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 adressing 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

$$PhysicalAddress = BaseAddress + \Delta \times ShortAddress$$

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).

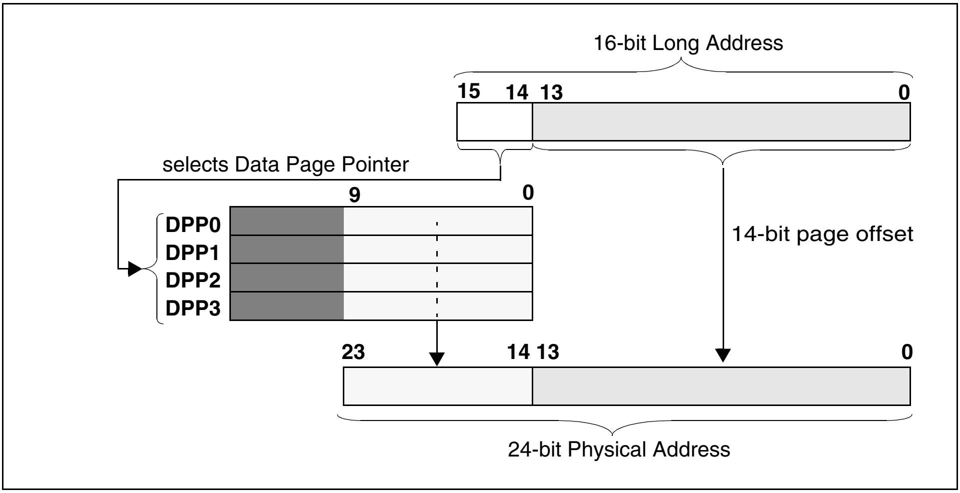

Figure 1 Interpretation of a 16-bit long address

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).

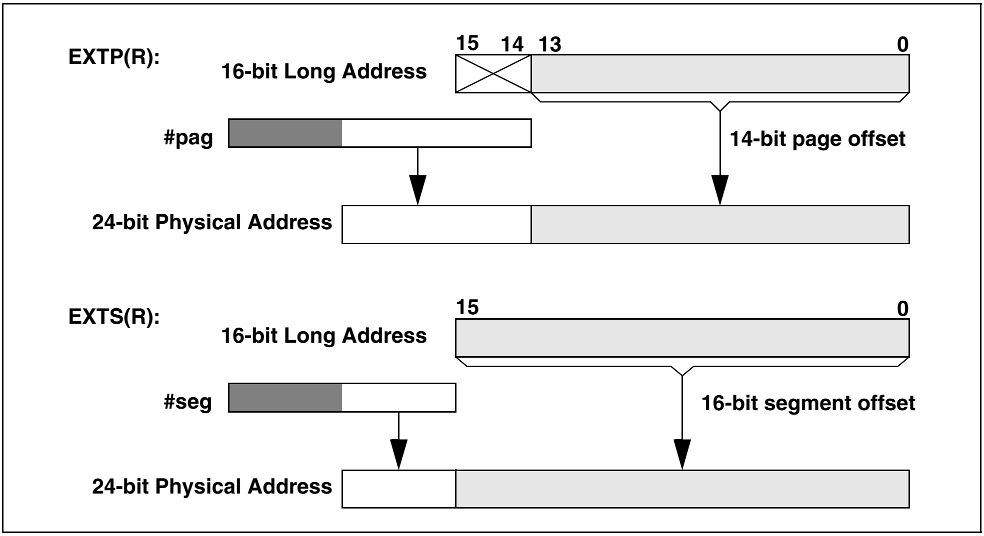

Figure 2 Overriding the DPP mechanism

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 EXTS(R) 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).

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

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:

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

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

Long Address = (GPR Pointer) + 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).

Physical Address = (DPPi) + 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):

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

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+#$data_{16}$]	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 bytewide 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
#$data_3$	0000_h + $data_3$	00_h + $data_3$
#$data_4$	0000_h + $data_4$	00_h + $data_4$
#$data_8$	0000_h + $data_8$	$data_8$
#$data_{16}$	$data_{16}$	$data_{16}$ ^ FF_h
#mask	0000_h + 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
#$trap_7$	(IP)	= 0000h + 4*$trap_7$	(CSP) = 0000h	$trap_7$	= 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_h) 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.

#$trap_7$: 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 [State]	= 1/f_{CPU}[s]	; for f_{CPU} = variable
	= 50[ns]	; for f_{CPU} = 20 MHz

[f_{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:

1*ACT = (2 + (15 – MCTC) + (1 – MTTC)) * States

= 100 n... 900 ns ; for f_{CPU} = 20 MHz

For multiplexed external bus modes:

1*ACT = (3 + (15 – MCTC) + (1 – MTTC)) * States

= 150 ns ... 950 ns ; for f_{CPU} = 20 MHz

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

$T_{tot} = T_{I1} + T_{I2} + ... + T_{In} + 6 *$ States

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

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

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 + #$data_{16}$]	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_{Imin}(RAM) = T_{Imin}(ROM) + 4 * States
- For 4-byte instructions: T_{Imin}(RAM) = T_{Imin}(ROM) + 6 * States

Unlike internal ROM program execution, the minimum time T_{Imin}(ext) to process an external instruction also depends on instruction length. T_{Imin}(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_{Imin}(ext) = 1*ACT + (T_{Imin}(ROM) - 2) * States
- For 4-byte instructions: T_{Imin}(ext) = 2*ACTs + (T_{Imin}(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_{In}. Since the additional time T_{Iadd} 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_{Iadd} = 2 * States
Both byte and word operand reads always require 2 additional state times.

Internal RAM operand reads via indirect addressing modes: T_{Iadd} = 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_{Iadd} = 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 * State or 2 * 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 * 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 * State ... 1 * 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_{Iadd} = 0 or 2 * 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_{Iadd} = 0 or 1 * 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

Lo \ Hi	0x	1x	2x	3x	4x	5x	6x	7x	8x	9x	Ax	Bx	Cx	Dx	Ex	Fx	Hi / Lo
x0	ADD Rw$_n$, Rw$_m$	ADDC Rw$_n$, Rw$_m$	SUB Rw$_n$, Rw$_m$	SUBC Rw$_n$, Rw$_m$	CMP Rw$_n$, Rw$_m$	XOR Rw$_n$, Rw$_m$	AND Rw$_n$, Rw$_m$	OR Rw$_n$, Rw$_m$	CMPI1 Rw$_n$, #d$_4$	CMPI2 Rw$_n$, #d$_4$	CMPD1 Rw$_n$, #d$_4$	CMPD2 Rw$_n$, #d$_4$	MOVBZ Rw$_n$, Rw$_m$	MOVBS Rw$_n$, Rw$_m$	MOV Rw$_n$, #data$_4$	MOV Rw$_n$, #data$_4$	x0
x1	ADDB Rw$_n$, Rw$_m$	ADDCB Rw$_n$, Rw$_m$	SUBB Rw$_n$, Rw$_m$	SUBCB Rw$_n$, Rw$_m$	CMPB Rw$_n$, Rw$_m$	XORB Rw$_n$, Rw$_m$	ANDB Rw$_n$, Rw$_m$	ORB Rw$_n$, Rw$_m$	NEG Rw$_n$	CPL Rw$_n$	NEGB Rw$_n$	CPLB Rw$_n$	-	ATOMIC /EXTR #data$_2$	MOVB Rw$_n$, #data$_4$	MOVB Rw$_n$, #data$_4$	x1
x2	ADD REG, MEM	ADDC REG, MEM	SUB REG, MEM	SUBC REG, MEM	CMP REG, MEM	XOR REG, MEM	AND REG, MEM	OR REG, MEM	CMPI Rw$_n$, MEM	CMPI2 Rw$_n$, MEM	CMPD1 Rw$_n$, MEM	CMPD2 Rw$_n$, MEM	MOVBZ REG, MEM	MOVBS REG, MEM	PCALL REG,CADDR	MOV REG, MEM	x2
x3	ADDB REG, MEM	ADDCB REG, MEM	SUBB REG, MEM	SUBCB REG, MEM	CMPB REG, MEM	XORB REG, MEM	ANDB REG, MEM	ORB REG, MEM	CoXXX Rw$_n$,[Rw$_m$⊗]	CoXXX [IDXi⊗],[Rw$_m$⊗]	CoXXX Rw$_n$,Rw$_m$	CoSTORE Rw$_n$,CoREG	CoSTORE [Rw$_n$⊗],CoREG	CoMOV [IDXi⊗],[Rw$_m$⊗]	-	MOVB REG, MEM	x3
x4	ADD MEM, REG	ADDC MEM, REG	SUB MEM, REG	SUBC MEM, REG	- MEM, REG	XOR MEM, REG	AND MEM, REG	OR MEM, REG	MOV [Rw$_n$],MEM	MOV MEM,[Rw$_n$]	MOVB [Rw$_n$],MEM	MOVB [Rw$_m$+#d$_{16}$],Rw$_n$	MOV Rw$_n$,[Rw$_m$+#d$_{16}$]	MOV [Rw$_m$+#d$_{16}$],Rw$_n$	MOVB Rw$_n$,[Rwm+#d$_{16}$]	MOVB [Rw$_m$+#d$_{16}$],Rw$_n$	x4
x5	ADDB MEM, REG	ADDCB MEM, REG	SUBB MEM, REG	SUBCB MEM, REG	- MEM, REG	XORB MEM, REG	ANDB MEM, REG	ORB MEM, REG	-	-	DISWDT	EINIT	MOVBZ MEM,REG	MOVBS MEM,REG	-	-	x5
x6	ADD REG, #data$_{16}$	ADDC REG, #data$_{16}$	SUB REG, #data$_{16}$	SUBC REG, #data$_{16}$	CMP REG, #data$_{16}$	XOR REG, #data$_{16}$	AND REG, #data$_{16}$	OR REG, #data$_{16}$	CMPI1 Rw$_n$,#d$_{16}$	CMPI2 Rw$_n$,#d$_{16}$	CMPD1 Rw$_n$,#d$_{16}$	CMPD2 Rw$_n$,#d$_{16}$	SCXT REG,#d$_{16}$	SCXT REG,MEM	MOV REG, Data#$_{16}$	MOV MEM, REG	x6
x7	ADDB REG, #data$_{16}$	ADDCB REG, #data$_{16}$	SUBB REG, #data$_{16}$	SUBCB REG, #data$_{16}$	CMPB REG, #data$_{16}$	XORB REG, #data$_{16}$	ANDB REG, #data$_{16}$	ORB REG, #data$_{16}$	IDLE	PWRDN	SRVWDT	SRST	-	EXTP(R)/ EXTS(R) #pag,#data2	MOVB REG, Data#$_{16}$	MOVB MEM, REG	x7
x8	ADD Rw$_n$,[Rw$_i$] Rw$_n$,[Rw$_i$+] Rw$_n$, #data$_3$	ADDC Rw$_n$,[Rw$_i$] Rw$_n$,[Rw$_i$+] Rw$_n$, #data$_3$	SUB Rw$_n$,[Rw$_i$] Rw$_n$,[Rw$_i$+] Rw$_n$, #data$_3$	SUBC Rw$_n$,[Rw$_i$] Rw$_n$,[Rw$_i$+] Rw$_n$, #data$_3$	CMP Rw$_n$,[Rw$_i$] Rw$_n$,[Rw$_i$+] Rw$_n$, #data$_3$	XOR Rw$_n$,[Rw$_i$] Rw$_n$,[Rw$_i$+] Rw$_n$, #data$_3$	AND Rw$_n$,[Rw$_i$] Rw$_n$,[Rw$_i$+] Rw$_n$, #data$_3$	OR Rw$_n$,[Rw$_i$] Rw$_n$,[Rw$_i$+] Rw$_n$, #data$_3$	MOV [-Rw$_m$], Rw$_n$	MOV Rw$_n$, [Rw$_m$+]	MOV Rw$_n$, [Rw$_m$]	MOV [Rw$_m$], Rw$_n$	MOV [Rw$_n$], [Rw$_m$]	MOV [Rw$_n$+], [Rw$_m$]	MOV [Rw$_n$], [Rw$_m$+]	-	x8
x9	ADDB Rw$_n$,[Rw$_i$] Rw$_n$,[Rw$_i$+] Rw$_n$, #data$_3$	ADDCB Rw$_n$,[Rw$_i$] Rw$_n$,[Rw$_i$+] Rw$_n$, #data$_3$	SUBB Rw$_n$,[Rw$_i$] Rw$_n$,[Rw$_i$+] Rw$_n$, #data$_3$	SUBCB Rw$_n$,[Rw$_i$] Rw$_n$,[Rw$_i$+] Rw$_n$, #data$_3$	CMPB Rw$_n$,[Rw$_i$] Rw$_n$,[Rw$_i$+] Rw$_n$, #data$_3$	XORB Rw$_n$,[Rw$_i$] Rw$_n$,[Rw$_i$+] Rw$_n$, #data$_3$	ANDB Rw$_n$,[Rw$_i$] Rw$_n$,[Rw$_i$+] Rw$_n$, #data$_3$	ORB Rw$_n$,[Rw$_i$] Rw$_n$,[Rw$_i$+] Rw$_n$, #data$_3$	MOVB [-Rw$_m$], Rw$_n$	MOVB Rw$_n$, [Rw$_m$+]	MOVB Rw$_n$, [Rw$_m$]	MOVB [Rw$_m$], Rw$_n$	MOVB [Rw$_n$], [Rw$_m$]	MOVB [Rw$_n$+], [Rw$_m$]	MOVB [Rw$_n$], [Rw$_m$+]	-	x9
xA	BFLDL BITOFF, MASK, #data$_3$	BFLDH BITOFF, MASK, #data$_3$	BCMP BITadd, BITadd	BMOVN BITadd, BITadd	BMOV BITadd, BITadd	BOR BITadd, BITadd	BAND BITadd, BITadd	BXOR BITadd, BITadd	JB BITadd, REL	JNB BITadd, REL	JBC BITadd, REL	JNBS BITadd, REL	CALLA CC, CADDR	CALLS SEG, CADDR	JMPA CC, CADDR	JMPS SEG, CADDR	xA
xB	MUL Rw$_n$, Rw$_m$	MULU Rw$_n$, Rw$_m$	PRIOR Rw$_n$, Rw$_m$	-	DIV Rw$_n$	DIVU Rw$_n$	DIVL Rw$_n$	DIVLU Rw$_n$	-	TRAP #trap	CALLI cc, [Rw$_n$]	CALLR REL	RET	RETS	RETP REG	RETI	xB
xC	ROL Rw$_n$, Rw$_m$	ROL Rw$_n$, #d$_4$	ROR Rw$_n$, Rw$_m$	ROR Rw$_n$, #d$_4$	SHL Rw$_n$, Rw$_m$	SHL Rw$_n$, #d$_4$	SHR Rw$_n$, Rw$_m$	SHR Rw$_n$, #d$_4$	-	JMPI cc, [Rw$_n$]	ASHR Rw$_n$, Rw$_m$	ASHR Rw$_n$, #d$_4$	NOP	EXTP(R)/ EXTS(R) Rw$_m$, #d$_2$	PUSH REG	POP REG	xC
xD	JMPR cc, rel																xD
xE	BCLR BITaddrQ.q																xE
xF	BSET BITaddrQ.q																xF
Lo / Hi	0x	1x	2x	3x	4x	5x	6x	7x	8x	9x	Ax	Bx	Cx	Dx	Ex	Fx	Lo / Hi

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, mem	4
BAND	$bitaddr_{Z.z}$, $bitaddr_{Q.q}$	4	CMP[B]	Rw_n, Rw_m[1]	
BCMP				Rw_n, [Rw_i][1]	2
BMOV				Rw_n, [Rw_i+][1]	2
BMOVN				Rw_n, #$data_3$[1]	2
BOR / BXOR				reg, #$data_{16}$	4
				reg, mem	4
BCLR	$bitaddr_{Q.q}$,	2	CALLA	cc, caddr	4
BSET			JMPA		
BFLDH	$bitoff_Q$, #$mask_8$, #$data_8$	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	$bitaddr_{Q.q}$, 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, #$data_{16}$	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, #$data_{16}$	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	#$data_2$	2
	mem, reg	4	EXTR		
EXTS	Rw_m, #$data_2$	2	EXTP	Rw_m, #$data_2$	2
EXTSR	#seg, #$data_2$	4	EXTPR	#pag, #$data_2$	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
$\#data_x$:	Immediate constant (the number of significant bits that can be user-specified is given by the appendix “x”).
$\#mask_8$:	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, $\#data_3$	Add immediate word data to direct GPR	2	6	2	3	4	6	2
ADD	reg, $\#data_{16}$	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, $\#data_3$	Add immediate byte data to direct GPR	2	6	2	3	4	6	2
ADDB	reg, $\#data_{16}$	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, $\#data_3$	Add immediate word data to direct GPR with Carry	2	6	2	3	4	6	2
ADDC	reg, $\#data_{16}$	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-bitNon	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, $\#data_3$	Add immediate byte data to direct GPR with Carry	2	6	2	3	4	6	2
ADDCB	reg, $\#data_{16}$	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, $\#data_3$	Subtract immediate word data from direct GPR	2	6	2	3	4	6	2
SUB	reg, $\#data_{16}$	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, #$data_3$	Subtract immediate byte data from direct GPR	2	6	2	3	4	6	2
SUBB	reg, #$data_{16}$	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, #$data_3$	Subtract immediate word data from direct GPR with Carry	2	6	2	3	4	6	2
SUBC	reg, #$data_{16}$	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, #$data_3$	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, #$data_{16}$	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, #$data_3$	Bitwise AND immediate word data with direct GPR	2	6	2	3	4	6	2
AND	reg, #$data_{16}$	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, #$data_3$	Bitwise AND immediate byte data with direct GPR	2	6	2	3	4	6	2
ANDB	reg, #$data_{16}$	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, #$data_3$	Bitwise OR immediate word data with direct GPR	2	6	2	3	4	6	2
OR	reg, #$data_{16}$	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 andpost-increment source pointer by 1	2	6	2	3	4	6	2
ORB	Rb, #$data_3$	Bitwise OR immediate byte data with direct GPR	2	6	2	3	4	6	2
ORB	reg, #$data_{16}$	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, #$data_3$	Bitwise XOR immediate word data with direct GPR	2	6	2	3	4	6	2
XOR	reg, #$data_{16}$	Bitwise XOR immediate word data with direct regis-ter	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, #$data_3$	Bitwise XOR immediate byte data with direct GPR	2	6	2	3	4	6	2
XORB	reg, #$data_{16}$	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, #$mask_8$,#$data_8$	Bitwise modify masked high byte of bit-addressable direct word memory with immediate data	2	8	4	6	8	12	4
BFLDL bitoff, #$mask_8$, #$data_8$	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, #$data_3$	Compare immediate word data to direct GPR	2	6	2	3	4	6	2
CMP	reg, #$data_{16}$	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, #$data_3$	Compare immediate byte data to direct GPR	2	6	2	3	4	6	2
CMPB	reg, #$data_{16}$	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, #$data_4$	Compare immediate word data to direct GPR and decrement GPR by 1	2	6	2	3	4	6	2
CMPD1	Rw, #$data_{16}$	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, #$data_4$	Compare immediate word data to direct GPR and decrement GPR by 2	2	6	2	3	4	6	2
CMPD2	Rw, #$data_{16}$	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, $\#data_4$	Compare immediate word data to direct GPR and increment GPR by 1	2	6	2	3	4	6	2
CMPI1	Rw, $\#data_{16}$	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, $\#data_4$	Compare immediate word data to direct GPR and increment GPR by 2	2	6	2	3	4	6	2
CMPI2	Rw, $\#data_{16}$	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, $\#data_4$	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, #$data_4$	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, #$data_4$	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, #$data_4$	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, #$data_4$	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, #$data_4$	Move immediate word data to direct GPR	2	6	2	3	4	6	2
MOV	reg, #$data_{16}$	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+ #$data_{16}$]	Move indirect word memory by base plus constant to direct GPR	4	10	6	8	10	14	4
MOV [Rw+ #$data_{16}$], 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, #$data_4$	Move immediate byte data to direct GPR	2	6	2	3	4	6	2
MOVB reg, #$data_{16}$	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+ #$data_{16}$]	Move indirect byte memory by base plus constant to direct GPR	4	10	6	8	10	14	4
MOVB [Rw+ #$data_{16}$], 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
MOVBZ	Rw, Rb	Move direct byte GPR with zero extension to direct word GPR	2	6	2	3	4	6	2
MOVBZ	reg, mem	Move direct byte memory with zero extension to direct word register	2	8	4	6	8	12	4
MOVBZ	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, #$data_{16}$	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$_2$	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$_2$	Begin EXTended Register sequence *)	2	6	2	3	4	6	2
EXTP Rw, #data$_2$	Begin EXTended Page sequence*)	2	6	2	3	4	6	2
EXTP #pag, #data$_2$	Begin EXTended Page sequence*)	2	8	4	6	8	12	4
EXTPR Rw, #data$_2$	Begin EXTended Page and Register sequence *)	2	6	2	3	4	6	2
EXTPR #pag, #data$_2$	Begin EXTended Page and Register sequence *)	2	8	4	6	8	12	4
EXTS Rw, #data$_2$	Begin EXTended Segment sequence*)	2	6	2	3	4	6	2
EXTS #seg, #data$_2$	Begin EXTended Segment sequence*)	2	8	4	6	8	12	4
EXTSR Rw, #data$_2$	Begin EXTended Segment and Register sequence *)	2	6	2	3	4	6	2
EXTSR #seg, #data$_2$	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 $\overline{\text{NMI}}$-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, #$data_3$	or	Rb, #$data_3$
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 "$bitaddr_{Q.q}$" (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_n, Rw_m
01	2	ADDB	Rb_n, Rb_m
02	4	ADD	reg, mem
03	4	ADDB	reg, mem
04	4	ADD	mem, reg
05	4	ADDB	mem, reg
06	4	ADD	reg, $\#data_{16}$
07	4	ADDB	reg, $\#data_{16}$
08	2	ADD	Rw_n, [Rw_i+] or Rw_n, [Rw_i] or Rw_n, $\#data_3$
09	2	ADDB	Rb_n, [Rw_i+] or Rb_n, [Rw_i] or Rb_n, $\#data_3$
0A	4	BFLDL	$bitoff_Q$, $\#mask_8$, $\#data_8$
0B	2	MUL	Rw_n, Rw_m
0C	2	ROL	Rw_n, Rw_m
0D	2	JMPR	cc_UC, rel
0E	2	BCLR	$bitaddr_{Q.0}$
0F	2	BSET	$bitaddr_{Q.0}$
10	2	ADDC	Rw_n, Rw_m
11	2	ADDCB	Rb_n, Rb_m
12	4	ADDC	reg, mem
13	4	ADDCB	reg, mem
14	4	ADDC	mem, reg
15	4	ADDCB	mem, reg
16	4	ADDC	reg, $\#data_{16}$
17	4	ADDCB	reg, $\#data_{16}$
18	2	ADDC	Rw_n, [Rw_i+] or Rw_n, [Rw_i] or Rw_n, $\#data_3$
19	2	ADDCB	Rb_n, [Rw_i+] or Rb_n, [Rw_i] or Rb_n, $\#data_3$
1A	4	BFLDH	$bitoff_Q$, $\#mask_8$, $\#data_8$
1B	2	MULU	Rw_n, Rw_m
1C	2	ROL	Rw_n, $\#data_4$
1D	2	JMPR	cc_NET, rel

Table 21 Instruction set ordered by Hex code

Hex-code	Number of Bytes	Mnemonic	Operand
1E	2	BCLR	$bitaddr_{Q.1}$
1F	2	BSET	$bitaddr_{Q.1}$
20	2	SUB	Rw_n, Rw_m
21	2	SUBB	Rb_n, Rb_m
22	4	SUB	reg, mem
23	4	SUBB	reg, mem
24	4	SUB	mem, reg
25	4	SUBB	mem, reg
26	4	SUB	reg, $#data_{16}$
27	4	SUBB	reg, $#data_{16}$
28	2	SUB	Rw_n, [Rw_i+] or Rw_n, [Rw_i] or Rw_n, $#data_3$
29	2	SUBB	Rb_n, [Rw_i+] or Rb_n, [Rw_i] or Rb_n, $#data_3$
2A	4	BCMP	$bitaddr_{Z.z}$, $bitaddr_{Q.q}$
2B	2	PRIOR	Rw_n, Rw_m
2C	2	ROR	Rw_n, Rw_m
2D	2	JMPR	cc_EQ, rel or cc_Z, rel
2E	2	BCLR	$bitaddr_{Q.2}$
2F	2	BSET	$bitaddr_{Q.2}$
30	2	SUBC	Rw_n, Rw_m
31	2	SUBCB	Rb_n, Rb_m
32	4	SUBC	reg, mem
33	4	SUBCB	reg, mem
34	4	SUBC	mem, reg
35	4	SUBCB	mem, reg
36	4	SUBC	reg, $#data_{16}$
37	4	SUBCB	reg, $#data_{16}$
38	2	SUBC	Rw_n, [Rw_i+] or Rw_n, [Rw_i] or Rw_n, $#data_3$
39	2	SUBCB	Rb_n, [Rw_i+] or Rb_n, [Rw_i] or Rb_n, $#data_3$
3A	4	BMOVN	$bitaddr_{Z.z}$, $bitaddr_{Q.q}$
3B	-	-	-
3C	2	ROR	Rw_n, $#data_4$
3D	2	JMPR	cc_NE, rel or cc_NZ, rel
3E	2	BCLR	$bitaddr_{Q.3}$

Table 21 Instruction set ordered by Hex code (Continued)

Hex-code	Number of Bytes	Mnemonic	Operand
3F	2	BSET	$bitaddr_{Q.3}$
40	2	CMP	Rw_n, Rw_m
41	2	CMPB	Rb_n, Rb_m
42	4	CMP	reg, mem
43	4	CMPB	reg, mem
44	-	-	-
45	-	-	-
46	4	CMP	reg, $\#data_{16}$
47	4	CMPB	reg, $\#data_{16}$
48	2	CMP	Rw_n, [Rw_i+] or Rw_n, [Rw_i] or Rw_n, $\#data_3$
49	2	CMPB	Rb_n, [Rw_i+] or Rb_n, [Rw_i] or Rb_n, $\#data_3$
4A	4	BMOV	$bitaddr_{Z.z}$, $bitaddr_{Q.q}$
4B	2	DIV	Rw_n
4C	2	SHL	Rw_n, Rw_m
4D	2	JMPR	cc_V, rel
4E	2	BCLR	$bitaddr_{Q.4}$
4F	2	BSET	$bitaddr_{Q.4}$
50	2	XOR	Rw_n, Rw_m
51	2	XORB	Rb_n, Rb_m
52	4	XOR	reg, mem
53	4	XORB	reg, mem
54	4	XOR	mem, reg
55	4	XORB	mem, reg
56	4	XOR	reg, $\#data_{16}$
57	4	XORB	reg, $\#data_{16}$
58	2	XOR	Rw_n, [Rw_i+] or Rw_n, [Rw_i] or Rw_n, $\#data_3$
59	2	XORB	Rb_n, [Rw_i+] or Rb_n, [Rw_i] or Rb_n, $\#data_3$
5A	4	BOR	$bitaddr_{Z.z}$, $bitaddr_{Q.q}$
5B	2	DIVU	Rw_n
5C	2	SHL	Rw_n, $\#data_4$
5D	2	JMPR	cc_NV, rel
5E	2	BCLR	$bitaddr_{Q.5}$
5F	2	BSET	$bitaddr_{Q.5}$

Table 21 Instruction set ordered by Hex code (Continued)

Hex-code	Number of Bytes	Mnemonic	Operand
60	2	AND	Rw_n, Rw_m
61	2	ANDB	Rb_n, Rb_m
62	4	AND	reg, mem
63	4	ANDB	reg, mem
64	4	AND	mem, reg
65	4	ANDB	mem, reg
66	4	AND	reg, $\#data_{16}$
67	4	ANDB	reg, $\#data_{16}$
68	2	AND	Rw_n, [Rw_i+] or Rw_n, [Rw_i] or Rw_n, $\#data_3$
69	2	ANDB	Rb_n, [Rw_i+] or Rb_n, [Rw_i] or Rb_n, $\#data_3$
6A	4	BAND	$bitaddr_{Z.z}$, $bitaddr_{Q.q}$
6B	2	DIVL	Rw_n
6C	2	SHR	Rw_n, Rw_m
6D	2	JMPR	cc_N, rel
6E	2	BCLR	$bitaddr_{Q.6}$
6F	2	BSET	$bitaddr_{Q.6}$
70	2	OR	Rw_n, Rw_m
71	2	ORB	Rb_n, Rb_m
72	4	OR	reg, mem
73	4	ORB	reg, mem
74	4	OR	mem, reg
75	4	ORB	mem, reg
76	4	OR	reg, $\#data_{16}$
77	4	ORB	reg, $\#data_{16}$
78	2	OR	Rw_n, [Rw_i+] or Rw_n, [Rw_i] or Rw_n, $\#data_3$
79	2	ORB	Rb_n, [Rw_i+] or Rb_n, [Rw_i] or Rb_n, $\#data_3$
7A	4	BXOR	$bitaddr_{Z.z}$, $bitaddr_{Q.q}$
7B	2	DIVLU	Rw_n
7C	2	SHR	Rw_n, $\#data_4$
7D	2	JMPR	cc_NN, rel
7E	2	BCLR	$bitaddr_{Q.7}$
7F	2	BSET	$bitaddr_{Q.7}$
80	2	CMPI1	Rw_n, $\#data_4$

Table 21 Instruction set ordered by Hex code (Continued)

Hex-code	Number of Bytes	Mnemonic	Operand
81	2	NEG	Rw_n
82	4	CMPI1	Rw_n, mem
83	4	CoXXX[1]	Rw_n, [Rw_m⊗]
84	4	MOV	[Rw_n], mem
85	-	-	-
86	4	CMPI1	Rw_n, #$data_{16}$
87	4	IDLE	
88	2	MOV	[-Rw_m], Rw_n
89	2	MOVB	[-Rw_m], Rb_n
8A	4	JB	$bitaddr_{Q.q}$, rel
8B	-	-	-
8C	-	-	-
8D	2	JMPR	cc_C, rel or cc_ULT, rel
8E	2	BCLR	$bitaddr_{Q.8}$
8F	2	BSET	$bitaddr_{Q.8}$
90	2	CMPI2	Rw_n, #$data_4$
91	2	CPL	Rw_n
92	4	CMPI2	Rw_n, mem
93	4	CoXXX[1]	[IDXi⊗], [Rw_n⊗]
94	4	MOV	mem, [Rw_n]
95	-	-	-
96	4	CMPI2	Rw_n, #$data_{16}$
97	4	PWRDN	
98	2	MOV	Rw_n, [Rw_m+]
99	2	MOVB	Rb_n, [Rw_m+]
9A	4	JNB	$bitaddr_{Q.q}$, rel
9B	2	TRAP	#trap7
9C	2	JMPI	cc, [Rw_n]
9D	2	JMPR	cc_NC, rel or cc_UGE, rel
9E	2	BCLR	$bitaddr_{Q.9}$
9F	2	BSET	$bitaddr_{Q.9}$
A0	2	CMPD1	Rw_n, #$data_4$
A1	2	NEGB	Rb_n

Table 21 Instruction set ordered by Hex code (Continued)

Hex-code	Number of Bytes	Mnemonic	Operand
A2	4	CMPD1	Rw_n, mem
A3	4	CoXXX[1]	Rw_n, Rw_m
A4	4	MOVB	[Rw_n], mem
A5	4	DISWDT	
A6	4	CMPD1	Rw_n, #$data_{16}$
A7	4	SRVWDT	
A8	2	MOV	Rw_n, [Rw_m]
A9	2	MOVB	Rb_n, [Rw_m]
AA	4	JBC	$bitaddr_{Q.q}$, rel
AB	2	CALLI	cc, [Rw_n]
AC	2	ASHR	Rw_n, Rw_m
AD	2	JMPR	cc_SGT, rel
AE	2	BCLR	$bitaddr_{Q.10}$
AF	2	BSET	$bitaddr_{Q.10}$
B0	2	CMPD2	Rw_n, #$data_4$
B1	2	CPLB	Rb_n
B2	4	CMPD2	Rw_n, mem
B3	4	CoSTORE[1]	[$Rw_n \otimes$], CoReg
B4	4	MOVB	mem, [Rw_n]
B5	4	EINIT	
B6	4	CMPD2	Rw_n, #$data_{16}$
B7	4	SRST	
B8	2	MOV	[Rw_m], Rw_n
B9	2	MOVB	[Rw_m], Rb_n
BA	4	JNBS	$bitaddr_{Q.q}$, rel
BB	2	CALLR	rel
BC	2	ASHR	Rw_n, #$data_4$
BD	2	JMPR	cc_SLE, rel
BE	2	BCLR	$bitaddr_{Q.11}$
BF	2	BSET	$bitaddr_{Q.11}$
C0	2	MOVBZ	Rb_n, Rb_m
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[1]	Rw_n, CoReg
C4	4	MOV	[Rw_m+#$data_{16}$], Rw_n
C5	4	MOVBZ	mem, reg
C6	4	SCXT	reg, #$data_{16}$
C7	-	-	-
C8	2	MOV	[Rw_n], [Rw_m]
C9	2	MOVB	[Rw_n], [Rw_m]
CA	4	CALLA	cc, caddr
CB	2	RET	
CC	2	NOP	
CD	2	JMPR	cc_SLT, rel
CE	2	BCLR	$bitaddr_{Q.12}$
CF	2	BSET	$bitaddr_{Q.12}$
D0	2	MOVBS	Rb_n, Rb_m
D1	2	ATOMIC/EXTR	#$data_2$
D2	4	MOVBS	reg, mem
D3	4	CoMOV[1]	[IDXi⊗], [Rw_n⊗]
D4	4	MOV	Rw_n, [Rw_m+#$data_{16}$]
D5	4	MOVBS	mem, reg
D6	4	SCXT	reg, mem
D7	4	EXTP(R)/EXTS(R)	#pag, #$data_2$
D8	2	MOV	[Rw_n+], [Rw_m]
D9	2	MOVB	[Rw_n+], [Rw_m]
DA	4	CALLS	seg, caddr
DB	2	RETS	
DC	2	EXTP(R)/EXTS(R)	Rw_m, #$data_2$
DD	2	JMPR	cc_SGE, rel
DE	2	BCLR	$bitaddr_{Q.13}$
DF	2	BSET	$bitaddr_{Q.13}$
E0	2	MOV	Rw_n, #$data_4$
E1	2	MOVB	Rb_n, #$data_4$
E2	4	PCALL	reg, caddr
E3	-	-	-
E4	4	MOVB	[Rw_m+#$data_{16}$], Rb_n

Table 21 Instruction set ordered by Hex code (Continued)

Hex-code	Number of Bytes	Mnemonic	Operand
E5	-	-	-
E6	4	MOV	reg, #$data_{16}$
E7	4	MOVB	reg, #$data_{16}$
E8	2	MOV	[Rw_n], [Rw_m+]
E9	2	MOVB	[Rw_n], [Rw_m+]
EA	4	JMPA	cc, caddr
EB	2	RETP	reg
EC	2	PUSH	reg
ED	2	JMPR	cc_UGT, rel
EE	2	BCLR	$bitaddr_{Q.14}$
EF	2	BSET	$bitaddr_{Q.14}$
F0	2	MOV	Rw_n, Rw_m
F1	2	MOVB	Rb_n, Rb_m
F2	4	MOV	reg, mem
F3	4	MOVB	reg, mem
F4	4	MOVB	Rb_n, [Rw_m+#$data_{16}$]
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	$bitaddr_{Q.15}$
FF	2	BSET	$bitaddr_{Q.15}$

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_n)	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 v C) = 1	Unsigned less than or equal	Fh
cc_UGE	C = 0	Unsigned greater than or equal	9h
cc_UGT	(Z v 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 v 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_h through FF_h	**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_i)
ss	8-bit code segment number (seg).
:..##	2-bit immediate constant (#data$_2$)
:.###	3-bit immediate constant (#data$_3$)
c	4-bit condition code specification (cc)
n	4-bit short GPR address (Rw_n or Rb_n)
m	4-bit short GPR address (Rw_m or Rb_m)
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$_4$)
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$_8$)
@@	8-bit immediate constant (#mask$_8$)
pp 0:00pp	10-bit page address (#pag10)
MM MM	16-bit address (mem or caddr; low byte, high byte)
## ##	16-bit immediate constant (#data$_{16}$; 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.

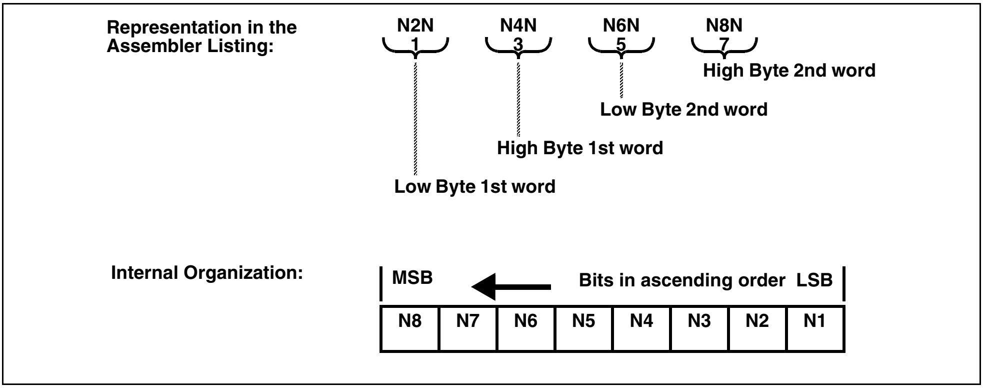

Figure 3 Instruction format representation

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

Integer Addition

Syntax

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_n, Rw_m	00 nm	2
ADD	Rw_n, [Rw_i]	08 n:10ii	2
ADD	Rw_n, [Rw_i+]	08 n:11ii	2
ADD	Rw_n, #$data_3$	08 n:0###	2
ADD	reg, #$data_{16}$	06 RR ## ##	4
ADD	reg, mem	02 RR MM MM	4
ADD	mem, reg	04 RR MM MM	4

ADDB

Integer Addition

Syntax

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_n, Rb_m	01 nm	2
ADDB	Rb_n, $[Rw_i]$	09 n:10ii	2
ADDB	Rb_n, $[Rw_i+]$	09 n:11ii	2
ADDB	Rb_n, $\#data_3$	09 n:0###	2
ADDB	reg, $\#data_{16}$	07 RR ## ##	4
ADDB	reg, mem	03 RR MM MM	4
ADDB	mem, reg	05 RR MM MM	4

ADDC

Integer Addition with Carry

Syntax

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

Integer Addition with Carry

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_n, Rb_m	11 nm	2
ADDCB	Rb_n, [Rw_i]	19 n:10ii	2
ADDCB	Rb_n, [Rw_i+]	19 n:11ii	2
ADDCB	Rb_n, #$data_3$	19 n:0###	2
ADDCB	reg, #$data_{16}$	17 RR ## ##	4
ADDCB	reg, mem	13 RR MM MM	4
ADDCB	mem, reg	15 RR MM MM	4

AND

Logical AND

Syntax

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_n, Rw_m	60 nm	2
AND	Rw_n, $[Rw_i]$	68 n:10ii	2
AND	Rw_n, $[Rw_i+]$	68 n:11ii	2
AND	Rw_n, $\#data_3$	68 n:0###	2
AND	reg, $\#data_{16}$	66 RR ## ##	4
AND	reg, mem	62 RR MM MM	4
AND	mem, reg	64 RR MM MM	4

ANDB

Logical AND

Syntax

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_n, Rb_m	61 nm	2
ANDB	Rb_n, [Rw_i]	69 n:10ii	2
ANDB	Rb_n, [Rw_i+]	69 n:11ii	2
ANDB	Rb_n, #$data_3$	69 n:0###	2
ANDB	reg, #$data_{16}$	67 RR ## ##	4
ANDB	reg, mem	63 RR MM MM	4
ANDB	mem, reg	65 RR MM MM	4

ASHR

Arithmetic Shift Right

Syntax

ASHR op1, op2

Operation

(count) <-- (op2)
(V) <-- 0
(C) <-- 0
DO WHILE (count) ≠ 0
    (V) <-- (C) v (V)
    (C) <-- ($op1_0$)
    ($op1_n$) <-- ($op1_{n+1}$) [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_n, Rw_m	AC nm	2
ASHR	Rw_n, $\#data_4$	BC #n	2

ATOMIC

Begin ATOMIC Sequence

Syntax

ATOMIC op1

Operation

(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

Description

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.

Note

The ATOMIC 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
ATOMIC #$data_2$	D1 00##:0	2

BAND

Bit Logical AND

Syntax

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$_{Z.z}$, bitaddr$_{Q.q}$	6A QQ ZZ qz	4

BCLR

Bit Clear

Syntax

BCLR op1

Operation

(op1) <-- 0

Data Types

BIT

Description

Clears 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
BCLR	$bitaddr_{Q.q}$	qE QQ	2

BCMP

Bit to Bit Compare

Syntax

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	$bitaddr_{Z.z}$, $bitaddr_{Q.q}$	2A QQ ZZ qz	4

BFLDH

Bit Field High Byte

Syntax

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 $bitoff_Q$, $\#mask_8$, $\#data_8$	1A QQ ## @ @	4

BFLDL

Bit Field Low Byte

Syntax

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$_Q$, #mask$_8$, #data$_8$	0A QQ @@##	4

BMOV

Bit to Bit Move

Syntax

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$_{Z.z}$, bitaddr$_{Q.q}$	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$_{Z.z}$, bitaddr$_{Q.q}$	3A QQ ZZ qz	4

BOR

Bit Logical OR

Syntax

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$_{Z.z}$, bitaddr$_{Q.q}$	5A QQ ZZ qz	4

BSET

Bit Set

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	$bitaddr_{Q.q}$	qF QQ	2

BXOR

Bit Logical XOR

Syntax

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$_{Z.z}$, bitaddr$_{Q.q}$	7A QQ ZZ qz	4

CALLA

Call Subroutine Absolute

Syntax

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

Call Subroutine Indirect

Syntax

CALLI 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 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.

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
CALLI	cc, $[Rw_n]$	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_n, Rw_m	40 nm	2
CMP	Rw_n, [Rw_i]	48 n:10ii	2
CMP	Rw_n, [Rw_i+]	48 n:11ii	2
CMP	Rw_n, #$data_3$	48 n:0###	2
CMP	reg, #$data_{16}$	46 RR ## ##	4
CMP	reg, mem	42 RR MM MM	4

CMPB

Integer Compare

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_n, Rb_m	41 nm	2
CMPB	Rb_n, [Rw_i]	49 n:10ii	2
CMPB	Rb_n, [Rw_i+]	49 n:11ii	2
CMPB	Rb_n, #$data_3$	49 n:0###	2
CMPB	reg, #$data_{16}$	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_n, $\#data_4$	A0 #n	2
CMPD1	Rw_n, $\#data_{16}$	A6 Fn ## ##	4
CMPD1	Rw_n, mem	A2 Fn MM MM	4

CMPD2

Integer Compare & Decrement by 2

Syntax

CMPD2 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 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_n, $\#data_4$	B0 #n	2
CMPD2	Rw_n, $\#data_{16}$	B6 Fn ## ##	4
CMPD2	Rw_n, 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_n, $\#data_4$	80 #n	2
CMPI1	Rw_n, $\#data_{16}$	86 Fn ## ##	4
CMPI1	Rw_n, mem	82 Fn MM MM	4

CMPI2

Integer Compare & Increment by 2

Syntax

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_n, #$data_4$	90 #n	2
CMPI2	Rw_n, #$data_{16}$	96 Fn ## ##	4
CMPI2	Rw_n, 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_n	91 n0	2

CPLB

Integer One's Complement

Syntax

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_n	B1 n0	2

DISWDT

Disable Watchdog Timer

Syntax

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

16-by-16 Signed Division

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_n	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_n	6B nn	2

DIVLU

32-by-16 Unsigned Division

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	Rw_n	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_n	5B nn	2

EINIT

End of Initialization

Syntax

EINIT

Operation

End of Initialization

Description

This instruction is used to signal the end of the initialization portion of a program. After a reset, the reset output pin $\overline{\text{RSTOUT}}$ 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.

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
EINIT	B5 4A B5 B5	4

EXTP

Begin EXTended Page Sequence

Syntax

EXTP op1, op2

Operation

(count) <-- (op2) [$1 \leq op2 \leq 4$]
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, #$data_2$	DC 01##:m	2
EXTP	#pag, #$data_2$	D7 01##:0 pp 0:00pp	4

EXTPR

Begin EXTended Page & Register Sequence

Syntax

EXTPR op1, op2

Operation

(count) <-- (op2) [$1 \leq$ op2 ≤ 4]
Disable interrupts and Class A traps
Data_Page = (op1) AND SFR_range = Extended
DO WHILE ((count) $\neq$ 0 AND Class_B_trap_condition $\neq$ 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. 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 EXTPR 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
EXTPR	Rwm, #$data_2$	DC 11##:m	2
EXTPR	#pag, #$data_2$	D7 11##:0 pp 0:00pp	4

EXTR

Begin EXTended Register Sequence

Syntax

EXTR op1

Operation

(count) <-- (op1) [$1 \leq op1 \leq 4$]
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	#$data_2$	D1 10##:0	2

EXTS

Begin EXTended Segment Sequence

Syntax

EXTS op1, op2

Operation

(count) <-- (op2) [$1 \leq op2 \leq 4$]
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

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 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.

Note

The EXTS 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
EXTS	Rwm, #$data_2$	DC 00##:m	2
EXTS	#seg, #$data_2$	D7 00##:0 ss 00	4

EXTSR

Begin EXTended Segment & Register Sequence

Syntax

EXTSR op1, op2

Operation

(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$_2$	DC 10##:m	2
EXTSR	#seg, #data$_2$	D7 10##:0 ss 00	4

IDLE

Enter Idle Mode

Syntax

IDLE

Operation

Enter Idle Mode

Description

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.

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
IDLE	87 78 87 87	4

JB

Relative Jump if Bit Set

Syntax

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	$bitaddr_{Q.q}$, rel	8A QQ rr q0	4

JBC

Relative Jump if Bit Set & Clear Bit

Syntax

JBC op1, op2

Operation

```
IF (op1) = 1 THEN
        (op1) = 0
        (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 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.

Flags

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.

Addressing Modes

Mnemonic		Format	Bytes
JBC	bitaddr$_{Q.q}$, 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, $[Rw_n]$	9C cn	2

JMPR

Relative Conditional Jump

Syntax

JMPR op1, op2

Operation

```
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

Absolute Inter-Segment Jump

Syntax

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

Relative Jump if Bit Clear

Syntax

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	$bitaddr_{Q.q}$, rel	9A QQ rr q0	4

JNBS

Relative Jump if Bit Clear & Set Bit

Syntax

JNBS op1, op2

Operation

```
IF (op1) = 0 THEN
        (op1) = 1
        (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 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.

Flags

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.

Addressing Modes

Mnemonic		Format	Bytes
JNBS	$bitaddr_{Q.q}$, rel	BA QQ rr q0	4

MOV

Move Data

Syntax

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

Move Data

Syntax

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_n, Rb_m	F1 nm	2
MOVB	Rb_n, #$data_4$	E1 #n	2
MOVB	reg, #$data_{16}$	E7 RR ## ##	4
MOVB	Rb_n, [Rw_m]	A9 nm	2
MOVB	Rb_n, [Rw_m+]	99 nm	2
MOVB	[Rw_m], Rb_n	B9 nm	2
MOVB	[-Rw_m], Rb_n	89 nm	2
MOVB	[Rw_n], [Rw_m]	C9 nm	2
MOVB	[Rw_n+], [Rw_m]	D9 nm	2
MOVB	[Rw_n], [Rw_m+]	E9 nm	2
MOVB	Rb_n, [Rw_m+#$data_{16}$]	F4 nm ## ##	4
MOVB	[Rw_m+#$data_{16}$], Rb_n	E4 nm ## ##	4
MOVB	[Rw_n], mem	A4 0n MM MM	4
MOVB	mem, [Rw_n]	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 ($op2_7$) = 1 THEN
    (high byte op1) <-- FF_h
ELSE
    (high byte op1) <-- 00_h
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_n, Rb_m	D0 mn	2
MOVBS	reg, mem	D2 RR MM MM	4
MOVBS	mem, reg	D5 RR MM MM	4

MOVBZ

Move Byte Zero Extend

Syntax

MOVBZ op1, op2

Operation

(low byte op1) <-- (op2)
(high byte op1) <-- 00_h

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_n, Rb_m	C0 mn	2
MOVBZ	reg, mem	C2 RR MM MM	4
MOVBZ	mem, reg	C5 RR MM MM	4

MUL

Signed Multiplication

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

Unsigned Multiplication

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_n, Rw_m	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_n	81 n0	2

NEGB

Integer Two's Complement

Syntax

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_n	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

Logical OR

Syntax

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_n, Rw_m	70 nm	2
OR	Rw_n, [Rw_i]	78 n:10ii	2
OR	Rw_n, [Rw_i+]	78 n:11ii	2
OR	Rw_n, #$data_3$	78 n:0###	2
OR	reg, #$data_{16}$	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_n, Rb_m	71 nm	2
ORB	Rb_n, [Rw_i]	79 n:10ii	2
ORB	Rb_n, [Rw_i+]	79 n:11ii	2
ORB	Rb_n, #$data_3$	79 n:0###	2
ORB	reg, #$data_{16}$	77 RR ## ##	4
ORB	reg, mem	73 RR MM MM	4
ORB	mem, reg	75 RR MM MM	4

PCALL

Push Word & Call Subroutine Absolute

Syntax

PCALL op1, op2

Operation

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

Data Types

WORD

Description

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.

Flags

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.

Addressing Modes

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

POP

Pop Word from System Stack

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

E	Z	V	C	N
*	*	-	-	*

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

Z Set if the value of the popped word equals zero. Cleared otherwise.

V Not affected.

C Not affected.

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

Addressing Modes

Mnemonic		Format	Bytes
POP	reg	FC RR	2

PRIOR

Prioritize Register

Syntax

PRIOR op1, op2

Operation

(tmp) <-- (op2)
(count) <-- 0
DO WHILE (tmp_{15}) ≠ 1 AND (count) ≠ 15 AND (op2) ≠ 0
    (tmp_n) <-- (tmp_{n-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	Rw_n, Rw_m	2B nm	2

PUSH

Push Word on System Stack

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

E	Z	V	C	N
*	*	-	-	*

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

Z Set if the value of the pushed word equals zero. Cleared otherwise.

V Not affected.

C Not affected.

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

Addressing Modes

Mnemonic		Format	Bytes
PUSH	reg	EC RR	2

PWRDN

Enter Power Down Mode

Syntax

PWRDN

Operation

Enter Power Down Mode

Description

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 ($\overline{NMI}$) is in the low state. Otherwise, this instruction has no effect.

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
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	Format	Bytes
RET	CB 00	2

RETI

Return from Interrupt Routine

Syntax

RETI

Operation

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

Description

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.

Flags

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.

Addressing Modes

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

Return from Inter-Segment Subroutine

Syntax

RETS

Operation

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

Description

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.

Flags

E	Z	V	C	N
-	-	-	-	-

E Not affected.

Z Not affected.

V Not affected.

C Not affected.

N Not affected.

Addressing Mode

Mnemonic	Format	Bytes
RETS	DB 00	2

ROL

Rotate Left

Syntax

ROL op1, op2

Operation

(count) <-- (op2)
(C) <-- 0
DO WHILE (count) $\neq$ 0
(C) <-- ($op1_{15}$)
($op1_n$) <-- ($op1_{n-1}$) [n=1...15]
($op1_0$) <-- (C)
(count) <-- (count) - 1
END WHILE

Data Types

WORD

Description

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.

Flags

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.

Addressing Modes

Mnemonic		Format	Bytes
ROL	Rw_n, Rw_m	0C nm	2
ROL	Rw_n, $\#data_4$	1C #n	2

ROR

Rotate Right

Syntax

ROR op1, op2

Operation

(count) <-- (op2)
(C) <-- 0
(V) <-- 0
DO WHILE (count) $\neq$ 0
    (V) <-- (V) v (C)
    (C) <-- ($op1_0$)
    ($op1_n$) <-- ($op1_{n+1}$) [n=0...14]
    ($op1_{15}$) <-- (C)
    (count) <-- (count) - 1
END WHILE

Data Types

WORD

Description

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_n, Rw_m	2C nm	2
ROR	Rw_n, #$data_4$	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, $\#data_{16}$	C6 RR ## ##	4
SCXT	reg, mem	D6 RR MM MM	4

SHL

Shift Left

Syntax

SHL op1, op2

Operation

(count) <-- (op2)
(C) <-- 0
DO WHILE (count) $\neq$ 0
    (C) <-- ($op1_{15}$)
    ($op1_n$) <-- ($op1_{n-1}$) [n=1...15]
    ($op1_0$) <-- 0
    (count) <-- (count) - 1
END WHILE

Data Types

WORD

Description

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.

Flags

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.

Addressing Modes

Mnemonic		Format	Bytes
SHL	Rw_n, Rw_m	4C nm	2
SHL	Rw_n, $\#data_4$	5C #n	2

SHR

Shift Right

Syntax

SHR op1, op2

Operation

(count) <-- (op2)
(C) <-- 0
(V) <-- 0
DO WHILE (count) $\neq$ 0
    (V) <-- (C) v (V)
    (C) <-- ($op1_0$)
    ($op1_n$) <-- ($op1_{n+1}$) [n=0...14]
    ($op1_{15}$) <-- 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_n, Rw_m	6C nm	2
SHR	Rw_n, $\#data_4$	7C #n	2

SRST

Software Reset

Syntax

SRST

Operation

Software Reset

Description

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.

Flags

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.

Addressing Modes

Mnemonic	Format	Bytes
SRST	B7 48 B7 B7	4

SRVWDT

Service Watchdog Timer

Syntax

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

Integer Subtraction

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_n, Rb_m	21 nm	2
SUBB	Rb_n, [Rw_i]	29 n:10ii	2
SUBB	Rb_n, [Rw_i+]	29 n:11ii	2
SUBB	Rb_n, #$data_3$	29 n:0###	2
SUBB	reg, #$data_{16}$	27 RR ## ##	4
SUBB	reg, mem	23 RR MM MM	4
SUBB	mem, reg	25 RR MM MM	4

SUBC

Integer Subtraction with Carry

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_n, Rw_m	30 nm	2
SUBC	Rw_n, [Rw_i]	38 n:10ii	2
SUBC	Rw_n, [Rw_i+]	38 n:11ii	2
SUBC	Rw_n, #$data_3$	38 n:0###	2
SUBC	reg, #$data_{16}$	36 RR ## ##	4
SUBC	reg, mem	32 RR MM MM	4
SUBC	mem, reg	34 RR MM MM	4

SUBCB

Integer Subtraction with Carry

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_n, Rb_m	31 nm	2
SUBCB	Rb_n, [Rw_i]	39 n:10ii	2
SUBCB	Rb_n, [Rw_i+]	39 n:11ii	2
SUBCB	Rb_n, #$data_3$	39 n:0###	2
SUBCB	reg, #$data_{16}$	37 RR ## ##	4
SUBCB	reg, mem	33 RR MM MM	4
SUBCB	mem, reg	35 RR MM MM	4

TRAP

Software Trap

Syntax

TRAP op1

Operation

```
(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)
```

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) $\oplus$ (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_n, Rw_m	50 nm	2
XOR	Rw_n, [Rw_i]	58 n:10ii	2
XOR	Rw_n, [Rw_i+]	58 n:11ii	2
XOR	Rw_n, #$data_3$	58 n:0###	2
XOR	reg, #$data_{16}$	56 RR ## ##	4
XOR	reg, mem	52 RR MM MM	4
XOR	mem, reg	54 RR MM MM	4

XORB

Logical Exclusive OR

Syntax

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_n, Rb_m	51 nm	2
XORB	Rb_n, [Rw_i]	59 n:10ii	2
XORB	Rb_n, [Rw_i+]	59 n:11ii	2
XORB	Rb_n, #$data_3$	59 n:0###	2
XORB	reg, #$data_{16}$	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 #$data_5$ 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 QR0/QR1 and QX0/QX1 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
[1]"[IDX_i⊗]" 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⊗]" 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⊗]" and "[IDXi⊗] 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 R0 when using [R0] post-modification adressing mode) will trigger the class-B hardware Trap 28h (Illegal Word Operand Access Trap (ILLOPA)).

In this document the symbols "[Rw_n⊗]" and "[IDX_i⊗]" 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
CoMUL	Rw_n, Rw_m	No
CoMULu	$[IDX_i\otimes]$, $[Rw_m\otimes]$	No
CoMULus	Rw_n, $[Rw_m\otimes]$	No
CoMULsu		
CoMUL-		
CoMULu-		
CoMULus-		
CoMULsu-		
CoMUL + rnd		
CoMULu + rnd		
CoMULus + rnd		
CoMULsu + rnd		
CoMAC	Rw_n, Rw_m	No
CoMACu	$[IDX_i\otimes]$, $[Rw_m\otimes]$	Yes
CoMACus	Rw_n, $[Rw_m\otimes]$	Yes
CoMACsu		
CoMAC-		
CoMACu-		
CoMACus-		
CoMACsu-		
CoMAC + rnd		
CoMACu + rnd		
CoMACus + rnd		
CoMACsu + rnd		
CoMACR		
CoMACRu		
CoMACRus		
CoMACRsu		
CoMACR + rnd		
CoMACRu + rnd		
CoMACRus + rnd		
CoMACRsu + rnd		
CoMACM	$[IDX_i\otimes]$, $[Rw_m\otimes]$	Yes
CoMACMu		
CoMACMus		
CoMACMsu		
CoMACM-		
CoMACMu-		
CoMACMus-		
CoMACMsu-		
CoMACM + rnd		
CoMACMu + rnd		
CoMACMus + rnd		
CoMACMsu + rnd		
CoMACMR		
CoMACMRu		
CoMACMRus		
CoMACMRsu		
CoMACMR + rnd		
CoMACMRu + rnd		
CoMACMRus + rnd		
CoMACMRsu + rnd		
CoADD	Rw_n, Rw_m	No
CoADD2	$[IDX_i\otimes]$, $[Rw_m\otimes]$	Yes
CoSUB	Rw_n, $[Rw_m\otimes]$	Yes
CoSUB2		
CoSUBR		
CoSUB2R		
CoMAX		
CoMIN		
CoLOAD	Rw_n, Rw_m	No
CoLOAD-	$[IDX_i\otimes]$, $[Rw_m\otimes]$	No
CoLOAD2	Rw_n, $[Rw_m\otimes]$	No
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
			CoASHR	$[Rw_m\otimes]$	Yes
CoNEG	-	No	CoASHR + rnd		
CoNEG + rnd			CoABS	-	No
CoRND				Rw_n, Rw_m	No
CoSTORE	Rw_n , CoReg	No		$[IDX_i\otimes]$, $[Rw_m\otimes]$	No
	$[Rw_n\otimes]$, CoReg	Yes		Rw_n, $[Rw_m\otimes]$	No
CoMOV	$[IDX_i\otimes]$, $[Rw_m\otimes]$	Yes			

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 #$data_5$	82
CoNEG + rnd	72	CoSHL other	8A
CoRND	B2	CoSHR #$data_5$	92
CoABS -	1A	CoSHR other	9A
CoABS op1, op2	CA	CoASHR #$data_5$	A2
CoSTORE	wwww:w000	CoASHR other	AA
CoMOV	00	CoASHR + rnd #$data_5$	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_n)	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_h

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) $>>_a$	(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_n”, or “Rw_m” :	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.
$\#data_x$:	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.
wwww: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
IDX0	1_h
IDX0 +	2_h
IDX0 -	3_h
IDX0 + QX0	4_h
IDX0 - QX0	5_h
IDX0 + QX1	6_h
IDX0 - QX1	7_h
IDX1	9_h
IDX1 +	A_h
IDX1 -	B_h
IDX1 + QX0	C_h
IDX1 - QX0	D_h
IDX1 + QX1	E_h
IDX1 - QX1	F_h

GPR Offset	3-bit Encoding
no-op	1_h
+	2_h
-	3_h
+ QR0	4_h
- QR0	5_h
+ QR1	6_h
- QR1	7_h

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	#$data_5$	**times**	CoXXX...	or
Repeat	MRW	**times**	CoXXX...	

When MRW is invoked, the instruction is repeated ($MRW_{12\text{-}0}$) + 1 times, therefore the maximum number of times an instruction can be repeated is 8 192 (2^{13}) times.

#$data_5$ is an integer value specifying the number of times an instruction is repeated, #$data_5$ 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_n, Rw_m	No	A3 nm CA 00	4
CoABS	[IDX_i⊗], [Rw_m⊗]	No	93 Xm CA 0:0qqq	4
CoABS	Rw_n, [Rw_m⊗]	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 $FFFF_h$ or FF 8000 0000_h, 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⊗], [Rw_m⊗]	Yes	93 Xm 02 rrrr:rqqq	4
CoADD2	[IDX_i⊗], [Rw_m⊗]	Yes	93 Xm 42 rrrr:rqqq	4
CoADD	Rw_n, [Rw_m⊗]	Yes	83 nm 02 rrrr:rqqq	4
CoADD2	Rw_n, [Rw_m⊗]	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_h	$FFFF_h$	00 0100 0000_h	00 00FF 0000_h	0	0	1	-	0	-
CoADD2	x	0000_h	0200_h	00 0300 0000_h	00 0700 0000_h	0	0	0	-	0	-
CoADD	0	0000_h	4000_h	7F BFFF $FFFF_h$	7F FFFF $FFFF_h$	0	0	0	-	1	-
CoADD	0	0001_h	4000_h	7F BFFF $FFFF_h$	80 0000 0000_h	1	0	0	1	1	-
CoADD	0	$FFFF_h$	$FFFF_h$	FF FFFF $FFFF_h$	FF FFFF $FFFE_h$	1	0	1	-	0	-
CoADD	0	$FFFF_h$	$FFFF_h$	00 0000 0001_h	00 0000 0000_h	0	1	1	-	0	-
CoADD	0	$FFFF_h$	$FFFF_h$	80 0000 0000_h	7F FFFF $FFFF_h$	0	0	1	1	1	-
CoADD2	0	0001_h	2000_h	FF C000 0001_h	00 0000 0003_h	0	0	1	-	0	-
CoADD2	0	0001_h	1800_h	FF C000 0001_h	FF F000 0003_h	1	0	0	-	0	-
CoADD	0	$B4A1_h$	$73C2_h$	00 7241 $A0C3_h$	00 E604 5564_h	0	0	0	-	1	-
	1				00 7FFF $FFFF_h$	0	0	0	-	0	1
CoADD	0	$B4A1_h$	$A3C2_h$	FF 8241 $A0C3_h$	FF 2604 5564_h	1	0	1	-	1	-
	1				FF 8000 0000_h	1	0	1	-	0	1
CoADD	0	$B4A1_h$	$73C2_h$	7F B241 $A0C3_h$	80 2604 5564_h	1	0	0	1	1	-
CoADD	0	$B4A1_h$	$A3C2_h$	80 0241 $A0C3_h$	7F A604 5564_h	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) $\neq$ 0
    (ACC_n) <-- (ACC_{n+1})   [n=0-38]
    (count) <-- (count) -1
END WHILE
IF (rnd) THEN
    (ACC) <-- (ACC) + 00008000_H
    (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 $FFFF_h$ or FF 8000 0000_h, 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_n	Yes	A3 nn AA rrrr:r000	4
CoASHR	Rw_n, rnd	Yes	A3 nn BA rrrr:r000	4
CoASHR	#$data_5$	No	A3 00 A2 ssss:s000	4
CoASHR	#$data_5$, rnd	No	A3 00 B2 ssss:s000	4
CoASHR	[Rw_m⊗]	Yes	83 mm AA rrrr:rqqq	4
CoASHR	[Rw_m⊗], rnd	Yes	83 mm BA rrrr:rqqq	4

Examples

CoASHR	#3, rnd	; (ACC) <-- (ACC) >>a 3 + rnd
CoASHR	R3	; (ACC) <-- (ACC) >>a $(R3)_{4-0}$
CoASHR	[R10 - QR0]	; (ACC) <-- (ACC) >>a $((R10))_{4-0}$
		; (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⊗], [Rw_m⊗]	No	93 Xm C2 0:0qqq	4
CoCMP	Rw_n, [Rw_m⊗]	No	83 nm C2 0:0qqq	4

Examples

```
CoCMP    [IDX1+QX0], [R11+QR1]   ; MSW(N,Z,C)<--(ACC) - ((R11))\((IDX1))
                                 ; (R11) <-- (R11) + (QR1)
                                 ; (IDX1) <-- (IDX1) + (QX0)
CoCMP    R1, [R2-]               ; MSW(N,Z,C) <-- (ACC) - ((R2))\(R1)
                                 ; (R2) <-- (R2) - 2
CoCMP    R2, R5                  ; MSW(N,Z,C) <-- (ACC) - (R5)\(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 $FFFF_h$ or FF 8000 0000_h, 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⊗], [Rw_m⊗]	No	93 Xm 22 0:0qqq	4
CoLOAD-	[IDX_i⊗], [Rw_m⊗]	No	93 Xm 2A 0:0qqq	4
CoLOAD2	[IDX_i⊗], [Rw_m⊗]	No	93 Xm 62 0:0qqq	4
CoLOAD2-	[IDX_i⊗], [Rw_m⊗]	No	93 Xm 6A 0:0qqq	4
CoLOAD	Rw_n, [Rw_m⊗]	No	83 nm 22 0:0qqq	4
CoLOAD-	Rw_n, [Rw_m⊗]	No	83 nm 2A 0:0qqq	4
CoLOAD2	Rw_n, [Rw_m⊗]	No	83 nm 62 0:0qqq	4
CoLOAD2-	Rw_n, [Rw_m⊗]	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 8000_h
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_n, Rw_m	No	A3 nm D0 00	4
CoMAC-	Rw_n, Rw_m	No	A3 nm E0 00	4
CoMAC	Rw_n, Rw_m, rnd	No	A3 nm D1 00	4
CoMACR	Rw_n, Rw_m	No	A3 nm F0 00	4
CoMACR	Rw_n, Rw_m, rnd	No	A3 nm F1 00	4
CoMAC	[IDX_i⊗], [Rw_m⊗]	Yes	93 Xm D0 rrrr:rqqq	4
CoMAC-	[IDX_i⊗], [Rw_m⊗]	Yes	93 Xm E0 rrrr:rqqq	4
CoMAC	[IDX_i⊗], [Rw_m⊗], rnd	Yes	93 Xm D1 rrrr:rqqq	4
CoMACR	[IDX_i⊗], [Rw_m⊗]	Yes	93 Xm F0 rrrr:rqqq	4
CoMACR	[IDX_i⊗], [Rw_m⊗], rnd	Yes	93 Xm F1 rrrr:rqqq	4
CoMAC	Rw_n, [Rw_m⊗]	Yes	83 nm D0 rrrr:rqqq	4
CoMAC-	Rw_n, [Rw_m⊗]	Yes	83 nm E0 rrrr:rqqq	4
CoMAC	Rw_n, [Rw_m⊗], rnd	Yes	83 nm D1rrrr:rqqq	4
CoMACR	Rw_n, [Rw_m⊗]	Yes	83 nm F0 rrrr:rqqq	4
CoMACR	Rw_n, [Rw_m⊗], 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_h
(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_h
(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⊗], [Rw_m⊗]	Yes	93 Xm 10 rrrr:rqqq	4
CoMACu-	[IDX_i⊗], [Rw_m⊗]	Yes	93 Xm 20 rrrr:rqqq	4
CoMACu	[IDX_i⊗], [Rw_m⊗], rnd	Yes	93 Xm 11 rrrr:rqqq	4
CoMACRu	[IDX_i⊗], [Rw_m⊗]	Yes	93 Xm 30 rrrr:rqqq	4
CoMACRu	[IDX_i⊗], [Rw_m⊗], rnd	Yes	93 Xm 31 rrrr:rqqq	4
CoMACu	Rw_n, [Rw_m⊗]	Yes	83 nm 10 rrrr:rqqq	4
CoMACu-	Rw_n, [Rw_m⊗]	Yes	83 nm 20 rrrr:rqqq	4
CoMACu	Rw_n, [Rw_m⊗], rnd	Yes	83 nm 11 rrrr:rqqq	4
CoMACRu	Rw_n, [Rw_m⊗]	Yes	83 nm 30 rrrr:rqqq	4
CoMACRu	Rw_n, [Rw_m⊗], 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$_h$
(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$_h$
(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⊗], [Rw_m⊗]	Yes	93 Xm 90 rrrr:rqqq	4
CoMACus-	[IDX_i⊗], [Rw_m⊗]	Yes	93 Xm A0 rrrr:rqqq	4
CoMACus	[IDX_i⊗], [Rw_m⊗], rnd	Yes	93 Xm 91 rrrr:rqqq	4
CoMACRus	[IDX_i⊗], [Rw_m⊗]	Yes	93 Xm B0 rrrr:rqqq	4
CoMACRus	[IDX_i⊗], [Rw_m⊗], rnd	Yes	93 Xm B1 rrrr:rqqq	4
CoMACus	Rw_n, [Rw_m⊗]	Yes	83 nm 90 rrrr:rqqq	4
CoMACus-	Rw_n, [Rw_m⊗]	Yes	83 nm A0 rrrr:rqqq	4
CoMACus	Rw_n, [Rw_m⊗], rnd	Yes	83 nm 91 rrrr:rqqq	4
CoMACRus	Rw_n, [Rw_m⊗]	Yes	83 nm B0 rrrr:rqqq	4
CoMACRus	Rw_n, [Rw_m⊗], 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) <-- (op1) * (op2)
(ACC) <-- (ACC) + (tmp)

Syntax

CoMACsu op1, op2, rnd

Operation

(tmp) <-- (op1) * (op2)
(ACC) <-- (ACC) + (tmp) + 00 0000 8000_h
(MAL) <-- 0

Syntax

CoMACsu- op1, op2

Operation

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

Syntax

CoMACRsu op1, op2

Operation

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

Syntax

CoMACRsu op1, op2, rnd

Operation

(tmp) <-- (op1) * (op2)
(ACC) <-- (tmp) - (ACC) + 00 0000 8000_h
(MAL) <-- 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⊗], [Rw_m⊗]	Yes	93 Xm 50 rrrr:rqqq	4
CoMACsu-	[IDX_i⊗], [Rw_m⊗]	Yes	93 Xm 60 rrrr:rqqq	4
CoMACsu	[IDX_i⊗], [Rw_m⊗], rnd	Yes	93 Xm 51 rrrr:rqqq	4
CoMACRsu	[IDX_i⊗], [Rw_m⊗]	Yes	93 Xm 70 rrrr:rqqq	4
CoMACRsu	[IDX_i⊗], [Rw_m⊗], rnd	Yes	93 Xm 71 rrrr:rqqq	4
CoMACsu	Rw_n, [Rw_m⊗]	Yes	83 nm 50 rrrr:rqqq	4
CoMACsu-	Rw_n, [Rw_m⊗]	Yes	83 nm 60 rrrr:rqqq	4
CoMACsu	Rw_n, [Rw_m⊗], rnd	Yes	83 nm 51 rrrr:rqqq	4
CoMACRsu	Rw_n, [Rw_m⊗]	Yes	83 nm 70 rrrr:rqqq	4
CoMACRsu	Rw_n, [Rw_m⊗], 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
((IDX_i(-⊗))) <-- ((IDX_i))

Syntax

CoMACM op1, op2, rnd

Operation

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

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
((IDX_i(-⊗))) <-- ((IDX_i))

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
((IDX_i(-⊗))) <-- ((IDX_i))

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_i overwrites another data located in memory (DPRAM). The address of the overwritten data depends on the operation executed on IDX_i, as explained 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
CoMACM	[IDX_i⊗], [Rw_m⊗]	Yes	93 Xm D8 rrrr:rqqq	4
CoMACM-	[IDX_i⊗], [Rw_m⊗]	Yes	93 Xm E8 rrrr:rqqq	4
CoMACM	[IDX_i⊗], [Rw_m⊗], rnd	Yes	93 Xm D9 rrrr:rqqq	4
CoMACMR	[IDX_i⊗], [Rw_m⊗]	Yes	93 Xm F8 rrrr:rqqq	4
CoMACMR	[IDX_i⊗], [Rw_m⊗], rnd	Yes	93 Xm F9 rrrr:rqqq	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) <-- ((op1))*((op2))
(ACC) <-- (ACC) + (tmp)
$((IDX_i(-\otimes)))$ <-- $((IDX_i))$

Syntax

CoMACMu op1, op2, rnd

Operation

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

Syntax

CoMACMu- op1, op2

Operation

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

Syntax

CoMACMRu op1, op2

Operation

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

Syntax

CoMACMRu op1, op2, rnd

Operation

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

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⊗], [Rw_m⊗]	Yes	93 Xm 18 rrrr:rqqq	4
CoMACMu-	[IDX_i⊗], [Rw_m⊗]	Yes	93 Xm 28 rrrr:rqqq	4
CoMACMu	[IDX_i⊗], [Rw_m⊗], rnd	Yes	93 Xm 19 rrrr:rqqq	4
CoMACMRu	[IDX_i⊗], [Rw_m⊗]	Yes	93 Xm 38 rrrr:rqqq	4
CoMACMRu	[IDX_i⊗], [Rw_m⊗], rnd	Yes	93 Xm 39 rrrr:rqqq	4

Examples

```
CoMACMu                 [IDX1+QX0], [R10+QR1], 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) <-- ((op1))*((op2))
(ACC) <-- (ACC) + (tmp)
$((IDX_i(-\otimes)))$ <-- $((IDX_i))$

Syntax

CoMACMus op1, op2, rnd

Operation

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

Syntax

CoMACMus- op1, op2

Operation

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

Syntax

CoMACMRus op1, op2

Operation

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

Syntax

CoMACMRus op1, op2, rnd

Operation

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

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 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$_i$⊗], [Rw$_m$⊗]	Yes	93 Xm 98 rrrr:rqqq	4
CoMACMus-	[IDX$_i$⊗], [Rw$_m$⊗]	Yes	93 Xm A8 rrrr:rqqq	4
CoMACMus	[IDX$_i$⊗], [Rw$_m$⊗], rnd	Yes	93 Xm 99 rrrr:rqqq	4
CoMACMRus	[IDX$_i$⊗], [Rw$_m$⊗]	Yes	93 Xm B8 rrrr:rqqq	4
CoMACMRus	[IDX$_i$⊗], [Rw$_m$⊗], rnd	Yes	93 Xm B9 rrrr:rqqq	4

Examples

CoMACMus	[IDX1+QX0], [R10+QR1], rnd	; (ACC)<--(ACC) + ((IDX1))*((R10)) +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], rnd	; (ACC)<--((IDX1))*((R7))-(ACC)+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) <-- ((op1))*((op2))
(ACC) <-- (ACC) + (tmp)
((IDX_i(-⊗))) <-- ((IDX_i))

Syntax

CoMACMsu op1, op2, rnd

Operation

(tmp) <-- ((op1))*((op2))
(ACC) <-- (ACC) + (tmp) + 00 0000 8000_h
(MAL) <-- 0
((IDX_i(-⊗))) <-- ((IDX_i))

Syntax

CoMACMsu- op1, op2

Operation

(tmp) <-- ((op1))*((op2))
(ACC) <-- (ACC) - (tmp)
((IDX_i(-⊗))) <-- ((IDX_i))

Syntax

CoMACMRsu op1, op2

Operation

(tmp) <-- ((op1))*((op2))
(ACC) <-- (tmp) - (ACC)
((IDX_i(-⊗))) <-- ((IDX_i))

Syntax

CoMACMRsu op1, op2, rnd

Operation

(tmp) <-- ((op1))*((op2))
(ACC) <-- (tmp) - (ACC) + 00 0000 8000_h
(MAL) <-- 0
((IDX_i(-⊗))) <-- ((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⊗], [Rw_m⊗]	Yes	93 Xm 58 rrrr:rqqq	4
CoMACMsu-	[IDX_i⊗], [Rw_m⊗]	Yes	93 Xm 68 rrrr:rqqq	4
CoMACMsu	[IDX_i⊗], [Rw_m⊗], rnd	Yes	93 Xm 59 rrrr:rqqq	4
CoMACMRsu	[IDX_i⊗], [Rw_m⊗]	Yes	93 Xm 78 rrrr:rqqq	4
CoMACMRsu	[IDX_i⊗], [Rw_m⊗], rnd	Yes	93 Xm 79 rrrr:rqqq	4

Example

```
CoMACMsu                      [IDX1+QX0], [R10+QR1], rnd ; (ACC)<-- (ACC)+((IDX1))*((R10)) + rnd
                                                         ; (R10) <-- (R10) + (QR1)
                                                         ; ( ((IDX1) -(QX0)) ) <-- ((IDX1))
                                                         ; (IDX1) <-- (IDX1) + (QX0)
Repeat 3 times CoMACMsu        [IDX0 - QX0], [R8+QR0], rnd ; (ACC) <-- (ACC) + ((IDX0))*((R8))
                                                         ; (R8) <-- (R8) + (QR0)
                                                         ; ( ((IDX0) + (QX0)) )<-- ((IDX0))
                                                         ; (IDX0) <-- (IDX0) - (QX0)
Repeat MRW times CoMACMRsu [IDX1+QX1], [R7 - QR0], rnd  ; (ACC) <-- ((IDX1))*((R7)) - (ACC) + 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_n, Rw_m	No	A3 nm 3A 00	4
CoMAX	[IDX_i⊗], [Rw_m⊗]	Yes	93 Xm 3A rrrr:rqqq	4
CoMAX	Rw_n, [Rw_m⊗]	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_n, Rw_m	No	A3 nm 7A 00	4
CoMIN	[IDX_i⊗], [Rw_m⊗]	Yes	93 Xm 7A rrrr:rqqq	4
CoMIN	Rw_n, [Rw_m⊗]	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, IDX_i 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_i⊗], [Rw_m⊗]	Yes	D3 Xm 00 rrrr:rqqq	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_h
ELSE
    (ACC) <-- (op1) * (op2) + 00 0000 8000_h
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_h by 8000_h multiplication.
SL	Not affected when MP or MS are cleared, otherwise, only set in case of 8000_h by 8000_h 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_h	8000_h	0	00_h	4000_h	0000_h	0	0	0	-	0	-
MP=1, MS=0			0	00_h	8000_h	0000_h	0	0	0	-	1	-
MP=1, MS=1			0	00_h	$7FFF_h$	$FFFF_h$	0	0	0	-	0	1
MP=0, MS=x	$7FFF_h$	$7FFF_h$	0	00_h	$3FFF_h$	0001_h	0	0	0	-	0	-
MP=1, MS=x			0	00_h	$7FFE_h$	0002_h	0	0	0	-	0	-
MP=1, MS=x			1	00_h	$7FFE_h$	0000_h	0	0	0	-	0	-
MP=0, MS=x	4001_h	$F456_h$	0	FF_h	$FD15_h$	7456_h	1	0	0	-	0	-
MP=1, MS=x			0	FF_h	$FA2A_h$	$E8AC_h$	1	0	0	-	0	-
MP=0, MS=x			1	FF_h	$FD15_h$	0000_h	1	0	0	-	0	-
MP=1, MS=x			1	FF_h	$FA2B_h$	0000_h	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_h
(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_h	8000_h	x	00_h	4000_h	0000_h	0	0	0	-	0	-
MP=x, MS=x	$7FFF_h$	$7FFF_h$	0	00_h	$3FFF_h$	0001_h	0	0	0	-	0	-
			1	00_h	$3FFF_h$	0000_h	0	0	0	-	0	-
MP=x, MS=x	8001_h	$F456_h$	0	00_h	$7A2B_h$	$F456_h$	0	0	0	-	0	-
			1	00_h	$7A2C_h$	0000_h	0	0	0	-	0	-
MP=x, MS=x	$FFFF_h$	$FFFF_h$	0	00_h	$FFFE_h$	0001_h	0	0	0	-	0	-
			1	00_h	$FFFE_h$	0000_h	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_h
(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⊗], [Rw_m⊗]	No	93 Xm 80 0:0qqq	4
CoMULus-	[IDX_i⊗], [Rw_m⊗]	No	93 Xm 88 0:0qqq	4
CoMULus	[IDX_i⊗], [Rw_m⊗], rnd	No	93 Xm 81 0:0qqq	4
CoMULus	Rw_n, [Rw_m⊗]	No	83 nm 80 0:0qqq	4
CoMULus-	Rw_n, [Rw_m⊗]	No	83 nm 88 0:0qqq	4
CoMULus	Rw_n, [Rw_m⊗], 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_h	8000_h	x	FF_h	$C000_h$	0000_h	1	0	0	-	0	-
MP=x, MS=x	$7FFF_h$	$7FFF_h$	0	00_h	$3FFF_h$	0001_h	0	0	0	-	0	-
			1	00_h	$3FFF_h$	0000_h	0	0	0	-	0	-
MP=x, MS=x	8001_h	$F456_h$	0	FF_h	$FA2A_h$	$F456_h$	1	0	0	-	0	-
			1	FF_h	$FA2B_h$	0000_h	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_h
(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$_i$⊗], [Rw$_m$⊗]	No	93 Xm 40 0:0qqq	4
CoMULsu-	[IDX$_i$⊗], [Rw$_m$⊗]	No	93 Xm 48 0:0qqq	4
CoMULsu	[IDX$_i$⊗], [Rw$_m$⊗], rnd	No	93 Xm 41 0:0qqq	4
CoMULsu	Rw$_n$, [Rw$_m$⊗]	No	83 nm 40 0:0qqq	4
CoMULsu-	Rw$_n$, [Rw$_m$⊗]	No	83 nm 48 0:0qqq	4
CoMULsu	Rw$_n$, [Rw$_m$⊗], 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$_h$	8000$_h$	x	FF$_h$	C000$_h$	0000$_h$	1	0	0	-	0	-
MP=x, MS=x	7FFF$_h$	7FFF$_h$	0	00$_h$	3FFF$_h$	0001$_h$	0	0	0	-	0	-
			1	00$_h$	3FFF$_h$	0000$_h$	0	0	0	-	0	-
MP=x, MS=x	8001$_h$	F456$_h$	0	FF$_h$	85D5$_h$	F456$_h$	1	0	0	-	0	-
			1	FF$_h$	85D6$_h$	0000$_h$	1	0	0	-	0	-

CoNEG

Negate Accumulator with Optional Rounding

Group

32-bit Arithmetic Instructions

Syntax

CoNEG
CoNEG rnd

Operation

IF (rnd) THEN
(ACC) <-- 0 - (ACC) + 00 0000 8000_h
(MAL) <-- 0
ELSE
(ACC) <-- 0 - (ACC)
END IF

Data Types

ACCUMULATOR

Result

40-bit signed value

Description

The 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 $FFFF_h$ or FF 8000 0000_h, respectively. This instruction is not repeatable

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 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
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_h	FF EDCB $A988_h$	1	0	0	-	0	-
CoNEG	x	Yes	00 1234 5678_h	FF EDCC 0000_h	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_m⊗]	Yes	93 1m 5A rrrr:rqqq	4
CoNOP	[IDX_i⊗], [Rw_m⊗]	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_h
(MAL) <-- 0

Data Types

ACCUMULATOR

Result

40-bit signed value

Description

Rounds the ACC register contents by adding 0000 8000h 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 $FFFF_h$ or FF 8000 0000_h, 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) $\neq$ 0
    (C) <-- (ACC_{39})
    (ACC_n) <-- (ACC_{n-1}) [n=1...39]
    (ACC_0) <-- 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 $FFFF_h$ or FF 8000 0000_h, 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_n	Yes	A3 nn 8A rrrr:r000	4
CoSHL	$\#data_5$	No	A3 00 82 ssss:s000	4
CoSHL	$[Rw_m \otimes]$	Yes	83 mm 8A rrrr:rqqq	4

Examples

CoSHL	#3	; (ACC) <-- (ACC) << 3
CoSHL	R3	; (ACC) <-- (ACC) << $(R3)_{4-0}$
CoSHL	[R10 - QR0]	; (ACC) <-- (ACC) << $((R10))_{4-0}$
		; (R10) <-- (R10) - (QR0)

CoSHR — Accumulator Logical Shift Right

Group

Shift Instructions

Syntax

CoSHR op1

Operation

(count) <-- (op1)
(C) <-- 0
DO WHILE (count) $\neq$ 0
    ((ACC_n) <-- (ACC_{n+1})   [n=0-38]
    (ACC_{39}) <-- 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_n	Yes	A3 nn 9A rrrr:r000	4
CoSHR	$\#data_5$	No	A3 00 92 ssss:s000	4
CoSHR	$[Rw_m \otimes]$	Yes	83 mm 9A rrrr:rqqq	4

Examples

```
CoSHR   #3            ; (ACC) <-- (ACC) >> 3
CoSHR   R3            ; (ACC) <-- (ACC) >> (R3)4-0
CoSHR   [R10 - QR0]   ; (ACC) <-- (ACC) >> ((R10))4-0
                      ; (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 wwww:w000 00	4
CoSTORE	[Rw_n⊗], CoReg	Yes	B3 nn wwww: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 $FFFF_h$ or FF 8000 0000_h, 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⊗], [Rw_m⊗]	Yes	93 Xm 0A rrrr:rqqq	4
CoSUBR	[IDX_i⊗], [Rw_m⊗]	Yes	93 Xm 12 rrrr:rqqq	4
CoSUB2	[IDX_i⊗], [Rw_m⊗]	Yes	93 Xm 4A rrrr:rqqq	4
CoSUB2R	[IDX_i⊗], [Rw_m⊗]	Yes	93 Xm 52 rrrr:rqqq	4
CoSUB	Rw_n, [Rw_m⊗]	Yes	83 nm 0A rrrr:rqqq	4
CoSUBR	Rw_n, [Rw_m⊗]	Yes	83 nm 12 rrrr:rqqq	4
CoSUB2	Rw_n, [Rw_m⊗]	Yes	83 nm 4A rrrr:rqqq	4
CoSUB2R	Rw_n, [Rw_m⊗]	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	$183A_h$	$72AC_h$	00 7FFF $FFFF_h$	00 0D53 $E7C5_h$	0	0	0	-	0	-
CoSUBR	x	$183A_h$	$72AC_h$	00 7FFF $FFFF_h$	FF F2AC $183B_h$	1	0	1	-	0	-
CoSUB2	x	$0C1D_h$	3956_h	00 E604 5564_h	00 7358 $3D2A_h$	0	0	0	-	0	-
CoSUB2R	x	$0C1D_h$	3956_h	00 E604 5564_h	FF 8CA7 $C2D6_h$	1	0	1	-	0	-
CoSUB	0	$FFFF_h$	$FFFF_h$	7F FFFF $FFFF_h$	80 0000 0000_h	1	0	1	1	1	-
	1				00 7FFF $FFFF_h$	0	0	1	1	0	1
CoSUB2	0	0000_h	3000_h	7F FFFF $FFFF_h$	7F 9FFF $FFFF_h$	0	0	0	-	1	-
CoSUB2	0	0001_h	0000_h	80 0000 0000_h	7F FFFF $FFFE_h$	0	0	0	1	1	-
	1				FF 8000 0000_h	1	0	0	1	0	1

3 Revision History

Document revision history

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

Revision 5—Revision 4		Current document (7096626A) is a reformatted version of document 42-1735-05. r -> R: In MAC instructions, upper case R has replaced lower case r for Reverse operation. #data$_4$ -> #data$_5$: In MAC instructions, immediate shift value uses 5 bits to be coded, not 4. Table 30: Function codes for Instr. CoMACMus, Instr. CoMACMus-, Instr. CoMACMus rnd, and Instr. CoMACR are 98, A8, 99, and F9 respectively. The mneumonics and formats of the following addressing modes of Instr. CoMACM(R)su(-) are: CoMACRsu [IDX$_i$⊗], [Rw$_m$⊗] — 93 Xm 70 rrrr:rqqq CoMACRsu [IDX$_i$⊗], [Rw$_m$⊗], rnd — 93 Xm 71 rrrr:rqqq CoMACRsu Rw$_n$, [Rw$_m$⊗], rnd — 93 Xm 71 rrrr:rqqq Correction in Multiplication examples CoMULu(-) and coMULus(-) For instructions BMOV, BMOVN, JNBS, MUL, MULU, SUBCB: Flag Z, Z, Z, N, N, and Z corrected.
Jan 2000	Rev 6	First EDOCs release Section 1.1.4: *Indirect addressing modes*: See 1, 3, 4, and 5 respectively: GPRAddress = (CP + 2 x ShortAddress), LongAddress = (GPRAddress) + Constant), PhysicalAddress = (DPPi) + LongAddress ^ 3FFFh, and (GPRPAddress) = (GPRDAddress) + Δ. See Section 1.2.3: *Additional state times*: ‘Jumps into the internal ROM Space :...’ example code. Section 1.4: *Instruction set ordered by functional group*: See teh columns Table 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, and 19. All column 16 bit N-MUX, 16 bit MUX, 8 bit N-MUX, 8 bit MUX.
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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