The following notes apply to this summary:

### Data addressing modes

Rw:	Word GPR (R0, R1, ... , R15)
Rb:	Byte GPR (RL0, RH0, ..., RL7, RH7)
reg:	SFR or GPR (in case of a byte operation on an SFR, only the low byte can be accessed via 'reg')
mem:	Direct word or byte memory location
[...]:	Indirect word or byte memory location. (Any word GPR can be used as indirect address pointer, except for the arithmetic, logical and compare instructions, where only R0 to R3 are allowed)
bitaddr:	Direct bit in the bit-addressable memory area
bitoff:	Direct word in the bit-addressable memory area
#data <sub>x</sub> :	Immediate constant (the number of significant bits that can be user-specified is given by the appendix "X").
#mask <sub>g</sub> :	Immediate 8-bit mask used for bit-field modifications

### Multiply and divide operations

The MDL and MDH registers are implicit source and/or destination operands of the multiply and divide instructions.

## Branch target addressing modes

- caddr: Direct 16-bit jump target address (Updates the Instruction Pointer)
- seg: Direct 8-bit segment address (Updates the Code Segment Pointer)
- rel: Signed 8-bit jump target word offset address relative to the Instruction Pointer of the following instruction
- #trap7: Immediate 7-bit trap or interrupt number.

## Extension operations

The EXT\* instructions override the standard DPP addressing scheme:

- #pag: Immediate 10-bit page address.
- #seg: Immediate 8-bit segment address.

**Branch condition codes**

cc:   Symbolically specifiable condition codes

cc_UC	Unconditional
cc_Z	Zero
cc_NZ	Not Zero
cc_V	Overflow
cc_NV	No Overflow
cc_N	Negative
cc_NN	Not Negative
cc_C	Carry
cc_NC	No Carry
cc_EQ	Equal
cc_NE	Not Equal
cc_ULT	Unsigned Less Than
cc_ULE	Unsigned Less Than or Equal
cc_UGE	Unsigned Greater Than or Equal
cc_UGT	Unsigned Greater Than
cc_SLE	Signed Less Than or Equal
cc_SLT	Signed Less Than
cc_SGE	Signed Greater Than or Equal
cc_SGT	Signed Greater Than
cc_NET	Not Equal and Not End-of-Table

Mnemonic			Description	Int.ROM	Int.RAM	16-bit Non	16-bit Mux	8-bitNon	8-bit Mux	Bytes
ADD	Rw, Rw		Add direct word GPR to direct GPR	2	6	2	3	4	6	2
ADD	Rw, [Rw]		Add indirect word memory to direct GPR	2	6	2	3	4	6	2
ADD	Rw, [Rw+]		Add indirect word memory to direct GPR and post-increment source pointer by 2	2	6	2	3	4	6	2
ADD	Rw, #data <sub>3</sub>		Add immediate word data to direct GPR	2	6	2	3	4	6	2
ADD	reg, #data <sub>16</sub>		Add immediate word data to direct register	2	8	4	6	8	12	4
ADD	reg, mem		Add direct word memory to direct register	2	8	4	6	8	12	4
ADD	mem, reg		Add direct word register to direct memory	2	8	4	6	8	12	4
ADDB	Rb, Rb		Add direct byte GPR to direct GPR	2	6	2	3	4	6	2
ADDB	Rb, [Rw]		Add indirect byte memory to direct GPR	2	6	2	3	4	6	2
ADDB	Rb, [Rw+]		Add indirect byte memory to direct GPR and post-increment source pointer by 1	2	6	2	3	4	6	2
ADDB	Rb, #data <sub>3</sub>		Add immediate byte data to direct GPR	2	6	2	3	4	6	2
ADDB	reg, #data <sub>16</sub>		Add immediate byte data to direct register	2	8	4	6	8	12	4
ADDB	reg, mem		Add direct byte memory to direct register	2	8	4	6	8	12	4
ADDB	mem, reg		Add direct byte register to direct memory	2	8	4	6	8	12	4
ADDC	Rw, Rw		Add direct word GPR to direct GPR with Carry	2	6	2	3	4	6	2
ADDC	Rw, [Rw]		Add indirect word memory to direct GPR with Carry	2	6	2	3	4	6	2
ADDC	Rw, [Rw+]		Add indirect word memory to direct GPR with Carry and post-increment source pointer by 2	2	6	2	3	4	6	2
ADDC	Rw, #data <sub>3</sub>		Add immediate word data to direct GPR with Carry	2	6	2	3	4	6	2
ADDC	reg, #data <sub>16</sub>		Add immediate word data to direct register with Carry	2	8	4	6	8	12	4
ADDC	reg, mem		Add direct word memory to direct register with Carry	2	8	4	6	8	12	4
ADDC	mem, reg		Add direct word register to direct memory with Carry	2	8	4	6	8	12	4
ADDCB	Rb, Rb		Add direct byte GPR to direct GPR with Carry	2	6	2	3	4	6	2
ADDCB	Rb, [Rw]		Add indirect byte memory to direct GPR with Carry	2	6	2	3	4	6	2

Table 9 Arithmetic instructions



Mnemonic	Description	Int. ROM	Int. RAM	16-bit Non	16-bit Mux	8-bit Non	8-bit Mux	Bytes
ADDCB Rb, [Rw+]	Add indirect byte memory to direct GPR with Carry and post-increment source pointer by 1	2	6	2	3	4	6	2
ADDCB Rb, #data <sub>3</sub>	Add immediate byte data to direct GPR with Carry	2	6	2	3	4	6	2
ADDCB reg, #data <sub>16</sub>	Add immediate byte data to direct register with Carry	2	8	4	6	8	12	4
ADDCB reg, mem	Add direct byte memory to direct register with Carry	2	8	4	6	8	12	4
ADDCB mem, reg	Add direct byte register to direct memory with Carry	2	8	4	6	8	12	4
CPL Rw	Complement direct word GPR	2	6	2	3	4	6	2
CPLB Rb	Complement direct byte GPR	2	6	2	3	4	6	2
DIV Rw	Signed divide register MDL by direct GPR (16-/16-bit)	20	24	20	21	22	24	2
DIVL Rw	Signed long divide register MD by direct GPR (32-/16-bit)	20	24	20	21	22	24	2
DIVLU Rw	Unsigned long divide register MD by direct GPR (32-/16-bit)	20	24	20	21	22	24	2
DIVU Rw	Unsigned divide register MDL by direct GPR (16-/16-bit)	20	24	20	21	22	24	2
MUL Rw, Rw	Signed multiply direct GPR by direct GPR (16-16-bit)	10	14	10	11	12	14	2
MULU Rw, Rw	Unsigned multiply direct GPR by direct GPR (16-16-bit)	10	14	10	11	12	14	2
NEG Rw	Negate direct word GPR	2	6	2	3	4	6	2
NEGB Rb	Negate direct byte GPR	2	6	2	3	4	6	2
SUB Rw, Rw	Subtract direct word GPR from direct GPR	2	6	2	3	4	6	2
SUB Rw, [Rw]	Subtract indirect word memory from direct GPR	2	6	2	3	4	6	2
SUB Rw, [Rw+]	Subtract indirect word memory from direct GPR & post-increment source pointer by 2	2	6	2	3	4	6	2
SUB Rw, #data <sub>3</sub>	Subtract immediate word data from direct GPR	2	6	2	3	4	6	2
SUB reg, #data <sub>16</sub>	Subtract immediate word data from direct register	2	8	4	6	8	12	4
SUB reg, mem	Subtract direct word memory from direct register	2	8	4	6	8	12	4

Table 9 Arithmetic instructions (Continued)

Mnemonic	Description	Int.ROM	Int.RAM	16-bit Non	16-bit Mux	8-bitNon	8-bit Mux	Bytes
SUB mem, reg	Subtract direct word register from direct memory	2	8	4	6	8	12	4
SUBB Rb, Rb	Subtract direct byte GPR from direct GPR	2	6	2	3	4	6	2
SUBB Rb, [Rw]	Subtract indirect byte memory from direct GPR	2	6	2	3	4	6	2
SUBB Rb, [Rw+]	Subtract indirect byte memory from direct GPR & post-increment source pointer by 1	2	6	2	3	4	6	2
SUBB Rb, #data <sub>3</sub>	Subtract immediate byte data from direct GPR	2	6	2	3	4	6	2
SUBB reg, #data <sub>16</sub>	Subtract immediate byte data from direct register	2	8	4	6	8	12	4
SUBB reg, mem	Subtract direct byte memory from direct register	2	8	4	6	8	12	4
SUBB mem, reg	Subtract direct byte register from direct memory	2	8	4	6	8	12	4
SUBC Rw, Rw	Subtract direct word GPR from direct GPR with Carry	2	6	2	3	4	6	2
SUBC Rw, [Rw]	Subtract indirect word memory from direct GPR with Carry	2	6	2	3	4	6	2
SUBC Rw, [Rw+]	Subtract indirect word memory from direct GPR with Carry and post-increment source pointer by 2	2	6	2	3	4	6	2
SUBC Rw, #data <sub>3</sub>	Subtract immediate word data from direct GPR with Carry	2	6	2	3	4	6	2
SUBC reg, #data <sub>16</sub>	Subtract immediate word data from direct register with Carry	2	8	4	6	8	12	4
SUBC reg, mem	Subtract direct word memory from direct register with Carry	2	8	4	6	8	12	4
SUBC mem, reg	Subtract direct word register from direct memory with Carry	2	8	4	6	8	12	4
SUBCB Rb, Rb	Subtract direct byte GPR from direct GPR with Carry	2	6	2	3	4	6	2
SUBCB Rb, [Rw]	Subtract indirect byte memory from direct GPR with Carry	2	6	2	3	4	6	2
SUBCB Rb, [Rw+]	Subtract indirect byte memory from direct GPR with Carry and post-increment source pointer by 1	2	6	2	3	4	6	2
SUBCB Rb, #data <sub>3</sub>	Subtract immediate byte data from direct GPR with Carry	2	6	2	3	4	6	2

Table 9 Arithmetic instructions (Continued)

Mnemonic	Description	Int.ROM	Int.RAM	16-bit Non	16-bit Mux	8-bitNon	8-bit Mux	Bytes
SUBCB reg, #data <sub>16</sub>	Subtract immediate byte data from direct register with Carry	2	8	4	6	8	12	4
SUBCB reg, mem	Subtract direct byte memory from direct register with Carry	2	8	4	6	8	12	4
SUBCB mem, reg	Subtract direct byte register from direct memory with Carry	2	8	4	6	8	12	4

Table 9 Arithmetic instructions (Continued)

Mnemonic	Description	Int ROM	Int. RAM	16-bit	16-bit	8-bit	8-bit	Bytes
AND Rw, Rw	Bitwise AND direct word GPR with direct GPR	2	6	2	3	4	6	2
AND Rw, [Rw]	Bitwise AND indirect word memory with direct GPR	2	6	2	3	4	6	2
AND Rw, [Rw+]	Bitwise AND indirect word memory with direct GPR and post-increment source pointer by 2	2	6	2	3	4	6	2
AND Rw, #data <sub>3</sub>	Bitwise AND immediate word data with direct GPR	2	6	2	3	4	6	2
AND reg, #data <sub>16</sub>	Bitwise AND immediate word data with direct register	2	8	4	6	8	12	4
AND reg, mem	Bitwise AND direct word memory with direct register	2	8	4	6	8	12	4
AND mem, reg	Bitwise AND direct word register with direct memory	2	8	4	6	8	12	4
ANDB Rb, Rb	Bitwise AND direct byte GPR with direct GPR	2	6	2	3	4	6	2
ANDB Rb, [Rw]	Bitwise AND indirect byte memory with direct GPR	2	6	2	3	4	6	2
ANDB Rb, [Rw+]	Bitwise AND indirect byte memory with direct GPR and post-increment source pointer by 1	2	6	2	3	4	6	2
ANDB Rb, #data <sub>3</sub>	Bitwise AND immediate byte data with direct GPR	2	6	2	3	4	6	2
ANDB reg, #data <sub>16</sub>	Bitwise AND immediate byte data with direct register	2	8	4	6	8	12	4
ANDB reg, mem	Bitwise AND direct byte memory with direct register	2	8	4	6	8	12	4
ANDB mem, reg	Bitwise AND direct byte register with direct memory	2	8	4	6	8	12	4

Table 10 Logical instructions

Mnemonic		Description	Int ROM	Int. RAM	16-bit	16-bit	8-bit	8-bit	Bytes
OR	Rw, Rw	Bitwise OR direct word GPR with direct GPR	2	6	2	3	4	6	2
OR	Rw, [Rw]	Bitwise OR indirect word memory with direct GPR	2	6	2	3	4	6	2
OR	Rw, [Rw+]	Bitwise OR indirect word memory with direct GPR and post-increment source pointer by 2	2	6	2	3	4	6	2
OR	Rw, #data <sub>3</sub>	Bitwise OR immediate word data with direct GPR	2	6	2	3	4	6	2
OR	reg, #data <sub>16</sub>	Bitwise OR immediate word data with direct register	2	8	4	6	8	12	4
OR	reg, mem	Bitwise OR direct word memory with direct register	2	8	4	6	8	12	4
OR	mem, reg	Bitwise OR direct word register with direct memory	2	8	4	6	8	12	4
ORB	Rb, Rb	Bitwise OR direct byte GPR with direct GPR	2	6	2	3	4	6	2
ORB	Rb, [Rw]	Bitwise OR indirect byte memory with direct GPR	2	6	2	3	4	6	2
ORB	Rb, [Rw+]	Bitwise OR indirect byte memory with direct GPR and post-increment source pointer by 1	2	6	2	3	4	6	2
ORB	Rb, #data <sub>3</sub>	Bitwise OR immediate byte data with direct GPR	2	6	2	3	4	6	2
ORB	reg, #data <sub>16</sub>	Bitwise OR immediate byte data with direct register	2	8	4	6	8	12	4
ORB	reg, mem	Bitwise OR direct byte memory with direct register	2	8	4	6	8	12	4
ORB	mem, reg	Bitwise OR direct byte register with direct memory	2	8	4	6	8	12	4
XOR	Rw, Rw	Bitwise XOR direct word GPR with direct GPR	2	6	2	3	4	6	2
XOR	Rw, [Rw]	Bitwise XOR indirect word memory with direct GPR	2	6	2	3	4	6	2
XOR	Rw, [Rw+]	Bitwise XOR indirect word memory with direct GPR and post-increment source pointer by 2	2	6	2	3	4	6	2
XOR	Rw, #data <sub>3</sub>	Bitwise XOR immediate word data with direct GPR	2	6	2	3	4	6	2
XOR	reg, #data <sub>16</sub>	Bitwise XOR immediate word data with direct register	2	8	4	6	8	12	4
XOR	reg, mem	Bitwise XOR direct word memory with direct register	2	8	4	6	8	12	4
XOR	mem, reg	Bitwise XOR direct word register with direct memory	2	8	4	6	8	12	4
XORB	Rb, Rb	Bitwise XOR direct byte GPR with direct GPR	2	6	2	3	4	6	2
XORB	Rb, [Rw]	Bitwise XOR indirect byte memory with direct GPR	2	6	2	3	4	6	2

Table 10 Logical instructions (Continued)

Mnemonic	Description	Int. ROM	Int. RAM	16-bit	16-bit	8-bit	8-bit	Bytes
XORB Rb, [Rw+]	Bitwise XOR indirect byte memory with direct GPR and post-increment source pointer by 1	2	6	2	3	4	6	2
XORB Rb, #data <sub>3</sub>	Bitwise XOR immediate byte data with direct GPR	2	6	2	3	4	6	2
XORB reg, #data <sub>16</sub>	Bitwise XOR immediate byte data with direct register	2	8	4	6	8	12	4
XORB reg, mem	Bitwise XOR direct byte memory with direct register	2	8	4	6	8	12	4
XORB mem, reg	Bitwise XOR direct byte register with direct memory	2	8	4	6	8	12	4

Table 10 Logical instructions (Continued)

Mnemonic	Description	Int. ROM	Int. RAM	16-bit	16-bit	8-bit	8-bit	Bytes
BAND bitaddr, bitaddr	AND direct bit with direct bit	2	8	4	6	8	12	4
BCLR bitaddr	Clear direct bit	2	6	2	3	4	6	2
BCMP bitaddr, bitaddr	Compare direct bit to direct bit	2	8	4	6	8	12	4
BFLDH bitoff, #mask <sub>8</sub> , #data <sub>8</sub>	Bitwise modify masked high byte of bit-addressable direct word memory with immediate data	2	8	4	6	8	12	4
BFLDL bitoff, #mask <sub>8</sub> , #data <sub>8</sub>	Bitwise modify masked low byte of bit-addressable direct word memory with immediate data	2	8	4	6	8	12	4
BMOV bitaddr, bitaddr	Move direct bit to direct bit	2	8	4	6	8	12	4
BMOVN bitaddr, bitaddr	Move negated direct bit to direct bit	2	8	4	6	8	12	4
BOR bitaddr, bitaddr	OR direct bit with direct bit	2	8	4	6	8	12	4
BSET bitaddr	Set direct bit	2	6	2	3	4	6	2
BXOR bitaddr, bitaddr	XOR direct bit with direct bit	2	8	4	6	8	12	4
CMP Rw, Rw	Compare direct word GPR to direct GPR	2	6	2	3	4	6	2
CMP Rw, [Rw]	Compare indirect word memory to direct GPR	2	6	2	3	4	6	2

Table 11 Boolean bit map instructions

Mnemonic	Description	Int. ROM	Int. RAM	16-bit	16-bit	8-bit	8-bit	Bytes
CMP Rw, [Rw+]	Compare indirect word memory to direct GPR and post-increment source pointer by 2	2	6	2	3	4	6	2
CMP Rw, #data <sub>3</sub>	Compare immediate word data to direct GPR	2	6	2	3	4	6	2
CMP reg, #data <sub>16</sub>	Compare immediate word data to direct register	2	8	4	6	8	12	4
CMP reg, mem	Compare direct word memory to direct register	2	8	4	6	8	12	4
CMPB Rb, Rb	Compare direct byte GPR to direct GPR	2	6	2	3	4	6	2
CMPB Rb, [Rw]	Compare indirect byte memory to direct GPR	2	6	2	3	4	6	2
CMPB Rb, [Rw+]	Compare indirect byte memory to direct GPR and post-increment source pointer by 1	2	6	2	3	4	6	2
CMPB Rb, #data <sub>3</sub>	Compare immediate byte data to direct GPR	2	6	2	3	4	6	2
CMPB reg, #data <sub>16</sub>	Compare immediate byte data to direct register	2	8	4	6	8	12	4
CMPB reg, mem	Compare direct byte memory to direct register	2	8	4	6	8	12	4

Table 11 Boolean bit map instructions (Continued)

Mnemonic	Description	Int. ROM	Int. RAM	16-bit	16-bit	8-bit	8-bit	Bytes
CMPD1 Rw, #data <sub>4</sub>	Compare immediate word data to direct GPR and decrement GPR by 1	2	6	2	3	4	6	2
CMPD1 Rw, #data <sub>16</sub>	Compare immediate word data to direct GPR and decrement GPR by 1	2	8	4	6	8	12	4
CMPD1 Rw, mem	Compare direct word memory to direct GPR and decrement GPR by 1	2	8	4	6	8	12	4
CMPD2 Rw, #data <sub>4</sub>	Compare immediate word data to direct GPR and decrement GPR by 2	2	6	2	3	4	6	2
CMPD2 Rw, #data <sub>16</sub>	Compare immediate word data to direct GPR and decrement GPR by 2	2	8	4	6	8	12	4
CMPD2 Rw, mem	Compare direct word memory to direct GPR and decrement GPR by 2	2	8	4	6	8	12	4

Table 12 Compare and loop instructions

Mnemonic	Description	Int. ROM	Int. RAM	16-bit	16-bit	8-bit	8-bit	Bytes
CMPI1 Rw, #data <sub>4</sub>	Compare immediate word data to direct GPR and increment GPR by 1	2	6	2	3	4	6	2
CMPI1 Rw, #data <sub>16</sub>	Compare immediate word data to direct GPR and increment GPR by 1	2	8	4	6	8	12	4
CMPI1 Rw, mem	Compare direct word memory to direct GPR and increment GPR by 1	2	8	4	6	8	12	4
CMPI2 Rw, #data <sub>4</sub>	Compare immediate word data to direct GPR and increment GPR by 2	2	6	2	3	4	6	2
CMPI2 Rw, #data <sub>16</sub>	Compare immediate word data to direct GPR and increment GPR by 2	2	8	4	6	8	12	4
CMPI2 Rw, mem	Compare direct word memory to direct GPR and increment GPR by 2	2	8	4	6	8	12	4

Table 12 Compare and loop instructions (Continued)

Mnemonic	Description	Int. ROM	Int. RAM	16-bit	16-bit	8-bit	8-bit	Bytes
PRIOR Rw, Rw	Determine number of shift cycles to normalize direct word GPR and store result in direct word GPR	2	6	2	3	4	6	2

Table 13 Prioritize instructions

Mnemonic	Description	Int. ROM	Int. RAM	16-bit	16-bit	8-bit	8-bit	Bytes
ASHR Rw, Rw	Arithmetic (sign bit) shift right direct word GPR; number of shift cycles specified by direct GPR	2	6	2	3	4	6	2
ASHR Rw, #data <sub>4</sub>	Arithmetic (sign bit) shift right direct word GPR; number of shift cycles specified by immediate data	2	6	2	3	4	6	2

Table 14 Shift and rotate instructions

Mnemonic		Description	Int. ROM	Int. RAM	16-bit	16-bit	8-bit	8-bit	Bytes
ROL	Rw, Rw	Rotate left direct word GPR; number of shift cycles specified by direct GPR	2	6	2	3	4	6	2
ROL	Rw, #data <sub>4</sub>	Rotate left direct word GPR; number of shift cycles specified by immediate data	2	6	2	3	4	6	2
ROR	Rw, Rw	Rotate right direct word GPR; number of shift cycles specified by direct GPR	2	6	2	3	4	6	2
ROR	Rw, #data <sub>4</sub>	Rotate right direct word GPR; number of shift cycles specified by immediate data	2	6	2	3	4	6	2
SHL	Rw, Rw	Shift left direct word GPR; number of shift cycles specified by direct GPR	2	6	2	3	4	6	2
SHL	Rw, #data <sub>4</sub>	Shift left direct word GPR; number of shift cycles specified by immediate data	2	6	2	3	4	6	2
SHR	Rw, Rw	Shift right direct word GPR; number of shift cycles specified by direct GPR	2	6	2	3	4	6	2
SHR	Rw, #data <sub>4</sub>	Shift right direct word GPR; number of shift cycles specified by immediate data	2	6	2	3	4	6	2

Table 14 Shift and rotate instructions (Continued)

Mnemonic		Description	Int. ROM	Int. RAM	16-bit	16-bit	8-bit	8-bit	Bytes
MOV	Rw, Rw	Move direct word GPR to direct GPR	2	6	2	3	4	6	2
MOV	Rw, #data <sub>4</sub>	Move immediate word data to direct GPR	2	6	2	3	4	6	2
MOV	reg, #data <sub>16</sub>	Move immediate word data to direct register	2	8	4	6	8	12	4
MOV	Rw, [Rw]	Move indirect word memory to direct GPR	2	6	2	3	4	6	2
MOV	Rw, [Rw+]	Move indirect word memory to direct GPR and post-increment source pointer by 2	2	6	2	3	4	6	2
MOV	[Rw], Rw	Move direct word GPR to indirect memory	2	6	2	3	4	6	2
MOV	[-Rw], Rw	Pre-decrement destination pointer by 2 and move direct word GPR to indirect memory	2	6	2	3	4	6	2
MOV	[Rw], [Rw]	Move indirect word memory to indirect memory	2	6	2	3	4	6	2

Table 15 Data movement instructions



Mnemonic	Description	Int. ROM	Int. RAM	16-bit	16-bit	8-bit	8-bit	Bytes
MOV [Rw+], [Rw]	Move indirect word memory to indirect memory & post-increment destination pointer by 2	2	6	2	3	4	6	2
MOV [Rw], [Rw+]	Move indirect word memory to indirect memory & post-increment source pointer by 2	2	6	2	3	4	6	2
MOV Rw, [Rw+ #data <sub>16</sub> ]	Move indirect word memory by base plus constant to direct GPR	4	10	6	8	10	14	4
MOV [Rw+ #data <sub>16</sub> ], Rw	Move direct word GPR to indirect memory by base plus constant	2	8	4	6	8	12	4
MOV [Rw], mem	Move direct word memory to indirect memory	2	8	4	6	8	12	4
MOV mem, [Rw]	Move indirect word memory to direct memory	2	8	4	6	8	12	4
MOV reg, mem	Move direct word memory to direct register	2	8	4	6	8	12	4
MOV mem, reg	Move direct word register to direct memory	2	8	4	6	8	12	4
MOVB Rb, Rb	Move direct byte GPR to direct GPR	2	6	2	3	4	6	2
MOVB Rb, #data <sub>4</sub>	Move immediate byte data to direct GPR	2	6	2	3	4	6	2
MOVB reg, #data <sub>16</sub>	Move immediate byte data to direct register	2	8	4	6	8	12	4
MOVB Rb, [Rw]	Move indirect byte memory to direct GPR	2	6	2	3	4	6	2
MOVB Rb, [Rw+]	Move indirect byte memory to direct GPR and post-increment source pointer by 1	2	6	2	3	4	6	2
MOVB [Rw], Rb	Move direct byte GPR to indirect memory	2	6	2	3	4	6	2
MOVB [-Rw], Rb	Pre-decrement destination pointer by 1 and move direct byte GPR to indirect memory	2	6	2	3	4	6	2
MOVB [Rw], [Rw]	Move indirect byte memory to indirect memory	2	6	2	3	4	6	2
MOVB [Rw+], [Rw]	Move indirect byte memory to indirect memory and post-increment destination pointer by 1	2	6	2	3	4	6	2
MOVB [Rw], [Rw+]	Move indirect byte memory to indirect memory and post-increment source pointer by 1	2	6	2	3	4	6	2
MOVB Rb, [Rw+ #data <sub>16</sub> ]	Move indirect byte memory by base plus constant to direct GPR	4	10	6	8	10	14	4
MOVB [Rw+ #data <sub>16</sub> ], Rb	Move direct byte GPR to indirect memory by base plus constant	2	8	4	6	8	12	4
MOVB [Rw], mem	Move direct byte memory to indirect memory	2	8	4	6	8	12	4
MOVB mem, [Rw]	Move indirect byte memory to direct memory	2	8	4	6	8	12	4
MOVB reg, mem	Move direct byte memory to direct register	2	8	4	6	8	12	4
MOVB mem, reg	Move direct byte register to direct memory	2	8	4	6	8	12	4

Table 15 Data movement instructions (Continued)

Mnemonic	Description	Int. ROM	Int. RAM	16-bit	16-bit	8-bit	8-bit	Bytes
MOVBS Rw, Rb	Move direct byte GPR with sign extension to direct word GPR	2	6	2	3	4	6	2
MOVBS reg, mem	Move direct byte memory with sign extension to direct word register	2	8	4	6	8	12	4
MOVBS mem, reg	Move direct byte register with sign extension to direct word memory	2	8	4	6	8	12	4
MOVZB Rw, Rb	Move direct byte GPR with zero extension to direct word GPR	2	6	2	3	4	6	2
MOVZB reg, mem	Move direct byte memory with zero extension to direct word register	2	8	4	6	8	12	4
MOVZB mem, reg	Move direct byte register with zero extension to direct word memory	2	8	4	6	8	12	4

Table 15 Data movement instructions (Continued)

Mnemonic	Description	Int. ROM	Int. RAM	16-bit	16-bit	8-bit	8-bit Mux	Bytes
CALLA cc, caddr	Call absolute subroutine if condition is met	4/2	10/8	6/4	8/6	10/8	14/12	4
CALLI cc, [Rw]	Call indirect subroutine if condition is met	4/2	8/6	4/2	5/3	6/4	8/6	2
CALLR rel	Call relative subroutine	4	8	4	5	6	8	2
CALLS seg, caddr	Call absolute subroutine in any code segment	4	10	6	8	10	14	4
JB bitaddr, rel	Jump relative if direct bit is set	4	10	6	8	10	14	4
JBC bitaddr, rel	Jump relative and clear bit if direct bit is set	4	10	6	8	10	14	4
JMPA cc, caddr	Jump absolute if condition is met	4/2	10/8	6/4	8/6	10/8	14/12	4
JMPI cc, [Rw]	Jump indirect if condition is met	4/2	8/6	4/2	5/3	6/4	8/6	2
JMPR cc, rel	Jump relative if condition is met	4/2	8/6	4/2	5/3	6/4	8/6	2
JMPS seg, caddr	Jump absolute to a code segment	4	10	6	8	10	14	4
JNB bitaddr, rel	Jump relative if direct bit is not set	4	10	6	8	10	14	4

Table 16 Jump and Call Instructions

Mnemonic	Description	Int. ROM	Int. RAM	16-bit	16-bit	8-bit	8-bit	Mux	Bytes
JNBS    bitaddr, rel	Jump relative and set bit if direct bit is not set	4	10	6	8	10	14		4
PCALL   reg, caddr	Push direct word register onto system stack and call absolute subroutine	4	10	6	8	10	14		4
TRAP    #trap7	Call interrupt service routine via immediate trap number	4	8	4	5	6	8		2

Table 16 Jump and Call Instructions (Continued)

Mnemonic	Description	Int. ROM	Int. RAM	16-bit	16-bit	8-bit	8-bit	Bytes
POP    reg	Pop direct word register from system stack	2	6	2	3	4	6	2
PUSH   reg	Push direct word register onto system stack	2	6	2	3	4	6	2
SCXT   reg, #data <sub>16</sub>	Push direct word register onto system stack and update register with immediate data	2	8	4	6	8	12	4
SCXT   reg, mem	Push direct word register onto system stack and update register with direct memory	2	8	4	6	8	12	4

Table 17 System Stack Instructions

Mnemonic	Description	Int. ROM	Int. RAM	16-bit	16-bit	8-bit	8-bit	Bytes
RET	Return from intra-segment subroutine	4	8	4	5	6	8	2
RETI	Return from interrupt service subroutine	4	8	4	5	6	8	2
RETP   reg	Return from intra-segment subroutine and pop direct word register from system stack	4	8	4	5	6	8	2
RETS	Return from inter-segment subroutine	4	8	4	5	6	8	2

Table 18 Return Instructions

Mnemonic	Description	Int. ROM	Int. RAM	16-bit	16-bit	8-bit	8-bit	Bytes
ATOMIC#data <sub>2</sub>	Begin ATOMIC sequence *)	2	6	2	3	4	6	2
DISWDT	Disable Watchdog Timer	2	8	4	6	8	12	4
EINIT	Signify End-of-Initialization on RSTOUT-pin	2	8	4	6	8	12	4
EXTR #data <sub>2</sub>	Begin EXTended Register sequence *)	2	6	2	3	4	6	2
EXTP Rw, #data <sub>2</sub>	Begin EXTended Page sequence*)	2	6	2	3	4	6	2
EXTP #pag, #data <sub>2</sub>	Begin EXTended Page sequence*)	2	8	4	6	8	12	4
EXTPR Rw, #data <sub>2</sub>	Begin EXTended Page and Register sequence *)	2	6	2	3	4	6	2
EXTPR #pag, #data <sub>2</sub>	Begin EXTended Page and Register sequence *)	2	8	4	6	8	12	4
EXTS Rw, #data <sub>2</sub>	Begin EXTended Segment sequence*)	2	6	2	3	4	6	2
EXTS #seg, #data <sub>2</sub>	Begin EXTended Segment sequence*)	2	8	4	6	8	12	4
EXTSR Rw, #data <sub>2</sub>	Begin EXTended Segment and Register sequence *)	2	6	2	3	4	6	2
EXTSR #seg, #data <sub>2</sub>	Begin EXTended Segment and Register sequence *)	2	8	4	6	8	12	4
IDLE	Enter Idle Mode	2	8	4	6	8	12	4
PWRDN	Enter Power Down Mode (supposes NMI-pin is low)	2	8	4	6	8	12	4
SRST	Software Reset	2	8	4	6	8	12	4
SRVWDT	Service Watchdog Timer	2	8	4	6	8	12	4

Table 19 System Control Instructions

Mnemonic	Description	Int. ROM	Int. RAM	16-bit	16-bit	8-bit	8-bit	Bytes
NOP	Null operation	2	6	2	3	4	6	2

Table 20 Miscellaneous instructions

# 1.5 Instruction set ordered by opcodes

The following pages list the instruction set ordered by their hexadecimal opcodes. This is used to identify specific instructions when reading executable code, i.e. during the debugging phase.

## Notes for Opcode Lists

- 1 These instructions are encoded by means of additional bits in the operand field of the instruction

x0h – x7h:	Rw, #data <sub>3</sub>	or	Rb, #data <sub>3</sub>
x8h – xBh:	Rw, [Rw]	or	Rb, [Rw]
xCh – xFh	Rw, [Rw+]	or	Rb, [Rw+]

For these instructions only the lowest four GPRs, R0 to R3, can be used as indirect address pointers.

- 2 These instructions are encoded by means of additional bits in the operand field of the instruction

00xx.xxxx:	EXTS	or	ATOMIC
01xx.xxxx:	EXTP		
10xx.xxxx:	EXTSR	or	EXTR
11xx.xxxx:	EXTPR		

## Notes on the JMPR instructions

The condition code to be tested for the JMPR instructions is specified by the opcode. Two mnemonic representation alternatives exist for some of the condition codes.

## Notes on the BCLR and BSET instructions

The position of the bit to be set or to be cleared is specified by the opcode. The operand “bitaddr<sub>Q,q</sub>” (where q=0 to 15) refers to a particular bit within a bit-addressable word.

## Notes on the undefined opcodes

A hardware trap occurs when one of the undefined opcodes signified by '----' is decoded by the CPU.

Hex-code	Number of Bytes	Mnemonic	Operand
00	2	ADD	Rw <sub>n</sub> , Rw <sub>m</sub>
01	2	ADDB	Rb <sub>n</sub> , Rb <sub>m</sub>
02	4	ADD	reg, mem
03	4	ADDB	reg, mem
04	4	ADD	mem, reg
05	4	ADDB	mem, reg
06	4	ADD	reg, #data <sub>16</sub>
07	4	ADDB	reg, #data <sub>16</sub>
08	2	ADD	Rw <sub>n</sub> , [Rw <sub>i</sub> + ] or Rw <sub>n</sub> , [Rw <sub>i</sub> ] or Rw <sub>n</sub> , #data <sub>3</sub>
09	2	ADDB	Rb <sub>n</sub> , [Rw <sub>i</sub> + ] or Rb <sub>n</sub> , [Rw <sub>i</sub> ] or Rb <sub>n</sub> , #data <sub>3</sub>
0A	4	BFLDL	bitoff <sub>Q</sub> , #mask <sub>8</sub> , #data <sub>8</sub>
0B	2	MUL	Rw <sub>n</sub> , Rw <sub>m</sub>
0C	2	ROL	Rw <sub>n</sub> , Rw <sub>m</sub>
0D	2	JMPR	cc_UC, rel
0E	2	BCLR	bitaddr <sub>Q,0</sub>
0F	2	BSET	bitaddr <sub>Q,0</sub>
10	2	ADDC	Rw <sub>n</sub> , Rw <sub>m</sub>
11	2	ADDCB	Rb <sub>n</sub> , Rb <sub>m</sub>
12	4	ADDC	reg, mem
13	4	ADDCB	reg, mem
14	4	ADDC	mem, reg
15	4	ADDCB	mem, reg
16	4	ADDC	reg, #data <sub>16</sub>
17	4	ADDCB	reg, #data <sub>16</sub>
18	2	ADDC	Rw <sub>n</sub> , [Rw <sub>i</sub> + ] or Rw <sub>n</sub> , [Rw <sub>i</sub> ] or Rw <sub>n</sub> , #data <sub>3</sub>
19	2	ADDCB	Rb <sub>n</sub> , [Rw <sub>i</sub> + ] or Rb <sub>n</sub> , [Rw <sub>i</sub> ] or Rb <sub>n</sub> , #data <sub>3</sub>
1A	4	BFLDH	bitoff <sub>Q</sub> , #mask <sub>8</sub> , #data <sub>8</sub>
1B	2	MULU	Rw <sub>n</sub> , Rw <sub>m</sub>
1C	2	ROL	Rw <sub>n</sub> , #data <sub>4</sub>
1D	2	JMPR	cc_NET, rel

Table 21 Instruction set ordered by Hex code

Hex-code	Number of Bytes	Mnemonic	Operand
1E	2	BCLR	bitaddr <sub>Q.1</sub>
1F	2	BSET	bitaddr <sub>Q.1</sub>
20	2	SUB	Rw <sub>n</sub> , Rw <sub>m</sub>
21	2	SUBB	Rb <sub>n</sub> , Rb <sub>m</sub>
22	4	SUB	reg, mem
23	4	SUBB	reg, mem
24	4	SUB	mem, reg
25	4	SUBB	mem, reg
26	4	SUB	reg, #data <sub>16</sub>
27	4	SUBB	reg, #data <sub>16</sub>
28	2	SUB	Rw <sub>n</sub> , [Rw <sub>i</sub> + ] or Rw <sub>n</sub> , [Rw <sub>i</sub> ] or Rw <sub>n</sub> , #data <sub>3</sub>
29	2	SUBB	Rb <sub>n</sub> , [Rw <sub>i</sub> + ] or Rb <sub>n</sub> , [Rw <sub>i</sub> ] or Rb <sub>n</sub> , #data <sub>3</sub>
2A	4	BCMP	bitaddr <sub>Z.Z</sub> , bitaddr <sub>Q.q</sub>
2B	2	PRIOR	Rw <sub>n</sub> , Rw <sub>m</sub>
2C	2	ROR	Rw <sub>n</sub> , Rw <sub>m</sub>
2D	2	JMPR	cc_EQ, rel or cc_Z, rel
2E	2	BCLR	bitaddr <sub>Q.2</sub>
2F	2	BSET	bitaddr <sub>Q.2</sub>
30	2	SUBC	Rw <sub>n</sub> , Rw <sub>m</sub>
31	2	SUBCB	Rb <sub>n</sub> , Rb <sub>m</sub>
32	4	SUBC	reg, mem
33	4	SUBCB	reg, mem
34	4	SUBC	mem, reg
35	4	SUBCB	mem, reg
36	4	SUBC	reg, #data <sub>16</sub>
37	4	SUBCB	reg, #data <sub>16</sub>
38	2	SUBC	Rw <sub>n</sub> , [Rw <sub>i</sub> + ] or Rw <sub>n</sub> , [Rw <sub>i</sub> ] or Rw <sub>n</sub> , #data <sub>3</sub>
39	2	SUBCB	Rb <sub>n</sub> , [Rw <sub>i</sub> + ] or Rb <sub>n</sub> , [Rw <sub>i</sub> ] or Rb <sub>n</sub> , #data <sub>3</sub>
3A	4	BMOVN	bitaddr <sub>Z.Z</sub> , bitaddr <sub>Q.q</sub>
3B	-	-	-
3C	2	ROR	Rw <sub>n</sub> , #data <sub>4</sub>
3D	2	JMPR	cc_NE, rel or cc_NZ, rel
3E	2	BCLR	bitaddr <sub>Q.3</sub>

Table 21 Instruction set ordered by Hex code (Continued)

Hex-code	Number of Bytes	Mnemonic	Operand
3F	2	BSET	bitaddr <sub>Q.3</sub>
40	2	CMP	Rw <sub>n</sub> , Rw <sub>m</sub>
41	2	CMPB	Rb <sub>n</sub> , Rb <sub>m</sub>
42	4	CMP	reg, mem
43	4	CMPB	reg, mem
44	-	-	-
45	-	-	-
46	4	CMP	reg, #data <sub>16</sub>
47	4	CMPB	reg, #data <sub>16</sub>
48	2	CMP	Rw <sub>n</sub> , [Rw <sub>i</sub> + ] or Rw <sub>n</sub> , [Rw <sub>i</sub> ] or Rw <sub>n</sub> , #data <sub>3</sub>
49	2	CMPB	Rb <sub>n</sub> , [Rw <sub>i</sub> + ] or Rb <sub>n</sub> , [Rw <sub>i</sub> ] or Rb <sub>n</sub> , #data <sub>3</sub>
4A	4	BMOV	bitaddr <sub>Z.z</sub> , bitaddr <sub>Q.q</sub>
4B	2	DIV	Rw <sub>n</sub>
4C	2	SHL	Rw <sub>n</sub> , Rw <sub>m</sub>
4D	2	JMPR	cc_V, rel
4E	2	BCLR	bitaddr <sub>Q.4</sub>
4F	2	BSET	bitaddr <sub>Q.4</sub>
50	2	XOR	Rw <sub>n</sub> , Rw <sub>m</sub>
51	2	XORB	Rb <sub>n</sub> , Rb <sub>m</sub>
52	4	XOR	reg, mem
53	4	XORB	reg, mem
54	4	XOR	mem, reg
55	4	XORB	mem, reg
56	4	XOR	reg, #data <sub>16</sub>
57	4	XORB	reg, #data <sub>16</sub>
58	2	XOR	Rw <sub>n</sub> , [Rw <sub>i</sub> + ] or Rw <sub>n</sub> , [Rw <sub>i</sub> ] or Rw <sub>n</sub> , #data <sub>3</sub>
59	2	XORB	Rb <sub>n</sub> , [Rw <sub>i</sub> + ] or Rb <sub>n</sub> , [Rw <sub>i</sub> ] or Rb <sub>n</sub> , #data <sub>3</sub>
5A	4	BOR	bitaddr <sub>Z.z</sub> , bitaddr <sub>Q.q</sub>
5B	2	DIVU	Rw <sub>n</sub>
5C	2	SHL	Rw <sub>n</sub> , #data <sub>4</sub>
5D	2	JMPR	cc_NV, rel
5E	2	BCLR	bitaddr <sub>Q.5</sub>
5F	2	BSET	bitaddr <sub>Q.5</sub>

Table 21 Instruction set ordered by Hex code (Continued)



Hex-code	Number of Bytes	Mnemonic	Operand
60	2	AND	Rw <sub>n</sub> , Rw <sub>m</sub>
61	2	ANDB	Rb <sub>n</sub> , Rb <sub>m</sub>
62	4	AND	reg, mem
63	4	ANDB	reg, mem
64	4	AND	mem, reg
65	4	ANDB	mem, reg
66	4	AND	reg, #data <sub>16</sub>
67	4	ANDB	reg, #data <sub>16</sub>
68	2	AND	Rw <sub>n</sub> , [Rw <sub>i</sub> + ] or Rw <sub>n</sub> , [Rw <sub>i</sub> ] or Rw <sub>n</sub> , #data <sub>3</sub>
69	2	ANDB	Rb <sub>n</sub> , [Rw <sub>i</sub> + ] or Rb <sub>n</sub> , [Rw <sub>i</sub> ] or Rb <sub>n</sub> , #data <sub>3</sub>
6A	4	BAND	bitaddr <sub>Z,Z</sub> , bitaddr <sub>Q,q</sub>
6B	2	DIVL	Rw <sub>n</sub>
6C	2	SHR	Rw <sub>n</sub> , Rw <sub>m</sub>
6D	2	JMPR	cc_N, rel
6E	2	BCLR	bitaddr <sub>Q,6</sub>
6F	2	BSET	bitaddr <sub>Q,6</sub>
70	2	OR	Rw <sub>n</sub> , Rw <sub>m</sub>
71	2	ORB	Rb <sub>n</sub> , Rb <sub>m</sub>
72	4	OR	reg, mem
73	4	ORB	reg, mem
74	4	OR	mem, reg
75	4	ORB	mem, reg
76	4	OR	reg, #data <sub>16</sub>
77	4	ORB	reg, #data <sub>16</sub>
78	2	OR	Rw <sub>n</sub> , [Rw <sub>i</sub> + ] or Rw <sub>n</sub> , [Rw <sub>i</sub> ] or Rw <sub>n</sub> , #data <sub>3</sub>
79	2	ORB	Rb <sub>n</sub> , [Rw <sub>i</sub> + ] or Rb <sub>n</sub> , [Rw <sub>i</sub> ] or Rb <sub>n</sub> , #data <sub>3</sub>
7A	4	BXOR	bitaddr <sub>Z,Z</sub> , bitaddr <sub>Q,q</sub>
7B	2	DIVLU	Rw <sub>n</sub>
7C	2	SHR	Rw <sub>n</sub> , #data <sub>4</sub>
7D	2	JMPR	cc_NN, rel
7E	2	BCLR	bitaddr <sub>Q,7</sub>
7F	2	BSET	bitaddr <sub>Q,7</sub>
80	2	CMPI1	Rw <sub>n</sub> , #data <sub>4</sub>

Table 21 Instruction set ordered by Hex code (Continued)

Hex-code	Number of Bytes	Mnemonic	Operand
81	2	NEG	Rw <sub>n</sub>
82	4	CMPI1	Rw <sub>n</sub> , mem
83	4	CoXXX <sup>1</sup>	Rw <sub>n</sub> , [Rw <sub>m</sub> ⊗]
84	4	MOV	[Rw <sub>n</sub> ], mem
85	-	-	-
86	4	CMPI1	Rw <sub>n</sub> , #data <sub>16</sub>
87	4	IDLE	
88	2	MOV	[-Rw <sub>m</sub> ], Rw <sub>n</sub>
89	2	MOVB	[-Rw <sub>m</sub> ], Rb <sub>n</sub>
8A	4	JB	bitaddr <sub>Q,q</sub> , rel
8B	-	-	-
8C	-	-	-
8D	2	JMPR	cc_C, rel or cc_ULT, rel
8E	2	BCLR	bitaddr <sub>Q,8</sub>
8F	2	BSET	bitaddr <sub>Q,8</sub>
90	2	CMPI2	Rw <sub>n</sub> , #data <sub>4</sub>
91	2	CPL	Rw <sub>n</sub>
92	4	CMPI2	Rw <sub>n</sub> , mem
93	4	CoXXX <sup>1</sup>	[IDXi⊗], [Rw <sub>n</sub> ⊗]
94	4	MOV	mem, [Rw <sub>n</sub> ]
95	-	-	-
96	4	CMPI2	Rw <sub>n</sub> , #data <sub>16</sub>
97	4	PWRDN	
98	2	MOV	Rw <sub>n</sub> , [Rw <sub>m</sub> +]
99	2	MOVB	Rb <sub>n</sub> , [Rw <sub>m</sub> +]
9A	4	JNB	bitaddr <sub>Q,q</sub> , rel
9B	2	TRAP	#trap7
9C	2	JMPI	cc, [Rw <sub>n</sub> ]
9D	2	JMPR	cc_NC, rel or cc_UGE, rel
9E	2	BCLR	bitaddr <sub>Q,9</sub>
9F	2	BSET	bitaddr <sub>Q,9</sub>
A0	2	CMPD1	Rw <sub>n</sub> , #data <sub>4</sub>
A1	2	NEGB	Rb <sub>n</sub>

Table 21 Instruction set ordered by Hex code (Continued)

Hex-code	Number of Bytes	Mnemonic	Operand
A2	4	CMPD1	Rw <sub>n</sub> , mem
A3	4	CoXXX <sup>1</sup>	Rw <sub>n</sub> , Rw <sub>m</sub>
A4	4	MOVB	[Rw <sub>n</sub> ], mem
A5	4	DISWDT	
A6	4	CMPD1	Rw <sub>n</sub> , #data <sub>16</sub>
A7	4	SRWDT	
A8	2	MOV	Rw <sub>n</sub> , [Rw <sub>m</sub> ]
A9	2	MOVB	Rb <sub>n</sub> , [Rw <sub>m</sub> ]
AA	4	JBC	bitaddr <sub>Q,q</sub> , rel
AB	2	CALLI	cc, [Rw <sub>n</sub> ]
AC	2	ASHR	Rw <sub>n</sub> , Rw <sub>m</sub>
AD	2	JMPR	cc_SGT, rel
AE	2	BCLR	bitaddr <sub>Q,10</sub>
AF	2	BSET	bitaddr <sub>Q,10</sub>
B0	2	CMPD2	Rw <sub>n</sub> , #data <sub>4</sub>
B1	2	CPLB	Rb <sub>n</sub>
B2	4	CMPD2	Rw <sub>n</sub> , mem
B3	4	CoSTORE <sup>1</sup>	[Rw <sub>n</sub> ⊗], CoReg
B4	4	MOVB	mem, [Rw <sub>n</sub> ]
B5	4	EINIT	
B6	4	CMPD2	Rw <sub>n</sub> , #data <sub>16</sub>
B7	4	SRST	
B8	2	MOV	[Rw <sub>m</sub> ], Rw <sub>n</sub>
B9	2	MOVB	[Rw <sub>m</sub> ], Rb <sub>n</sub>
BA	4	JNBS	bitaddr <sub>Q,q</sub> , rel
BB	2	CALLR	rel
BC	2	ASHR	Rw <sub>n</sub> , #data <sub>4</sub>
BD	2	JMPR	cc_SLE, rel
BE	2	BCLR	bitaddr <sub>Q,11</sub>
BF	2	BSET	bitaddr <sub>Q,11</sub>
C0	2	MOVBZ	Rb <sub>n</sub> , Rb <sub>m</sub>
C1	-	-	-
C2	4	MOVBZ	reg, mem

Table 21 Instruction set ordered by Hex code (Continued)

Hex-code	Number of Bytes	Mnemonic	Operand
C3	4	CoSTORE <sup>1</sup>	Rw <sub>n</sub> , CoReg
C4	4	MOV	[Rw <sub>m</sub> +#data <sub>16</sub> ], Rw <sub>n</sub>
C5	4	MOVBZ	mem, reg
C6	4	SCXT	reg, #data <sub>16</sub>
C7	-	-	-
C8	2	MOV	[Rw <sub>n</sub> ], [Rw <sub>m</sub> ]
C9	2	MOVB	[Rw <sub>n</sub> ], [Rw <sub>m</sub> ]
CA	4	CALLA	cc, caddr
CB	2	RET	
CC	2	NOP	
CD	2	JMPR	cc_SLT, rel
CE	2	BCLR	bitaddr <sub>Q.12</sub>
CF	2	BSET	bitaddr <sub>Q.12</sub>
D0	2	MOVBS	Rb <sub>n</sub> , Rb <sub>m</sub>
D1	2	ATOMIC/EXTR	#data <sub>2</sub>
D2	4	MOVBS	reg, mem
D3	4	CoMOV <sup>1</sup>	[IDXi⊗], [Rw <sub>n</sub> ⊗]
D4	4	MOV	Rw <sub>n</sub> , [Rw <sub>m</sub> +#data <sub>16</sub> ]
D5	4	MOVBS	mem, reg
D6	4	SCXT	reg, mem
D7	4	EXTP(R)/EXTS(R)	#pag, #data <sub>2</sub>
D8	2	MOV	[Rw <sub>n</sub> +], [Rw <sub>m</sub> ]
D9	2	MOVB	[Rw <sub>n</sub> +], [Rw <sub>m</sub> ]
DA	4	CALLS	seg, caddr
DB	2	RETS	
DC	2	EXTP(R)/EXTS(R)	Rw <sub>m</sub> , #data <sub>2</sub>
DD	2	JMPR	cc_SGE, rel
DE	2	BCLR	bitaddr <sub>Q.13</sub>
DF	2	BSET	bitaddr <sub>Q.13</sub>
E0	2	MOV	Rw <sub>n</sub> , #data <sub>4</sub>
E1	2	MOVB	Rb <sub>n</sub> , #data <sub>4</sub>
E2	4	PCALL	reg, caddr
E3	-	-	-
E4	4	MOVB	[Rw <sub>m</sub> +#data <sub>16</sub> ], Rb <sub>n</sub>

Table 21 Instruction set ordered by Hex code (Continued)

Hex-code	Number of Bytes	Mnemonic	Operand
E5	-	-	-
E6	4	MOV	reg, #data <sub>16</sub>
E7	4	MOVB	reg, #data <sub>16</sub>
E8	2	MOV	[Rw <sub>n</sub> ], [Rw <sub>m</sub> +]
E9	2	MOVB	[Rw <sub>n</sub> ], [Rw <sub>m</sub> +]
EA	4	JMPA	cc, caddr
EB	2	RETP	reg
EC	2	PUSH	reg
ED	2	JMPR	cc_UGT, rel
EE	2	BCLR	bitaddr <sub>Q.14</sub>
EF	2	BSET	bitaddr <sub>Q.14</sub>
F0	2	MOV	Rw <sub>n</sub> , Rw <sub>m</sub>
F1	2	MOVB	Rb <sub>n</sub> , Rb <sub>m</sub>
F2	4	MOV	reg, mem
F3	4	MOVB	reg, mem
F4	4	MOVB	Rb <sub>n</sub> , [Rw <sub>m</sub> +#data <sub>16</sub> ]
F5	-	-	-
F6	4	MOV	mem, reg
F7	4	MOVB	mem, reg
F8	-	-	-
F9	-	-	-
FA	4	JMPS	seg, caddr
FB	2	RETI	
FC	2	POP	reg
FD	2	JMPR	cc_ULE, rel
FE	2	BCLR	bitaddr <sub>Q.15</sub>
FF	2	BSET	bitaddr <sub>Q.15</sub>

**Table 21 Instruction set ordered by Hex code (Continued)**

1. This instruction only applies to products including the MAC.

## 1.6 Instruction conventions

This section details the conventions used in the individual instruction descriptions. Each individual instruction description is described in a standard format in separate sections under the following headings:

1.6.1 Instruction name

Specifies the mnemonic opcode of the instruction.

1.6.2 Syntax

Specifies the mnemonic opcode and the required formal operands of the instruction. Instructions can have either none, one, two or three operands which are separated from each other by commas:

```
MNEMONIC {op1 {,op2 {,op3 } } }
```

The operand syntax depends on the addressing mode. All of the available addressing modes are summarized at the end of each single instruction description.

1.6.3 Operation

The following symbols are used to represent data movement, arithmetic or logical operators.

Diadic operations		operator (opY)	
	(opx) <-- (opy)	(opY)	is MOVED into (opX)
	(opx) + (opy)	(opX)	is ADDED to (opY)
	(opx) - (opy)	(opY)	is SUBTRACTED from (opX)
	(opx) * (opy)	(opX)	is MULTIPLIED by (opY)
	(opx) / (opy)	(opX)	is DIVIDED by (opY)
	(opx) ^ (opy)	(opX)	is logically ANDed with (opY)
	(opx) v (opy)	(opX)	is logically ORed with (opY)
	(opx) ⊕ (opy)	(opX)	is logically EXCLUSIVELY ORed with (opY)
	(opx) <--> (opy)	(opX)	is COMPARED against (opY)
	(opx) mod (opy)	(opX)	is divided MODULO (opY)
Monadic operations		operator (opX)	
	(opx) ¬	(opX)	is logically COMPLEMENTED

Table 22 Instruction operation symbols



Missing or existing parentheses signifies that the operand specifies an immediate constant value, an address, or a pointer to an address as follows:

- opX            Specifies the immediate constant value of opX.
- (opX)        Specifies the contents of opX.
- (opX<sub>n</sub>)      Specifies the contents of bit n of opX.
- ((opX))      Specifies the contents of the contents of opX (i.e. opX is used as pointer to the actual operand).

The following abbreviations are used to describe operands:

Abbreviation	Description
CP	Context Pointer register.
CSP	Code Segment Pointer register.
IP	Instruction Pointer.
MD	Multiply/Divide register (32 bits wide, consists of MDH and MDL).
MDL, MDH	Multiply/Divide Low and High registers (each 16 bit wide).
PSW	Program Status Word register.
SP	System Stack Pointer register.
SYSCON	System Configuration register.
C	Carry flag in the PSW register.
V	Overflow flag in the PSW register.
SGTDIS	Segmentation Disable bit in the SYSCON register.
count	Temporary variable for an intermediate storage of the number of shift or rotate cycles which remain to complete the shift or rotate operation.
tmp	Temporary variable for an intermediate result.
0, 1, 2,...	Constant values due to the data format of the specified operation.

Table 23 Operand abbreviations

1.6.4 Data types

Specifies the particular data type according to the instruction. Basically, the following data types are used:

- BIT, BYTE, WORD, DOUBLEWORD

Except for those instructions which extend byte data to word data, all instructions have only one particular data type. Note that the data types mentioned here do not take into account accesses to indirect address pointers or to the system stack which are always performed with word data. Moreover, no data type is specified for System Control Instructions and for those of the branch instructions which do not access any explicitly addressed data.

1.6.5 Description

Describes the operation of the instruction.

1.6.6 Condition code

The following table summarizes the 16 possible condition codes that can be used within Call and Branch instructions and shows the mnemonic abbreviations, the test executed for a specific condition and the 4-bit condition code number.

Condition Code Mnemonic cc	Test	Description	Condition Code Number c
cc_UC	1 = 1	Unconditional	0h
cc_Z	Z = 1	Zero	2h
cc_NZ	Z = 0	Not zero	3h
cc_V	V = 1	Overflow	4h
cc_NV	V = 0	No overflow	5h
cc_N	N = 1	Negative	6h
cc_NN	N = 0	Not negative	7h
cc_C	C = 1	Carry	8h
cc_NC	C = 0	No carry	9h
cc_EQ	Z = 1	Equal	2h
cc_NE	Z = 0	Not equal	3h

Table 24 Condition codes



Condition Code Mnemonic cc	Test	Description	Condition Code Number c
cc_ULT	$C = 1$	Unsigned less than	8h
cc_ULE	$(Z \vee C) = 1$	Unsigned less than or equal	Fh
cc_UGE	$C = 0$	Unsigned greater than or equal	9h
cc_UGT	$(Z \vee C) = 0$	Unsigned greater than	Eh
cc_SLT	$(N \oplus V) = 1$	Signed less than	Ch
cc_SLE	$(Z \vee (N \oplus V)) = 1$	Signed less than or equal	Bh
cc_SGE	$(N \oplus V) = 0$	Signed greater than or equal	Dh
cc_SGT	$(Z \vee (N \oplus V)) = 0$	Signed greater than	Ah
cc_NET	$(Z \vee E) = 0$	Not equal AND not end of table	1h

Table 24 Condition codes

1.6.7 Flags

This section shows the state of the N, C, V, Z and E flags in the PSW register. The resulting state of the flags is represented by the following symbols

Symbol	Description
*	The flag is set according to the following standard rules
	N = 1 :   Most significant bit of the result is set
	N = 0 :   Most significant bit of the result is not set
	C = 1 :   Carry occurred during operation
	C = 0 :   No Carry occurred during operation
	V = 1 :   Arithmetic Overflow occurred during operation
	V = 0 :   No Arithmetic Overflow occurred during operation
	Z = 1 :   Result equals zero
	Z = 0 :   Result does not equal zero
	E = 1 :   Source operand represents the lowest negative number, either 8000h for word data or 80h for byte data.
	E = 0 :   Source operand does not represent the lowest negative number for the specified data type
"S"	The flag is set according to non-standard rules. Individual instruction pages or the ALU status flags description.
"_"	The flag is not affected by the operation
"0"	The flag is cleared by the operation.
"NOR"	The flag contains the logical NORing of the two specified bit operands.
"AND"	The flag contains the logical ANDing of the two specified bit operands.
"OR"	The flag contains the logical ORing of the two specified bit operands.
"XOR"	The flag contains the logical XORing of the two specified bit operands.
"B"	The flag contains the original value of the specified bit operand.
" $\overline{B}$ "	The flag contains the complemented value of the specified bit operand

Table 25 List of flags

If the PSW register is specified as the destination operand of an instruction, the flags can not be interpreted as described. This is because the PSW register is modified according to the data format of the instruction:

- For word operations, the PSW register is overwritten with the word result.
- For byte operations, the non-addressed byte is cleared and the addressed byte is overwritten.
- For bit or bit-field operations on the PSW register, only the specified bits are modified.

If the flags are not selected as destination bits, they stay unchanged i.e. they maintain the state existing after the previous instruction.

In all cases, if the PSW is the destination operand of an instruction, the PSW flags do NOT represent the flags of this instruction, in the normal way.

### 1.6.8 Addressing modes

Specifies available combinations of addressing modes. The selected addressing mode combination is generally specified by the opcode of the corresponding instruction. However, there are some arithmetic and logical instructions where the addressing mode combination is not specified by the (identical) opcodes but by particular bits within the operand field.

In the individual instruction description, the addressing mode is described in terms of mnemonic, format and number of bytes.

- **Mnemonic** gives an example of which operands the instruction will accept.
- **Format** specifies the format of the instruction as used in the assembler listing. *Figure 3* shows the reference between the instruction format representation of the assembler and the corresponding internal organization of the instruction format (N = nibble = 4 bits). The following symbols are used to describe the instruction formats:

00 <sub>h</sub> through FF <sub>h</sub>	Instruction Opcodes
0, 1	Constant Values
:....	Each of the 4 characters immediately following a colon represents a single bit
:.ii	2-bit short GPR address (Rw <sub>i</sub> )
ss	8-bit code segment number (seg).
:.##	2-bit immediate constant (#data <sub>2</sub> )
:.###	3-bit immediate constant (#data <sub>3</sub> )
c	4-bit condition code specification (cc)
n	4-bit short GPR address (Rw <sub>n</sub> or Rb <sub>n</sub> )
m	4-bit short GPR address (Rw <sub>m</sub> or Rb <sub>m</sub> )
q	4-bit position of the source bit within the word specified by QQ
z	4-bit position of the destination bit within the word specified by ZZ
#	4-bit immediate constant (#data <sub>4</sub> )
QQ	8-bit word address of the source bit (bitoff)
rr	8-bit relative target address word offset (rel)
RR	8-bit word address reg
ZZ	8-bit word address of the destination bit (bitoff)
##	8-bit immediate constant (#data <sub>8</sub> )
@ @	8-bit immediate constant (#mask <sub>8</sub> )
pp 0:00pp	10-bit page address (#pag <sub>10</sub> )
MM MM	16-bit address (mem or caddr; low byte, high byte)
## ##	16-bit immediate constant (#data <sub>16</sub> ; low byte, high byte)

Table 26 Instruction format symbols

**Number of bytes** Specifies the size of an instruction in bytes. All ST10 instructions are either 2 or 4 bytes. Instructions are classified as either single word or double word instructions.

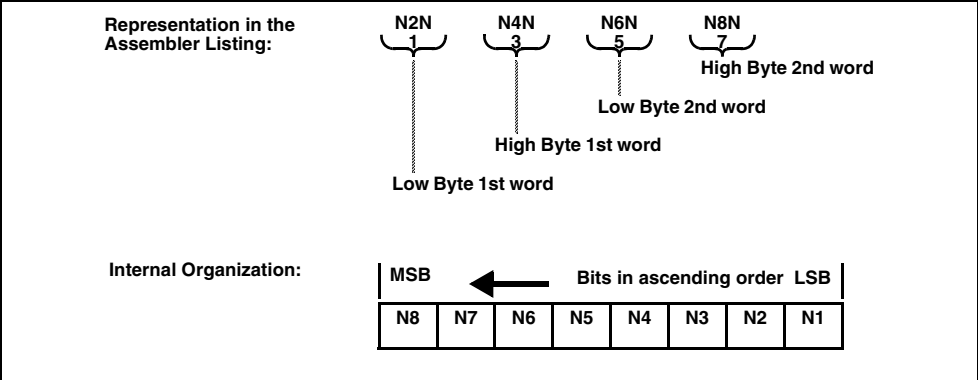


Figure 3 Instruction format representation

## 1.7 ATOMIC and EXTended instructions

ATOMIC, EXTR, EXTP, EXTS, EXTPR, EXTSR instructions disable standard and PEC interrupts and class A traps during a sequence of the following 1...4 instructions. The length of the sequence is determined by an operand (op1 or op2, depending on the instruction). The EXTended instructions also change the addressing mechanism during this sequence (see detailed instruction description).

The ATOMIC and EXTended instructions become active immediately, so no additional NOPs are required. All instructions requiring multiple cycles or hold states to be executed are regarded as one instruction in this sense. Any instruction type can be used with the ATOMIC and EXTended instructions.

**CAUTION:** When a Class B trap interrupts an ATOMIC or EXTended sequence, this sequence is terminated, the interrupt lock is removed and the standard condition is restored, before the trap routine is executed! The remaining instructions of the terminated sequence that are executed after returning from the trap routine, will run under standard conditions!

**CAUTION:** When using the ATOMIC and EXTended instructions with other system control or branch instructions.

**CAUTION:** When using nested ATOMIC and EXTended instructions. There is ONE counter to control the length of this sort of sequence, i.e. issuing an ATOMIC or EXTended instruction within a sequence will reload the counter with value of the new instruction.

## 1.8 Instruction descriptions

This section contains a detailed description of each instruction, listed in alphabetical order.

# ADD

Syntax

Integer Addition

ADD      op1, op2

Operation

(op1) <-- (op1) + (op2)

Data Types

WORD

Description

Performs a 2's complement binary addition of the source operand specified by op2 and the destination operand specified by op1. The sum is then stored in op1.

Flags

E	Z	V	C	N
*	*	*	*	*

- E      Set if the value of op2 represents the lowest possible negative number. Cleared otherwise. Used to signal the end of a table.
- Z      Set if result equals zero. Cleared otherwise.
- V      Set if an arithmetic overflow occurred, i.e. the result cannot be represented in the specified data type. Cleared otherwise.
- C      Set if a carry is generated from the most significant bit of the specified data type. Cleared otherwise.
- N      Set if the most significant bit of the result is set. Cleared otherwise.

Addressing Modes

	Mnemonic	Format	Bytes
ADD	Rw <sub>n</sub> , Rw <sub>m</sub>	00 nm	2
ADD	Rw <sub>n</sub> , [Rw <sub>i</sub> ]	08 n:10ii	2
ADD	Rw <sub>n</sub> , [Rw <sub>i</sub> +]	08 n:11ii	2
ADD	Rw <sub>n</sub> , #data <sub>3</sub>	08 n:0###	2
ADD	reg, #data <sub>16</sub>	06 RR ## ##	4
ADD	reg, mem	02 RR MM MM	4
ADD	mem, reg	04 RR MM MM	4

ADDB

Syntax

Integer Addition

ADDB op1, op2

Operation

(op1) <-- (op1) + (op2)

Data Types

BYTE

Description

Performs a 2's complement binary addition of the source operand specified by op2 and the destination operand specified by op1. The sum is then stored in op1.

Flags

E	Z	V	C	N
*	*	*	*	*

- E Set if the value of op2 represents the lowest possible negative number. Cleared otherwise. Used to signal the end of a table.
- Z Set if result equals zero. Cleared otherwise.
- V Set if an arithmetic overflow occurred, i.e. the result cannot be represented in the specified data type. Cleared otherwise.
- C Set if a carry is generated from the most significant bit of the specified data type. Cleared otherwise.
- N Set if the most significant bit of the result is set. Cleared otherwise.

Addressing Modes

Mnemonic		Format	Bytes
ADDB	Rb <sub>n</sub> , Rb <sub>m</sub>	01 nm	2
ADDB	Rb <sub>n</sub> , [Rw <sub>i</sub> ]	09 n:10ii	2
ADDB	Rb <sub>n</sub> , [Rw <sub>i</sub> +	09 n:11ii	2
ADDB	Rb <sub>n</sub> , #data <sub>3</sub>	09 n:0###	2
ADDB	reg, #data <sub>16</sub>	07 RR ## ##	4
ADDB	reg, mem	03 RR MM MM	4
ADDB	mem, reg	05 RR MM MM	4



# ADDC

Syntax

Integer Addition with Carry

ADDC     op1, op2

Operation

(op1) <-- (op1) + (op2) + (C)

Data Types

WORD

Description

Performs a 2's complement binary addition of the source operand specified by op2, the destination operand specified by op1 and the previously generated carry bit. The sum is then stored in op1. This instruction can be used to perform multiple precision arithmetic.

Flags

E	Z	V	C	N
*	S	*	*	*

- E     Set if the value of op2 represents the lowest possible negative number. Cleared otherwise. Used to signal the end of a table.
- Z     Set if result equals zero and previous Z flag was set. Cleared otherwise.
- V     Set if an arithmetic overflow occurred, i.e. the result cannot be represented in the specified data type. Cleared otherwise.
- C     Set if a carry is generated from the most significant bit of the specified data type. Cleared otherwise.
- N     Set if the most significant bit of the result is set. Cleared otherwise.

Addressing Modes

Mnemonic	Format	Bytes
ADDC $Rw_n, Rw_m$	10 nm	2
ADDC $Rw_n, [Rw_i]$	18 n:10ii	2
ADDC $Rw_n, [Rw_i+]$	18 n:11ii	2
ADDC $Rw_n, \#data_3$	18 n:0###	2
ADDC    reg, $\#data_{16}$	16 RR ## ##	4
ADDC    reg, mem	12 RR MM MM	4
ADDC    mem, reg	14 RR MM MM	4

# ADDCB

Syntax

ADDCB op1, op2

Operation

(op1) <-- (op1) + (op2) + (C)

Data Types

BYTE

Description

Performs a 2's complement binary addition of the source operand specified by op2, the destination operand specified by op1 and the previously generated carry bit. The sum is then stored in op1. This instruction can be used to perform multiple precision arithmetic.

Flags

E	Z	V	C	N
*	S	*	*	*

- E

Set if the value of op2 represents the lowest possible negative number. Cleared otherwise. Used to signal the end of a table.
- Z

Set if result equals zero and previous Z flag was set. Cleared otherwise.
- V

Set if an arithmetic overflow occurred, i.e. the result cannot be represented in the specified data type. Cleared otherwise.
- C

Set if a carry is generated from the most significant bit of the specified data type. Cleared otherwise.
- N

Set if the most significant bit of the result is set. Cleared otherwise.

Addressing Modes

Mnemonic	Format	Bytes
ADDCB Rb <sub>n</sub> , Rb <sub>m</sub>	11 nm	2
ADDCB Rb <sub>n</sub> , [Rw <sub>i</sub> ]	19 n:10ii	2
ADDCB Rb <sub>n</sub> , [Rw <sub>i</sub> +]	19 n:11ii	2
ADDCB Rb <sub>n</sub> , #data <sub>3</sub>	19 n:0###	2
ADDCB reg, #data <sub>16</sub>	17 RR ## ##	4
ADDCB reg, mem	13 RR MM MM	4
ADDCB mem, reg	15 RR MM MM	4



# AND

Syntax

Logical AND

AND        op1, op2

Operation

(op1) <-- (op1) ^ (op2)

Data Types

WORD

Description

Performs a bitwise logical AND of the source operand specified by op2 and the destination operand specified by op1. The result is then stored in op1.

Flags

E	Z	V	C	N
*	*	0	0	*

- E        Set if the value of op2 represents the lowest possible negative number. Cleared otherwise. Used to signal the end of a table.
- Z        Set if result equals zero. Cleared otherwise.
- V        Always cleared.
- C        Always cleared.
- N        Set if the most significant bit of the result is set. Cleared otherwise.

Addressing Modes

Mnemonic		Format	Bytes
AND	Rw <sub>n</sub> , Rw <sub>m</sub>	60 nm	2
AND	Rw <sub>n</sub> , [Rw <sub>i</sub> ]	68 n:10ii	2
AND	Rw <sub>n</sub> , [Rw <sub>i</sub> +]	68 n:11ii	2
AND	Rw <sub>n</sub> , #data <sub>3</sub>	68 n:0###	2
AND	reg, #data <sub>16</sub>	66 RR ## ##	4
AND	reg, mem	62 RR MM MM	4
AND	mem, reg	64 RR MM MM	4

ANDB

Syntax

Logical AND

ANDB op1, op2

Operation

(op1) <-- (op1) ^ (op2)

Data Types

BYTE

Description

Performs a bitwise logical AND of the source operand specified by op2 and the destination operand specified by op1. The result is then stored in op1.

Flags

E	Z	V	C	N
*	*	0	0	*

- E Set if the value of op2 represents the lowest possible negative number. Cleared otherwise. Used to signal the end of a table.
- Z Set if result equals zero. Cleared otherwise.
- V Always cleared.
- C Always cleared.
- N Set if the most significant bit of the result is set. Cleared otherwise.

Addressing Modes

Mnemonic		Format	Bytes
ANDB	Rb <sub>n</sub> , Rb <sub>m</sub>	61 nm	2
ANDB	Rb <sub>n</sub> , [Rw <sub>i</sub> ]	69 n:10ii	2
ANDB	Rb <sub>n</sub> , [Rw <sub>i</sub> +]	69 n:11ii	2
ANDB	Rb <sub>n</sub> , #data <sub>3</sub>	69 n:0###	2
ANDB	reg, #data <sub>16</sub>	67 RR ## ##	4
ANDB	reg, mem	63 RR MM MM	4
ANDB	mem, reg	65 RR MM MM	4

# ASHR

## Syntax

### Arithmetic Shift Right

ASHR     op1, op2

## Operation

```
(count) <-- (op2)
(V) <-- 0
(C) <-- 0
DO WHILE (count) ≠ 0
    (V) <-- (C) v (V)
    (C) <-- (op10)
    (op1n) <-- (op1n+1) [n=0...14]
    (count) <-- (count) - 1
END WHILE
```

## Data Types

WORD

## Description

Arithmetically shifts the destination word operand op1 right by as many times as specified in the source operand op2. To preserve the sign of the original operand op1, the most significant bits of the result are filled with zeros if the original most significant bit was a 0 or with ones if the original most significant bit was a 1. The Overflow flag is used as a Rounding flag. The least significant bit is shifted into the Carry. Only shift values between 0 and 15 are allowed. When using a GPR as the count control, only the least significant 4 bits are used.

## Flags

E	Z	V	C	N
0	*	S	S	*

- E     Always cleared.
- Z     Set if result equals zero. Cleared otherwise.
- V     Set if in any cycle of the shift operation a 1 is shifted out of the carry flag. Cleared for a shift count of zero.
- C     The carry flag is set according to the last least significant bit shifted out of op1. Cleared for a shift count of zero.
- N     Set if the most significant bit of the result is set. Cleared otherwise.

## Addressing Modes

Mnemonic		Format	Bytes
ASHR	Rw <sub>n</sub> , Rw <sub>m</sub>	AC nm	2
ASHR	Rw <sub>n</sub> , #data <sub>4</sub>	BC #n	2

ATOMIC

Syntax

Operation

Description

Note

Flags

Addressing Modes

Begin ATOMIC Sequence

ATOMIC    op1

(count) <-- (op1) [1 ≤ op1 ≤ 4]

Disable interrupts and Class A traps

DO WHILE ((count) ≠ 0 AND Class\_B\_trap\_condition ≠ TRUE)

    Next Instruction

    (count) <-- (count) - 1

END WHILE

(count) = 0

Enable interrupts and traps

Causes standard and PEC interrupts and class A hardware traps to be disabled for a specified number of instructions. The ATOMIC instruction becomes immediately active so that no additional NOPs are required.

Depending on the value of op1, the period of validity of the ATOMIC sequence extends over the sequence of the next 1 to 4 instructions being executed after the ATOMIC instruction. All instructions requiring multiple cycles or hold states to be executed are regarded as one instruction in this sense. Any instruction type can be used with the ATOMIC instruction.

The ATOMIC instruction must be used carefully (see *ATOMIC and EXTended instructions* on page 53 ).

E	Z	V	C	N
-	-	-	-	-

E            Not affected.

Z            Not affected.

V            Not affected.

C            Not affected.

N            Not affected.

Mnemonic	Format	Bytes
ATOMIC    #data <sub>2</sub>	D1 00##:0	2

BAND

Syntax

Bit Logical AND

BAND     op1, op2

Operation

(op1) <-- (op1) ^ (op2)

Data Types

BIT

Description

Performs a single bit logical AND of the source bit specified by op2 and the destination bit specified by op1. The result is then stored in op1.

Flags

E	Z	V	C	N
0	NOR	OR	AND	XOR

- E       Always cleared.
- Z       Contains the logical NOR of the two specified bits.
- V       Contains the logical OR of the two specified bits.
- C       Contains the logical AND of the two specified bits.
- N       Contains the logical XOR of the two specified bits.

Addressing Modes

Mnemonic	Format	Bytes
BAND bitaddr <sub>Z,Z</sub> , bitaddr <sub>Q,q</sub>	6A QQ ZZ qz	4

BCLR

Syntax

Operation

Data Types

Description

Flags

Addressing Modes

Bit Clear

BCLR     op1

(op1) <-- 0

BIT

Clears the bit specified by op1. This instruction is primarily used for peripheral and system control.

E	Z	V	C	N
0	$\overline{B}$	0	0	B

- E       Always cleared.
- Z       Contains the logical negation of the previous state of the specified bit.
- V       Always cleared.
- C       Always cleared.
- N       Contains the previous state of the specified bit.

Mnemonic	Format	Bytes
BCLR     bitaddr <sub>Q,q</sub>	qE QQ	2





BCMP

Syntax

Bit to Bit Compare

BCMP     op1, op2

Operation

(op1) <--> (op2)

Data Types

BIT

Description

Performs a single bit comparison of the source bit specified by operand op1 to the source bit specified by operand op2. No result is written by this instruction. Only the flags are updated.

Flags

E	Z	V	C	N
0	NOR	OR	AND	XOR

- E       Always cleared.
- Z       Contains the logical NOR of the two specified bits.
- V       Contains the logical OR of the two specified bits.
- C       Contains the logical AND of the two specified bits.
- N       Contains the logical XOR of the two specified bits.

Addressing Modes

Mnemonic	Format	Bytes
BCMP     bitaddr <sub>Z,Z</sub> , bitaddr <sub>Q,q</sub>	2A QQ ZZ qz	4

BFLDH

Syntax

Bit Field High Byte

BFLDH    op1, op2, op3

Operation

(tmp) <-- (op1)  
(high byte (tmp)) <-- ((high byte (tmp) ^ ~op2) v op3)  
(op1) <-- (tmp)

Data Types

WORD

Description

Replaces those bits in the high byte of the destination word operand op1 which are selected by an '1' in the AND mask op2 with the bits at the corresponding positions in the OR mask specified by op3.

Note

Bits which are masked off by a '0' in the AND mask op2 may be unintentionally altered if the corresponding bit in the OR mask op3 contains a '1'.

Flags

E	Z	V	C	N
0	*	0	0	*

- E       Always cleared.
- Z       Set if the word result equals zero. Cleared otherwise.
- V       Always cleared.
- C       Always cleared.
- N       Set if the most significant bit of the word result is set. Cleared otherwise.

Addressing Modes

Mnemonic	Format	Bytes
BFLDH bitoff <sub>Q</sub> , #mask <sub>8</sub> , #data <sub>8</sub>	1A QQ ## @ @	4

# BFLDL

## Syntax

### Bit Field Low Byte

BFLDL    op1, op2, op3

## Operation

(tmp) <-- (op1)  
(low byte (tmp)) <-- ((low byte (tmp) ^ ~op2) v op3)  
(op1) <-- (tmp)

## Data Types

WORD

## Description

Replaces those bits in the low byte of the destination word operand op1 which are selected by an '1' in the AND mask op2 with the bits at the corresponding positions in the OR mask specified by op3.

## Note

Bits which are masked off by a '0' in the AND mask op2 may be unintentionally altered if the corresponding bit in the OR mask op3 contains a '1'.

## Flags

E	Z	V	C	N
0	*	0	0	*

- E       Always cleared.
- Z       Set if the word result equals zero. Cleared otherwise.
- V       Always cleared.
- C       Always cleared.
- N       Set if the most significant bit of the word result is set. Cleared otherwise.

## Addressing Modes

Mnemonic	Format	Bytes
BFLDL bitoff <sub>Q</sub> , #mask <sub>8</sub> , #data <sub>8</sub>	0A QQ @ @##	4

BMOV

Syntax

Bit to Bit Move

BMOV     op1, op2

Operation

(op1) <-- (op2)

Data Types

BIT

Description

Moves a single bit from the source operand specified by op2 into the destination operand specified by op1. The source bit is examined and the flags are updated accordingly.

Flags

E	Z	V	C	N
0	$\overline{B}$	0	0	B

- E       Always cleared.
- Z       Contains the logical negation of the previous state of the source bit.
- V       Always cleared.
- C       Always cleared.
- N       Contains the previous state of the source bit.

Addressing Modes

Mnemonic	Format	Bytes
BMOV bitaddr <sub>Z,Z</sub> , bitaddr <sub>Q,q</sub>	4A QQ ZZ qz	4

# BMOVN

## Bit to Bit Move & Negate

**Syntax** BMOVN op1, op2

**Operation** (op1) <-- ¬(op2)

**Data Types** BIT

**Description** Moves the complement of a single bit from the source operand specified by op2 into the destination operand specified by op1. The source bit is examined and the flags are updated accordingly.

### Flags

E	Z	V	C	N
0	$\overline{B}$	0	0	B

- E Always cleared.
- Z Contains the logical negation of the previous state of the source bit.
- V Always cleared.
- C Always cleared.
- N Contains the previous state of the source bit.

### Addressing Modes

Mnemonic	Format	Bytes
BMOVN bitaddr <sub>Z,z</sub> , bitaddr <sub>Q,q</sub>	3A QQ ZZ qz	4

BOR

Syntax

Bit Logical OR

BOR        op1, op2

Operation

(op1) <-- (op1) v (op2)

Data Types

BIT

Description

Performs a single bit logical OR of the source bit specified by operand op2 with the destination bit specified by operand op1. The ORed result is then stored in op1.

Flags

E	Z	V	C	N
0	NOR	OR	AND	XOR

- E        Always cleared.
- Z        Contains the logical NOR of the two specified bits.
- V        Contains the logical OR of the two specified bits.
- C        Contains the logical AND of the two specified bits.
- N        Contains the logical XOR of the two specified bits.

Addressing Modes

Mnemonic	Format	Bytes
BOR bitaddr <sub>Z</sub> , bitaddr <sub>Q,q</sub>	5A QQ ZZ qz	4

# BSET

Syntax

BSET     op1

Operation

(op1) <-- 1

Data Types

BIT

Description

Sets the bit specified by op1. This instruction is primarily used for peripheral and system control.

## Flags

E	Z	V	C	N
0	$\overline{B}$	0	0	B

- E
- Always cleared.
- Z
- Contains the logical negation of the previous state of the specified bit.
- V
- Always cleared.
- C
- Always cleared.
- N
- Contains the previous state of the specified bit.

## Addressing Modes

Mnemonic	Format	Bytes
BSET     bitaddr <sub>Q,q</sub>	qF QQ	2

BXOR

Syntax

Bit Logical XOR

BXOR     op1, op2

Operation

(op1) <-- (op1) ⊕ (op2)

Data Types

BIT

Description

Performs a single bit logical EXCLUSIVE OR of the source bit specified by operand op2 with the destination bit specified by operand op1. The XORed result is then stored in op1.

Flags

E	Z	V	C	N
0	NOR	OR	AND	XOR

- E       Always cleared.
- Z       Contains the logical NOR of the two specified bits.
- V       Contains the logical OR of the two specified bits.
- C       Contains the logical AND of the two specified bits.
- N       Contains the logical XOR of the two specified bits.

Addressing Modes

Mnemonic	Format	Bytes
BXOR bitaddr <sub>Z,Z</sub> , bitaddr <sub>Q,q</sub>	7A QQ ZZ qz	4



# CALLA

## Syntax

### Call Subroutine Absolute

CALLA    op1, op2

## Operation

IF (op1) THEN  
    (SP) <-- (SP) - 2  
    ((SP)) <-- (IP)  
    (IP) <-- op2  
  
ELSE  
    next instruction  
  
END IF

## Description

If the condition specified by op1 is met, a branch to the absolute memory location specified by the second operand op2 is taken. The value of the instruction pointer, IP, is placed onto the system stack. Because the IP always points to the instruction following the branch instruction, the value stored on the system stack represents the return address of the calling routine. If the condition is not met, no action is taken and the next instruction is executed normally.

## Condition Codes

See condition code Table 24 on page 48.

## Flags

E	Z	V	C	N
-	-	-	-	-

E        Not affected.  
Z        Not affected.  
V        Not affected.  
C        Not affected.  
N        Not affected.

## Addressing Modes

Mnemonic	Format	Bytes
CALLA    cc, caddr	CA c0 MM MM	4

CALLI

Syntax

Operation

Description

Condition Codes

Flags

Addressing Modes

Call Subroutine Indirect

```
CALLI    op1, op2

IF (op1) THEN
    (SP) <-- (SP) - 2
    ((SP)) <-- (IP)
    (IP) <-- (op2)
ELSE
    next instruction
END IF
```

If the condition specified by op1 is met, a branch to the location specified indirectly by the second operand op2 is taken. The value of the instruction pointer, IP, is placed onto the system stack. Because the IP always points to the instruction following the branch instruction, the value stored on the system stack represents the return address of the calling routine. If the condition is not met, no action is taken and the next instruction is executed normally.

See condition code Table 24 on page 48.

E	Z	V	C	N
-	-	-	-	-

- E Not affected.
- Z Not affected.
- V Not affected.
- C Not affected.
- N Not affected.

Mnemonic	Format	Bytes
CALLI cc, [Rw <sub>n</sub> ]	AB cn	2



CALLR

Call Subroutine Relative

Syntax

CALLR    op1

Operation

(SP) <-- (SP) - 2  
((SP)) <-- (IP)  
(IP) <-- (IP) + sign\_extend (op1)

Description

A branch is taken to the location specified by the instruction pointer, IP, plus the relative displacement, op1. The displacement is a two's complement number which is sign extended and counts the relative distance in words. The value of the instruction pointer (IP) is placed onto the system stack. Because the IP always points to the instruction following the branch instruction, the value stored on the system stack represents the return address of the calling routine. The value of the IP used in the target address calculation is the address of the instruction following the CALLR instruction.

Condition Codes

See condition code Table 24 on page 48.

Flags

E	Z	V	C	N
-	-	-	-	-

E            Not affected.  
Z            Not affected.  
V            Not affected.  
C            Not affected.  
N            Not affected.

Addressing Modes

Mnemonic	Format	Bytes
CALLR    rel	BB rr	2

CALLS

Call Inter-Segment Subroutine

**Syntax** CALLS op1, op2

**Operation** (SP) <-- (SP) - 2  
((SP)) <-- (CSP)  
(SP) <-- (SP) - 2  
((SP)) <-- (IP)  
(CSP) <-- op1  
(IP) <-- op2

**Description** A branch is taken to the absolute location specified by op2 within the segment specified by op1. The value of the instruction pointer (IP) is placed onto the system stack. Because the IP always points to the instruction following the branch instruction, the value stored on the system stack represents the return address to the calling routine. The previous value of the CSP is also placed on the system stack to insure correct return to the calling segment.

**Condition Codes** See condition code Table 24 on page 48.

**Flags**

E	Z	V	C	N
-	-	-	-	-

E Not affected.  
Z Not affected.  
V Not affected.  
C Not affected.  
N Not affected.

**Addressing Modes**

Mnemonic	Format	Bytes
CALLS seg, caddr	DA ss MM MM	4

# CMP

## Integer Compare

**Syntax** CMP op1, op2

**Operation** (op1) <--> (op2)

**Data Types** WORD

**Description** The source operand specified by op1 is compared to the source operand specified by op2 by performing a 2's complement binary subtraction of op2 from op1. The flags are set according to the rules of subtraction. The operands remain unchanged.

### Flags

E	Z	V	C	N
*	*	*	S	*

- E Set if the value of op2 represents the lowest possible negative number. Cleared otherwise. Used to signal the end of a table.
- Z Set if result equals zero. Cleared otherwise.
- V Set if an arithmetic underflow occurred, i.e. the result cannot be represented in the specified data type. Cleared otherwise.
- C Set if a borrow is generated. Cleared otherwise.
- N Set if the most significant bit of the result is set. Cleared otherwise.

### Addressing Modes

Mnemonic	Format	Bytes
CMP Rw <sub>n</sub> , Rw <sub>m</sub>	40 nm	2
CMP Rw <sub>n</sub> , [Rw <sub>i</sub> ]	48 n:10ii	2
CMP Rw <sub>n</sub> , [Rw <sub>i</sub> +]	48 n:11ii	2
CMP Rw <sub>n</sub> , #data <sub>3</sub>	48 n:0###	2
CMP reg, #data <sub>16</sub>	46 RR ## ##	4
CMP reg, mem	42 RR MM MM	4

CMPB

Syntax

CMPB     op1, op2

Operation

(op1) <--> (op2)

Data Types

BYTE

Description

The source operand specified by op1 is compared to the source operand specified by op2 by performing a 2's complement binary subtraction of op2 from op1. The flags are set according to the rules of subtraction. The operands remain unchanged

Flags

E	Z	V	C	N
*	*	*	S	*

- E     Set if the value of op2 represents the lowest possible negative number. Cleared otherwise. Used to signal the end of a table.
- Z     Set if result equals zero. Cleared otherwise.
- V     Set if an arithmetic underflow occurred, i.e. the result cannot be represented in the specified data type. Cleared otherwise.
- C     Set if a borrow is generated. Cleared otherwise.
- N     Set if the most significant bit of the result is set. Cleared otherwise.

Addressing Modes

Mnemonic	Format	Bytes
CMPB     Rb <sub>n</sub> , Rb <sub>m</sub>	41 nm	2
CMPB     Rb <sub>n</sub> , [Rw <sub>i</sub> ]	49 n:10ii	2
CMPB     Rb <sub>n</sub> , [Rw <sub>i</sub> +]	49 n:11ii	2
CMPB     Rb <sub>n</sub> , #data <sub>3</sub>	49 n:0###	2
CMPB     reg, #data <sub>16</sub>	47 RR ## ##	4
CMPB     reg, mem	43 RR MM MM	4



# CMPD1

## Integer Compare & Decrement by 1

**Syntax** CMPD1 op1, op2

**Operation** (op1) <--> (op2)  
(op1) <-- (op1) - 1

**Data Types** WORD

**Description** This instruction is used to enhance the performance and flexibility of loops. The source operand specified by op1 is compared to the source operand specified by op2 by performing a 2's complement binary subtraction of op2 from op1. Operand op1 may specify ONLY GPR registers. Once the subtraction has completed, the operand op1 is decremented by one. Using the set flags, a branch instruction can then be used in conjunction with this instruction to form common high level language FOR loops of any range.

### Flags

E	Z	V	C	N
*	*	*	S	*

- E Set if the value of op2 represents the lowest possible negative number. Cleared otherwise. Used to signal the end of a table.
- Z Set if result equals zero. Cleared otherwise.
- V Set if an arithmetic underflow occurred, i.e. the result cannot be represented in the specified data type. Cleared otherwise.
- C Set if a borrow is generated. Cleared otherwise.
- N Set if the most significant bit of the result is set. Cleared otherwise.

Addressing Modes	Mnemonic	Format	Bytes
	CMPD1 Rw <sub>n</sub> , #data <sub>4</sub>	A0 #n	2
	CMPD1 Rw <sub>n</sub> , #data <sub>16</sub>	A6 Fn ## ##	4
	CMPD1 Rw <sub>n</sub> , mem	A2 Fn MM MM	4

CMPD2

Syntax

Operation

Data Types

Description

Integer Compare & Decrement by 2

CMPD2    op1, op2

(op1) <--> (op2)  
(op1) <-- (op1) - 2

WORD

This instruction is used to enhance the performance and flexibility of loops. The source operand specified by op1 is compared to the source operand specified by op2 by performing a 2's complement binary subtraction of op2 from op1. Operand op1 may specify ONLY GPR registers. Once the subtraction has completed, the operand op1 is decremented by two. Using the set flags, a branch instruction can then be used in conjunction with this instruction to form common high level language FOR loops of any range.

Flags

E	Z	V	C	N
*	*	*	S	*

- E        Set if the value of op2 represents the lowest possible negative number. Cleared otherwise. Used to signal the end of a table.
- Z        Set if result equals zero. Cleared otherwise.
- V        Set if an arithmetic underflow occurred, i.e. the result cannot be represented in the specified data type. Cleared otherwise.
- C        Set if a borrow is generated. Cleared otherwise.
- N        Set if the most significant bit of the result is set. Cleared otherwise.

Addressing Modes

Mnemonic		Format	Bytes
CMPD2	Rw <sub>n</sub> , #data <sub>4</sub>	B0 #n	2
CMPD2	Rw <sub>n</sub> , #data <sub>16</sub>	B6 Fn ## ##	4
CMPD2	Rw <sub>n</sub> , mem	B2 Fn MM MM	4





CMPI1

Integer Compare & Increment by 1

Syntax CMPI1 op1, op2

Operation (op1) <--> (op2)  
(op1) <-- (op1) + 1

Data Types WORD

Description This instruction is used to enhance the performance and flexibility of loops. The source operand specified by op1 is compared to the source operand specified by op2 by performing a 2's complement binary subtraction of op2 from op1. Operand op1 may specify ONLY GPR registers. Once the subtraction has completed, the operand op1 is incremented by one. Using the set flags, a branch instruction can then be used in conjunction with this instruction to form common high level language FOR loops of any range.

Flags

E	Z	V	C	N
*	*	*	S	*

- E Set if the value of op2 represents the lowest possible negative number. Cleared otherwise. Used to signal the end of a table.
- Z Set if result equals zero. Cleared otherwise.
- V Set if an arithmetic underflow occurred, i.e. the result cannot be represented in the specified data type. Cleared otherwise.
- C Set if a borrow is generated. Cleared otherwise.
- N Set if the most significant bit of the result is set. Cleared otherwise.

Addressing Modes

Mnemonic	Format	Bytes
CMPI1 Rw <sub>n</sub> , #data <sub>4</sub>	80 #n	2
CMPI1 Rw <sub>n</sub> , #data <sub>16</sub>	86 Fn ## ##	4
CMPI1 Rw <sub>n</sub> , mem	82 Fn MM MM	4

CMPI2

Syntax

Integer Compare & Increment by 2

CMPI2     op1, op2

Operation

(op1) <--> (op2)  
(op1) <-- (op1) + 2

Data Types

WORD

Description

This instruction is used to enhance the performance and flexibility of loops. The source operand specified by op1 is compared to the source operand specified by op2 by performing a 2's complement binary subtraction of op2 from op1. Operand op1 may specify ONLY GPR registers. Once the subtraction has completed, the operand op1 is incremented by two. Using the set flags, a branch instruction can then be used in conjunction with this instruction to form common high level language FOR loops of any range.

Flags

E	Z	V	C	N
*	*	*	S	*

- E     Set if the value of op2 represents the lowest possible negative number. Cleared otherwise. Used to signal the end of a table.
- Z     Set if result equals zero. Cleared otherwise.
- V     Set if an arithmetic underflow occurred, i.e. the result cannot be represented in the specified data type. Cleared otherwise.
- C     Set if a borrow is generated. Cleared otherwise.
- N     Set if the most significant bit of the result is set. Cleared otherwise.

Addressing Modes

Mnemonic		Format	Bytes
CMPI2	Rw <sub>n</sub> , #data <sub>4</sub>	90 #n	2
CMPI2	Rw <sub>n</sub> , #data <sub>16</sub>	96 Fn ## ##	4
CMPI2	Rw <sub>n</sub> , mem	92 Fn MM MM	4



CPL

Integer One's Complement

**Syntax** CPL op1

**Operation** (op1) <-- ~(op1)

**Data Types** WORD

**Description** Performs a 1's complement of the source operand specified by op1. The result is stored back into op1.

**Flags**

E	Z	V	C	N
*	*	0	0	*

E Set if the value of op1 represents the lowest possible negative number. Cleared otherwise. Used to signal the end of a table.

Z Set if result equals zero. Cleared otherwise.

V Always cleared.

C Always cleared.

N Set if the most significant bit of the result is set. Cleared otherwise.

Addressing Modes	Mnemonic	Format	Bytes
	CPL Rw <sub>n</sub>	91 n0	2

CPLB

Syntax

Integer One's Complement

CPL      op1

Operation

(op1) <-- ~(op1)

Data Types

BYTE

Description

Performs a 1's complement of the source operand specified by op1. The result is stored back into op1.

Flags

E	Z	V	C	N
*	*	0	0	*

- E      Set if the value of op1 represents the lowest possible negative number. Cleared otherwise. Used to signal the end of a table.
- Z      Set if result equals zero. Cleared otherwise.
- V      Always cleared.
- C      Always cleared.
- N      Set if the most significant bit of the result is set. Cleared otherwise.

Addressing Modes

Mnemonic	Format	Bytes
CPLB      Rb <sub>n</sub>	B1 n0	2

# DISWDT

Syntax

Disable Watchdog Timer

DISWDT

Operation

Disable the watchdog timer

Description

This instruction disables the watchdog timer. The watchdog timer is enabled by a reset. The DISWDT instruction allows the watchdog timer to be disabled for applications which do not require a watchdog function. Following a reset, this instruction can be executed at any time until either a Service Watchdog Timer instruction (SRVWDT) or an End of Initialization instruction (EINIT) are executed. Once one of these instructions has been executed, the DISWDT instruction will have no effect. To insure that this instruction is not accidentally executed, it is implemented as a protected instruction.

Flags

E	Z	V	C	N
-	-	-	-	-

- E Not affected.
- Z Not affected.
- V Not affected.
- C Not affected.
- N Not affected.

Addressing Modes

Mnemonic	Format	Bytes
DISWDT	A5 5A A5 A5	4

DIV

Syntax

DIV          op1

Operation

(MDL) <-- (MDL) / (op1)  
(MDH) <-- (MDL) mod (op1)

Data Types

WORD

Description

Performs a signed 16-bit by 16-bit division of the low order word stored in the MD register by the source word operand op1. The signed quotient is then stored in the low order word of the MD register (MDL) and the remainder is stored in the high order word of the MD register ( MDH).

Flags

E	Z	V	C	N
0	*	S	0	*

- E          Always cleared.
- Z          Set if result equals zero. Cleared otherwise.
- V          Set if an arithmetic overflow occurred, i.e. the result cannot be represented in a word data type, or if the divisor (op1) was zero. Cleared otherwise.
- C          Always cleared.
- N          Set if the most significant bit of the result is set. Cleared otherwise.

Addressing Modes

Mnemonic		Format	Bytes
DIV	Rw <sub>n</sub>	4B nn	2

DIVL

32-by-16 Signed Division

Syntax	DIVL      op1
Operation	(MDL) <-- (MD) / (op1) (MDH) <-- (MD) mod (op1)
Data Types	WORD, DOUBLEWORD
Description	Performs an extended signed 32-bit by 16-bit division of the two words stored in the MD register by the source word operand op1. The signed quotient is then stored in the low order word of the MD register (MDL) and the remainder is stored in the high order word of the MD register ( MDH).

Flags

E	Z	V	C	N
0	*	S	0	*

E	Always cleared.
Z	Set if result equals zero. Cleared otherwise.
V	Set if an arithmetic overflow occurred, i.e. the result cannot be represented in a word data type, or if the divisor (op1) was zero. Cleared otherwise.
C	Always cleared.
N	Set if the most significant bit of the result is set. Cleared otherwise.

Addressing Modes	Mnemonic	Format	Bytes
	DIVL      Rw <sub>n</sub>	6B nn	2

DIVLU

Syntax

DIVLU     op1

Operation

(MDL) <-- (MD) / (op1)  
(MDH) <-- (MD) mod (op1)

Data Types

WORD, DOUBLEWORD

Description

Performs an extended unsigned 32-bit by 16-bit division of the two words stored in the MD register by the source word operand op1. The unsigned quotient is then stored in the low order word of the MD register (MDL) and the remainder is stored in the high order word of the MD register ( MDH).

Flags

E	Z	V	C	N
0	*	S	0	*

- E       Always cleared.
- Z       Set if result equals zero. Cleared otherwise.
- V       Set if an arithmetic overflow occurred, i.e. the result cannot be represented in a word data type, or if the divisor (op1) was zero. Cleared otherwise.
- C       Always cleared.
- N       Set if the most significant bit of the result is set. Cleared otherwise.

Addressing Modes

Mnemonic	Format	Bytes
DIVLU     Rwn	7B nn	2



DIVU

16-by-16 Unsigned Division

Syntax

DIVU      op1

Operation

(MDL) <-- (MDL) / (op1)  
(MDH) <-- (MDL) mod (op1)

Data Types

WORD

Description

Performs an unsigned 16-bit by 16-bit division of the low order word stored in the MD register by the source word operand op1. The signed quotient is then stored in the low order word of the MD register (MDL) and the remainder is stored in the high order word of the MD register ( MDH).

Flags

E	Z	V	C	N
0	*	S	0	*

- E      Always cleared.
- Z      Set if result equals zero. Cleared otherwise.
- V      Set if an arithmetic overflow occurred, i.e. the result cannot be represented in a word data type, or if the divisor (op1) was zero. Cleared otherwise.
- C      Always cleared.
- N      Set if the most significant bit of the result is set. Cleared otherwise.

Addressing Modes

Mnemonic		Format	Bytes
DIVU	Rw <sub>n</sub>	5B nn	2

EINIT

Syntax

Operation

Description

Flags

Addressing Modes

End of Initialization

EINIT

End of Initialization

This instruction is used to signal the end of the initialization portion of a program. After a reset, the reset output pin RSTOUT is pulled low. It remains low until the EINIT instruction has been executed at which time it goes high. This enables the program to signal the external circuitry that it has successfully initialized the microcontroller. After the EINIT instruction has been executed, execution of the Disable Watchdog Timer instruction (DISWDT) has no effect. To insure that this instruction is not accidentally executed, it is implemented as a protected instruction.

E	Z	V	C	N
-	-	-	-	-

- E Not affected.
- Z Not affected.
- V Not affected.
- C Not affected.
- N Not affected.

Mnemonic	Format	Bytes
EINIT	B5 4A B5 B5	4

EXTP

Begin EXTended Page Sequence

Syntax

EXTP      op1, op2

Operation

(count) <-- (op2) [1 ≤ op2 ≤ 4]  
Disable interrupts and Class A traps  
Data\_Page = (op1)  
DO WHILE ((count) ≠ 0 AND Class\_B\_trap\_condition ≠ TRUE)  
    Next Instruction  
    (count) <-- (count) - 1  
END WHILE  
(count) = 0  
Data\_Page = (DPPx)  
Enable interrupts and traps

Description

Overrides the standard DPP addressing scheme of the long and indirect addressing modes for a specified number of instructions. During their execution, both standard and PEC interrupts and class A hardware traps are locked. The EXTP instruction becomes immediately active such that no additional NOPs are required.  
For any long ('mem') or indirect ([...]) address in the EXTP instruction sequence, the 10-bit page number (address bits A23-A14) is not determined by the contents of a DPP register but by the value of op1 itself. The 14-bit page offset (address bits A13-A0) is derived from the long or indirect address as usual. The value of op2 defines the length of the effected instruction sequence.

Note

The EXTP instruction must be used carefully (see *ATOMIC and EXTended instructions* on page 53).

Flags

E	Z	V	C	N
-	-	-	-	-
E	Not affected.			
Z	Not affected.			
V	Not affected.			
C	Not affected.			
N	Not affected.			

Addressing Modes

Mnemonic	Format	Bytes
EXTP      Rwm, #data <sub>2</sub>	DC 01##:m	2
EXTP      #pag, #data <sub>2</sub>	D7 01##:0 pp 0:00pp	4



EXTPR

Syntax

Operation

Description

Note

Flags

Addressing Modes

Begin EXTENDED Page & Register Sequence

```
EXTPR    op1, op2
(count) <-- (op2) [1 ≤ op2 ≤ 4]
Disable interrupts and Class A traps
Data_Page = (op1) AND SFR_range = Extended
DO WHILE ((count) ≠ 0 AND Class_B_trap_condition ≠ TRUE)
    Next Instruction
    (count) <-- (count) - 1
END WHILE
(count) = 0
Data_Page = (DPPx) AND SFR_range = Standard
Enable interrupts and traps
```

Overrides the standard DPP addressing scheme of the long and indirect addressing modes and causes all SFR or SFR bit accesses via the 'reg', 'bitoff' or 'bitaddr' addressing modes being made to the Extended SFR space for a specified number of instructions. During their execution, both standard and PEC interrupts and class A hardware traps are locked. For any long ('mem') or indirect ([...]) address in the EXTP instruction sequence, the 10-bit page number (address bits A23-A14) is not determined by the contents of a DPP register but by the value of op1 itself. The 14-bit page offset (address bits A13-A0) is derived from the long or indirect address as usual. The value of op2 defines the length of the effected instruction sequence.

The EXTPR instruction must be used carefully (see *ATOMIC and EXTENDED instructions* on page 53).

E	Z	V	C	N
-	-	-	-	-

- E Not affected.
- Z Not affected.
- V Not affected.
- C Not affected.
- N Not affected.

Mnemonic	Format	Bytes
EXTPR Rwm, #data <sub>2</sub>	DC 11##:m	2
EXTPR #pag, #data <sub>2</sub>	D7 11##:0 pp 0:00pp	4



# EXTR

## Begin EXTended Register Sequence

Syntax

EXTR      op1

Operation

(count) <-- (op1) [1 ≤ op1 ≤ 4]  
Disable interrupts and Class A traps  
SFR\_range = Extended  
DO WHILE ((count) ≠ 0 AND Class\_B\_trap\_condition ≠ TRUE)  
    Next Instruction  
    (count) <-- (count) - 1  
END WHILE  
(count) = 0  
SFR\_range = Standard  
Enable interrupts and traps

Description

Causes all SFR or SFR bit accesses via the “reg”, “bitoff” or “bitaddr” addressing modes being made to the Extended SFR space for a specified number of instructions. During their execution, both standard and PEC interrupts and class A hardware traps are locked.  
The value of op1 defines the length of the effected instruction sequence.

Note

The EXTR instruction must be used carefully (see *ATOMIC and EXTended instructions* on page 53).

### Flags

E	Z	V	C	N
-	-	-	-	-

E

Not affected.

Z

Not affected.

V

Not affected.

C

Not affected.

N

Not affected.

Addressing Modes

Mnemonic	Format	Bytes
EXTR      #data <sub>2</sub>	D1 10##:0	2

EXTS

Syntax

Operation

Description

Note

Flags

Addressing Modes

Begin EXTended Segment Sequence

```
EXTS      op1, op2

(count) <-- (op2) [1 ≤ op2 ≤ 4]
Disable interrupts and Class A traps
Data_Segment = (op1)
DO WHILE ((count) ≠ 0 AND Class_B_trap_condition ≠ TRUE)
    Next Instruction
    (count) <-- (count) - 1
END WHILE
(count) = 0
Data_Page = (DPPx)
Enable interrupts and traps
```

Overrides the standard DPP addressing scheme of the long and indirect addressing modes for a specified number of instructions. During their execution, both standard and PEC interrupts and class A hardware traps are locked. The EXTS instruction becomes immediately active such that no additional NOPs are required.

For any long ('mem') or indirect ([...]) address in an EXTS instruction sequence, the value of op1 determines the 8-bit segment (address bits A23-A16) valid for the corresponding data access. The long or indirect address itself represents the 16-bit segment offset (address bits A15-A0).

The value of op2 defines the length of the effected instruction sequence.

The EXTS instruction must be used carefully (see *ATOMIC and EXTended instructions* on page 53).

E	Z	V	C	N
-	-	-	-	-

- E Not affected.
- Z Not affected.
- V Not affected.
- C Not affected.
- N Not affected.

Mnemonic	Format	Bytes
EXTS Rwm, #data <sub>2</sub>	DC 00##:m	2
EXTS #seg, #data <sub>2</sub>	D7 00##:0 ss 00	4



# EXTSR

## Syntax

### Begin EXTENDED Segment & Register Sequence

## Operation

```
EXTSR    op1, op2

(count) <-- (op2) [1 ≤ op2 ≤ 4]
Disable interrupts and Class A traps
Data_Segment = (op1) AND SFR_range = Extended
DO WHILE ((count) ≠ 0 AND Class_B_trap_condition ≠ TRUE)
    Next Instruction
    (count) <-- (count) - 1
END WHILE
(count) = 0
Data_Page = (DPPx) AND SFR_range = Standard
Enable interrupts and traps
```

## Description

Overrides the standard DPP addressing scheme of the long and indirect addressing modes and causes all SFR or SFR bit accesses via the 'reg', 'bitoff' or 'bitaddr' addressing modes being made to the Extended SFR space for a specified number of instructions. During their execution, both standard and PEC interrupts and class A hardware traps are locked. The EXTSR instruction becomes immediately active such that no additional NOPs are required. For any long ('mem') or indirect ([...]) address in an EXTSR instruction sequence, the value of op1 determines the 8-bit segment (address bits A23-A16) valid for the corresponding data access. The long or indirect address itself represents the 16-bit segment offset (address bits A15-A0). The value of op2 defines the length of the effected instruction sequence.

## Note

The EXTSR instruction must be used carefully (see *ATOMIC and EXTENDED instructions* on page 53).

## Flags

E	Z	V	C	N
-	-	-	-	-
E	Not affected.			
Z	Not affected.			
V	Not affected.			
C	Not affected.			
N	Not affected.			

## Addressing Modes

Mnemonic	Format	Bytes
EXTSR Rwm, #data <sub>2</sub>	DC 10##:m	2
EXTSR #seg, #data <sub>2</sub>	D7 10##:0 ss 00	4

IDLE

Syntax

Operation

Description

Flags

Addressing Modes

Enter Idle Mode

IDLE

Enter Idle Mode

This instruction causes the part to enter the idle mode. In this mode, the CPU is powered down while the peripherals remain running. It remains powered down until a peripheral interrupt or external interrupt occurs. To insure that this instruction is not accidentally executed, it is implemented as a protected instruction.

E	Z	V	C	N
-	-	-	-	-

E            Not affected.  
Z            Not affected.  
V            Not affected.  
C            Not affected.  
N            Not affected.

Mnemonic	Format	Bytes
IDLE	87 78 87 87	4



# JB

## Syntax

### Relative Jump if Bit Set

JB            op1, op2

## Operation

IF (op1) = 1 THEN  
    (IP) <-- (IP) + sign\_extend (op2)  
ELSE  
    Next Instruction  
END IF

## Data Types

BIT

## Description

If the bit specified by op1 is set, program execution continues at the location of the instruction pointer, IP, plus the specified displacement, op2. The displacement is a two's complement number which is sign extended and counts the relative distance in words. The value of the IP used in the target address calculation is the address of the instruction following the JB instruction. If the specified bit is clear, the instruction following the JB instruction is executed.

## Flags

E	Z	V	C	N
-	-	-	-	-

E            Not affected.  
Z            Not affected.  
V            Not affected.  
C            Not affected.  
N            Not affected.

## Addressing Modes

Mnemonic	Format	Bytes
JB            bitaddr <sub>Q,q</sub> , rel	8A QQ rr q0	4

JBC

Syntax

Operation

Data Types

Description

Flags

Addressing Modes

Relative Jump if Bit Set & Clear Bit

```
JBC      op1, op2

IF (op1) = 1 THEN
    (op1) = 0
    (IP) <-- (IP) + sign_extend (op2)
ELSE
    Next Instruction
END IF

BIT
```

If the bit specified by op1 is set, program execution continues at the location of the instruction pointer, IP, plus the specified displacement, op2. The bit specified by op1 is cleared, allowing implementation of semaphore operations. The displacement is a two's complement number which is sign extended and counts the relative distance in words. The value of the IP used in the target address calculation is the address of the instruction following the JBC instruction. If the specified bit was clear, the instruction following the JBC instruction is executed.

E	Z	V	C	N
0	$\overline{B}$	0	0	B

- E Always cleared
- Z Contains logical negation of the previous state of the specified bit.
- V Always cleared
- C Always cleared
- N Contains the previous state of the specified bit.

Mnemonic	Format	Bytes
JBC	bitaddr <sub>Q,q</sub> , rel	AA QQ rr q0 4



# JMPA

## Absolute Conditional Jump

**Syntax**

JMPA      op1, op2

**Operation**

IF (op1) = 1 THEN  
    (IP) <-- op2  
  
ELSE  
    Next Instruction  
  
END IF

**Description**

If the condition specified by op1 is met, a branch to the absolute address specified by op2 is taken. If the condition is not met, no action is taken, and the instruction following the JMPA instruction is executed normally.

**Condition Codes**

See Condition code Table 24 on page 48.

**Flags**

E	Z	V	C	N
-	-	-	-	-

- E      Not affected.
- Z      Not affected.
- V      Not affected.
- C      Not affected.
- N      Not affected.

**Addressing Modes**

Mnemonic	Format	Bytes
JMPA      cc, caddr	EA c0 MM MM	4

JMPI

Indirect Conditional Jump

Syntax

JMPI      op1, op2

Operation

IF (op1) = 1 THEN  
    (IP) <-- (op2)  
ELSE  
    Next Instruction  
END IF

Description

If the condition specified by op1 is met, a branch to the absolute address specified by op2 is taken. If the condition is not met, no action is taken, and the instruction following the JMPI instruction is executed normally.

Condition Codes

See Condition code Table 24 on page 48.

Flags

E	Z	V	C	N
-	-	-	-	-

E      Not affected.  
Z      Not affected.  
V      Not affected.  
C      Not affected.  
N      Not affected.

Addressing Modes

Mnemonic	Format	Bytes
JMPI      cc, [Rw <sub>n</sub> ]	9C cn	2

# JMPR

## Relative Conditional Jump

Syntax

Operation

JMPR     op1, op2

IF (op1) = 1 THEN

(IP) <-- (IP) + sign\_extend (op2)

ELSE

Next Instruction

END IF

Description

If the condition specified by op1 is met, program execution continues at the location of the instruction pointer, IP, plus the specified displacement, op2. The displacement is a two's complement number which is sign extended and counts the relative distance in words. The value of the IP used in the target address calculation is the address of the instruction following the JMPR instruction. If the specified condition is not met, program execution continues normally with the instruction following the JMPR instruction.

Condition Codes

See condition code Table 24 on page 48.

Flags

E	Z	V	C	N
-	-	-	-	-

E

Not affected.

Z

Not affected.

V

Not affected.

C

Not affected.

N

Not affected.

Addressing Modes

Mnemonic	Format	Bytes
JMPR     cc, rel	cD rr	2

JMPS

Syntax

Absolute Inter-Segment Jump

JMPS      op1, op2

Operation

(CSP) <-- op1  
(IP) <-- op2

Description

Branches unconditionally to the absolute address specified by op2 within the segment specified by op1.

Flags

E	Z	V	C	N
-	-	-	-	-

E            Not affected.  
Z            Not affected.  
V            Not affected.  
C            Not affected.  
N            Not affected.

Addressing Modes

Mnemonic	Format	Bytes
JMPS      seg, caddr	FA ss MM MM	4

# JNB

## Syntax

### Relative Jump if Bit Clear

JNB          op1, op2

## Operation

IF (op1) = 0 THEN  
    (IP) <-- (IP) + sign\_extend (op2)  
ELSE  
    Next Instruction  
END IF

## Data Types

BIT

## Description

If the bit specified by op1 is clear, program execution continues at the location of the instruction pointer, IP, plus the specified displacement, op2. The displacement is a two's complement number which is sign extended and counts the relative distance in words. The value of the IP used in the target address calculation is the address of the instruction following the JNB instruction. If the specified bit is set, the instruction following the JNB instruction is executed.

## Flags

E	Z	V	C	N
-	-	-	-	-

E          Not affected.  
Z          Not affected.  
V          Not affected.  
C          Not affected.  
N          Not affected.

## Addressing Modes

Mnemonic	Format	Bytes
JNB          bitaddr <sub>Q,q</sub> , rel	9A QQ rr q0	4

JNBS

Syntax

Operation

Data Types

Description

Flags

Addressing Modes

Relative Jump if Bit Clear & Set Bit

```
JNBS      op1, op2

IF (op1) = 0 THEN
    (op1) = 1
    (IP) <-- (IP) + sign_extend (op2)
ELSE
    Next Instruction
END IF

BIT
```

If the bit specified by op1 is clear, program execution continues at the location of the instruction pointer, IP, plus the specified displacement, op2. The bit specified by op1 is set, allowing implementation of semaphore operations. The displacement is a two's complement number which is sign extended and counts the relative distance in words. The value of the IP used in the target address calculation is the address of the instruction following the JNBS instruction. If the specified bit was set, the instruction following the JNBS instruction is executed.

E	Z	V	C	N
0	$\overline{B}$	0	0	B

- E Always cleared.
- Z Contains logical negation of the previous state of the specified bit.
- V Always cleared.
- C Always cleared.
- N Contains the previous state of the specified bit.

Mnemonic	Format	Bytes
JNBS	bitaddr <sub>Q,q</sub> , rel	BA QQ rr q0 4





MOV

Syntax

Move Data

MOV        op1, op2

Operation

(op1) <-- (op2)

Data Types

WORD

Description

Moves the contents of the source operand specified by op2 to the location specified by the destination operand op1. The contents of the moved data is examined, and the flags are updated accordingly.

Flags

E	Z	V	C	N
*	*	-	-	*

- E        Set if the value of op2 represents the lowest possible negative number. Cleared otherwise. Used to signal the end of a table.
- Z        Set if the value of the source operand op2 equals zero. Cleared otherwise.
- V        Not affected.
- C        Not affected.
- N        Set if the most significant bit of the source operand op2 is set. Cleared otherwise.

Addressing Modes

Mnemonic	Format	Bytes
MOV $Rw_n, Rw_m$	F0 nm	2
MOV $Rw_n, \#data_4$	E0 #n	2
MOV $reg, \#data_{16}$	E6 RR ## ##	4
MOV $Rw_n, [Rw_m]$	A8 nm	2
MOV $Rw_n, [Rw_m+]$	98 nm	2
MOV $[Rw_m], Rw_n$	B8 nm	2
MOV $[-Rw_m], Rw_n$	88 nm	2
MOV $[Rw_n], [Rw_m]$	C8 nm	2
MOV $[Rw_n+], [Rw_m]$	D8 nm	2
MOV $[Rw_n], [Rw_m+]$	E8 nm	2
MOV $Rw_n, [Rw_m+\#data_{16}]$	D4 nm ## ##	4
MOV $[Rw_m+\#data_{16}], Rw_n$	C4 nm ## ##	4
MOV $[Rw_n], mem$	84 0n MM MM	4
MOV $mem, [Rw_n]$	94 0n MM MM	4
MOV $reg, mem$	F2 RR MM MM	4
MOV $mem, reg$	F6 RR MM MM	4

MOVB

Syntax

Move Data

MOVB op1, op2

Operation

(op1) <-- (op2)

Data Types

BYTE

Description

Moves the contents of the source operand specified by op2 to the location specified by the destination operand op1. The contents of the moved data is examined, and the flags are updated accordingly.

Flags

E	Z	V	C	N
*	*	-	-	*

- E Set if the value of op2 represents the lowest possible negative number. Cleared otherwise. Used to signal the end of a table.
- Z Set if the value of the source operand op2 equals zero. Cleared otherwise.
- V Not affected.
- C Not affected.
- N Set if the most significant bit of the source operand op2 is set. Cleared otherwise.

Addressing Modes

Mnemonic	Format	Bytes
MOVB Rb <sub>n</sub> , Rb <sub>m</sub>	F1 nm	2
MOVB Rb <sub>n</sub> , #data <sub>4</sub>	E1 #n	2
MOVB reg, #data <sub>16</sub>	E7 RR ## ##	4
MOVB Rb <sub>n</sub> , [Rw <sub>m</sub> ]	A9 nm	2
MOVB Rb <sub>n</sub> , [Rw <sub>m</sub> +]	99 nm	2
MOVB [Rw <sub>m</sub> ], Rb <sub>n</sub>	B9 nm	2
MOVB [-Rw <sub>m</sub> ], Rb <sub>n</sub>	89 nm	2
MOVB [Rw <sub>n</sub> ], [Rw <sub>m</sub> ]	C9 nm	2
MOVB [Rw <sub>n</sub> +] , [Rw <sub>m</sub> ]	D9 nm	2
MOVB [Rw <sub>n</sub> ], [Rw <sub>m</sub> +]	E9 nm	2
MOVB Rb <sub>n</sub> , [Rw <sub>m</sub> +#data <sub>16</sub> ]	F4 nm ## ##	4
MOVB [Rw <sub>m</sub> +#data <sub>16</sub> ], Rb <sub>n</sub>	E4 nm ## ##	4
MOVB [Rw <sub>n</sub> ], mem	A4 0n MM MM	4
MOVB mem, [Rw <sub>n</sub> ]	B4 0n MM MM	4
MOVB reg, mem	F3 RR MM MM	4
MOVB mem, reg	F7 RR MM MM	4

MOVBS

Move Byte Sign Extend

Syntax

MOVBS op1, op2

Operation

(low byte op1) <-- (op2)  
IF (op2<sub>7</sub>) = 1 THEN  
    (high byte op1) <-- FF<sub>h</sub>  
ELSE  
    (high byte op1) <-- 00<sub>h</sub>  
END IF

Data Types

WORD, BYTE

Description

Moves and sign extends the contents of the source byte specified by op2 to the word location specified by the destination operand op1. The contents of the moved data is examined, and the flags are updated accordingly.

Flags

E	Z	V	C	N
0	*	-	-	*

- E Always cleared.
- Z Set if the value of the source operand op2 equals zero. Cleared otherwise.
- V Not affected.
- C Not affected.
- N Set if the most significant bit of the source operand op2 is set. Cleared otherwise.

Addressing Modes

Mnemonic		Format	Bytes
MOVBS	Rb <sub>n</sub> , Rb <sub>m</sub>	D0 mn	2
MOVBS	reg, mem	D2 RR MM MM	4
MOVBS	mem, reg	D5 RR MM MM	4

MOVBZ

Syntax

Move Byte Zero Extend

MOVBZ    op1, op2

Operation

(low byte op1) <-- (op2)  
(high byte op1) <-- 00<sub>h</sub>

Data Types

WORD, BYTE

Description

Moves and zero extends the contents of the source byte specified by op2 to the word location specified by the destination operand op1. The contents of the moved data is examined, and the flags are updated accordingly.

Flags

E	Z	V	C	N
0	*	-	-	0

- E       Always cleared.
- Z       Set if the value of the source operand op2 equals zero. Cleared otherwise.
- V       Not affected.
- C       Not affected.
- N       Always cleared.

Addressing Modes

Mnemonic	Format	Bytes
MOVBZ    Rb <sub>n</sub> , Rb <sub>m</sub>	C0 mn	2
MOVBZ    reg, mem	C2 RR MM MM	4
MOVBZ    mem, reg	C5 RR MM MM	4

MUL

Syntax	MUL      op1, op2
Operation	(MD) <-- (op1) * (op2)
Data Types	WORD
Description	Performs a 16-bit by 16-bit signed multiplication using the two words specified by operands op1 and op2 respectively. The signed 32-bit result is placed in the MD register.

Flags

E	Z	V	C	N
0	*	S	0	*

E	Always cleared.
Z	Set if the result equals zero. Cleared otherwise.
V	This bit is set if the result cannot be represented in a word data type. Cleared otherwise.
C	Always cleared.
N	Set if the most significant bit of the result is set. Cleared otherwise.

Addressing Modes	Mnemonic	Format	Bytes
	MUL $Rw_n, Rw_m$	0B nm	2

MULU

Syntax

MULU     op1, op2

Operation

(MD) <-- (op1) \* (op2)

Data Types

WORD

Description

Performs a 16-bit by 16-bit unsigned multiplication using the two words specified by operands op1 and op2 respectively. The unsigned 32-bit result is placed in the MD register.

Flags

E	Z	V	C	N
0	*	S	0	*

- E       Always cleared.
- Z       Set if the result equals zero. Cleared otherwise.
- V       This bit is set if the result cannot be represented in a word data type. Cleared otherwise.
- C       Always cleared.
- N       Set if the most significant bit of the result is set. Cleared otherwise.

Addressing Modes

Mnemonic		Format	Bytes
MULU	Rw <sub>n</sub> , Rw <sub>m</sub>	1B nm	2

NEG

Integer Two's Complement

**Syntax** NEG op1

**Operation** (op1) <-- 0 - (op1)

**Data Types** WORD

**Description** Performs a binary 2's complement of the source operand specified by op1. The result is then stored in op1.

Flags

E	Z	V	C	N
*	*	*	S	*

- E Set if the value of op1 represents the lowest possible negative number. Cleared otherwise. Used to signal the end of a table.
- Z Set if result equals zero. Cleared otherwise.
- V Set if an arithmetic underflow occurred, i.e. the result cannot be represented in the specified data type. Cleared otherwise.
- C Set if a borrow is generated. Cleared otherwise.
- N Set if the most significant bit of the result is set. Cleared otherwise.

Addressing Modes

Mnemonic	Format	Bytes
NEG Rw <sub>n</sub>	81 n0	2

NEGB

Syntax

Integer Two’s Complement

NEGB     op1

Operation

(op1) <-- 0 - (op1)

Data Types

BYTE

Description

Performs a binary 2's complement of the source operand specified by op1. The result is then stored in op1.

Flags

E	Z	V	C	N
*	*	*	S	*

- E     Set if the value of op1 represents the lowest possible negative number. Cleared otherwise. Used to signal the end of a table.
- Z     Set if result equals zero. Cleared otherwise.
- V     Set if an arithmetic underflow occurred, i.e. the result cannot be represented in the specified data type. Cleared otherwise.
- C     Set if a borrow is generated. Cleared otherwise.
- N     Set if the most significant bit of the result is set. Cleared otherwise.

Addressing Modes

Mnemonic	Format	Bytes
NEGB     Rb <sub>n</sub>	A1 n0	2



# NOP

No Operation

Syntax

NOP

Operation

No Operation

Description

This instruction causes a null operation to be performed. A null operation causes no change in the status of the flags.

Flags

E	Z	V	C	N
-	-	-	-	-

- E Not affected.
- Z Not affected.
- V Not affected.
- C Not affected.
- N Not affected.

Addressing Modes

Mnemonic	Format	Bytes
NOP	CC 00	2

OR

Syntax

Logical OR

OR            op1, op2

Operation

(op1) <-- (op1) v (op2)

Data Types

WORD

Description

Performs a bitwise logical OR of the source operand specified by op2 and the destination operand specified by op1. The result is then stored in op1.

Flags

E	Z	V	C	N
*	*	0	0	*

- E            Set if the value of op2 represents the lowest possible negative number. Cleared otherwise. Used to signal the end of a table.
- Z            Set if result equals zero. Cleared otherwise.
- V            Always cleared.
- C            Always cleared.
- N            Set if the most significant bit of the result is set. Cleared otherwise.

Addressing Modes

Mnemonic		Format	Bytes
OR	Rw <sub>n</sub> , Rw <sub>m</sub>	70 nm	2
OR	Rw <sub>n</sub> , [Rw <sub>i</sub> ]	78 n:10ii	2
OR	Rw <sub>n</sub> , [Rw <sub>i</sub> +]	78 n:11ii	2
OR	Rw <sub>n</sub> , #data <sub>3</sub>	78 n:0###	2
OR	reg, #data <sub>16</sub>	76 RR ## ##	4
OR	reg, mem	72 RR MM MM	4
OR	mem, reg	74 RR MM MM	4

ORB

Logical OR

**Syntax** ORB op1, op2

**Operation** (op1) <-- (op1) v (op2)

**Data Types** BYTE

**Description** Performs a bitwise logical OR of the source operand specified by op2 and the destination operand specified by op1. The result is then stored in op1.

Flags

E	Z	V	C	N
*	*	0	0	*

- E Set if the value of op2 represents the lowest possible negative number. Cleared otherwise. Used to signal the end of a table.
- Z Set if result equals zero. Cleared otherwise.
- V Always cleared.
- C Always cleared.
- N Set if the most significant bit of the result is set. Cleared otherwise.

Addressing Modes

Mnemonic	Format	Bytes
ORB Rb <sub>n</sub> , Rb <sub>m</sub>	71 nm	2
ORB Rb <sub>n</sub> , [Rw <sub>i</sub> ]	79 n:10ii	2
ORB Rb <sub>n</sub> , [Rw <sub>i</sub> +]	79 n:11ii	2
ORB Rb <sub>n</sub> , #data <sub>3</sub>	79 n:0###	2
ORB reg, #data <sub>16</sub>	77 RR ## ##	4
ORB reg, mem	73 RR MM MM	4
ORB mem, reg	75 RR MM MM	4

PCALL

Syntax

Operation

Data Types

Description

Flags

Addressing Modes

Push Word & Call Subroutine Absolute

PCALL    op1, op2

(tmp) <-- (op1)  
(SP) <-- (SP) - 2  
((SP)) <-- (tmp)  
(SP) <-- (SP) - 2  
((SP)) <-- (IP)  
(IP) <-- op2

WORD

Pushes the word specified by operand op1 and the value of the instruction pointer, IP, onto the system stack, and branches to the absolute memory location specified by the second operand op2. Because IP always points to the instruction following the branch instruction, the value stored on the system stack represents the return address of the calling routine.

E	Z	V	C	N
*	*	-	-	*

- E      Set if the value of the pushed operand op1 represents the lowest possible negative number. Cleared otherwise. Used to signal the end of a table.
- Z      Set if the value of the pushed operand op1 equals zero. Cleared otherwise.
- V      Not affected.
- C      Not affected.
- N      Set if the most significant bit of the pushed operand op1 is set. Cleared otherwise.

Mnemonic	Format	Bytes
PCALL    reg, caddr	E2 RR MM MM	4



# POP

Syntax	POP      op1												
Operation	(tmp) <-- ((SP)) (SP) <-- (SP) + 2 (op1) <-- (tmp)												
Data Types	WORD												
Description	Pops one word from the system stack specified by the Stack Pointer into the operand specified by op1. The Stack Pointer is then incremented by two.												
Flags	<table><tr><td>E</td><td>Z</td><td>V</td><td>C</td><td>N</td></tr><tr><td>*</td><td>*</td><td>-</td><td>-</td><td>*</td></tr></table> <div><div>E</div><div>Set if the value of the popped word represents the lowest possible negative number. Cleared otherwise. Used to signal the end of a table.</div><div>Z</div><div>Set if the value of the popped word equals zero. Cleared otherwise.</div><div>V</div><div>Not affected.</div><div>C</div><div>Not affected.</div><div>N</div><div>Set if the most significant bit of the popped word is set. Cleared otherwise.</div></div>			E	Z	V	C	N	*	*	-	-	*
E	Z	V	C	N									
*	*	-	-	*									
Addressing Modes	Mnemonic	Format	Bytes										
	POP      reg	FC RR	2										

PRIOR

Syntax

Prioritize Register

PRIOR    op1, op2

Operation

```
(tmp) <-- (op2)
(count) <-- 0
DO WHILE (tmp15) ≠ 1 AND (count) ≠ 15 AND (op2) ≠ 0
    (tmpn) <-- (tmpn-1)
    (count) <-- (count) + 1
END WHILE
(op1) <-- (count)
```

Data Types

WORD

Description

This instruction stores a count value in the word operand specified by op1 indicating the number of single bit shifts required to normalize the operand op2 so that its most significant bit is equal to one. If the source operand op2 equals zero, a zero is written to operand op1 and the zero flag is set. Otherwise the zero flag is cleared.

Flags

E	Z	V	C	N
0	*	0	0	0

- E       Always cleared.
- Z       Set if the source operand op2 equals zero. Cleared otherwise.
- V       Always cleared.
- C       Always cleared.
- N       Always cleared.

Addressing Modes

Mnemonic	Format	Bytes
PRIOR    R <sub>wn</sub> , R <sub>wm</sub>	2B nm	2



# PUSH

Syntax	PUSH     op1												
Operation	(tmp) <-- (op1) (SP) <-- (SP) - 2 ((SP)) <-- (tmp)												
Data Types	WORD												
Description	Moves the word specified by operand op1 to the location in the internal system stack specified by the Stack Pointer, after the Stack Pointer has been decremented by two.												
Flags	<table><tr><td>E</td><td>Z</td><td>V</td><td>C</td><td>N</td></tr><tr><td>*</td><td>*</td><td>-</td><td>-</td><td>*</td></tr></table> <div><div>E</div><div>Set if the value of the pushed word represents the lowest possible negative number. Cleared otherwise. Used to signal the end of a table.</div><div>Z</div><div>Set if the value of the pushed word equals zero. Cleared otherwise.</div><div>V</div><div>Not affected.</div><div>C</div><div>Not affected.</div><div>N</div><div>Set if the most significant bit of the pushed word is set. Cleared otherwise.</div></div>			E	Z	V	C	N	*	*	-	-	*
E	Z	V	C	N									
*	*	-	-	*									
Addressing Modes	Mnemonic	Format	Bytes										
	PUSH     reg	EC RR	2										

PWRDN

Syntax

Operation

Description

Flags

Addressing Modes

Enter Power Down Mode

PWRDN

Enter Power Down Mode

This instruction causes the part to enter the power down mode. In this mode, all peripherals and the CPU are powered down until the part is externally reset. To insure that this instruction is not accidentally executed, it is implemented as a protected instruction. To further control the action of this instruction, the PWRDN instruction is only enabled when the non-maskable interrupt pin ( $\overline{\text{NMI}}$ ) is in the low state. Otherwise, this instruction has no effect.

E	Z	V	C	N
-	-	-	-	-

E            Not affected.  
Z            Not affected.  
V            Not affected.  
C            Not affected.  
N            Not affected.

Mnemonic	Format	Bytes
PWRDN	97 68 97 97	4



# RET

## Return from Subroutine

Syntax

RET

Operation

(IP) <-- ((SP))  
(SP) <-- (SP) + 2

Description

Returns from a subroutine. The IP is popped from the system stack. Execution resumes at the instruction following the CALL instruction in the calling routine.

### Flags

E	Z	V	C	N
-	-	-	-	-

E

Not affected.

Z

Not affected.

V

Not affected.

C

Not affected.

N

Not affected.

Addressing Modes

Mnemonic

RET

Format

CB 00

Bytes

2

RETI

Syntax

Operation

Description

Flags

Addressing Modes

Return from Interrupt Routine

```
RETI
(IP) <-- ((SP))
(SP) <-- (SP) + 2
IF (SYSCON.SGTDIS=0) THEN
    (CSP) <-- ((SP))
    (SP) <-- (SP) + 2
END IF
(PSW) <-- ((SP))
(SP) <-- (SP) + 2
```

Returns from an interrupt routine. The PSW, IP, and CSP are popped off the system stack. Execution resumes at the instruction which had been interrupted. The previous system state is restored after the PSW has been popped. The CSP is only popped if segmentation is enabled. This is indicated by the SGTDIS bit in the SYSCON register.

E	Z	V	C	N
S	S	S	S	S

- E Restored from the PSW popped from stack.
- Z Restored from the PSW popped from stack.
- V Restored from the PSW popped from stack.
- C Restored from the PSW popped from stack.
- N Restored from the PSW popped from stack.

Mnemonic	Format	Bytes
RETI	FB 88	2



# RETP

## Return from Subroutine & Pop Word

Syntax

RETP     op1

Operation

(IP) <-- ((SP))  
(SP) <-- (SP) + 2  
(tmp) <-- ((SP))  
(SP) <-- (SP) + 2  
(op1) <-- (tmp)

Data Types

WORD

Description

Returns from a subroutine. The IP is first popped from the system stack and then the next word is popped from the system stack into the operand specified by op1. Execution resumes at the instruction following the CALL instruction in the calling routine.

Flags

	E	Z	V	C	N
	*	*	-	-	*

E

Set if the value of the word popped into operand op1 represents the lowest possible negative number. Cleared otherwise. Used to signal the end of a table.

Z

Set if the value of the word popped into operand op1 equals zero. Cleared otherwise.

V

Not affected.

C

Not affected.

N

Set if the most significant bit of the word popped into operand op1 is set. Cleared otherwise.

Addressing Modes

Mnemonic	Format	Bytes
RETP     reg	EB RR	2

RETS

Syntax

Operation

Description

Flags

Addressing Mode

Return from Inter-Segment Subroutine

RETS

(IP) <-- ((SP))  
(SP) <-- (SP) + 2  
(CSP) <-- ((SP))  
(SP) <-- (SP) + 2

Returns from an inter-segment subroutine. The IP and CSP are popped from the system stack. Execution resumes at the instruction following the CALLS instruction in the calling routine.

E	Z	V	C	N
-	-	-	-	-

E        Not affected.  
Z        Not affected.  
V        Not affected.  
C        Not affected.  
N        Not affected.

Mnemonic	Format	Bytes
RETS	DB 00	2

ROL

Syntax

Operation

Data Types

Description

Flags

Addressing Modes

Rotate Left

```
ROL      op1, op2

(count) <-- (op2)
(C) <-- 0
DO WHILE (count) ≠ 0
    (C) <-- (op115)
    (op1n) <-- (op1n-1) [n=1...15]
    (op10) <-- (C)
    (count) <-- (count) - 1
END WHILE
```

WORD

Rotates the destination word operand op1 left by as many times as specified by the source operand op2. Bit 15 is rotated into Bit 0 and into the Carry. Only shift values between 0 and 15 are allowed. When using a GPR as the count control, only the least significant 4 bits are used.

E	Z	V	C	N
0	*	0	S	*

- E Always cleared.
- Z Set if result equals zero. Cleared otherwise.
- V Always cleared.
- C The carry flag is set according to the last most significant bit shifted out of op1. Cleared for a rotate count of zero.
- N Set if the most significant bit of the result is set. Cleared otherwise.

Mnemonic		Format	Bytes
ROL	Rw <sub>n</sub> , Rw <sub>m</sub>	0C nm	2
ROL	Rw <sub>n</sub> , #data <sub>4</sub>	1C #n	2

ROR

Syntax

Operation

Rotate Right

```
ROR      op1, op2

(count) <-- (op2)
(C) <-- 0
(V) <-- 0
DO WHILE (count) ≠ 0
    (V) <-- (V) v (C)
    (C) <-- (op10)
    (op1n) <-- (op1n+1) [n=0...14]
    (op115) <-- (C)
    (count) <-- (count) - 1
END WHILE
```

Data Types

Description

WORD

Rotates the destination word operand op1 right by as many times as specified by the source operand op2. Bit 0 is rotated into Bit 15 and into the Carry. Only shift values between 0 and 15 are allowed. When using a GPR as the count control, only the least significant 4 bits are used.

Flags

E	Z	V	C	N
0	*	S	S	*

- E Always cleared.
- Z Set if result equals zero. Cleared otherwise.
- V Set if in any cycle of the rotate operation a ‘1’ is shifted out of the carry flag. Cleared for a rotate count of zero.
- C The carry flag is set according to the last least significant bit shifted out of op1. Cleared for a rotate count of zero.
- N Set if the most significant bit of the result is set. Cleared otherwise.

Addressing Modes

Mnemonic		Format	Bytes
ROR	Rw <sub>n</sub> , Rw <sub>m</sub>	2C nm	2
ROR	Rw <sub>n</sub> , #data <sub>4</sub>	3C #n	2



# SCXT

## Switch Context

**Syntax** SCXT op1, op2

**Operation** (tmp1) <-- (op1)  
(tmp2) <-- (op2)  
(SP) <-- (SP) - 2  
((SP)) <-- (tmp1)  
(op1) <-- (tmp2)

**Description** Used to switch contexts for any register. Switching context is a push and load operation. The contents of the register specified by the first operand, op1, are pushed onto the stack. That register is then loaded with the value specified by the second operand, op2.

**Data Types** WORD

**Flags**

E	Z	V	C	N
-	-	-	-	-

E Not affected.  
Z Not affected.  
V Not affected.  
C Not affected.  
N Not affected.

Addressing Modes	Mnemonic	Format	Bytes
	SCXT reg, #data <sub>16</sub>	C6 RR ## ##	4
	SCXT reg, mem	D6 RR MM MM	4

SHL

Syntax

Operation

Data Types

Description

Flags

Addressing Modes

Shift Left

```
SHL      op1, op2

(count) <-- (op2)
(C) <-- 0
DO WHILE (count) ≠ 0
    (C) <-- (op115)
    (op1n) <-- (op1n-1) [n=1...15]
    (op10) <-- 0
    (count) <-- (count) - 1
END WHILE
```

WORD

Shifts the destination word operand op1 left by as many times as specified by the source operand op2. The least significant bits of the result are filled with zeros accordingly. The most significant bit is shifted into the Carry. Only shift values between 0 and 15 are allowed. When using a GPR as the count control, only the least significant 4 bits are used.

E	Z	V	C	N
0	*	0	S	*

- E Always cleared.
- Z Set if result equals zero. Cleared otherwise.
- V Always cleared.
- C The carry flag is set according to the last most significant bit shifted out of op1. Cleared for a shift count of zero.
- N Set if the most significant bit of the result is set. Cleared otherwise.

Mnemonic		Format	Bytes
SHL	Rw <sub>n</sub> , Rw <sub>m</sub>	4C nm	2
SHL	Rw <sub>n</sub> , #data <sub>4</sub>	5C #n	2



SHR

Shift Right

Syntax

SHR        op1, op2

Operation

```
(count) <-- (op2)
(C) <-- 0
(V) <-- 0
DO WHILE (count) ≠ 0
    (V) <-- (C) v (V)
    (C) <-- (op10)
    (op1n) <-- (op1n+1) [n=0...14]
    (op115) <-- 0
    (count) <-- (count) - 1
END WHILE
```

Data Types

WORD

Description

Shifts the destination word operand op1 right by as many times as specified by the source operand op2. The most significant bits of the result are filled with zeros accordingly. Since the bits shifted out effectively represent the remainder, the Overflow flag is used instead as a Rounding flag. This flag together with the Carry flag helps the user to determine whether the remainder bits lost were greater than, less than or equal to one half an least significant bit. Only shift values between 0 and 15 are allowed. When using a GPR as the count control, only the least significant 4 bits are used.

Flags

E	Z	V	C	N
0	*	S	S	*

- E        Always cleared.
- Z        Set if result equals zero. Cleared otherwise.
- V        Set if in any cycle of the shift operation a ‘1’ is shifted out of the carry flag. Cleared for a shift count of zero.
- C        The carry flag is set according to the last least significant bit shifted out of op1. Cleared for a shift count of zero.
- N        Set if the most significant bit of the result is set. Cleared otherwise.

Addressing Modes

Mnemonic		Format	Bytes
SHR	Rw <sub>n</sub> , Rw <sub>m</sub>	6C nm	2
SHR	Rw <sub>n</sub> , #data <sub>4</sub>	7C #n	2



SRST

Syntax

Operation

Description

Flags

Addressing Modes

Software Reset

SRST

Software Reset

This instruction is used to perform a software reset. A software reset has the same effect on the microcontroller as an externally applied hardware reset. To insure that this instruction is not accidentally executed, it is implemented as a protected instruction.

E	Z	V	C	N
0	0	0	0	0

- E Always cleared.
- Z Always cleared.
- V Always cleared.
- C Always cleared.
- N Always cleared.

Mnemonic	Format	Bytes
SRST	B7 48 B7 B7	4

# SRVWDT

Syntax

Service Watchdog Timer

SRVWDT

Operation

Service Watchdog Timer

Description

This instruction services the Watchdog Timer. It reloads the high order byte of the Watchdog Timer with a preset value and clears the low byte on every occurrence. Once this instruction has been executed, the watchdog timer cannot be disabled. To insure that this instruction is not accidentally executed, it is implemented as a protected instruction.

Flags

E	Z	V	C	N
-	-	-	-	-

- E Not affected.
- Z Not affected.
- V Not affected.
- C Not affected.
- N Not affected.

Addressing Modes

Mnemonic	Format	Bytes
SRVWDT	A7 58 A7 A7	4

SUB

Syntax

SUB      op1, op2

Operation

(op1) <-- (op1) - (op2)

Data Types

WORD

Description

Performs a 2's complement binary subtraction of the source operand specified by op2 from the destination operand specified by op1. The result is then stored in op1.

Flags

E	Z	V	C	N
*	*	*	S	*

- E      Set if the value of op2 represents the lowest possible negative number. Cleared otherwise. Used to signal the end of a table.
- Z      Set if result equals zero. Cleared otherwise.
- V      Set if an arithmetic underflow occurred, i.e. the result cannot be represented in the specified data type. Cleared otherwise.
- C      Set if a borrow is generated. Cleared otherwise.
- N      Set if the most significant bit of the result is set. Cleared otherwise.

Addressing Modes

Mnemonic	Format	Bytes
SUB $Rw_n, Rw_m$	20 nm	2
SUB $Rw_n, [Rw_i]$	28 n:10ii	2
SUB $Rw_n, [Rw_i+]$	28 n:11ii	2
SUB $Rw_n, \#data_3$	28 n:0###	2
SUB      reg, $\#data_{16}$	26 RR ## ##	4
SUB      reg, mem	22 RR MM MM	4
SUB      mem, reg	24 RR MM MM	4



# SUBB

## Integer Subtraction

**Syntax** SUBB op1, op2

**Operation** (op1) <-- (op1) - (op2)

**Data Types** BYTE

**Description** Performs a 2's complement binary subtraction of the source operand specified by op2 from the destination operand specified by op1. The result is then stored in op1.

### Flags

E	Z	V	C	N
*	*	*	S	*

- E Set if the value of op2 represents the lowest possible negative number. Cleared otherwise. Used to signal the end of a table.
- Z Set if result equals zero. Cleared otherwise.
- V Set if an arithmetic underflow occurred, ie. the result cannot be represented in the specified data type. Cleared otherwise.
- C Set if a borrow is generated. Cleared otherwise.
- N Set if the most significant bit of the result is set. Cleared otherwise.

### Addressing Modes

Mnemonic	Format	Bytes
SUBB Rb <sub>n</sub> , Rb <sub>m</sub>	21 nm	2
SUBB Rb <sub>n</sub> , [Rw <sub>i</sub> ]	29 n:10ii	2
SUBB Rb <sub>n</sub> , [Rw <sub>i</sub> +]	29 n:11ii	2
SUBB Rb <sub>n</sub> , #data <sub>3</sub>	29 n:0###	2
SUBB reg, #data <sub>16</sub>	27 RR ## ##	4
SUBB reg, mem	23 RR MM MM	4
SUBB mem, reg	25 RR MM MM	4

SUBC

Synta

SUBC     op1, op2

Operation

(op1) <-- (op1) - (op2) - (C)

Data Types

WORD

Description

Performs a 2's complement binary subtraction of the source operand specified by op2 and the previously generated carry bit from the destination operand specified by op1. The result is then stored in op1. This instruction can be used to perform multiple precision arithmetic.

Flags

E	Z	V	C	N
*	S	*	S	*

- E     Set if the value of op2 represents the lowest possible negative number. Cleared otherwise. Used to signal the end of a table.
- Z     Set if result equals zero and the previous Z flag was set. Cleared otherwise.
- V     Set if an arithmetic underflow occurred, i.e. the result cannot be represented in the specified data type. Cleared otherwise.
- C     Set if a borrow is generated. Cleared otherwise.
- N     Set if the most significant bit of the result is set. Cleared otherwise.

Addressing Modes

Mnemonic		Format	Bytes
SUBC	Rw <sub>n</sub> , Rw <sub>m</sub>	30 nm	2
SUBC	Rw <sub>n</sub> , [Rw <sub>i</sub> ]	38 n:10ii	2
SUBC	Rw <sub>n</sub> , [Rw <sub>i</sub> +]	38 n:11ii	2
SUBC	Rw <sub>n</sub> , #data <sub>3</sub>	38 n:0###	2
SUBC	reg, #data <sub>16</sub>	36 RR ## ##	4
SUBC	reg, mem	32 RR MM MM	4
SUBC	mem, reg	34 RR MM MM	4



# SUBCB

## Syntax

SUBCB op1, op2

## Operation

(op1) <-- (op1) - (op2) - (C)

## Data Types

BYTE

## Description

Performs a 2's complement binary subtraction of the source operand specified by op2 and the previously generated carry bit from the destination operand specified by op1. The result is then stored in op1. This instruction can be used to perform multiple precision arithmetic.

## Flags

E	Z	V	C	N
*	S	*	S	*

- E Set if the value of op2 represents the lowest possible negative number. Cleared otherwise. Used to signal the end of a table.
- Z Set if result equals zero and the previous Z flag was set. Cleared otherwise.
- V Set if an arithmetic underflow occurred, i.e. the result cannot be represented in the specified data type. Cleared otherwise.
- C Set if a borrow is generated. Cleared otherwise.
- N Set if the most significant bit of the result is set. Cleared otherwise.

## Addressing Modes

Mnemonic	Format	Bytes
SUBCB Rb <sub>n</sub> , Rb <sub>m</sub>	31 nm	2
SUBCB Rb <sub>n</sub> , [Rw <sub>i</sub> ]	39 n:10ii	2
SUBCB Rb <sub>n</sub> , [Rw <sub>i</sub> +]	39 n:11ii	2
SUBCB Rb <sub>n</sub> , #data <sub>3</sub>	39 n:0###	2
SUBCB reg, #data <sub>16</sub>	37 RR ## ##	4
SUBCB reg, mem	33 RR MM MM	4
SUBCB mem, reg	35 RR MM MM	4

TRAP

Syntax

Software Trap

```
TRAP      op1

(SP) <-- (SP) - 2
((SP)) <-- (PSW)
IF (SYSCON.SGTDIS=0) THEN
    (SP) <-- (SP) - 2
    ((SP)) <-- (CSP)
    (CSP) <-- 0
END IF
(SP) <-- (SP) - 2
((SP)) <-- (IP)
(IP) <-- zero_extend (op1*4)
```

Operation

Description

Invokes a trap or interrupt routine based on the specified operand, op1. The invoked routine is determined by branching to the specified vector table entry point. This routine has no indication of whether it was called by software or hardware. System state is preserved identically to hardware interrupt entry except that the CPU priority level is not affected. The RETI, return from interrupt, instruction is used to resume execution after the trap or interrupt routine has completed. The CSP is pushed if segmentation is enabled. This is indicated by the SGTDIS bit in the SYSCON register.

Flags

E	Z	V	C	N
-	-	-	-	-
E	Not affected.			
Z	Not affected.			
V	Not affected.			
C	Not affected.			
N	Not affected.			

Addressing Modes

Mnemonic	Format	Bytes
TRAP      #trap7	9B t:ttt0	2



# XOR

## Logical Exclusive OR

**Syntax** XOR op1, op2

**Operation** (op1) <-- (op1) ⊕ (op2)

**Data Types** WORD

**Description** Performs a bitwise logical EXCLUSIVE OR of the source operand specified by op2 and the destination operand specified by op1. The result is then stored in op1.

### Flags

E	Z	V	C	N
*	*	0	0	*

- E Set if the value of op2 represents the lowest possible negative number. Cleared otherwise. Used to signal the end of a table.
- Z Set if result equals zero. Cleared otherwise.
- V Always cleared.
- C Always cleared.
- N Set if the most significant bit of the result is set. Cleared otherwise.

### Addressing Modes

Mnemonic	Format	Bytes
XOR Rw <sub>n</sub> , Rw <sub>m</sub>	50 nm	2
XOR Rw <sub>n</sub> , [Rw <sub>i</sub> ]	58 n:10ii	2
XOR Rw <sub>n</sub> , [Rw <sub>i</sub> +]	58 n:11ii	2
XOR Rw <sub>n</sub> , #data <sub>3</sub>	58 n:0###	2
XOR reg, #data <sub>16</sub>	56 RR ## ##	4
XOR reg, mem	52 RR MM MM	4
XOR mem, reg	54 RR MM MM	4

XORB

Syntax

Logical Exclusive OR

XORB     op1, op2

Operation

(op1) <-- (op1)  $\oplus$  (op2)

Data Types

BYTE

Description

Performs a bitwise logical EXCLUSIVE OR of the source operand specified by op2 and the destination operand specified by op1. The result is then stored in op1.

Flags

E	Z	V	C	N
*	*	0	0	*

- E     Set if the value of op2 represents the lowest possible negative number. Cleared otherwise. Used to signal the end of a table.
- Z     Set if result equals zero. Cleared otherwise.
- V     Always cleared.
- C     Always cleared.
- N     Set if the most significant bit of the result is set. Cleared otherwise.

Addressing Modes

Mnemonic		Format	Bytes
XORB	Rb <sub>n</sub> , Rb <sub>m</sub>	51 nm	2
XORB	Rb <sub>n</sub> , [Rw <sub>i</sub> ]	59 n:10ii	2
XORB	Rb <sub>n</sub> , [Rw <sub>i</sub> +]	59 n:11ii	2
XORB	Rb <sub>n</sub> , #data <sub>3</sub>	59 n:0###	2
XORB	reg, #data <sub>16</sub>	57 RR ## ##	4
XORB	reg, mem	53 RR MM MM	4
XORB	mem, reg	55 RR MM MM	4

## 2 MAC Instruction set

This section describes the instruction set for the MAC. Refer to device datasheets for information about which ST10 devices include the MAC.

### 2.1 Addressing modes

MAC instructions use some standard ST10 addressing modes such as GPR direct or #data<sub>5</sub> for immediate shift value. To supply the MAC with up to 2 new operands per instruction cycle, new MAC instruction addressing modes have been added. These allow indirect addressing with address pointer post-modification. Double indirect addressing requires 2 pointers, one of which can be supplied by any GPR, the other is provided by one of two new specific SFRs  $IDX_0$  and  $IDX_1$ . Two pairs of offset registers  $QR_0/QR_1$  and  $QX_0/QX_1$  are associated with each pointer (GPR or  $IDX_i$ ). The GPR pointer gives access to the entire memory space, whereas  $IDX_i$  are limited to the internal Dual-Port RAM, except for the CoMOV instruction. The following table shows the various combinations of pointer post-modification for each of these 2 new addressing modes.

Symbol	Mnemonic	Address Pointer Operation
<sup>1</sup> “ $[IDX_i \otimes]$ ” stands for	$[IDX_i]$	$(IDX_i) <-- (IDX_i)$ (no-op)
	$[IDX_i+]$	$(IDX_i) <-- (IDX_i) + 2$ ( $i=0,1$ )
	$[IDX_i-]$	$(IDX_i) <-- (IDX_i) - 2$ ( $i=0,1$ )
	$[IDX_i + QX_j]$	$(IDX_i) <-- (IDX_i) + (QX_j)$ ( $i, j=0,1$ )
	$[IDX_i - QX_j]$	$(IDX_i) <-- (IDX_i) - (QX_j)$ ( $i, j=0,1$ )
“ $[Rw_n \otimes]$ ” stands for	$[Rw_n]$	$(Rw_n) <-- (Rw_n)$ (no-op)
	$[Rw_n+]$	$(Rw_n) <-- (Rw_n) + 2$ ( $n=0...15$ )
	$[Rw_n-]$	$(Rw_n) <-- (Rw_n) - 2$ ( $n=0...15$ )
	$[Rw_n + QR_j]$	$(Rw_n) <-- (Rw_n) + (QR_j)$ ( $n=0...15; j=0,1$ )
	$[Rw_n - QR_j]$	$(Rw_n) <-- (Rw_n) - (QR_j)$ ( $n=0...15; j=0,1$ )

**Table 27 Pointer post-modification for  $[Rw_n \otimes]$ ” and “ $[IDX_i \otimes]$  addressing modes**

1.  $IDX_i$  can only contain even values. Therefore, bit 0 always equals zero.

When using pointer post-modification addressing modes, the address pointed to (i.e the value in the  $IDX_i$  or  $Rw_n$  register) must be a legal address, even if its content is not modified. An odd value (e.g. in  $R_0$  when using  $[R_0]$  post-modification addressing mode) will trigger the class-B hardware Trap 28h (Illegal Word Operand Access Trap (ILLOPA)).

In this document the symbols “ $[Rw_n \otimes]$ ” and “ $[IDX_i \otimes]$ ” are used to refer to these addressing modes.

A new instruction CoSTORE transfers a value from a MAC register to any location in memory. This instruction uses a specific addressing mode for the MAC registers, called **CoReg**. The following table gives the 5-bit addresses of the MAC registers corresponding to this CoReg addressing mode. Unused addresses are reserved for future revisions.

Register	Description	Address
MSW	MAC-Unit Status Word	00000
MAH	MAC-Unit Accumulator High	00001
MAS	“limited” MAH	00010
MAL	MAC-Unit Accumulator Low	00100
MCW	MAC-Unit Control Word	00101
MRW	MAC-Unit Repeat Word	00110

Table 28 MAC register addresses for CoReg

## 2.2 MAC instruction execution time

The instruction execution time for MAC instructions is calculated in the same way as that of the standard instruction set. To calculate the execution time for MAC instructions, refer to *Instruction execution times* on page 12, considering MAC instructions to be 4-byte instructions with a minimum state time number of 2.

## 2.3 MAC instruction set summary

Mnemonic	Addressing Modes	Rep	Mnemonic	Addressing Modes	Rep
CoMUL	$Rw_n, Rw_m$	No	CoMACM	$[IDX_i \otimes], [Rw_m \otimes]$	Yes
CoMULu	$[IDX_i \otimes], [Rw_m \otimes]$	No	CoMACMu		
CoMULus	$Rw_n, [Rw_m \otimes]$	No	CoMACMus		
CoMULsu			CoMACMSu		
CoMUL-			CoMACM-		
CoMULu-			CoMACMu-		
CoMULus-			CoMACMus-		
CoMULsu-			CoMACMSu-		
CoMUL + rnd			CoMACM + rnd		
CoMULu + rnd			CoMACMu + rnd		
CoMULus + rnd			CoMACMus + rnd		
CoMULsu + rnd			CoMACMSu + rnd		
CoMAC	$Rw_n, Rw_m$	No	CoMACMR		
CoMACu	$[IDX_i \otimes], [Rw_m \otimes]$	Yes	CoMACMRu		
CoMACus	$Rw_n, [Rw_m \otimes]$	Yes	CoMACMRus		
CoMACsu			CoMACMRsu		
CoMAC-			CoMACMR + rnd		
CoMACu-			CoMACMRu + rnd		
CoMACus-			CoMACMRus + rnd		
CoMACsu-			CoMACMRsu + rnd		
CoMAC + rnd			CoADD	$Rw_n, Rw_m$	No
CoMACu + rnd			CoADD2	$[IDX_i \otimes], [Rw_m \otimes]$	Yes
CoMACus + rnd			CoSUB	$Rw_n, [Rw_m \otimes]$	Yes
CoMACsu + rnd			CoSUB2		
CoMACR			CoSUBR		
CoMACRu			CoSUB2R		
CoMACRus			CoMAX		
CoMACRsu			CoMIN		
CoMACR + rnd			CoLOAD	$Rw_n, Rw_m$	No
CoMACRu + rnd			CoLOAD-	$[IDX_i \otimes], [Rw_m \otimes]$	No
CoMACRus + rnd			CoLOAD2	$Rw_n, [Rw_m \otimes]$	No
CoMACRsu + rnd			CoLOAD2-		
			CoCMP		

**Table 29 MAC instruction mnemonic by addressing mode and repeatability**

Mnemonic	Addressing Modes	Rep	Mnemonic	Addressing Modes	Rep
CoNOP	$[Rw_m \otimes]$	Yes	CoSHL	$Rw_n$	Yes
	$[IDX_i \otimes], [Rw_m \otimes]$	Yes	CoSHR	$\#data_5$	No
CoNEG	-	No	CoASHR	$[Rw_m \otimes]$	Yes
CoNEG + rnd			CoASHR + rnd		
CoRND			CoABS	-	No
CoSTORE	$Rw_n, CoReg$	No		$Rw_n, Rw_m$	No
	$[Rw_n \otimes], CoReg$	Yes		$[IDX_i \otimes], [Rw_m \otimes]$	No
CoMOV	$[IDX_i \otimes], [Rw_m \otimes]$	Yes		$Rw_n, [Rw_m \otimes]$	No

Table 29 MAC instruction mnemonic by addressing mode and repeatability

The following table gives the MAC Function Code of each instruction. This Function Code is the third byte of the new instruction and is used by the co-processor as its operation code. Unused function codes are treated as CoNOP Function Code by the MAC.

Mnemonic	Function Code	Mnemonic	Function Code
CoMUL	C0	CoMACM	D8
CoMULu	00	CoMACMu	18
CoMULus	80	CoMACMus	98
CoMULsu	40	CoMACMsu	58
CoMUL-	C8	CoMACM-	E8
CoMULu-	08	CoMACMu-	28
CoMULus-	88	CoMACMus-	A8
CoMULsu-	48	CoMACMsu-	68
CoMUL + rnd	C1	CoMACM + rnd	D9
CoMULu + rnd	01	CoMACMu + rnd	19
CoMULus + rnd	81	CoMACMus + rnd	99
CoMULsu + rnd	41	CoMACMsu + rnd	59
CoMAC	D0	CoMACMR	F9
CoMACu	10	CoMACMRu	38
CoMACus	90	CoMACMRus	B8
CoMACsu	50	CoMACMRsu	78
CoMAC-	E0	CoMACMR + rnd	F9
CoMACu-	20	CoMACMRu + rnd	39
CoMACus-	A0	CoMACMRus + rnd	B9
CoMACsu-	60	CoMACMRsu + rnd	79

Table 30 MAC instruction function code (hexa)

Mnemonic	Function Code	Mnemonic	Function Code
CoMAC + rnd	D1	CoADD	02
CoMACu + rnd	11	CoADD2	42
CoMACus + rnd	91	CoSUB	0A
CoMACsu + rnd	51	CoSUB2	4A
CoMACR	F0	CoSUBR	12
CoMACRu	30	CoSUB2R	52
CoMACRus	B0	CoMAX	3A
CoMACRsu	70	CoMIN	7A
CoMACR + rnd	F1	CoLOAD	22
CoMACRu + rnd	31	CoLOAD-	2A
CoMACRus + rnd	B1	CoLOAD2	62
CoMACRsu + rnd	71	CoLOAD2-	6A
CoNOP	5A	CoCMP	C2
CoNEG	32	CoSHL #data <sub>5</sub>	82
CoNEG + rnd	72	CoSHL other	8A
CoRND	B2	CoSHR #data <sub>5</sub>	92
CoABS -	1A	CoSHR other	9A
CoABS op1, op2	CA	CoASHR #data <sub>5</sub>	A2
CoSTORE	www:w000	CoASHR other	AA
CoMOV	00	CoASHR + rnd #data <sub>5</sub>	B2
		CoASHR + rnd other	BA

Table 30 MAC instruction function code (hexa) (Continued)

2.4 MAC instruction conventions

This section details the conventions used to describe the MAC instruction set.

2.4.1 Operands

Operand	Description
opX	Specifies the immediate constant value of opX
(opX)	Specifies the contents of opX
(opX <sub>n</sub> )	Specifies the contents of bit n of opX
((opX))	Specifies the contents of opX (i.e. opX is used as pointer to the actual operand)
rnd	plus 00 0000 8000 <sub>n</sub>

2.4.2 Operations

Diadic operations	(opX)<-- (opY)	(opY)	is	MOVED into (opX)
	(opX) + (opY)	(opX)	is	ADDED to (opY)
	(opX) - (opY)	(opY)	is	SUBTRACTED from (opX)
	(opX) * (opY)	(opX)	is	MULTIPLIED by (opY)
	(opX) <--> (opY)	(opY)	is	COMPARED against (opX)
	opX\opY	(opX)	is	CONCATANATED to (opY) (LSW)
	Max ((opX), (opY))	MAXIMUM value between (opX) and (opY)		
	Min ((opX), (opY))	MINIMUM value between (opX) and (opY)		
Monadic Operations	(opX) <<	(opX)	is	Logically SHIFTED Left
	(opX) >>	(opX)	is	Logically SHIFTED Right
	(opX) >> <sub>a</sub>	(opX)	is	Arithmetically SHIFTED Right
	Abs (opX)	ABSOLUTE value of (opX)		



## 2.4.3 Abbreviations

Abbreviation	Description
C	Carry flag in the MSW register
MP	MP mode in the MCW register
MS	MS mode in the MCW register
MAE	8 most significant bits of the accumulator (lowest byte of the MSW register)

## 2.4.4 Data addressing modes

Addressing mode	Description
"Rw <sub>n</sub> ", or "Rw <sub>m</sub> " :	General Purpose Registers (GPRs) where "n" and "m" are any value between 0 and 15.
[...] :	Indirect word memory location
CoReg :	MAC-Unit Register (MSW, MAH, MAL, MAS, MRW, MCW)
ACC :	MAC Accumulator consisting of (lowest byte of MSW)\MAH\MAL.
#data <sub>x</sub> :	Immediate constant (the number of significant bits is represented by 'x').

## 2.4.5 Instruction format

The instruction format is the same as that of the standard instruction set. In addition, the following new symbols are used:

Instruction	Description
X	4-bit IDX addressing mode encoding. (see following table)
:qqq	3-bit GPR offset encoding for new GPR indirect with offset encoding.
rrrr:r...	5-bit repeat field.
www:w...	5-bit CoReg address for CoSTORE instructions.
ssss:	4-bit immediate shift value.
ssss:s...	5-bit immediate shift value.

Addressing Mode	4-bit Encoding	GPR Offset	3-bit Encoding
IDX0	1 <sub>h</sub>	no-op	1 <sub>h</sub>
IDX0 +	2 <sub>h</sub>	+	2 <sub>h</sub>
IDX0 -	3 <sub>h</sub>	-	3 <sub>h</sub>
IDX0 + QX0	4 <sub>h</sub>	+ QR0	4 <sub>h</sub>
IDX0 - QX0	5 <sub>h</sub>	- QR0	5 <sub>h</sub>
IDX0 + QX1	6 <sub>h</sub>	+ QR1	6 <sub>h</sub>
IDX0 - QX1	7 <sub>h</sub>	- QR1	7 <sub>h</sub>
IDX1	9 <sub>h</sub>		
IDX1 +	A <sub>h</sub>		
IDX1 -	B <sub>h</sub>		
IDX1 + QX0	C <sub>h</sub>		
IDX1 - QX0	D <sub>h</sub>		
IDX1 + QX1	E <sub>h</sub>		
IDX1 - QX1	F <sub>h</sub>		

Table 31 IDX Addressing Mode Encoding and GPR offset Encoding

2.4.6 Flag states

Flag	Description
-	Unchanged
*	Modified

2.4.7 Repeated instruction syntax

Repeatable instructions CoXXX are expressed as follows when repeated

Repeat	#data <sub>5</sub>	times	CoXXX...	or
Repeat	MRW	times	CoXXX...	

When MRW is invoked, the instruction is repeated (MRW<sub>12-0</sub>) + 1 times, therefore the maximum number of times an instruction can be repeated is 8 192 (2<sup>13</sup>) times.

#data<sub>5</sub> is an integer value specifying the number of times an instruction is repeated, #data<sub>5</sub> must be less than 32. Therefore, CoXXX can only be repeated less than 32 times. When the MRW register is used in the repeat instruction, the 5-bit repeat field is set to 1.

### 2.4.8 Shift value

The shifter authorizes only 8-bit left/right shifts. Shift values must be between 0-8 (inclusive).

## 2.5 MAC instruction descriptions

Each instruction is described in a standard format. See “MAC instruction conventions” on page 144 for detailed information about the instruction conventions.

The MAC instruction set is divided into 5 functional groups:

- Multiply and Multiply-Accumulate Instructions
- 40-bit Arithmetic Instructions
- Shift Instructions
- Compare Instructions
- Transfer Instructions

The instructions are described in alphabetical order.

CoABS

Absolute Value

Group

40-bit Arithmetic Instructions

Syntax

CoABS

Operation

(ACC) <-- Abs( ACC )

Syntax

CoABS op1, op2

Operation

(ACC) <-- Abs( (op2)\(op1) )

Data Types

ACCUMULATOR, DOUBLE WORD

Result

40-bit signed value

Description

Compute the absolute value of the Accumulator if no operands are specified or the absolute value of a 40-bit source operand and load the result in the Accumulator. The 40-bit operand results from the concatenation of the two source operands op1 (LSW) and op2 (MSW) which is then sign-extended. This instruction is not repeatable

MAC Flags

N	Z	C	SV	E	SL
*	*	0	-	*	*

- N     Set if the most significant bit of the result is set. Cleared otherwise.
- Z     Set if the result equals zero. Cleared otherwise.
- C     Always cleared.
- SV    Not affected.
- E     Set if the MAE is used. Cleared otherwise.
- SL    Set if the contents of the ACC is automatically saturated. Not affected otherwise.

Addressing Modes

Mnemonic		Rep	Format	Bytes
CoABS		No	A3 00 1A 00	4
CoABS	Rw <sub>n</sub> , Rw <sub>m</sub>	No	A3 nm CA 00	4
CoABS	[IDX <sub>i</sub> ⊗], [Rw <sub>m</sub> ⊗]	No	93 Xm CA 0:0qqq	4
CoABS	Rw <sub>n</sub> , [Rw <sub>m</sub> ⊗]	No	83 nm CA 0:0qqq	4

CoADD(2)

Add

**Group** 40-bit Arithmetic Instructions

**Syntax** CoADD op1, op2

**Operation**  
(tmp) <-- (op2)\(op1)  
(ACC) <-- (ACC) + (tmp)

**Syntax** CoADD2op1, op2

**Operation**  
(tmp) <-- 2 \* (op2)\(op1)  
(ACC) <-- (ACC) + (tmp)

**Data Types** DOUBLE WORD

**Result** 40-bit signed value

**Description** Adds a 40-bit operand to the 40-bit Accumulator contents and store the result in the accumulator. The 40-bit operand results from the concatenation of the two source operands op1 (LSW) and op2 (MSW) which is then sign-extended. “2” option indicates that the 40-bit operand is also multiplied by two prior being added to ACC. When the MS bit of the MCW register is set and when a 32-bit overflow or underflow occurs, the obtained result becomes 00 7FFF FFFF<sub>h</sub> or FF 8000 0000<sub>h</sub>, respectively. This instruction is repeatable with indirect addressing modes and allows up to two parallel memory reads

MAC Flags

N	Z	C	SV	E	SL
*	*	*	*	*	*

- N Set if the most significant bit of the result is set. Cleared otherwise.
- Z Set if the result equals zero. Cleared otherwise.
- C Set if a carry is generated. Cleared otherwise.
- SV Set if an arithmetic overflow occurred. Not affected otherwise.
- E Set if MAE is used. Cleared otherwise.
- SL Set if the contents of the ACC is automatically saturated. Not affected otherwise.

**Note** The E-flag is set when the nine highest bits of the accumulator are not equal. The SV-flag is set, when a 40-bit arithmetic overflow/ underflow occurs.

## Addressing Modes

	Mnemonic	Rep	Format	Bytes
	CoADD $Rw_n, Rw_m$	No	A3 nm 02 00	4
	CoADD2 $Rw_n, Rw_m$	No	A3 nm 42 00	4
	CoADD $[IDX_i \otimes], [Rw_m \otimes]$	Yes	93 Xm 02 rrrr:rqqq	4
	CoADD2 $[IDX_i \otimes], [Rw_m \otimes]$	Yes	93 Xm 42 rrrr:rqqq	4
	CoADD $Rw_n, [Rw_m \otimes]$	Yes	83 nm 02 rrrr:rqqq	4
	CoADD2 $Rw_n, [Rw_m \otimes]$	Yes	83 nm 42 rrrr:rqqq	4

## Examples

```

CoADD          R0, R1          ; (ACC) <-- (ACC) + (R1)\(R0)
CoADD2         R2, [R6+]       ; (ACC) <-- (ACC) + 2*((R6))\ (R2) )
                                   ; (R6) <-- (R6) + 2
Repeat 3 times CoADD [IDX1+QX1], [R10+QR0] ; (ACC) <-- (ACC) + ( ((R10))\((IDX1)) )
                                   ; (R10) <-- (R10) + (QR0)
                                   ; (IDX1) <-- (IDX1) + (QX1)
Repeat MRW times CoADD2 R4, [R8 - QR1] ; (ACC) <-- (ACC) + 2*((R8))\ (R4) )
                                   ; (R8) <-- (R8) - (QR1)

```

## Addition Examples

Instr.	MS	op 1	op 2	ACC (before)	ACC (after)	N	Z	C	SV	E	SL
CoADD	x	0000 <sub>h</sub>	FFFF <sub>h</sub>	00 0100 0000 <sub>h</sub>	00 00FF 0000 <sub>h</sub>	0	0	1	-	0	-
CoADD2	x	0000 <sub>h</sub>	0200 <sub>h</sub>	00 0300 0000 <sub>h</sub>	00 0700 0000 <sub>h</sub>	0	0	0	-	0	-
CoADD	0	0000 <sub>h</sub>	4000 <sub>h</sub>	7F BFFF FFFF <sub>h</sub>	7F FFFF FFFF <sub>h</sub>	0	0	0	-	1	-
CoADD	0	0001 <sub>h</sub>	4000 <sub>h</sub>	7F BFFF FFFF <sub>h</sub>	80 0000 0000 <sub>h</sub>	1	0	0	1	1	-
CoADD	0	FFFF <sub>h</sub>	FFFF <sub>h</sub>	FF FFFF FFFF <sub>h</sub>	FF FFFF FFFE <sub>h</sub>	1	0	1	-	0	-
CoADD	0	FFFF <sub>h</sub>	FFFF <sub>h</sub>	00 0000 0001 <sub>h</sub>	00 0000 0000 <sub>h</sub>	0	1	1	-	0	-
CoADD	0	FFFF <sub>h</sub>	FFFF <sub>h</sub>	80 0000 0000 <sub>h</sub>	7F FFFF FFFF <sub>h</sub>	0	0	1	1	1	-
CoADD2	0	0001 <sub>h</sub>	2000 <sub>h</sub>	FF C000 0001 <sub>h</sub>	00 0000 0003 <sub>h</sub>	0	0	1	-	0	-
CoADD2	0	0001 <sub>h</sub>	1800 <sub>h</sub>	FF C000 0001 <sub>h</sub>	FF F000 0003 <sub>h</sub>	1	0	0	-	0	-
CoADD	0	B4A1 <sub>h</sub>	73C2 <sub>h</sub>	00 7241 A0C3 <sub>h</sub>	00 E604 5564 <sub>h</sub>	0	0	0	-	1	-
	1				00 7FFF FFFF <sub>h</sub>	0	0	0	-	0	1
CoADD	0	B4A1 <sub>h</sub>	A3C2 <sub>h</sub>	FF 8241 A0C3 <sub>h</sub>	FF 2604 5564 <sub>h</sub>	1	0	1	-	1	-
	1				FF 8000 0000 <sub>h</sub>	1	0	1	-	0	1
CoADD	0	B4A1 <sub>h</sub>	73C2 <sub>h</sub>	7F B241 A0C3 <sub>h</sub>	80 2604 5564 <sub>h</sub>	1	0	0	1	1	-
CoADD	0	B4A1 <sub>h</sub>	A3C2 <sub>h</sub>	80 0241 A0C3 <sub>h</sub>	7F A604 5564 <sub>h</sub>	0	0	1	1	1	-

CoASHR

Accumulator Arithmetic Shift Right with Optional Round

Group

Shift Instructions

Syntax

CoASHRop1  
CoASHRop1, rnd

Operation

(count) <-- (op1)  
(C) <-- 0  
DO WHILE (count) ≠ 0  
    (ACC<sub>n</sub>) <-- (ACC<sub>n+1</sub>)                      [n=0-38]  
    (count) <-- (count) -1  
END WHILE  
IF (rnd) THEN  
    (ACC) <-- (ACC) + 00008000<sub>H</sub>  
    (MAL) <-- 0  
END IF

Data Types

ACCUMULATOR

Result

40-bit signed value

Description

Arithmetically shifts the ACC register right by as many times as specified by the operand op1. To preserve the sign of the ACC register, the most significant bits of the result are filled with sign 0 if the original most significant bit was a 0 or with sign 1 if the original most significant bit was 1. Only shift values between 0 and 8 are allowed. “op1” can be either a 5-bit unsigned immediate data, or the least significant 5 bits (considered as unsigned data) of any register directly or indirectly addressed operand. Without “rnd” option, the MS bit of the MCW register does not affect the result. While with “rnd” option and if the MS bit is set and when a 32-bit overflow or underflow occurs, the obtained result becomes 00 7FFF FFFF<sub>H</sub> or FF 8000 0000<sub>H</sub>, respectively. This instruction is repeatable when “op 1” is not an immediate operand.

MAC Flags

N	Z	C	SV	E	SL
*	*	*	*	*	*

- N
- Set if the most significant bit of the result is set. Cleared otherwise.
- Z
- Set if the result equals zero. Cleared otherwise.
- C
- Set if a carry is generated (rnd). Cleared otherwise.
- SV
- Set if an arithmetic overflow occurred (rnd). Not affected otherwise.
- E
- Set if the MAE is used. Cleared otherwise.
- SL
- Set if the contents of the ACC is automatically saturated (rnd). Not affected otherwise

Addressing Modes

Mnemonic		Rep	Format	Bytes
CoASHR	Rw <sub>n</sub>	Yes	A3 nn AA rrrr:r000	4
CoASHR	Rw <sub>n</sub> , rnd	Yes	A3 nn BA rrrr:r000	4
CoASHR	#data <sub>5</sub>	No	A3 00 A2 ssss:s000	4
CoASHR	#data <sub>5</sub> , rnd	No	A3 00 B2 ssss:s000	4
CoASHR	[Rw <sub>m</sub> ⊗]	Yes	83 mm AA rrrr:rqqq	4
CoASHR	[Rw <sub>m</sub> ⊗], rnd	Yes	83 mm BA rrrr:rqqq	4

Examples

CoASHR	#3, rnd	; (ACC) <-- (ACC) >>a 3 + rnd
CoASHR	R3	; (ACC) <-- (ACC) >>a (R3) <sub>4-0</sub>
CoASHR	[R10 - QR0]	; (ACC) <-- (ACC) >>a ((R10)) <sub>4-0</sub>
		; (R10) <-- (R10) - (QR0)



CoCMP

Compare

Group	Compare Instructions
Syntax	CoCMP op1, op2
Operation	tmp <-- (op2)\(op1) (ACC) <--> (tmp)
Data Types	DOUBLE WORD
Description	Subtracts a 40-bit signed operand from the 40-bit Accumulator content and update the N, Z and C flags contained in the MSW register leaving the accumulator unchanged. The 40-bit operand results from the concatenation, “\”, of the two source operands op1 (LSW) and op2 (MSW) which is then sign-extended. The MS bit of the MCW register does not affect the result. This instruction is not repeatable and allows up to two parallel memory reads.

MAC Flags

N	Z	C	SV	E	SL
*	*	*	-	-	-

N	Set if the most significant bit of the result is set. Cleared otherwise.
Z	Set if the result equals zero. Cleared otherwise.
C	Set if a borrow is generated. Cleared otherwise.
SV	Not affected.
E	Not affected.
SL	Not affected.

Addressing Modes

Mnemonic	Rep	Format	Bytes
CoCMP $Rw_n, Rw_m$	No	A3 nm C2 00	4
CoCMP $[IDX_i \otimes], [Rw_m \otimes]$	No	93 Xm C2 0:0qqq	4
CoCMP $Rw_n, [Rw_m \otimes]$	No	83 nm C2 0:0qqq	4

Examples

CoCMP	$[IDX1+QX0], [R11+QR1]$	$; MSW(N,Z,C) <-- (ACC) - ((R11)) \setminus ((IDX1))$ $; (R11) <-- (R11) + (QR1)$ $; (IDX1) <-- (IDX1) + (QX0)$
CoCMP	$R1, [R2-]$	$; MSW(N,Z,C) <-- (ACC) - ((R2)) \setminus (R1)$ $; (R2) <-- (R2) - 2$
CoCMP	$R2, R5$	$; MSW(N,Z,C) <-- (ACC) - (R5) \setminus (R2)$

CoLOAD(2)(-)

Load Accumulator

**Group** 40-bit Arithmetic Instructions

**Syntax** CoLOAD op1, op2

**Operation** (tmp) <-- (op2)\(op1)  
(ACC) <-- 0 + (tmp)

**Syntax** CoLOAD- op1, op2

**Operation** (tmp) <-- (op2)\(op1)  
(ACC) <-- 0 - (tmp)

**Syntax** CoLOAD2 op1, op2

**Operation** (tmp) <-- 2 \* (op2)\(op1)  
(ACC) <-- 0 + (tmp)

**Syntax** CoLOAD2- op1, op2

**Operation** (tmp) <-- 2 \* (op2)\(op1)  
(ACC) <-- 0 - (tmp)

**Data Types** DOUBLE WORD

**Result** 40-bit signed value

**Description** Loads the accumulator with a 40-bit source operand. The 40-bit source operand results from the concatenation of the two source operands op1 (LSW) and op2 (MSW) which is then sign-extended. “2” and “-” options indicate that the 40-bit operand is also multiplied by two or/and negated, respectively, prior being stored in the accumulator. The “.” option indicates that the source operand is 2’s complemented. When the MS bit of the MCW register is set and when a 32-bit overflow or underflow occurs, the obtained result becomes 00 7FFF FFFF<sub>h</sub> or FF 8000 0000<sub>h</sub>, respectively. This instruction is not repeatable and allows up to two parallel memory reads.

MAC Flags

N	Z	C	SV	E	SL
*	*	*	-	*	*

- N Set if the most significant bit of the result is set. Cleared otherwise.
- Z Set if the result equals zero. Cleared otherwise.
- C Set if a borrow is generated. Cleared otherwise.
- SV Not affected.
- E Set if the MAE is used. Cleared otherwise.
- SL Set if the contents of the ACC is automatically saturated. Not affected otherwise.



## Addressing Modes

Mnemonic		Rep	Format	Bytes
CoLOAD	$Rw_n, Rw_m$	No	A3 nm 22 00	4
CoLOAD-	$Rw_n, Rw_m$	No	A3 nm 2A 00	4
CoLOAD2	$Rw_n, Rw_m$	No	A3 nm 62 00	4
CoLOAD2-	$Rw_n, Rw_m$	No	A3 nm 6A 00	4
CoLOAD	$[IDX_i \otimes], [Rw_m \otimes]$	No	93 Xm 22 0:0qqq	4
CoLOAD-	$[IDX_i \otimes], [Rw_m \otimes]$	No	93 Xm 2A 0:0qqq	4
CoLOAD2	$[IDX_i \otimes], [Rw_m \otimes]$	No	93 Xm 62 0:0qqq	4
CoLOAD2-	$[IDX_i \otimes], [Rw_m \otimes]$	No	93 Xm 6A 0:0qqq	4
CoLOAD	$Rw_n, [Rw_m \otimes]$	No	83 nm 22 0:0qqq	4
CoLOAD-	$Rw_n, [Rw_m \otimes]$	No	83 nm 2A 0:0qqq	4
CoLOAD2	$Rw_n, [Rw_m \otimes]$	No	83 nm 62 0:0qqq	4
CoLOAD2-	$Rw_n, [Rw_m \otimes]$	No	83 nm 6A 0:0qqq	4

**CoMAC(R/-)****Multiply-Accumulate & Optional Round****Group**

Multiply/Multiply-Accumulate Instructions

**Syntax**

CoMAC            op1, op2

**Operation**

```
IF (MP = 1) THEN
    (tmp) <-- ((op1) * (op2)) << 1
    (ACC) <-- (ACC) + (tmp)
ELSE
    (tmp) <-- (op1) * (op2)
    (ACC) <-- (ACC) + (tmp)
END IF
```

**Syntax**

CoMAC            op1, op2, rnd

**Operation**

```
IF (MP = 1) THEN
    (tmp) <-- ((op1) * (op2)) << 1
    (ACC) <-- (ACC) + (tmp) + 00 0000 8000h
ELSE
    (tmp) <-- (op1) * (op2)
    (ACC) <-- (ACC) + (tmp) + 00 0000 8000h
END IF
(MAL) <-- 0
```

**Syntax**

CoMAC-           op1, op2

**Operation**

```
IF (MP = 1) THEN
    (tmp) <-- ((op1) * (op2)) << 1
    (ACC) <-- (ACC) - (tmp)
ELSE
    (tmp) <-- (op1) * (op2)
    (ACC) <-- (ACC) - (tmp)
END IF
```

**Syntax**

CoMACR           op1, op2

**Operation**

```
IF (MP = 1) THEN
    (tmp) <-- ((op1) * (op2)) << 1
    (ACC) <-- (tmp) - (ACC)
ELSE
    (tmp) <-- (op1) * (op2)
    (ACC) <-- (tmp) - (ACC)
END IF
```

**Syntax**

CoMACR           op1, op2, rnd

**Operation**

```
IF (MP = 1) THEN
    (tmp) <-- ((op1) * (op2)) << 1
    (ACC) <-- (tmp) - (ACC) + 00 0000 8000h
ELSE
```

```
(tmp) <-- (op1) * (op2)
(ACC) <-- (tmp) - (ACC) + 00 0000 8000h
END IF
(MAL) <-- 0
```

Data Types

DOUBLE WORD

Result

40-bit signed value

Description

Multiplies the two signed 16-bit source operands “op1” and “op2”. The obtained signed 32-bit product is first sign-extended, then the condition MP flag is set, it is one-bit left shifted, then it is optionally negated prior being added/subtracted to/from the 40-bit ACC register content. Finally, the obtained result is optionally rounded before being stored in the 40-bit ACC register. The “-” option is used to negate the specified product, the “R” option is used to negate the accumulator content, and finally the “rnd” option is used to round the result using two’s complement rounding. The default sign option is “+” and the default round option is “no round”. When “rnd” option is used, MAL register is automatically cleared. Note that “rnd” and “-” are exclusive as well as “-” and “R”. This instruction might be repeated and allows up to two parallel memory reads.

MAC Flags

N	Z	C	SV	E	SL
*	*	*	*	*	*

- N Set if the most significant bit of the result is set. Cleared otherwise.
- Z Set if the result equals zero. Cleared otherwise.
- C Set if a carry or borrow is generated. Cleared otherwise.
- SV Set if an arithmetic overflow occurred. Not affected otherwise.
- E Set if the MAE is used. Cleared otherwise.
- SL Set if the contents of the ACC is automatically saturated. Not affected otherwise.

## Addressing Modes

	Mnemonic	Rep	Format	Bytes
CoMAC	Rw <sub>n</sub> , Rw <sub>m</sub>	No	A3 nm D0 00	4
CoMAC-	Rw <sub>n</sub> , Rw <sub>m</sub>	No	A3 nm E0 00	4
CoMAC	Rw <sub>n</sub> , Rw <sub>m</sub> , rnd	No	A3 nm D1 00	4
CoMACR	Rw <sub>n</sub> , Rw <sub>m</sub>	No	A3 nm F0 00	4
CoMACR	Rw <sub>n</sub> , Rw <sub>m</sub> , rnd	No	A3 nm F1 00	4
CoMAC	[IDX <sub>i</sub> ⊗], [Rw <sub>m</sub> ⊗]	Yes	93 Xm D0 rrrr:rqqq	4
CoMAC-	[IDX <sub>i</sub> ⊗], [Rw <sub>m</sub> ⊗]	Yes	93 Xm E0 rrrr:rqqq	4
CoMAC	[IDX <sub>i</sub> ⊗], [Rw <sub>m</sub> ⊗], rnd	Yes	93 Xm D1 rrrr:rqqq	4
CoMACR	[IDX <sub>i</sub> ⊗], [Rw <sub>m</sub> ⊗]	Yes	93 Xm F0 rrrr:rqqq	4
CoMACR	[IDX <sub>i</sub> ⊗], [Rw <sub>m</sub> ⊗], rnd	Yes	93 Xm F1 rrrr:rqqq	4
CoMAC	Rw <sub>n</sub> , [Rw <sub>m</sub> ⊗]	Yes	83 nm D0 rrrr:rqqq	4
CoMAC-	Rw <sub>n</sub> , [Rw <sub>m</sub> ⊗]	Yes	83 nm E0 rrrr:rqqq	4
CoMAC	Rw <sub>n</sub> , [Rw <sub>m</sub> ⊗], rnd	Yes	83 nm D1 rrrr:rqqq	4
CoMACR	Rw <sub>n</sub> , [Rw <sub>m</sub> ⊗]	Yes	83 nm F0 rrrr:rqqq	4
CoMACR	Rw <sub>n</sub> , [Rw <sub>m</sub> ⊗], rnd	Yes	83 nm F1 rrrr:rqqq	4

## Examples

```

CoMAC      R3, R4, rnd      ; (ACC) <-- (ACC) + (R3)*(R4) + rnd
CoMAC-     R2, [R6+]        ; (ACC) <-- (ACC) - (R2)*((R6))
                                   ; (R6) <-- (R6) + 2
CoMAC      [IDX0+QX0], [R11+QR0] ; (ACC) <-- (ACC) + ((IDX0))*((R11))
                                   ; (R11) <-- (R11) + (QR0)
                                   ; (IDX0) <-- (IDX0) + (QX0)
Repeat 3 times CoMAC [IDX1 - QX1], [R9+QR1] ; (ACC) <-- (ACC) + ((IDX1))*((R9))
                                   ; (R9) <-- (R9) + (QR1)
                                   ; (IDX1) <-- (IDX1) - (QX1)
Repeat MRW times CoMAC- R3, [R7 - QR0] ; (ACC) <-- (ACC) - (R3)*((R7))
                                   ; (R7) <-- (R7) - (QR0)
CoMACR     [IDX1], [R4+], rnd ; (ACC) <-- ((IDX1))*((R4)) - (ACC) + rnd
                                   ; (R4) <-- (R4) + 2

```

CoMAC(R)u(-)

Unsigned Multiply-Accumulate & Optional Round

Group

Multiply/Multiply-Accumulate Instructions

Syntax

CoMACu          op1, op2

Operation

(tmp) <-- (op1) \* (op2)  
(ACC) <-- (ACC) + (tmp)

Syntax

CoMACu          op1, op2, rnd

Operation

(tmp) <-- (op1) \* (op2)  
(ACC) <-- (ACC) + (tmp) + 00 0000 8000<sub>h</sub>  
(MAL) <-- 0

Syntax

CoMACu-op1, op2

Operation

(tmp) <-- (op1) \* (op2)  
(ACC) <-- (ACC) - (tmp)

Syntax

CoMACRu          op1, op2

Operation

(tmp) <-- (op1) \* (op2)  
(ACC) <-- (tmp) - (ACC)

Syntax

CoMACRu          op1, op2, rnd

Operation

(tmp) <-- (op1) \* (op2)  
(ACC) <-- (tmp) - (ACC) + 00 0000 8000<sub>h</sub>  
(MAL) <-- 0

Data Types

DOUBLE WORD

Result

40-bit signed value

Description

Multiplies the two unsigned 16-bit source operands “op1” and “op2”. The obtained unsigned 32-bit product is first zero-extended and then optionally negated prior being added/subtracted to/from the 40-bit ACC register content, finally, the obtained result is optionally rounded before being stored in the 40-bit ACC register. The result is never affected by the MP mode flag contained in the MCW register. “-” option is used to negate the specified product, “R” option is used to negate the accumulator content, and finally “rnd” option is used to round the result using two’s complement rounding. The default sign option is “+” and the default round option is “no round”. When “rnd” option is used, MAL register is automatically cleared. Note that “rnd” and “-” are exclusive as well as “+” and “R”. This instruction might be repeated and allows up to two parallel memory reads.

MAC Flags

N	Z	C	SV	E	SL
*	*	*	*	*	*

N	Set if the most significant bit of the result is set. Cleared otherwise.
Z	Set if the result equals zero. Cleared otherwise.
C	Set if a carry or borrow is generated. Cleared otherwise.
SV	Set if an arithmetic overflow occurred. Not affected otherwise.
E	Set if the MAE is used. Cleared otherwise.
SL	Set if the contents of the ACC is automatically saturated. Not affected otherwise.

## Addressing Modes

Mnemonic	Rep	Format	Bytes
CoMACu $Rw_n, Rw_m$	No	A3 nm 10 00	4
CoMACu- $Rw_n, Rw_m$	No	A3 nm 20 00	4
CoMACu $Rw_n, Rw_m, rnd$	No	A3 nm 11 00	4
CoMACRu $Rw_n, Rw_m$	No	A3 nm 30 00	4
CoMACRu $Rw_n, Rw_m, rnd$	No	A3 nm 31 00	4
CoMACu $[IDX_i \otimes], [Rw_m \otimes]$	Yes	93 Xm 10 rrrr:rqqq	4
CoMACu- $[IDX_i \otimes], [Rw_m \otimes]$	Yes	93 Xm 20 rrrr:rqqq	4
CoMACu $[IDX_i \otimes], [Rw_m \otimes], rnd$	Yes	93 Xm 11 rrrr:rqqq	4
CoMACRu $[IDX_i \otimes], [Rw_m \otimes]$	Yes	93 Xm 30 rrrr:rqqq	4
CoMACRu $[IDX_i \otimes], [Rw_m \otimes], rnd$	Yes	93 Xm 31 rrrr:rqqq	4
CoMACu $Rw_n, [Rw_m \otimes]$	Yes	83 nm 10 rrrr:rqqq	4
CoMACu- $Rw_n, [Rw_m \otimes]$	Yes	83 nm 20 rrrr:rqqq	4
CoMACu $Rw_n, [Rw_m \otimes], rnd$	Yes	83 nm 11 rrrr:rqqq	4
CoMACRu $Rw_n, [Rw_m \otimes]$	Yes	83 nm 30 rrrr:rqqq	4
CoMACRu $Rw_n, [Rw_m \otimes], rnd$	Yes	83 nm 31 rrrr:rqqq	4

## Examples

CoMACu	R5, R8, rnd	; (ACC) <-- (ACC) + (R5)*(R8) + rnd
CoMACu-	R2, [R7]	; (ACC) <-- (ACC) - (R2)*((R7))
CoMACu	[IDX0 - QX0], [R11 - QR0]	; (ACC) <-- (ACC) + (((IDX0))*((R11)))
		; (R11) <-- (R11) - (QR0)
		; (IDX0) <-- (IDX0) - (QX0)
Repeat 3 times	CoMACu [IDX1+], [R9-]	; (ACC) <-- (ACC) + (((IDX1))*((R9)))
		; (R9) <-- (R9) - 2
		; (IDX1) <-- (IDX1) + 2
Repeat MRW times	CoMACu- R3, [R7 - QR0]	; (ACC) <-- (ACC) - (R3)*((R7))
		; (R7) <-- (R7) - (QR0)
CoMACRu	[IDX1 - QX0], [R4], rnd	; (ACC) <-- (((IDX1))*((R4)))-(ACC)+ rnd
		; (IDX1) <-- (IDX1) - (QX0)



**CoMAC(R)us(-)****Mixed Multiply-Accumulate & Optional Round**

**Group** Multiply/Multiply-Accumulate Instructions

**Syntax** CoMACUs op1, op2

**Operation**  
 (tmp) <-- (op1) \* (op2)  
 (ACC) <-- (ACC) + (tmp)

**Syntax** CoMACUs op1, op2, rnd

**Operation**  
 (tmp) <-- (op1) \* (op2)  
 (ACC) <-- (ACC) + (tmp) + 00 0000 8000<sub>h</sub>  
 (MAL) <-- 0

**Syntax** CoMACUs- op1, op2

**Operation**  
 (tmp) <-- (op1) \* (op2)  
 (ACC) <-- (ACC) - (tmp)

**Syntax** CoMACRus op1, op2

**Operation**  
 (tmp) <-- (op1) \* (op2)  
 (ACC) <-- (tmp) - (ACC)

**Syntax** CoMACRus op1, op2, rnd

**Operation**  
 (tmp) <-- (op1) \* (op2)  
 (ACC) <-- (tmp) - (ACC) + 00 0000 8000<sub>h</sub>  
 (MAL) <-- 0

**Data Types** DOUBLE WORD

**Result** 40-bit signed value

**Description** Multiplies the two unsigned and signed 16-bit source operands “op1” and “op2”, respectively. The obtained signed 32-bit product is first sign-extended, and then, it is optionally negated prior being added/subtracted to/from the 40-bit ACC register content, finally the obtained result is optionally rounded before being stored in the 40-bit ACC register. The result is never affected by the MP mode flag contained in the MCW register. “-” option is used to negate the specified product, “R” option is used to negate the accumulator content, and finally “rnd” option is used to round the result using two’s complement rounding. The default sign option is “+” and the default round option is “no round”. When “rnd” option is used, MAL register is automatically cleared. Note that “rnd” and “-” are exclusive as well as “-” and “R”. This instruction might be repeated and allows up to two parallel memory reads.

## MAC Flags

N	Z	C	SV	E	SL
*	*	*	*	*	*

N	Set if the most significant bit of the result is set. Cleared otherwise.
Z	Set if the result equals zero. Cleared otherwise.
C	Set if a carry or borrow is generated. Cleared otherwise.
SV	Set if an arithmetic overflow occurred. Not affected otherwise.
E	Set if the MAE is used. Cleared otherwise.
SL	Set if the contents of the ACC is automatically saturated. Not affected otherwise.

## Addressing Modes

Mnemonic	Rep	Format	Bytes
CoMACus $Rw_n, Rw_m$	No	A3 nm 90 00	4
CoMACus- $Rw_n, Rw_m$	No	A3 nm A0 00	4
CoMACus $Rw_n, Rw_m, rnd$	No	A3 nm 91 00	4
CoMACRus $Rw_n, Rw_m$	No	A3 nm B0 00	4
CoMACRus $Rw_n, Rw_m, rnd$	No	A3 nm B1 00	4
CoMACus $[IDX_i \otimes], [Rw_m \otimes]$	Yes	93 Xm 90 rrrr:rqqq	4
CoMACus- $[IDX_i \otimes], [Rw_m \otimes]$	Yes	93 Xm A0 rrrr:rqqq	4
CoMACus $[IDX_i \otimes], [Rw_m \otimes], rnd$	Yes	93 Xm 91 rrrr:rqqq	4
CoMACRus $[IDX_i \otimes], [Rw_m \otimes]$	Yes	93 Xm B0 rrrr:rqqq	4
CoMACRus $[IDX_i \otimes], [Rw_m \otimes], rnd$	Yes	93 Xm B1 rrrr:rqqq	4
CoMACus $Rw_n, [Rw_m \otimes]$	Yes	83 nm 90 rrrr:rqqq	4
CoMACus- $Rw_n, [Rw_m \otimes]$	Yes	83 nm A0 rrrr:rqqq	4
CoMACus $Rw_n, [Rw_m \otimes], rnd$	Yes	83 nm 91 rrrr:rqqq	4
CoMACRus $Rw_n, [Rw_m \otimes]$	Yes	83 nm B0 rrrr:rqqq	4
CoMACRus $Rw_n, [Rw_m \otimes], rnd$	Yes	83 nm B1 rrrr:rqqq	4

## Examples

CoMACus	$R5, R8, rnd$	; (ACC) <-- (ACC) + (R5)*(R8) + rnd
CoMACus-	$R2, [R7]$	; (ACC) <-- (ACC) - (R2)*((R7))
CoMACus	$[IDX0 - QX0], [R11 - QR0]$	; (ACC) <-- (ACC) + ((IDX0))*((R11))
		; (R11) <-- (R11) - (QR0)
		; (IDX0) <-- (IDX0) - (QX0)
Repeat 3 times	CoMACus[ $IDX1+$ ], [R9-]	; (ACC) <-- (ACC) + ((IDX1))*((R9))
		; (R9) <-- (R9) - 2
		; (IDX1) <-- (IDX1) + 2
Repeat MRW times	CoMACus- $R3, [R7 - QR0]$	; (ACC) <-- (ACC) - (R3)*((R7))
		; (R7) <-- (R7) - (QR0)
CoMACRus	$[IDX1 - QX0], [R4], rnd$	; (ACC) <-- ((IDX1))*((R4))-(ACC)+rnd
		; (IDX1) <-- (IDX1) - (QX0)

**CoMAC(R)su(-)****Mixed Multiply-Accumulate & Optional Round**

**Group** Multiply/Multiply-Accumulate Instructions

**Syntax** CoMACsu op1, op2

**Operation**  
 $(tmp) \leftarrow (op1) * (op2)$   
 $(ACC) \leftarrow (ACC) + (tmp)$

**Syntax** CoMACsu op1, op2, rnd

**Operation**  
 $(tmp) \leftarrow (op1) * (op2)$   
 $(ACC) \leftarrow (ACC) + (tmp) + 00\ 0000\ 8000_h$   
 $(MAL) \leftarrow 0$

**Syntax** CoMACsu- op1, op2

**Operation**  
 $(tmp) \leftarrow (op1) * (op2)$   
 $(ACC) \leftarrow (ACC) - (tmp)$

**Syntax** CoMACRsu op1, op2

**Operation**  
 $(tmp) \leftarrow (op1) * (op2)$   
 $(ACC) \leftarrow (tmp) - (ACC)$

**Syntax** CoMACRsu op1, op2, rnd

**Operation**  
 $(tmp) \leftarrow (op1) * (op2)$   
 $(ACC) \leftarrow (tmp) - (ACC) + 00\ 0000\ 8000_h$   
 $(MAL) \leftarrow 0$

**Data Types** DOUBLE WORD

**Result** 40-bit signed value

**Description** Multiplies the two signed and unsigned 16-bit source operands “op1” and “op2”, respectively. The obtained signed 32-bit product is first sign-extended, and then, it is optionally negated prior being added/subtracted to/from the 40-bit ACC register content, finally the obtained result is optionally rounded before being stored in the 40-bit ACC register. The result is never affected by the MP mode flag contained in the MCW register. “-” option is used to negate the specified product, “R” option is used to negate the accumulator content, and finally “rnd” option is used to round the result using two’s complement rounding. The default sign option is “+” and the default round option is “no round”. When “rnd” option is used, MAL register is automatically cleared. Note that “rnd” and “-” are exclusive as well as “-” and “R”. This instruction might be repeated and allows up to two parallel memory reads.

MAC Flags

N	Z	C	SV	E	SL
*	*	*	*	*	*

N	Set if the most significant bit of the result is set. Cleared otherwise.
Z	Set if the result equals zero. Cleared otherwise.
C	Set if a carry or borrow is generated. Cleared otherwise.
SV	Set if an arithmetic overflow occurred. Not affected otherwise.
E	Set if the MAE is used. Cleared otherwise.
SL	Set if the contents of the ACC is automatically saturated. Not affected otherwise.

Addressing Modes

Mnemonic	Rep	Format	Bytes
CoMACsu $Rw_n, Rw_m$	No	A3 nm 50 00	4
CoMACsu- $Rw_n, Rw_m$	No	A3 nm 60 00	4
CoMACsu $Rw_n, Rw_m, rnd$	No	A3 nm 51 00	4
CoMACRsu $Rw_n, Rw_m$	No	A3 nm 70 00	4
CoMACRsu $Rw_n, Rw_m, rnd$	No	A3 nm 71 00	4
CoMACsu $[IDX_i \otimes], [Rw_m \otimes]$	Yes	93 Xm 50 rrrr:rqqq	4
CoMACsu- $[IDX_i \otimes], [Rw_m \otimes]$	Yes	93 Xm 60 rrrr:rqqq	4
CoMACsu $[IDX_i \otimes], [Rw_m \otimes], rnd$	Yes	93 Xm 51 rrrr:rqqq	4
CoMACRsu $[IDX_i \otimes], [Rw_m \otimes]$	Yes	93 Xm 70 rrrr:rqqq	4
CoMACRsu $[IDX_i \otimes], [Rw_m \otimes], rnd$	Yes	93 Xm 71 rrrr:rqqq	4
CoMACsu $Rw_n, [Rw_m \otimes]$	Yes	83 nm 50 rrrr:rqqq	4
CoMACsu- $Rw_n, [Rw_m \otimes]$	Yes	83 nm 60 rrrr:rqqq	4
CoMACsu $Rw_n, [Rw_m \otimes], rnd$	Yes	83 nm 51 rrrr:rqqq	4
CoMACRsu $Rw_n, [Rw_m \otimes]$	Yes	83 nm 70 rrrr:rqqq	4
CoMACRsu $Rw_n, [Rw_m \otimes], rnd$	Yes	83 nm 71 rrrr:rqqq	4

Examples

CoMACsu	R5, R8, rnd	; (ACC) <-- (ACC) + (R5)*(R8) + rnd
CoMACsu-	R2, [R7]	; (ACC) <-- (ACC) - (R2)*((R7))
CoMACsu	[IDX0 - QX0], [R11 - QR0]	; (ACC) <-- (ACC) + (((IDX0))*((R11)))
		; (R11) <-- (R11) - (QR0)
		; (IDX0) <-- (IDX0) - (QX0)
Repeat 3 times	CoMACsu [IDX1+], [R9-]	; (ACC) <-- (ACC) + (((IDX1))*((R9)))
		; (R9) <-- (R9) - 2
		; (IDX1) <-- (IDX1) + 2
Repeat MRW times	CoMACsu- R3, [R7 - QR0]	; (ACC) <-- (ACC) - (R3)*((R7))
		; (R7) <-- (R7) - (QR0)
CoMACRsu	[IDX1 - QX0], [R4], rnd	; (ACC) <-- (((IDX1))*((R4))) - (ACC)
		; (IDX1) <-- (IDX1) - (QX0)

**CoMACM(R/-)****Multiply-Accumulate  
Parallel Data Move & Optional Round****Group**

Multiply/Multiply-Accumulate Instructions

**Syntax**

CoMACM      op1, op2

**Operation**

```

IF (MP = 1) THEN
    (tmp) <-- ((op1))*((op2)) << 1
    (ACC) <-- (ACC) + (tmp)
ELSE
    (tmp) <-- ((op1))*((op2))
    (ACC) <-- (ACC) + (tmp)
END IF
((IDXi(-⊗))) <-- ((IDXi))

```

**Syntax**

CoMACM      op1, op2, rnd

**Operation**

```

IF (MP = 1) THEN
    (tmp) <-- ((op1))*((op2)) << 1
    (ACC) <-- (ACC) + (tmp) + 00 0000 8000h
ELSE
    (tmp) <-- ((op1))*((op2))
    (ACC) <-- (ACC) + (tmp) + 00 0000 8000h
END IF
(MAL) <-- 0
((IDXi(-⊗))) ← ((IDXi))

```

**Syntax**

CoMACM-      op1, op2

**Operation**

```

IF (MP = 1) THEN
    (tmp) <-- ((op1))*((op2)) << 1
    (ACC) <-- (ACC) - (tmp)
ELSE
    (tmp) <-- ((op1))*((op2))
    (ACC) <-- (ACC) - (tmp)
END IF
((IDXi(-⊗))) <-- ((IDXi))

```

**Syntax**

CoMACMR      op1, op2

**Operation**

```

IF (MP = 1) THEN
    (tmp) <-- ((op1))*((op2)) << 1
    (ACC) <-- (tmp) - (ACC)
ELSE
    (tmp) <-- ((op1))*((op2))
    (ACC) <-- (tmp) - (ACC)
END IF
((IDXi(-⊗))) <-- ((IDXi))

```

Syntax

CoMACMR     op1, op2, rnd

Operation

```
IF (MP = 1) THEN
    (tmp) <-- ((op1))*((op2)) << 1
    (ACC) <-- (tmp) - (ACC) + 00 0000 8000h
ELSE
    (tmp) <-- ((op1))*((op2))
    (ACC) <-- (tmp) - (ACC) + 00 0000 8000h
END IF
(MAL) <-- 0
((IDXi(-⊗))) <-- ((IDXi))
```

Data Types

DOUBLE WORD

Result

40-bit signed value

Description

Multiplies the two signed 16-bit source operands “op1” and “op2”. The obtained signed 32-bit product is first sign-extended, then and on condition the MP flag is set, it is one-bit left shifted, and next, it is optionally negated prior being added/subtracted to/from the 40-bit ACC register content, finally the obtained result is optionally rounded before being stored in the 40-bit ACC register. “-” option is used to negate the specified product, “R” option is used to negate the accumulator content, and finally “rnd” option is used to round the result using two’s complement rounding. The default sign option is “+” and the default round option is “no round”. When “rnd” option is used, MAL register is automatically cleared. Note that “rnd” and “-” are exclusive as well as “-” and “R”. This instruction might be repeated and performs two parallel memory reads. In parallel to the arithmetic operation and to the two parallel reads, the data pointed to by IDX<sub>i</sub> overwrites another data located in memory (DPRAM). The address of the overwritten data depends on the operation executed on IDX<sub>i</sub>, as explained by the following table

Addressing Mode	Overwritten Address
[IDX <sub>i</sub> ]	(no change)
[IDX <sub>i</sub> +]	(IDX <sub>i</sub> ) - 2
[IDX <sub>i</sub> -]	(IDX <sub>i</sub> ) + 2
[IDX <sub>i</sub> +QX <sub>j</sub> ]	(IDX <sub>i</sub> ) - (QX <sub>j</sub> )
[IDX <sub>i</sub> -QX <sub>j</sub> ]	(IDX <sub>i</sub> ) + (QX <sub>j</sub> )

MAC Flags

N	Z	C	SV	E	SL
*	*	*	*	*	*

- N     Set if the most significant bit of the result is set. Cleared otherwise.
- Z     Set if the result equals zero. Cleared otherwise.

C	Set if a carry or borrow is generated. Cleared otherwise.
SV	Set if an arithmetic overflow occurred. Not affected otherwise.
E	Set if the MAE is used. Cleared otherwise.
SL	Set if the contents of the ACC is automatically saturated. Not affected otherwise.

## Addressing Modes

Mnemonic		Rep	Format	Bytes
CoMACM	[ $IDX_i \otimes$ ], [ $Rw_m \otimes$ ]	Yes	93 Xm D8 rrrr:qqq	4
CoMACM-	[ $IDX_i \otimes$ ], [ $Rw_m \otimes$ ]	Yes	93 Xm E8 rrrr:qqq	4
CoMACM	[ $IDX_i \otimes$ ], [ $Rw_m \otimes$ ], rnd	Yes	93 Xm D9 rrrr:qqq	4
CoMACMR	[ $IDX_i \otimes$ ], [ $Rw_m \otimes$ ]	Yes	93 Xm F8 rrrr:qqq	4
CoMACMR	[ $IDX_i \otimes$ ], [ $Rw_m \otimes$ ], rnd	Yes	93 Xm F9 rrrr:qqq	4

## Examples

```

CoMACM    [IDX1+QX0],[R10+QR1], rnd          ; (ACC) <-- (ACC) + ((IDX1))*(R10) + rnd
                                                ; (R10) <-- (R10) + (QR1)
                                                ; ( ((IDX1)-(QX0)) ) <-- ((IDX1))
                                                ; (IDX1) <-- (IDX1) + (QX0)
Repeat 3 times CoMACM [IDX0 - QX0], [R8+QR0]  ; (ACC) <-- (ACC) + ((IDX0))*(R8)
                                                ; (R8) <-- (R8) + (QR0)
                                                ; ( ((IDX0) + (QX0)) ) <-- ((IDX0))
                                                ; (IDX0) <-- (IDX0) - (QX0)
Repeat MRW times CoMACM- [IDX1+QX1], [R7 - QR0] ; (ACC) <-- (ACC) - ((IDX1))*(R7)
                                                ; (R7) <-- (R7) - (QR0)
                                                ; ( ((IDX1) - (QX1)) ) <-- ((IDX1))
                                                ; (IDX1) <-- (IDX1) + (QX1)

```

**CoMACM(R)u(-)****Unsigned Multiply-Accumulate  
Parallel Data Move & Optional Round**

**Group** Multiply/Multiply-Accumulate Instructions

**Syntax** CoMACMu op1, op2

**Operation**  
 $(tmp) \leftarrow ((op1)) * ((op2))$   
 $(ACC) \leftarrow (ACC) + (tmp)$   
 $((IDX_i(-\otimes))) \leftarrow ((IDX_i))$

**Syntax** CoMACMu op1, op2, rnd

**Operation**  
 $(tmp) \leftarrow ((op1)) * ((op2))$   
 $(ACC) \leftarrow (ACC) + (tmp) + 00\ 0000\ 8000_h$   
 $(MAL) \leftarrow 0$   
 $((IDX_i(-\otimes))) \leftarrow ((IDX_i))$

**Syntax** CoMACMu- op1, op2

**Operation**  
 $(tmp) \leftarrow ((op1)) * ((op2))$   
 $(ACC) \leftarrow (ACC) - (tmp)$   
 $((IDX_i(-\otimes))) \leftarrow ((IDX_i))$

**Syntax** CoMACMRu op1, op2

**Operation**  
 $(tmp) \leftarrow ((op1)) * ((op2))$   
 $(ACC) \leftarrow (tmp) - (ACC)$   
 $((IDX_i(-\otimes))) \leftarrow ((IDX_i))$

**Syntax** CoMACMRu op1, op2, rnd

**Operation**  
 $(tmp) \leftarrow ((op1)) * ((op2))$   
 $(ACC) \leftarrow (tmp) - (ACC) + 00\ 0000\ 8000_h$   
 $(MAL) \leftarrow 0$   
 $((IDX_i(-\otimes))) \leftarrow ((IDX_i))$

**Data Types** DOUBLE WORD

**Result** 40-bit signed value

**Description** Multiplies the two signed 16-bit source operands “op1” and “op2”. The unsigned 32-bit product is first zero-extended, then optionally negated prior being added/subtracted to/from the 40-bit ACC register content, finally the obtained result is optionally rounded before being stored in the 40-bit ACC register. “-” option is used to negate the specified product, “R” option is used to negate the accumulator content, and finally “rnd” option is used to round the result using two’s complement rounding. The default sign option is “+” and the default round option is “no round”. When “rnd” option is used, MAL register is automatically cleared. Note that “rnd” and “-” are exclusive as well as “-” and “R”. This instruction might be repeated and performs two parallel memory



reads. In parallel to the arithmetic operation and to the two parallel reads, the data pointed to by  $IDX_i$  overwrites another data located in memory (DPRAM). The address of the overwritten data depends on the operation executed on  $IDX_i$ , as illustrated by the following table

Addressing Mode	Overwritten Address
$[IDX_i]$	(no change)
$[IDX_i+]$	$(IDX_i) - 2$
$[IDX_i-]$	$(IDX_i) + 2$
$[IDX_i+QX_j]$	$(IDX_i) - (QX_j)$
$[IDX_i-QX_j]$	$(IDX_i) + (QX_j)$

## MAC Flags

N	Z	C	SV	E	SL
*	*	*	*	*	*

N	Set if the most significant bit of the result is set. Cleared otherwise.
Z	Set if the result equals zero. Cleared otherwise.
C	Set if a carry or borrow is generated. Cleared otherwise.
SV	Set if an arithmetic overflow occurred. Not affected otherwise.
E	Set if the MAE is used. Cleared otherwise.
SL	Set if the contents of the ACC is automatically saturated. Not affected otherwise.

## Addressing Modes

Mnemonic	Rep	Format	Bytes
CoMACMu $[IDX_i \otimes], [Rw_m \otimes]$	Yes	93 Xm 18 rrrr:qqqq	4
CoMACMu- $[IDX_i \otimes], [Rw_m \otimes]$	Yes	93 Xm 28 rrrr:qqqq	4
CoMACMu $[IDX_i \otimes], [Rw_m \otimes], \text{rnd}$	Yes	93 Xm 19 rrrr:qqqq	4
CoMACMRu $[IDX_i \otimes], [Rw_m \otimes]$	Yes	93 Xm 38 rrrr:qqqq	4
CoMACMRu $[IDX_i \otimes], [Rw_m \otimes], \text{rnd}$	Yes	93 Xm 39 rrrr:qqqq	4

## Examples

CoMACMu	$[IDX1+QX0], [R10+QR1], \text{rnd}$	; (ACC)<--(ACC)+ ((IDX1)) * ((R10))+ rnd ; (R10) <-- (R10) + (QR1) ; ( ((IDX1) - (QX0)) ) <-- ((IDX1)) ; (IDX1) <-- (IDX1) + (QX0)
Repeat 3 times CoMACMu	$[IDX0 - QX0], [R8+QR0]$	; (ACC) <-- (ACC) + ((IDX0))*((R8)) ; (R8) <-- (R8) + (QR0) ; ( ((IDX0) + (QX0)) ) <-- ((IDX0)) ; (IDX0) <-- (IDX0) - (QX0)
Repeat MRW times CoMACMRu	$[IDX1+QX1], [R7 - QR0]$	; (ACC) <-- ((IDX1))*((R7)) - (ACC) ; (R7) <-- (R7) - (QR0) ; ( ((IDX1) - (QX1)) ) <-- ((IDX1)) ; (IDX1) <-- (IDX1) + (QX1)

**CoMACM(R)us(-)****Mixed Multiply-Accumulate  
Parallel Data Move & Optional Round**

**Group** Multiply/Multiply-Accumulate Instructions

**Syntax** CoMACMus op1, op2

**Operation**  
 $(tmp) \leftarrow ((op1)) * ((op2))$   
 $(ACC) \leftarrow (ACC) + (tmp)$   
 $((IDX_i(-\otimes))) \leftarrow ((IDX_i))$

**Syntax** CoMACMus op1, op2, rnd

**Operation**  
 $(tmp) \leftarrow ((op1)) * ((op2))$   
 $(ACC) \leftarrow (ACC) + (tmp) + 00\ 0000\ 8000_h$   
 $(MAL) \leftarrow 0$   
 $((IDX_i(-\otimes))) \leftarrow ((IDX_i))$

**Syntax** CoMACMus- op1, op2

**Operation**  
 $(tmp) \leftarrow ((op1)) * ((op2))$   
 $(ACC) \leftarrow (ACC) - (tmp)$   
 $((IDX_i(-\otimes))) \leftarrow ((IDX_i))$

**Syntax** CoMACMRus op1, op2

**Operation**  
 $(tmp) \leftarrow ((op1)) * ((op2))$   
 $(ACC) \leftarrow (tmp) - (ACC)$   
 $((IDX_i(-\otimes))) \leftarrow ((IDX_i))$

**Syntax** CoMACMRus op1, op2, rnd

**Operation**  
 $(tmp) \leftarrow ((op1)) * ((op2))$   
 $(ACC) \leftarrow (tmp) - (ACC) + 00\ 0000\ 8000_h$   
 $(MAL) \leftarrow 0$   
 $((IDX_i(-\otimes))) \leftarrow ((IDX_i))$

**Data Types** DOUBLE WORD

**Result** 40-bit signed value

**Description** Multiplies the two signed 16-bit source operands “op1” and “op2”. The obtained signed 32-bit product is first sign-extended, it is then optionally negated prior being added/subtracted to/from the 40-bit ACC register content, finally the obtained result is optionally rounded before being stored in the 40-bit ACC register. “-” option is used to negate the specified product, “R” option is used to negate the accumulator content, and finally “rnd” option is used to round the result using two’s complement rounding. The default sign option is “+” and the default round option is “no round”. When “rnd” option is used, MAL register is automatically cleared. Note that “rnd” and “-” are exclusive as well as “-” and “R”. This instruction might be repeated and performs two

parallel memory reads.  
In parallel to the arithmetic operation and to the two parallel reads, the data pointed to by  $IDX_i$  overwrites another data located in memory (DPRAM). The address of the overwritten data depends on the operation executed on  $IDX_i$ , as illustrated by the following table

Addressing Mode	Overwritten Address
$[IDX_i]$	(no change)
$[IDX_i+]$	$(IDX_i) - 2$
$[IDX_i-]$	$(IDX_i) + 2$
$[IDX_i+QX_i]$	$(IDX_i) - (QX_i)$
$[IDX_i - QX_i]$	$(IDX_i) + (QX_i)$

MAC Flags

N	Z	C	SV	E	SL
*	*	*	*	*	*

N Set if the most significant bit of the result is set. Cleared otherwise.

Z Set if the result equals zero. Cleared otherwise.

C Set if a carry or borrow is generated. Cleared otherwise.

SV Set if an arithmetic overflow occurred. Not affected otherwise.

E Set if the MAE is used. Cleared otherwise.

SL Set if the contents of the ACC is automatically saturated. Not affected otherwise.

Addressing Modes

Mnemonic	Rep	Format	Bytes
CoMACMus $[IDX_i\otimes], [Rw_m\otimes]$	Yes	93 Xm 98 rrrr:rqqq	4
CoMACMus- $[IDX_i\otimes], [Rw_m\otimes]$	Yes	93 Xm A8 rrrr:rqqq	4
CoMACMus $[IDX_i\otimes], [Rw_m\otimes], \text{rnd}$	Yes	93 Xm 99 rrrr:rqqq	4
CoMACMRus $[IDX_i\otimes], [Rw_m\otimes]$	Yes	93 Xm B8 rrrr:rqqq	4
CoMACMRus $[IDX_i\otimes], [Rw_m\otimes], \text{rnd}$	Yes	93 Xm B9 rrrr:rqqq	4

Examples

CoMACMus	$[IDX1+QX0], [R10+QR1], \text{rnd}$	$;(ACC)<--(ACC) + ((IDX1))*((R10)) + \text{rnd}$ $;(R10) <-- (R10) + (QR1)$ $;( ((IDX1) - (QX0)) )<-- ((IDX1))$ $;(IDX1) <-- (IDX1) + (QX0)$
Repeat 3 times CoMACMus	$[IDX0 - QX0], [R8+QR0]$	$;(ACC) <-- (ACC) + ((IDX0))*((R8))$ $;(R8) <-- (R8) + (QR0)$ $;( ((IDX0) + (QX0)) ) <-- ((IDX0))$ $;(IDX0) <-- (IDX0) - (QX0)$
Repeat MRW times CoMACMRus	$[IDX1+QX1], [R7 - QR0], \text{rnd}$	$;(ACC)<--((IDX1))*((R7))-(ACC)+\text{rnd}$ $;(R7) <-- (R7) - (QR0)$ $;( ((IDX1) - (QX1)) )<-- ((IDX1))$ $;(IDX1) <-- (IDX1) + (QX1)$



**CoMACM(R)su(-)****Mix. Multiply-Accumulate  
Parallel Data Move & Optional Round**

**Group** Multiply/Multiply-Accumulate Instructions

**Syntax** CoMACMsu op1, op2

**Operation**  
 $(tmp) \leftarrow ((op1)) * ((op2))$   
 $(ACC) \leftarrow (ACC) + (tmp)$   
 $((IDX_i(-\otimes))) \leftarrow ((IDX_i))$

**Syntax** CoMACMsu op1, op2, rnd

**Operation**  
 $(tmp) \leftarrow ((op1)) * ((op2))$   
 $(ACC) \leftarrow (ACC) + (tmp) + 00\ 0000\ 8000_h$   
 $(MAL) \leftarrow 0$   
 $((IDX_i(-\otimes))) \leftarrow ((IDX_i))$

**Syntax** CoMACMsu- op1, op2

**Operation**  
 $(tmp) \leftarrow ((op1)) * ((op2))$   
 $(ACC) \leftarrow (ACC) - (tmp)$   
 $((IDX_i(-\otimes))) \leftarrow ((IDX_i))$

**Syntax** CoMACMRsu op1, op2

**Operation**  
 $(tmp) \leftarrow ((op1)) * ((op2))$   
 $(ACC) \leftarrow (tmp) - (ACC)$   
 $((IDX_i(-\otimes))) \leftarrow ((IDX_i))$

**Syntax** CoMACMRsu op1, op2, rnd

**Operation**  
 $(tmp) \leftarrow ((op1)) * ((op2))$   
 $(ACC) \leftarrow (tmp) - (ACC) + 00\ 0000\ 8000_h$   
 $(MAL) \leftarrow 0$   
 $((IDX_i(-\otimes))) \leftarrow ((IDX_i))$

**Data Types** DOUBLE WORD

**Result** 40-bit signed value

**Description** Multiplies the two signed 16-bit source operands “op1” and “op2”. The obtained signed 32-bit product is first sign-extended, it is then optionally negated prior being added/subtracted to/from the 40-bit ACC register content, finally the obtained result is optionally rounded before being stored in the 40-bit ACC register. “-” option is used to negate the specified product, “R” option is used to negate the accumulator content, and finally “rnd” option is used to round the result using two’s complement rounding. The default sign option is “+” and the default round option is “no round”. When “rnd” option is used, MAL register is automatically cleared. Note that “rnd” and “-” are exclusive as well as “-” and “R”. This instruction might be repeated and performs two

parallel memory reads.

In parallel to the arithmetic operation and to the two parallel reads, the data pointed to by  $IDX_i$  overwrites another data located in memory (DPRAM). The address of the overwritten data depends on the operation executed on  $IDX_i$ , as illustrated by the following table

Addressing Mode	Overwritten Address
$[IDX_i]$	(no change)
$[IDX_i+]$	$(IDX_i) - 2$
$[IDX_i-]$	$(IDX_i) + 2$
$[IDX_i+QX_j]$	$(IDX_i) - (QX_j)$
$[IDX_i - QX_j]$	$(IDX_i) + (QX_j)$

## MAC Flags

N	Z	C	SV	E	SL
*	*	*	*	*	*

- N** Set if the m.s.b. of the result is set. Cleared otherwise.
- Z** Set if the result equals zero. Cleared otherwise.
- C** Set if a carry or borrow is generated. Cleared otherwise.
- SV** Set if an arithmetic overflow occurred. Not affected otherwise.
- E** Set if the MAE is used. Cleared otherwise.
- SL** Set if the contents of the ACC is automatically saturated. Not affected otherwise.

## Addressing Modes

Mnemonic		Rep	Format	Bytes
CoMACMsu	$[IDX_i \otimes], [Rw_m \otimes]$	Yes	93 Xm 58 rrrr:rqqq	4
CoMACMsu-	$[IDX_i \otimes], [Rw_m \otimes]$	Yes	93 Xm 68 rrrr:rqqq	4
CoMACMsu	$[IDX_i \otimes], [Rw_m \otimes], \text{rnd}$	Yes	93 Xm 59 rrrr:rqqq	4
CoMACMRsu	$[IDX_i \otimes], [Rw_m \otimes]$	Yes	93 Xm 78 rrrr:rqqq	4
CoMACMRsu	$[IDX_i \otimes], [Rw_m \otimes], \text{rnd}$	Yes	93 Xm 79 rrrr:rqqq	4

## Example

CoMACMsu	$[IDX1+QX0], [R10+QR1], \text{rnd}$	$(ACC) <-- (ACC) + ((IDX1)) * ((R10)) + \text{rnd}$ $; (R10) <-- (R10) + (QR1)$ $; ( ((IDX1) - (QX0)) ) <-- ((IDX1))$ $; (IDX1) <-- (IDX1) + (QX0)$
Repeat 3 times CoMACMsu	$[IDX0 - QX0], [R8+QR0], \text{rnd}$	$(ACC) <-- (ACC) + ((IDX0)) * ((R8))$ $; (R8) <-- (R8) + (QR0)$ $; ( ((IDX0) + (QX0)) ) <-- ((IDX0))$ $; (IDX0) <-- (IDX0) - (QX0)$
Repeat MRW times CoMACMRsu	$[IDX1+QX1], [R7 - QR0], \text{rnd}$	$(ACC) <-- ((IDX1)) * ((R7)) - (ACC) + \text{rnd}$ $; (R7) <-- (R7) - (QR0)$ $; ( ((IDX1)) - (QX1)) <-- ((IDX1))$ $; (IDX1) <-- (IDX1) + (QX1)$

CoMAX

Maximum

Group

Compare Instructions

Syntax

CoMAX            op1, op2

Operation

(tmp) <-- (op2)\(op1)  
(ACC) <-- max( (ACC), (tmp) )

Data Types

DOUBLE WORD

Result

40-bit signed value

Description

Compares a signed 40-bit operand against the ACC register content. The 40-bit operand results from the concatenation of the two source operands op1 (LSW) and op2 (MSW) which is then sign-extended. If the contents of the ACC register is smaller than the 40-bit operand, then the ACC register is loaded with it. Otherwise the ACC register remains unchanged. The MS bit of the MCW register does not affect the result. This instruction is repeatable with indirect addressing modes.

MAC Flags

N	Z	C	SV	E	SL
*	*	0	-	*	*

- N        Set if the most significant bit of the result is set. Cleared otherwise.
- Z        Set if the result equals zero. Cleared otherwise.
- C        Cleared always.
- SV       Not affected.
- E        Set if the MAE is used. Cleared otherwise.
- SL       Set if the contents of the ACC register is changed. Not affected otherwise.

Addressing Modes

Mnemonic		Rep	Format	Bytes
CoMAX	Rw <sub>n</sub> , Rw <sub>m</sub>	No	A3 nm 3A 00	4
CoMAX	[IDX <sub>i</sub> ⊗], [Rw <sub>m</sub> ⊗]	Yes	93 Xm 3A rrrr:rqqq	4
CoMAX	Rw <sub>n</sub> , [Rw <sub>m</sub> ⊗]	Yes	83 nm 3A rrrr:rqqq	4

Examples

```
CoMAX            [IDX1+QX0], [R11+QR1] ; (ACC)<-- Max((ACC),((R11))\((IDX1)))  
                                         ; (R11) <-- (R11) + (QR1)  
                                         ; (IDX1) <-- (IDX1) + (QX0)  
CoMAX            R1, R10               ; (ACC) <-- Max( (ACC), (R10)\(R1) )  
Repeat 23 times CoMAX R5, [R6 - QR0] ; (ACC) <-- Max( (ACC), ((R6))\((R5)) )  
                                         ; (R6) <-- (R6) - (QR0)
```



CoMIN

Minimum

Group

Compare Instructions

Syntax

CoMIN                    op1, op2

Operation

(tmp) <-- (op2)\(op1)  
(ACC) <-- min( (ACC), (tmp) )

Data Types

DOUBLE WORD

Result

40-bit signed value

Description

Compares a signed 40-bit operand against the ACC register content. The 40-bit operand results from the concatenation of the two source operands op1 (LSW) and op2 (MSW) which is then sign-extended. If the contents of the ACC register is greater than the 40-bit operand, then the ACC register is loaded with it. Otherwise the ACC register remains unchanged. The MS bit of the MCW register does not affect the result. This instruction is repeatable with indirect addressing modes.

MAC Flags

N	Z	C	SV	E	SL
*	*	0	-	*	*

- N        Set if the most significant bit of the result is set. Cleared otherwise.
- Z        Set if the result equals zero. Cleared otherwise.
- C        Cleared always.
- SV       Not affected.
- E        Set if the MAE is used. Cleared otherwise.
- SL       Set if the contents of the ACC register is changed. Not affected otherwise.

Addressing Modes

Mnemonic		Rep	Format	Bytes
CoMIN	Rw <sub>n</sub> , Rw <sub>m</sub>	No	A3 nm 7A 00	4
CoMIN	[IDX <sub>i</sub> ⊗], [Rw <sub>m</sub> ⊗]	Yes	93 Xm 7A rrrr:rqqq	4
CoMIN	Rw <sub>n</sub> , [Rw <sub>m</sub> ⊗]	Yes	83 nm 7A rrrr:rqqq	4

Examples

CoMIN                    [IDX1+QX0], [R11+QR1]    ; (ACC)<-- min( (ACC), ((R11))\((IDX1)) )  
   ; (R11) <-- (R11) + (QR1)  
   ; (IDX1) <-- (IDX1) + (QX0)

CoMIN                    R1, R10     ; (ACC) <-- min( (ACC), (R10)\(R1) )  
Repeat 23 times CoMIN R5, [R6 - QR0]     ; (ACC) <-- min( (ACC), ((R6))\((R5)) )  
   ; (R6) <-- (R6) - (QR0)

## CoMOV

## Memory to Memory Move

## Group

## Transfer Instructions

## Syntax

CoMOV          op1, op2

## Operation

```
(op1) <-- (op2)
```

## Data Types

WORD

### Description

Moves the contents of the memory location specified by the source operand, op2, to the memory location specified by the destination operand op1. This instruction is repeatable. Note that, unlike for the other instructions, `IDXi` can address the entire memory. This instruction does not affect the Mac Flags but modify the CPU Flags as any other `MOV` instruction.

## CPU Flags

E	Z	V	C	N
*	*	-	-	*

E Set if the value of op2 represents the lowest possible negative number. Cleared otherwise. Used to signal the end of a table.

**Z** Set if the value of the source operand op2 equals zero.  
Cleared otherwise.

V Not affected.

C Not affected.

N	Set if the most significant bit of the source operand op2 is set. Cleared otherwise.
---	--

## MAC Flags

N	Z	C	SV	E	SL
-	-	-	-	-	-

N Not affected.

Z Not affected.

C Not affected.

SV Not affected.

E Not affected.

SL      Not affected.

## Addressing Modes

Mnemonic	Rep	Format	Bytes
CoMOV $[IDX_{\otimes}], [Rw_m_{\otimes}]$	Yes	D3 Xm 00 rrrr:qqqq	4

## Examples

```
Repeat 24 times CoMOV [IDX1+QX0], [R11+QR1] ; ((IDX1)) <-- ((R11))
; (R11) <-- (R11) + (QR1)
; (IDX1) <-- (IDX1) + (QX0)
```



CoMUL(-)

Signed Multiply & Optional Round

Group

Multiply/Multiply-Accumulate Instructions

Syntax

CoMUL            op1, op2

Operation

IF (MP = 1) THEN  
    (ACC) <-- ((op1) \* (op2)) << 1  
ELSE  
    (ACC) <-- (op1) \* (op2)  
END IF

Syntax

CoMUL-           op1, op2

Operation

IF (MP = 1) THEN  
    (ACC) <-- - ( (op1) \* (op2)) << 1)  
ELSE  
    (ACC) <-- - ( (op1) \* (op2) )  
END IF

Syntax

CoMUL            op1, op2, rnd

Operation

IF (MP = 1) THEN  
    (ACC) <-- ((op1) \* (op2)) << 1 + 00 0000 8000<sub>h</sub>  
ELSE  
    (ACC) <-- (op1) \* (op2) + 00 0000 8000<sub>h</sub>  
END IF  
(MAL) <-- 0

Data Types

DOUBLE WORD

Result

32-bit signed value

Description

Multiplies the two signed 16-bit source operands “op1” and “op2”. The obtained signed 32-bit product is first sign-extended, then and on condition MP is set, it is one-bit left shifted, and finally, it is optionally either negated or rounded before being stored in the 40-bit ACC register. The “-” option is used to negate the specified product while the “rnd” option is used to round the product using two’s complement rounding. The default sign option is “+” and the default round option is “no round”. When “rnd” option is used, MAL register is automatically cleared. “rnd” and “-” are exclusive. This non-repeatable instruction allows up to two parallel memory reads

MAC Flags

N	Z	C	SV	E	SL
*	*	0	-	*	*

- N        Set if the most significant bit of the result is set. Cleared otherwise.
- Z        Set if the result equals zero. Cleared otherwise.

C	Always cleared.
SV	Not affected.
E	Always cleared when MP is cleared, otherwise, only set in case of 8000 <sub>h</sub> by 8000 <sub>h</sub> multiplication.
SL	Not affected when MP or MS are cleared, otherwise, only set in case of 8000 <sub>h</sub> by 8000 <sub>h</sub> multiplication.

## Addressing Modes

Mnemonic	Rep	Format	Bytes
CoMUL $Rw_n, Rw_m$	No	A3 nm C0 00	4
CoMUL- $Rw_n, Rw_m$	No	A3 nm C8 00	4
CoMUL $Rw_n, Rw_m, rnd$	No	A3 nm C1 00	4
CoMUL $[IDX_i \otimes], [Rw_m \otimes]$	No	93 Xm C0 0:0qqq	4
CoMUL- $[IDX_i \otimes], [Rw_m \otimes]$	No	93 Xm C8 0:0qqq	4
CoMUL $[IDX_i \otimes], [Rw_m \otimes], rnd$	No	93 Xm C1 0:0qqq	4
CoMUL $Rw_n, [Rw_m \otimes]$	No	83 nm C0 0:0qqq	4
CoMUL- $Rw_n, [Rw_m \otimes]$	No	83 nm C8 0:0qqq	4
CoMUL $Rw_n, [Rw_m \otimes], rnd$	No	83 nm C1 0:0qqq	4

## Examples

```

CoMUL  R0, R1, rnd      ; (ACC) <-- (R0)*(R1) + rnd
CoMUL- R2, [R6+]        ; (ACC)<-- -(R2)*((R6))
                        ; (R6) <-- (R6) + 2
CoMUL  [IDX0+QX1], [R11+] ; (ACC) <-- ((IDX0))*((R11))
                        ; (R11)<-- (R11) + 2
                        ; (IDX0) <-- (IDX0) + (QX1)
CoMUL- [IDX1-], [R15+QR0] ; (ACC) <-- -((IDX1))*((R15))
                        ; (R15) <-- (R15) + (QR0)
                        ; (IDX1) <-- (IDX1) - 2
CoMUL  [IDX1+QX0], [R9 - QR1], rnd ; (ACC) <-- ((IDX1))*((R9)) + rnd
                        ; (R9) <-- (R9) - (QR1)
                        ; (IDX1) <-- (IDX1) + (QX0).

```

Multiplication Examples

Cases	op 1	op 2	rnd	MAE	MAH	MAL	N	Z	C	SV	E	SL
MP=0, MS=x	8000 <sub>h</sub>	8000 <sub>h</sub>	0	00 <sub>h</sub>	4000 <sub>h</sub>	0000 <sub>h</sub>	0	0	0	-	0	-
MP=1, MS=0			0	00 <sub>h</sub>	8000 <sub>h</sub>	0000 <sub>h</sub>	0	0	0	-	1	-
MP=1, MS=1			0	00 <sub>h</sub>	7FFF <sub>h</sub>	FFFF <sub>h</sub>	0	0	0	-	0	1
MP=0, MS=x	7FFF <sub>h</sub>	7FFF <sub>h</sub>	0	00 <sub>h</sub>	3FFF <sub>h</sub>	0001 <sub>h</sub>	0	0	0	-	0	-
MP=1, MS=x			0	00 <sub>h</sub>	7FFE <sub>h</sub>	0002 <sub>h</sub>	0	0	0	-	0	-
MP=1, MS=x			1	00 <sub>h</sub>	7FFE <sub>h</sub>	0000 <sub>h</sub>	0	0	0	-	0	-
MP=0, MS=x	4001 <sub>h</sub>	F456 <sub>h</sub>	0	FF <sub>h</sub>	FD15 <sub>h</sub>	7456 <sub>h</sub>	1	0	0	-	0	-
MP=1, MS=x			0	FF <sub>h</sub>	FA2A <sub>h</sub>	E8AC <sub>h</sub>	1	0	0	-	0	-
MP=0, MS=x			1	FF <sub>h</sub>	FD15 <sub>h</sub>	0000 <sub>h</sub>	1	0	0	-	0	-
MP=1, MS=x			1	FF <sub>h</sub>	FA2B <sub>h</sub>	0000 <sub>h</sub>	1	0	0	-	0	-

CoMULu(-)

Unsigned Multiply & Optional Round

Group

Multiply/Multiply-Accumulate Instructions

Syntax

CoMULu          op1, op2

Operation

(ACC) <-- (op1) \* (op2)

Syntax

CoMULu-        op1, op2

Operation

(ACC) <-- - ((op1) \* (op2))

Syntax

CoMULu          op1, op2, rnd

Operation

(ACC) <-- (op1) \* (op2) + 00 0000 8000<sub>h</sub>  
(MAL) <-- 0

Data Types

DOUBLE WORD

Result

32-bit signed value

Description

Multiply the two unsigned 16-bit source operands “op1” and “op2”. The unsigned 32-bit product is first zero-extended, and then, it is optionally either negated or rounded before being stored in the 40-bit ACC register. The result is never affected by the MP mode flag of the MCW register. The “-” option is used to negate the specified product while the “rnd” option is used to round the product using two’s complement rounding. The default sign option is “+” and the default round option is “no round”. When “rnd” option is used, MAL register is automatically cleared. “rnd” and “-” are exclusive. This non-repeatable instruction allows up to two parallel memory reads.

MAC Flags

N	Z	C	SV	E	SL
*	*	0	-	0	-

- N      Set if the most significant bit of the result is set. Cleared otherwise.
- Z      Set if the result equals zero. Cleared otherwise.
- C      Always cleared.
- SV     Not affected.
- E      Always cleared.
- SL     Not affected.



## Addressing Modes

Mnemonic	Rep	Format	Bytes
CoMULu $Rw_n, Rw_m$	No	A3 nm 00 00	4
CoMULu- $Rw_n, Rw_m$	No	A3 nm 08 00	4
CoMULu $Rw_n, Rw_m, rnd$	No	A3 nm 01 00	4
CoMULu $[IDX_i \otimes], [Rw_m \otimes]$	No	93 Xm 00 0:0qqq	4
CoMULu- $[IDX_i \otimes], [Rw_m \otimes]$	No	93 Xm 08 0:0qqq	4
CoMULu $[IDX_i \otimes], [Rw_m \otimes], rnd$	No	93 Xm 01 0:0qqq	4
CoMULu $Rw_n, [Rw_m \otimes]$	No	83 nm 00 0:0qqq	4
CoMULu- $Rw_n, [Rw_m \otimes]$	No	83 nm 08 0:0qqq	4
CoMULu $Rw_n, [Rw_m \otimes], rnd$	No	83 nm 01 0:0qqq	4

## Notes

The result of CoMULu is never saturated, whatever the value of MS bit is. (see multiplication examples below)

## Examples

```

CoMULu    R0, R1, rnd      ; (ACC) <-- (R0)*(R1) + rnd
CoMULu-   R2, [R6+]        ; (ACC) <-- -(R2)*((R6))
                                   ; (R6) <-- (R6) + 2
CoMULu    [IDX0], [R11+]   ; (ACC) <-- ((IDX0))*((R11))
                                   ; (R11) <-- (R11) + 2
CoMULu-   [IDX1-], [R15+QR0] ; (ACC) <-- -((IDX1))*((R15))
                                   ; (R15) <-- (R15) + (QR0)
                                   ; (IDX1) <-- (IDX1) - 2
CoMULu    [IDX0+QX0], [R9-], rnd ; (ACC) <-- ((IDX0))*((R9)) + rnd
                                   ; (R9) <-- (R9) - 2
                                   ; (IDX0) <-- (IDX0) + (QX0).

```

## Multiplication Examples

Cases	op 1	op 2	rnd	MAE	MAH	MAL	N	Z	C	SV	E	SL
MP=x, MS=x	8000 <sub>h</sub>	8000 <sub>h</sub>	x	00 <sub>h</sub>	4000 <sub>h</sub>	0000 <sub>h</sub>	0	0	0	-	0	-
MP=x, MS=x	7FFF <sub>h</sub>	7FFF <sub>h</sub>	0	00 <sub>h</sub>	3FFF <sub>h</sub>	0001 <sub>h</sub>	0	0	0	-	0	-
			1	00 <sub>h</sub>	3FFF <sub>h</sub>	0000 <sub>h</sub>	0	0	0	-	0	-
MP=x, MS=x	8001 <sub>h</sub>	F456 <sub>h</sub>	0	00 <sub>h</sub>	7A2B <sub>h</sub>	F456 <sub>h</sub>	0	0	0	-	0	-
			1	00 <sub>h</sub>	7A2C <sub>h</sub>	0000 <sub>h</sub>	0	0	0	-	0	-
MP=x, MS=x	FFFF <sub>h</sub>	FFFF <sub>h</sub>	0	00 <sub>h</sub>	FFFE <sub>h</sub>	0001 <sub>h</sub>	0	0	0	-	0	-
			1	00 <sub>h</sub>	FFFE <sub>h</sub>	0000 <sub>h</sub>	0	0	0	-	0	-

CoMULus(-)

Mixed Multiply & Optional Round

Group

Multiply/Multiply-Accumulate Instructions

Syntax

CoMULus      op1, op2

Operation

(ACC) <-- (op1) \* (op2)

Syntax

CoMULus-      op1, op2

Operation

(ACC) <-- - ((op1) \* (op2))

Syntax

CoMULus      op1, op2, rnd

Operation

(ACC) <-- (op1) \* (op2) + 00 0000 8000<sub>h</sub>  
(MAL) <-- 0

Data Types

DOUBLE WORD

Result

32-bit signed value

Description

Multiply the two 16-bit unsigned and signed source operands “op1” and “op2”, respectively. The obtained signed 32-bit product is first sign-extended, then it is optionally either negated or rounded before being stored in the 40-bit ACC register. The result is never affected by the MP mode flag contained in the MCW register. The “-” option is used to negate the specified product while the “rnd” option is used to round the product using two’s complement rounding. The default sign option is “+” and the default round option is “no round”. When “rnd” option is used, MAL register is automatically cleared. “rnd” and “-” are exclusive. This non-repeatable instruction allows up to two parallel memory reads.

MAC Flags

N	Z	C	SV	E	SL
*	*	0	-	0	-

- N      Set if the most significant bit of the result is set. Cleared otherwise.
- Z      Set if the result equals zero. Cleared otherwise.
- C      Always cleared.
- SV     Not affected.
- E      Always cleared.
- SL     Not affected.

Addressing Modes

Mnemonic	Rep	Format	Bytes
CoMULus $Rw_n, Rw_m$	No	A3 nm 80 00	4
CoMULus- $Rw_n, Rw_m$	No	A3 nm 88 00	4
CoMULus $Rw_n, Rw_m, rnd$	No	A3 nm 81 00	4
CoMULus $[IDX_i \otimes], [Rw_m \otimes]$	No	93 Xm 80 0:0qqq	4
CoMULus- $[IDX_i \otimes], [Rw_m \otimes]$	No	93 Xm 88 0:0qqq	4
CoMULus $[IDX_i \otimes], [Rw_m \otimes], rnd$	No	93 Xm 81 0:0qqq	4
CoMULus $Rw_n, [Rw_m \otimes]$	No	83 nm 80 0:0qqq	4
CoMULus- $Rw_n, [Rw_m \otimes]$	No	83 nm 88 0:0qqq	4
CoMULus $Rw_n, [Rw_m \otimes], rnd$	No	83 nm 81 0:0qqq	4

Examples

```
CoMULus  R0, R1, rnd      ; (ACC) <-- (R0)*(R1) + rnd
CoMULus- R2, [R6+]        ; (ACC) <-- -(R2)*((R6))
                        ; (R6) <-- (R6) + 2
CoMULus  [IDX1+QX0], [R11+QR0] ; (ACC) <-- ((IDX1))*((R11))
                        ; (R11) <-- (R11) + (QR0)
                        ; (IDX1) <-- (IDX1) + (QX0)
CoMULus- [IDX0], [R15]     ; (ACC) <-- -((IDX0))*((R15))
CoMULus  [IDX0+QX0], [R9-QR1], rnd ; (ACC) <-- ((IDX0))*((R9)) + rnd
                        ; (R9) <-- (R9) - (QR1)
                        ; (IDX0) <-- (IDX0) + (QX0).
```

Multiplication Examples

Cases	op 1	op 2	rnd	MAE	MAH	MAL	N	Z	C	SV	E	SL
MP=x, MS=x	8000 <sub>h</sub>	8000 <sub>h</sub>	x	FF <sub>h</sub>	C000 <sub>h</sub>	0000 <sub>h</sub>	1	0	0	-	0	-
MP=x, MS=x	7FFF <sub>h</sub>	7FFF <sub>h</sub>	0	00 <sub>h</sub>	3FFF <sub>h</sub>	0001 <sub>h</sub>	0	0	0	-	0	-
			1	00 <sub>h</sub>	3FFF <sub>h</sub>	0000 <sub>h</sub>	0	0	0	-	0	-
MP=x, MS=x	8001 <sub>h</sub>	F456 <sub>h</sub>	0	FF <sub>h</sub>	FA2A <sub>h</sub>	F456 <sub>h</sub>	1	0	0	-	0	-
			1	FF <sub>h</sub>	FA2B <sub>h</sub>	0000 <sub>h</sub>	1	0	0	-	0	-

CoMULsu(-)

Mixed Multiply & Optional Round

Group

Multiply/Multiply-Accumulate Instructions

Syntax

CoMULsu      op1, op2

Operation

(ACC) <-- (op1) \* (op2)

Syntax

CoMULsu-      op1, op2

Operation

(ACC) <-- - ((op1) \* (op2))

Syntax

CoMULsu      op1, op2, rnd

Operation

(ACC) <-- (op1) \* (op2) + 00 0000 8000<sub>h</sub>  
(MAL) <-- 0

Data Types

DOUBLE WORD

Result

32-bit signed value

Description

Multiply the two 16-bit signed and unsigned source operands “op1” and “op2”, respectively. The obtained signed 32-bit product is first sign-extended, then, it is optionally either negated or rounded before being stored in the 40-bit ACC register. The result is never affected by the MP mode flag contained in the MCW register. The “-” option is used to negate the specified product while the “rnd” option is used to round the product using two’s complement rounding. The default sign option is “+” and the default round option is “no round”. When “rnd” option is used, MAL register is automatically cleared. “rnd” and “-” are exclusive. This non-repeatable instruction allows up to two parallel memory reads.

MAC Flags

N	Z	C	SV	E	SL
*	*	0	-	0	-

- N      Set if the most significant bit of the result is set. Cleared otherwise.
- Z      Set if the result equals zero. Cleared otherwise.
- C      Always cleared.
- SV     Not affected.
- E      Always cleared.
- SL     Not affected.





## Addressing Modes

Mnemonic	Rep	Format	Bytes
CoMULsu $Rw_n, Rw_m$	No	A3 nm 40 00	4
CoMULsu- $Rw_n, Rw_m$	No	A3 nm 48 00	4
CoMULsu $Rw_n, Rw_m, rnd$	No	A3 nm 41 00	4
CoMULsu $[IDX_i \otimes], [Rw_m \otimes]$	No	93 Xm 40 0:0qqq	4
CoMULsu- $[IDX_i \otimes], [Rw_m \otimes]$	No	93 Xm 48 0:0qqq	4
CoMULsu $[IDX_i \otimes], [Rw_m \otimes], rnd$	No	93 Xm 41 0:0qqq	4
CoMULsu $Rw_n, [Rw_m \otimes]$	No	83 nm 40 0:0qqq	4
CoMULsu- $Rw_n, [Rw_m \otimes]$	No	83 nm 48 0:0qqq	4
CoMULsu $Rw_n, [Rw_m \otimes], rnd$	No	83 nm 41 0:0qqq	4

## Examples

```

CoMULsu  R0, R1, rnd          ; (ACC) <-- (R0)*(R1) + rnd
CoMULsu- R2, [R6+]           ; (ACC) <-- -(R2)*((R6))
                                ; (R6) <-- (R6) + 2
CoMULsu  [IDX0], [R11+]       ; (ACC) <-- ((IDX0))*((R11))
                                ; (R11) <-- (R11) + 2
CoMULsu- [IDX1-], [R15]       ; (ACC) <-- -((IDX1))*((R15))
                                ; (IDX1) <-- (IDX1) - 2
CoMULsu  [IDX0+QX0], [R9 - QR1], rnd ; (ACC) <-- ((IDX0))*((R9)) + rnd
                                ; (R9) <-- (R9) - (QR1)
                                ; (IDX0) <-- (IDX0) + (QX0).

```

## Multiplication Examples

Cases	op 1	op 2	rnd	MAE	MAH	MAL	N	Z	C	SV	E	SL
MP=x, MS=x	8000 <sub>h</sub>	8000 <sub>h</sub>	x	FF <sub>h</sub>	C000 <sub>h</sub>	0000 <sub>h</sub>	1	0	0	-	0	-
MP=x, MS=x	7FFF <sub>h</sub>	7FFF <sub>h</sub>	0	00 <sub>h</sub>	3FFF <sub>h</sub>	0001 <sub>h</sub>	0	0	0	-	0	-
			1	00 <sub>h</sub>	3FFF <sub>h</sub>	0000 <sub>h</sub>	0	0	0	-	0	-
MP=x, MS=x	8001 <sub>h</sub>	F456 <sub>h</sub>	0	FF <sub>h</sub>	85D5 <sub>h</sub>	F456 <sub>h</sub>	1	0	0	-	0	-
			1	FF <sub>h</sub>	85D6 <sub>h</sub>	0000 <sub>h</sub>	1	0	0	-	0	-

CoNEG

Negate Accumulator with Optional Rounding

Group32-bit Arithmetic Instructions

SyntaxCoNEG  
CoNEG                   rnd

OperationIF (rnd) THEN  
                  (ACC) <-- 0 - (ACC) + 00 0000 8000<sub>h</sub>  
                  (MAL) <-- 0  
ELSE  
                  (ACC) <-- 0 - (ACC)  
END IF

Data TypesACCUMULATOR

Result40-bit signed value

DescriptionThe Accumulator content is subtracted from zero and the result is optionally rounded before being stored in the accumulator register. With “rnd” option MAL is cleared. When the MS bit of the MCW register is set and when a 32-bit overflow or underflow occurs, the obtained result becomes 00 7FFF FFFF<sub>h</sub> or FF 8000 0000<sub>h</sub>, respectively. This instruction is not repeatable

MAC Flags

N	Z	C	SV	E	SL
*	*	*	*	*	*

- NSet if the m.s.b. of the result is set. Cleared otherwise.
- ZSet if the result equals zero. Cleared otherwise.
- CSet if a borrow is generated. Cleared otherwise.
- SVSet if an arithmetic overflow occurred. Not affected otherwise.
- ESet if the MAE is used. Cleared otherwise.
- SLSet if the contents of the ACC is automatically saturated. Not affected otherwise.

Addressing Modes

Mnemonic	Rep	Format	Bytes
CoNEG	No	A3 00 32 00	4
CoNEG     rnd	No	A3 00 72 00	4

Examples

CoNEG                   ; (ACC) <-- 0 - (ACC)  
CoNEG     rnd         ; (ACC) <-- 0 - (ACC) + rnd

Instr	MS	rnd	ACC (before)	ACC (after)	N	Z	C	SV	E	SL
CoNEG	x	No	00 1234 5678 <sub>h</sub>	FF EDCB A988 <sub>h</sub>	1	0	0	-	0	-
CoNEG	x	Yes	00 1234 5678 <sub>h</sub>	FF EDCC 0000 <sub>h</sub>	1	0	0	-	0	-

CoNOP

No-Operation

Group

40-bit Arithmetic Instructions

Syntax

CoNOP

Operation

No Operation

Description

Modifies the address pointers without changing the internal MAC-Unit registers.

MAC Flags

N	Z	C	SV	E	SL
-	-	-	-	-	-

- N Not affected.
- Z Not affected.
- C Not affected.
- SV Not affected.
- E Not affected.
- SL Not affected.

Addressing Modes

Mnemonic	Rep	Format	Bytes
CoNOP [Rw <sub>m</sub> ⊗]	Yes	93 1m 5A rrrr:rqqq	4
CoNOP [IDX <sub>i</sub> ⊗], [Rw <sub>m</sub> ⊗]	Yes	93 Xm 5A rrrr:rqqq	4

Example

CoNOP [IDX0+QX1], [R11+QR1] ; (R11) <-- (R11) + (QR1)  
; (IDX0) <-- (IDX0) + (QX1)

CoRND

Round Accumulator

Group

Shift Instructions

Syntax

CoRND

Operation

(ACC) <-- (ACC) + 00 0000 8000<sub>h</sub>  
(MAL) <-- 0

Data Types

ACCUMULATOR

Result

40-bit signed value

Description

Rounds the ACC register contents by adding 0000 8000<sub>h</sub> to it and store the result in the ACC register and the lower part of the ACC register, MAL, is cleared. When the MS bit of the MCW register is set and when a 32-bit overflow or underflow occurs, the obtained result becomes 00 7FFF FFFF<sub>h</sub> or FF 8000 0000<sub>h</sub>, respectively. This instruction is not repeatable.

MAC Flags

N	Z	C	SV	E	SL
*	*	*	*	*	*

- N Set if the most significant bit of the result is set. Cleared otherwise.
- Z Set if the result equals zero. Cleared otherwise.
- C Set if a carry is generated. Cleared otherwise.
- SV Set if an arithmetic overflow occurred. Not affected otherwise.
- E Set if the MAE is used. Cleared otherwise.
- SL Set if the contents of the ACC is automatically saturated. Not affected otherwise.

Addressing Modes

Mnemonic	Rep	Format	Bytes
CoRND	No	A3 00 B2 00	4

Notes

CoRND is equivalent to CoASHR #0, rnd.

Example

CoRND ; (ACC) <-- (ACC) + rnd

CoSHL

Accumulator Logical Shift Left

Group

Shift Instructions

Syntax

CoSHL            op1

Operation

(count) <-- (op1)  
(C) <-- 0  
DO WHILE (count) ≠ 0  
    (C) <-- (ACC<sub>39</sub>)  
    (ACC<sub>n</sub>) <-- (ACC<sub>n-1</sub>)            [n=1...39]  
    (ACC<sub>0</sub>) <-- 0  
    (count) <-- (count) -1  
END WHILE

Data types

ACCUMULATOR

Result

40-bit signed value

Description

Shifts the ACC register left by the number of times specified by the operand op1. The least significant bits of the result are filled with zeros. Only shift values from 0 to 8 (inclusive) are allowed. “op1” can be either a 5-bit unsigned immediate data, or the least significant 5 bits (considered as unsigned data) of any register directly or indirectly addressed operand. When the MS bit of the MCW register is set and when a 32-bit overflow or underflow occurs, the obtained result becomes 00 7FFF FFFF<sub>h</sub> or FF 8000 0000<sub>h</sub>, respectively. This instruction is repeatable when “op1” is not an immediate operand.

MAC Flags

	N	Z	C	SV	E	SL
	*	*	*	*	*	*
N	Set if the most significant bit of the result is set. Cleared otherwise.					
Z	Set if the result equals zero. Cleared otherwise.					
C	Carry flag is set according to the last most significant bit shifted out of ACC.					
SV	Set if the last shifted out bit is different from N.					
E	Set if the MAE is used. Cleared otherwise.					
SL	Set if the content of the ACC is automatically saturated. Not affected otherwise.					

Addressing Modes

Mnemonic		Rep	Format	Bytes
CoSHL	Rw <sub>n</sub>	Yes	A3 nn 8A rrrr:r000	4
CoSHL	#data <sub>5</sub>	No	A3 00 82 ssss:s000	4
CoSHL	[Rw <sub>m</sub> ⊗]	Yes	83 mm 8A rrrr:rqqq	4

Examples

CoSHL	#3	; (ACC) <-- (ACC) << 3		
CoSHL	R3	; (ACC) <-- (ACC) << (R3) <sub>4-0</sub>		
CoSHL	[R10 - QR0]	; (ACC) <-- (ACC) << ((R10)) <sub>4-0</sub> ; (R10) <-- (R10) - (QR0)		

CoSHR

Accumulator Logical Shift Right

Group

Shift Instructions

Syntax

CoSHR            op1

Operation

(count) <-- (op1)  
(C) <-- 0  
DO WHILE (count) ≠ 0  
    ((ACC<sub>n</sub>) <-- (ACC<sub>n+1</sub>)            [n=0-38]  
    (ACC<sub>39</sub>) <-- 0  
    (count) <-- (count) -1  
END WHILE

Data Types

ACCUMULATOR

Result

40-bit signed value

Description

Shifts the ACC register right by as many times as specified by the operand op1. The most significant bits of the result are filled with zeros accordingly. Only shift values contained between 0 and 8 are allowed. “op1” can be either a 5-bit unsigned immediate data, or the least significant 5 bits (considered as unsigned data) of any register directly or indirectly addressed operand. The MS bit of the MCW register does not affect the result. This instruction is repeatable when “op 1” is not an immediate operand.

MAC Flags

N	Z	C	SV	E	SL
*	*	0	-	*	-

- N        Set if the most significant bit of the result is set. Cleared otherwise.
- Z        Set if the result equals zero. Cleared otherwise.
- C        Cleared always.
- SV       Not affected.
- E        Set if the MAE is used. Cleared otherwise.
- SL       Not affected.

Addressing Modes

Mnemonic		Rep	Format	Bytes
CoSHR	Rw <sub>n</sub>	Yes	A3 nn 9A rrrr:r000	4
CoSHR	#data <sub>5</sub>	No	A3 00 92 ssss:s000	4
CoSHR	[Rw <sub>m</sub> ⊗]	Yes	83 mm 9A rrrr:rqqq	4

Examples

CoSHR    #3                    ; (ACC) <-- (ACC) >> 3  
CoSHR    R3                    ; (ACC) <-- (ACC) >> (R3)<sub>4-0</sub>  
CoSHR    [R10 - QR0]        ; (ACC) <-- (ACC) >> ((R10))<sub>4-0</sub>  
                                 ; (R10) <-- (R10) - (QR0)



CoSTORE

Store a MAC-Unit Register

Group	Transfer Instructions
Syntax	CoSTORE      op1, op2
Operation	(op1) <-- (op2)
Data Types	WORD
Description	Moves the contents of a MAC-Unit register specified by the source operand op2 to the location specified by the destination operand op1. This instruction is repeatable with destination indirect addressing mode (for example to clear a table in memory)

MAC Flags

N	Z	C	SV	E	SL
-	-	-	-	-	-
N	Not affected				
Z	Not affected				
C	Not affected				
SV	Not affected				
E	Not affected				
SL	Not affected				

Addressing Modes

Mnemonic	Rep	Format	Bytes
CoSTORE $Rw_n$ , CoReg	No	C3 nn $www:w000\ 00$	4
CoSTORE $[Rw_n\otimes]$ , CoReg	Yes	B3 nn $www:w000\ rrrr:rqqq\ 4$	

**Note** Due to pipeline side effects, CoSTORE cannot be directly followed by a MOV instruction, the source operand of which is also a MAC-Unit register such as MSW, MAH, MAL, MAS, MRW or MCW. In this case, a NOP must be inserted between the CoSTORE and MOV instruction.

Examples

CoSTORE $[R11+QR1]$ , MAS	; ((R11)) <-- limited((ACC))
	; (R11) <-- (R11) + (QR1)
Repeat 3 times CoSTORE $[R2-]$ , MAL	; ((R2)) <-- (MAL)
	; (R2) <-- (R2) - 2



CoSUB(2)(R)

Subtract

Group	Arithmetic Instructions
Syntax	CoSUB            op1, op2
Operation	(tmp) <-- (op2)\(op1) (ACC) <-- (ACC) - (tmp)
Syntax	CoSUB2           op1, op2
Operation	(tmp) <-- 2 * (op2)\(op1) (ACC) <-- (ACC) - (tmp)
Syntax	CoSUBR           op1, op2
Operation	(tmp) <-- (op2)\(op1) (ACC) <-- (tmp) - (ACC)
Syntax	CoSUB2R          op1, op2
Operation	(tmp) <-- 2 * (op2)\(op1) (ACC) <-- (tmp) - (ACC)
Data Types	DOUBLE WORD
Result	40-bit signed value

Description

Subtracts a 40-bit operand from the 40-bit Accumulator contents or vice-versa when the “R” option is used, and stores the result in the accumulator. The 40-bit operand results from the concatenation of the two source operands op1 (LSW) and op2 (MSW), which is then sign-extended. The “2” option indicates that the 40-bit operand is also multiplied by 2, prior to being subtracted/added from/to the ACC/negated ACC. When the most significant bit of the MCW register is set and when a 32-bit overflow or underflow occurs, the obtained result becomes 00 7FFF FFFF<sub>h</sub> or FF 8000 0000<sub>h</sub>, respectively. This instruction is repeatable with indirect addressing modes, and allows up to two parallel memory reads

MAC Flags

N	Z	C	SV	E	SL
*	*	*	*	*	*

- N     Set if the most significant bit of the result is set. Cleared otherwise.
- Z     Set if the result equals zero. Cleared otherwise.
- C     Set if a borrow is generated. Cleared otherwise.
- SV    Set if an arithmetic overflow occurred. Not affected otherwise.
- E     Set if the MAE is used. Cleared otherwise.

SL Set if the contents of the ACC is automatically saturated. Not affected otherwise.

## Note

The E-flag is set when the nine highest bits of the accumulator are not equal. The SV-flag is set, when a 40-bit arithmetic overflow/ underflow occurs.

## Addressing Modes

Mnemonic	Rep	Format	Bytes
CoSUB $Rw_n, Rw_m$	No	A3 nm 0A 00	4
CoSUBR $Rw_n, Rw_m$	No	A3 nm 12 00	4
CoSUB2 $Rw_n, Rw_m$	No	A3 nm 4A 00	4
CoSUB2R $Rw_n, Rw_m$	No	A3 nm 52 00	4
CoSUB $[IDX_i \otimes], [Rw_m \otimes]$	Yes	93 Xm 0A rrrr:rqqq	4
CoSUBR $[IDX_i \otimes], [Rw_m \otimes]$	Yes	93 Xm 12 rrrr:rqqq	4
CoSUB2 $[IDX_i \otimes], [Rw_m \otimes]$	Yes	93 Xm 4A rrrr:rqqq	4
CoSUB2R $[IDX_i \otimes], [Rw_m \otimes]$	Yes	93 Xm 52 rrrr:rqqq	4
CoSUB $Rw_n, [Rw_m \otimes]$	Yes	83 nm 0A rrrr:rqqq	4
CoSUBR $Rw_n, [Rw_m \otimes]$	Yes	83 nm 12 rrrr:rqqq	4
CoSUB2 $Rw_n, [Rw_m \otimes]$	Yes	83 nm 4A rrrr:rqqq	4
CoSUB2R $Rw_n, [Rw_m \otimes]$	Yes	83 nm 52 rrrr:rqqq	4

## Examples

```

CoSUB      R0, R1                ; (ACC) <-- (ACC) - (R1)\(R0)
CoSUB2     R2, [R6+]             ; (ACC) <-- (ACC) - 2* ((R6)) \ (R2) )
                                   ; (R6) <-- (R6) + 2
Repeat 3 times  CoSUB [IDX1+QX1], [R10+QR0] ; (ACC) <-- (ACC) - ( ((R10))\((IDX1)) )
                                   ; (R10) <-- (R10) + (QR0)
                                   ; (IDX1) <-- (IDX1) + (QX1)
Repeat MRW times CoSUB2R R4, [R8 - QR1] ; (ACC) <-- 2* ((R8))\ (R4) ) - (ACC)
                                   ; (R8) <-- (R8) - (QR1)

```

## Subtraction Examples

Instr.	MS	op 1	op 2	ACC (before)	ACC (after)	N	Z	C	SV	E	SL
CoSUB	x	183A <sub>h</sub>	72AC <sub>h</sub>	00 7FFF FFFF <sub>h</sub>	00 0D53 E7C5 <sub>h</sub>	0	0	0	-	0	-
CoSUBR	x	183A <sub>h</sub>	72AC <sub>h</sub>	00 7FFF FFFF <sub>h</sub>	FF F2AC 183B <sub>h</sub>	1	0	1	-	0	-
CoSUB2	x	0C1D <sub>h</sub>	3956 <sub>h</sub>	00 E604 5564 <sub>h</sub>	00 7358 3D2A <sub>h</sub>	0	0	0	-	0	-
CoSUB2R	x	0C1D <sub>h</sub>	3956 <sub>h</sub>	00 E604 5564 <sub>h</sub>	FF 8CA7 C2D6 <sub>h</sub>	1	0	1	-	0	-
CoSUB	0	FFFF <sub>h</sub>	FFFF <sub>h</sub>	7F FFFF FFFF <sub>h</sub>	80 0000 0000 <sub>h</sub>	1	0	1	1	1	-
	1				00 7FFF FFFF <sub>h</sub>	0	0	1	1	0	1
CoSUB2	0	0000 <sub>h</sub>	3000 <sub>h</sub>	7F FFFF FFFF <sub>h</sub>	7F 9FFF FFFF <sub>h</sub>	0	0	0	-	1	-
CoSUB2	0	0001 <sub>h</sub>	0000 <sub>h</sub>	80 0000 0000 <sub>h</sub>	7F FFFF FFFE <sub>h</sub>	0	0	0	1	1	-
	1				FF 8000 0000 <sub>h</sub>	1	0	0	1	0	1

# 3 Revision History

## Document revision history

Revision 1	
Revision 2—Revision 1	<p>‘Definition of measurement units’ on page 12, ALE Cycle Time corrected.</p> <p>‘Integer Addition with Carry’ on page 58: Instruction name changed from ADDBC to ADDCB.</p>
Revision 3—Revision 2	<p>CoSUB2r replaced CoSUBr2.</p> <p>In MAC instructions, lower case <i>r</i> replaced upper case <i>R</i> for optional repeat.</p>
Revision 4—Revision 3	<p>Function codes (Table 30) and addressing modes of the following instructions corrected: CoMULsu(-), CoMULus(-), CoMAC(r)su(-), CoMAC(r)us(-), CoMACM(r)su(-), CoMAC(r)us(-), CoNOP, CoSHL, CoSHR, CoASHR, and CoSTORE.</p> <p>Condition flags corrected for JBC and JNBS instructions.</p> <p>Updated Table 21: <i>Instruction set ordered by Hex code</i> to include section C0-FF, MAC instructions and working register indexes.</p> <p>Instruction CoMULus(-) corrected.</p> <p>Seg address range corrected in Table 5: <i>Branch target address summary</i></p> <p>Condition Code Mnemonic cc_N corrected in Table 24: <i>Condition codes</i></p> <p>Sentence added to Section 2.4.7: <i>Repeated instruction syntax</i>.</p> <p>Clarified description of Instruction CoSHL: Only shift values from 0 to 8 (inclusive).</p> <p>[IDX<sub>i</sub>⊗] addressing mode and example removed from instruction CoNOP. Reference to this addressing mode removed from Table 29 Table 29.</p> <p>Condition flag Z corrected for instruction BCLR.</p> <p>MAC instruction descriptions ordered alphabetically.</p> <p>Paragraph added to Section 2.1: <i>Addressing modes</i>.</p> <p>[Fcpu] chaged to 0-50MHz in Section 1.2.1: <i>Definition of mea- surement units</i>.</p>

Revision 5—Revision 4		<p>Current document (7096626A) is a reformatted version of document 42-1735-05.</p> <p>r -&gt; R: In MAC instructions, upper case R has replaced lower case r for Reverse operation.</p> <p>#data<sub>4</sub> -&gt; #data<sub>5</sub>: In MAC instructions, immediate shift value uses 5 bits to be coded, not 4.</p> <p>Table 30: Function codes for Instr. CoMACMus, Instr. CoMACMus-, Instr. CoMACMus rnd, and Instr. CoMACR are 98, A8, 99, and F9 respectively.</p> <p>The mneumonics and formats of the following addressing modes of Instr. CoMACM(R)su(-) are:  CoMACRsu [IDX<sub>i</sub>⊗], [Rw<sub>m</sub>⊗]□ — 93 Xm 70 rrrr:rqqq  CoMACRsu [IDX<sub>i</sub>⊗], [Rw<sub>m</sub>⊗], rnd — 93 Xm 71 rrrr:rqqq  CoMACRsu Rw<sub>n</sub>, [Rw<sub>m</sub>⊗], rnd — 93 Xm 71 rrrr:rqqq</p> <p>Correction in Multiplication examples CoMULu(-) and coMULus(-)</p> <p>For instructions BMOV, BMOVN, JNBS, MUL, MULU, SUBCB: Flag Z, Z, Z, N, N, and Z corrected.</p>
Jan 2000	Rev 6	<p>First EDOCs release</p> <p>Section 1.1.4: <i>Indirect addressing modes</i>: See 1, 3, 4, and 5 respectively: GPRAddress = (CP + 2 x ShortAddress), LongAddress = (GPRAddress) + Constant, PhysicalAddress = (DPPI) + LongAddress ^ 3FFFh, and (GPRPAddress) = (GPRDAddress) + Δ.</p> <p>See Section 1.2.3: <i>Additional state times</i>: ‘Jumps into the internal ROM Space :...’ example code.</p> <p>Section 1.4: <i>Instruction set ordered by functional group</i>: See teh columns Table 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, and 19.</p> <p>All column 16 bit N-MUX, 16 bit MUX, 8 bit N-MUX, 8 bit MUX.</p>
20-Mar-2009	Rev 7	Standardized revision history and added revision number to title page.
25-Sep-2013	Rev 8	Updated disclaimer.

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