

Am29116

A High-Performance 16-Bit Bipolar Microprocessor

Am29116

PRELIMINARY

DISTINCTIVE CHARACTERISTICS

- **Optimized for High-Performance Controllers**
Excellent solution for applications requiring speed and bit-manipulation power.
- **Fast**
Supports 100ns microcycle time/10MHz data rate for all instructions.
- **16-Bit Barrel Shifter**
Contains a 16-bit Barrel Shifter which can shift or rotate a word up to 15 positions in a single instruction cycle.
- **Immediate Instruction Capability**
May be used for storing constants in microcode or for configuring a second data port.
- **Powerful Field Insertion/Extraction and Bit Manipulation Instructions**
Rotate and Merge, Rotate and Compare and bit manipulation instructions provided for complex bit control.
- **32-Working Registers**
Single port RAM may be configured to accept different source and destination addresses within single cycle.
- **52-Pin Hermetic DIP**

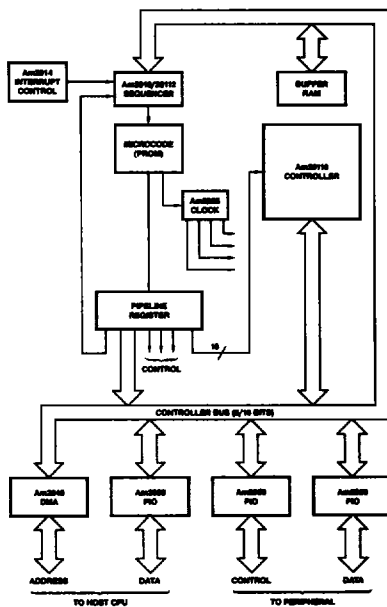
GENERAL DESCRIPTION

The Am29116 is a microprogrammable 16-bit bipolar microprocessor whose architecture and instruction set is optimized for high performance peripheral controllers, like graphics controllers, disk controllers, communications controllers, front-end concentrators and modems. The device also performs well in microprogrammed processor applications, especially when combined with the Am29517 16 x 16

multiplier (65ns worst-case 16 x 16 multiply). In addition to its complete arithmetic and logic instruction set, the Am29116 instruction set contains functions particularly useful in controller applications; bit set, bit reset, bit test, rotate and merge, rotate and compare, and cyclic-redundancy-check (CRC) generation.

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BLOCK DIAGRAM



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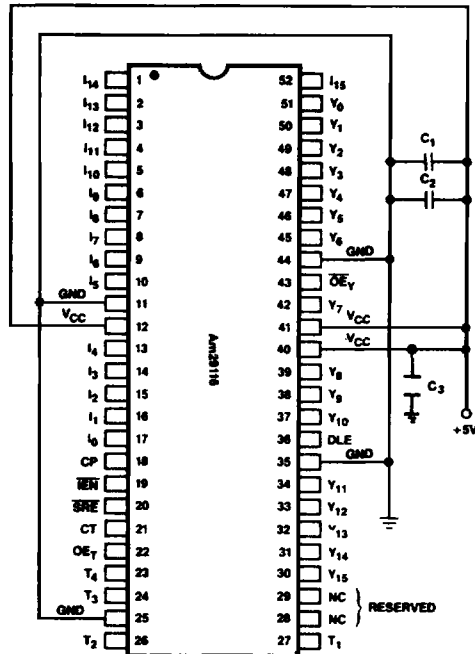
Am29116 BASED HIGH PERFORMANCE PERIPHERAL CONTROLLER

02112C

RELATED PRODUCTS

OTHER LITERATURE

- An Intelligent Fast Disk Controller using the Am29116 Application Note.
- A Microprogrammed CPU Using the Am29116 Application Note.

V_{CC} AND GROUND PIN CONNECTIONS

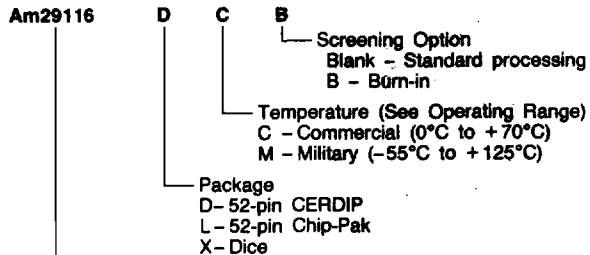
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- Notes: 1. All V_{CC} and all GND pins must be connected as shown. Offsets between any two V_{CC} pins or between any two GND pins should be avoided.
 2. C₁ = 1.0μF, C₂ = C₃ = 0.01μF.

The C₁, C₂, and C₃ capacitors should be used to shunt low- and high-frequency noise from V_{CC}. Do not replace with one capacitor.

ORDERING INFORMATION

AMD products are available in several packages and operating ranges. The order number is formed by a combination of the following: Device number, speed option (if applicable), package type, operating range and screening option (if desired).



Device type
A High-Performance 16-Bit Bipolar Microprocessor

Valid Combinations

Valid Combinations	
Am29116	DC, DCB, DMB LC, LMB XC, XM

Valid Combinations

Consult the AMD sales office in your area to determine if a device is currently available in the combination you wish.

PIN DESCRIPTION			
Pin No.	Name	I/O	Description
	Y ₀ -Y ₁₅	I/O	Data Input/Output Lines. When OE _Y is HIGH, Y ₀ -Y ₁₅ are used as external data inputs which allow data to be directly loaded into the 16-bit data latch. Having OE _Y LOW allows the ALU data to be output on Y ₀ -Y ₁₅ .
36	DLE	I	Data Latch Enable. When DLE is HIGH, the 16-bit data latch is transparent and is latched when DLE is LOW.
43	OE _Y	I	Output Enable. When OE _Y is HIGH, the 16-bit Y outputs are disabled (high-impedance); when OE _Y is LOW, the 16-bit Y outputs are enabled (HIGH or LOW).
	I ₀ -I ₁₅	I	Sixteen instruction Inputs. Used to select the operations to be performed in the Am29116. Also used as data inputs while performing immediate instructions.
19	IEN	I	Instruction Enable. With IEN LOW, data can be written into the RAM when the clock is LOW. The Accumulator can accept data during the LOW-HIGH transition of the clock. Having IEN LOW, the Status Register can be updated when SRE is LOW. With IEN HIGH, the conditional test output, CT, is disabled as a function of the instruction inputs. IEN should be LOW for the first half of the first cycle of an immediate instruction.
20	SRE		Status Register Enable. When SRE and IEN are both LOW, the Status Register is updated at the end of all instructions with the exception of NO-OP, Save Status, and Test Status. Having either SRE or IEN HIGH will inhibit the Status Register from changing.
18	CP	I	Clock Pulse. The clock input to the Am29116. The RAM latch is transparent when the clock is HIGH. When the clock goes LOW, the RAM output is latched. Data is written into the RAM during the low period of the clock provided IEN is LOW and if the instruction being executed designates the RAM as the destination of operation. The Accumulator and Status Register will accept data on the LOW-HIGH transition of the clock if IEN is also LOW. The instruction latch becomes transparent when it exits an immediate instruction mode during a LOW-HIGH transition of the clock.
27, 26, 24, 23	T ₁ -T ₄	I/O	Input/Output Pin. Under the control of OE _T , the four lower status bits Z, C, N, OVR become outputs on T ₁ -T ₄ , respectively when OE _T goes HIGH. When OE _T is LOW, T ₁ -T ₄ are used as inputs to generate the CT output.
22	OE _T	I	Output Enable. When OE _T is LOW, the 4-bit T outputs are disabled (high-impedance); when OE _T is HIGH, the 4-bit T outputs are enabled (HIGH or LOW).
21	CT	O	Conditional Test. The condition code multiplexer selects one of the twelve condition code signals and places them on the CT output. A HIGH on the CT output indicates a passed condition and a LOW indicates a failed condition.

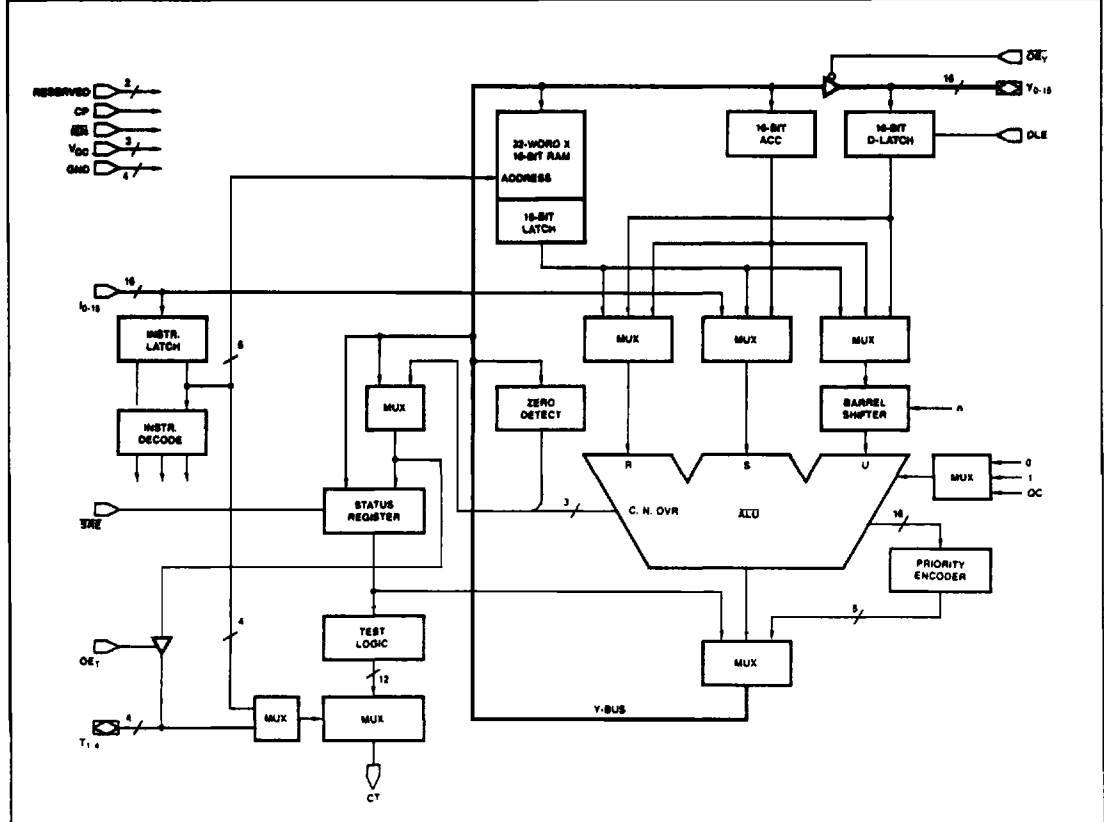


Figure 1. Detailed Am29116 Block Diagram.

BD001960

ARCHITECTURE OF THE Am29116

The Am29116 is a high-performance, microprogrammable 16-bit bipolar microprocessor.

As shown in the Block Diagram, Figure 1, the device consists of the following elements interconnected with 16-bit data paths.

- 32-Word by 16-Bit RAM
- Accumulator
- Data Latch
- Barrel Shifter
- ALU
- Priority Encoder
- Status Register
- Condition-Code Generator/Multiplexer
- Three-State Output Buffers
- Instruction Latch and Decoder

32-Word by 16-Bit RAM

The 32-Word by 16-Bit RAM is a single-port RAM with a 16-bit latch at its output. The latches are transparent when the clock input (CP) is HIGH and latched when the clock input is LOW. Data is written into the RAM while the clock is LOW if the IEN input is also LOW and if the instruction being executed defines the RAM as the destination of the operation. For byte instructions, only the lower eight RAM bits are written into; for word instructions, all 16 bits are written into. With the use of an external multiplexer on five of the instruction inputs, it is possible to select separate read and write addresses for the same instruction. This two-address operation is not allowed for immediate instructions.

Accumulator

The 16-bit Accumulator is an edge-triggered register. The Accumulator accepts data on the LOW-to-HIGH transition of the clock input if the IEN input is LOW and if the instruction being executed defines the Accumulator as the destination of the operation. For byte instructions, only the lower eight bits of the Accumulator are written into; for word instructions, all 16 bits are written into.

Data Latch

The 16-bit Data Latch holds the data input to the Am29116 on the bi-directional Y bus. The latch is transparent when the DLE input is HIGH and latched when the DLE input is LOW.

Barrel Shifter

A 16-bit Barrel Shifter is used as one of the ALU inputs. This permits rotating data from either the RAM, the Accumulator or the Data Latch up to 15 positions. In the word mode, the Barrel Shifter rotates a 16-bit word; in the byte mode, it rotates only the lower eight bits.

Arithmetic Logic Unit

The Am29116 contains a 16-bit ALU with full carry lookahead across all 16 bits in the arithmetic mode. The ALU is capable of operating on either one, two or three operands, depending upon the instruction being executed. It has the ability to execute all conventional one and two operand operations, such as pass, complement, two's complement, add, subtract, AND, NAND, OR, NOR, EXOR, and EX-NOR. In addition, the ALU can also execute three-operand instructions such as rotate and merge and rotate and compare with mask. All ALU operations can be performed on either a word or byte basis, byte operations being performed on the lower eight bits only.

The ALU produces three status outputs, C (carry), N (negative) and OVR (overflow). The appropriate flags are generated at

the byte or word level, depending upon whether the device is executing in the byte or word mode. The Z (zero) flag, although not generated by the ALU, detects zero at both the byte and word level.

The carry input to the ALU is generated by the Carry Multiplexer which can select an input of zero, one, or the stored carry bit from the Status Register, QC. Using QC as the carry input allows execution of multiprecision addition and subtractions.

Priority Encoder

The Priority Encoder produces a binary-weighted code to indicate the locations of the highest order ONE at its input. The input to the Priority Encoder is generated by the ALU which performs an AND operation on the operand to be prioritized and a mask. The mask determines which bit locations to eliminate from prioritization. In the word mode, if no bit is HIGH, the output is a binary zero. If bit 15 is HIGH, the output is a binary one. Bit 14 produces a binary two, etc. Finally, if only bit 0 is HIGH, a binary 16 is produced.

In the byte mode, bits 8 thru 15 do not participate. If none of bits 7 thru 0 are HIGH, the output is a binary zero. If bit 7 is HIGH a binary one is produced. Bit 6 produces a binary two, etc. Finally, if only bit 0 is HIGH, a binary 8 is produced.

Status Register

The Status Register holds the 8-bit status word. With the Status-Register Enable, (SRE) input LOW and the IEN input LOW, the Status Register is updated at the end of all instructions except NO-OP, Save-Status and Test-Status instructions. SRE going HIGH or IEN going HIGH inhibits the Status Register from changing.

The lower four bits of the Status Register contain the ALU status bits of Zero (Z), Carry, (C) Negative (N), and Overflow (OVR). The upper four bits contain a Link bit and three user-definable status bits (Flag 1, Flag 2, Flag 3).

With SRE LOW and IEN LOW, the lower four status bits are updated after each instruction except those mentioned above, NO-OP, Save Status, Status Test and the Status Set/Reset instruction for the upper four bits. Under the same conditions, the upper four status bits are changed only during their respective Status Set/Reset instructions and during Status Load instructions in the word mode. The Link-Status bit is also updated after each shift instruction.

The Status Register can be loaded from the internal Y-bus, and can also be selected as a source for the internal Y-bus. When the Status Register is loaded in the word mode, all 8-bits are updated; in the byte mode, only the lower 4 bits (Z, C, N, OVR) are updated.

When the Status Register is selected as a source in the word mode, all eight bits are loaded into the lower byte of the destination; the upper byte of the destination is loaded with all zeros. In the byte mode, the Status Register again loads into the lower byte of the destination, but the upper byte remains unchanged. This Store and Load combination allows saving the restoring the Status Register for interrupt and subroutine processing. The four lower status bits (Z, C, N, OVR) can be read directly via the bidirectional T bus. These four bits are available as outputs on the T₁₋₄ outputs whenever OE_T is HIGH.

Condition-Code Generator/Multiplexer

The Condition-Code Generator/Multiplexer contains the logic necessary to develop the 12 condition-code test signals. The

multiplexer portion can select one of these test signals and place it on the CT output for use by the microprogram sequence. The multiplexer may be addressed in two different ways. One way is through the Test Instruction. This instruction specifies the test condition to be placed in the CT output, but does not allow an ALU operation at the same time. The second method uses the bidirectional T bus as an input. This requires extra bits in the microword, but provides the ability to simultaneously test and execute. The test instruction lines, I₀₋₄, have priority over T₁₋₄ for testing status.

Three-State Output Buffers

There are two sets of Three-State Output Buffers in the Am29116. One set controls the bidirectional, 16-bit Y bus. These outputs are enabled by placing a LOW on the OE input. A HIGH puts the Y outputs in the high-impedance state, allowing data to be input to the Data latch from an external source.

The second set of Three-State Output Buffers controls the bidirectional 4-bit T bus and is enabled by placing a HIGH on the OE_T input. This allows storing the four internal ALU status

bits (Z, C, N, OVR) externally. A LOW OE_T input forces the T outputs into the high-impedance state. External devices can then drive the T bus to select a test condition for the CT output.

Instruction Latch and Decoder

The 16-bit Instruction Latch is normally transparent to allow decoding of the Instruction Inputs by the Instruction Decoder into the internal control signals for the Am29116. All instructions except Immediate Instructions are executed in a single clock cycle.

Immediate instructions require two clock cycles for execution. During the first clock cycle, the Instruction Decoder recognizes that an Immediate Instruction is being specified and captures the data on the Instruction Inputs in the Instruction Latch. During the second clock cycle, the data on the Instruction Inputs is used as one of the operands for the function specified during the first clock cycle. At the end of the second clock cycle, the Instruction Latch is returned to its transparent state.

INSTRUCTION SET

The instruction set of the Am29116 is very powerful. In addition to the single and two operand logical and arithmetic instructions, the Am29116 instruction set contains functions particularly useful in controller applications: bit set, bit reset, bit test, rotate and merge, rotate and compare, and cyclic-redundancy-check (CRC) generation. Complex instructions like rotate and merge, rotate and compare, and prioritize are executed in a single microcycle.

Three data types are supported by the Am29116.

- Bit
- Byte
- Word (16-bit)

In the byte mode data is written into the lower half of the word and the upper half is unchanged. The special case is when the status register is specified as the destination. In the byte mode the LSH (OVR, N, C, Z) of the status register is updated and in the word mode all eight bits of the status register are updated. The status register does not change for save status and test status instructions. In the test status instructions the CT output has the result and the Y-bus is undefined.

The Am29116 Instruction Set can be divided into eleven types of instructions. These are:

- | | |
|--------------------|---------------------------|
| ● Single Operand | ● Rotate and Compare |
| ● Two Operand | ● Prioritize |
| ● Single Bit Shift | ● Cyclic-Redundancy-Check |
| ● Rotate and Merge | ● Status |
| ● Bit Oriented | ● No-Op |
| ● Rotate by n Bits | |

Each instruction type is arbitrarily divided into quadrants. Two of the sixteen instruction lines decode to four quadrants labelled from 0 to 3. The quadrants were defined mainly for convenience in classification of the instruction set and addressing modes and can be used together with the OP CODES to distinguish the instructions.

The following pages describe each of the instruction types in detail. Throughout the description OE_Y is assumed to be LOW allowing ALU outputs on the Y-bus.

Table 1 illustrates operand source-destination combinations for each instruction type.

TABLE 1. OPERAND SOURCE DESTINATION COMBINATIONS

Instruction Type	Operand Combinations (Note 1)		
	Source (R/S)	Destination	
Single Operand	RAM (Note 2) ACC D D(0E) D(SE) I 0	RAM ACC Y Bus Status ACC and Status	
	Source (R) | Source (S)	Destination	
	RAM | ACC RAM | I D | RAM D | ACC ACC | I D | I	RAM ACC Y Bus Status ACC and Status	
	Source (U)	Destination	
	RAM ACC ACC D D D	RAM ACC Y Bus RAM ACC Y Bus	
Rotate n Bits	Source (U)	Destination	
	RAM ACC D	RAM ACC Y Bus	
Bit Oriented	Source (R/S)	Destination	
	RAM ACC D	RAM ACC Y Bus	
Rotate and Merge	Rotated Source (U)	Mask (S)	Non-Rotated Source/ Destination (R)
	D D D D ACC RAM	| RAM | ACC | |	ACC ACC RAM RAM RAM ACC
	Rotated Source (U)	Mask (S)	Non-Rotated Source/ Destination (R)
	D D D RAM	| | ACC |	RAM RAM ACC

Instruction Type	Operand Combinations (Note 1)		
	Source (R)	Mask (S)	Destination
Prioritize (Note 3)	RAM ACC D	RAM ACC I 0	RAM ACC Y Bus
	Data In	Destination	Polynomial
Cyclic Redundancy Check	QLINK	RAM	ACC
No Operation	-		
Set Reset Status	Bits Affected		
	OVR, N, C, Z LINK Flag1 Flag2 Flag3		
	Source	Destination	
Store Status	Status	RAM ACC Y Bus	
	Source (R)	Source (S)	Destination
Status Load	D ACC D	ACC I I	Status Status and ACC
	Test Condition (CT)		
Test Status	(N⊕OVR) + Z N⊕OVR Z OVR Low C Z + C̄ N LINK Flag 1 Flag 2 Flag 3		

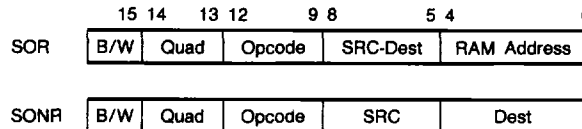
- Notes: 1. When there is no dividing line between the R&S OPERAND or SOURCE and DESTINATION, the two must be used as a given pair. But where there exists such a separation, any combination of them is possible.
2. In the SINGLE OPERAND INSTRUCTION, RAM cannot be used when both ACC and STATUS are designated as a DESTINATION.
3. In the PRIORITIZE INSTRUCTION, OPERAND and MASK must be different sources.

SINGLE OPERAND INSTRUCTIONS

The Single Operand Instructions contain four indicators: byte or word mode, opcode, source and destination. They are further subdivided into two types. The first type uses RAM as a source or destination or both, and the second type does not use RAM as a source or destination. Both types have different instruction formats as shown below. Under the control of instruction inputs, the desired function is performed on the source and the result is either stored in the specified destination or placed on the Y-bus or both. For a special case where

8-bit to 16-bit conversion is needed, the Am29116 is capable of extending sign bit (D(SE)) or binary zero (D(OE)) over 16-bits in the word mode. The least significant four bits of the Status Register (OVR, N, C, Z) are affected by the function performed in this category. The most significant bits of status register (FLAG1, FLAG2, FLAG3, LINK) are not affected. The only limitation in this type is that the RAM cannot be used as a source when both ACC and the Status Register are specified as a destination.

SINGLE OPERAND FIELD DEFINITIONS



SINGLE OPERAND INSTRUCTION

Instruction ¹	B/W ²	Quad ³	Opcode	R/S ⁴ Dest ⁴	RAM Address
SOR	0 = B 1 = W	10	1100 MOVE SRC _ Dest	0000 SORA RAM ACC	00000 R00 RAM Reg 00
			1101 COMP SRC _ Dest	0010 SORY RAM Y Bus	...
			1110 INC SRC + 1 _ Dest	0011 SORS RAM Status	11111 R31 RAM Reg 31
			1111 NEG SRC + 1 _ Dest	0100 SOAR ACC RAM	
				0110 SODR D RAM	
	0111 SOIR I RAM				
	1000 SOZR 0 RAM				
	1001 SOZER D(OE) RAM				
	1010 SOSER D(SE) RAM				
	1011 SORR RAM RAM				
Instruction	B/W	Quad	Opcode	R/S ⁴	Destination
SONR	0 = B 1 = W	11	1100 MOVE SRC _ Dest	0100 SOA ACC	00000 NRY Y Bus
			1101 COMP SRC _ Dest	0110 SOD D	00001 NRA ACC
			1110 INC SRC + 1 _ Dest	0111 SOI I	00100 NRS Status ⁵
			1111 NEG SRC + 1 _ Dest	1000 SOZ 0	00101 NRAS ACC, Status ⁵
				1001 SOZE D(OE)	
	1010 SOSE D(SE)				

- Notes:
1. The instruction mnemonic designates different instruction formats used in the Am29116. They are useful in assembly microcode with the System 29 AMDASM™ meta assembler.
 2. B = Byte Mode, W = Word Mode.
 3. See Instruction Set description.
 4. R = Source; S = Source; Dest = Destination.
 5. When status is destination,
Status i - Yi i = 0 to 3 (Byte mode)
i = 0 to 7 (Word mode)

Y BUS AND STATUS - SINGLE OPERAND INSTRUCTIONS

Instruction	Opcode	Description	B/W	Y - Bus	Flag3	Flag2	Flag1	LINK	OVR	N	C	Z
SOR	MOVE	SRC _ Dest	0 = B	Y _ SRC	NC	NC	NC	NC	0	U	0	U
	COMP	SRC _ Dest	1 = W	Y _ SRC	NC	NC	NC	NC	0	U	0	U
SONR	INC	SRC + 1 _ Dest		Y _ SRC + 1	NC	NC	NC	NC	U	U	U	U
	NEG	SRC + 1 _ Dest		Y _ SRC + 1	NC	NC	NC	NC	U	U	U	U

SRC = Source
U = Update
NC = No Change

0 = Reset
1 = Set
i = 0 to 15 when not specified

6

TWO OPERAND INSTRUCTIONS

The Two Operand Instructions contain five indicators: byte or word mode, opcode, R source, S source, and destination. They are further subdivided into two types. The first type uses RAM as the source and/or destination and the second type does not use RAM as source or destination. The first type has two formats; the only difference is in the quadrant. Under the control of instruction inputs, the desired function is performed on the specified sources and the result is stored in the

specified destination or placed on the Y-bus or both. The least significant four bits of the status register (OVR, N, C, Z) are affected by the arithmetic functions performed and only the N and Z bits are affected by the logical functions performed. The OVR and C bits of the status register are forced to ZERO for logical functions. Add with carry and Subtract with carry instructions are useful for Multiprecision Add or Subtract.

TWO OPERAND FIELD DEFINITIONS

	15	14	13	12	9	8	5	4	0	
TOR1	B/W		Quad		SRC-SRC -Dest		Opcode		RAM Address	
TOR2	B/W		Quad		SRC-SRC -Dest		Opcode		RAM Address	
TONR	B/W		Quad		SRC-SRC		Opcode		Dest	

TWO OPERAND INSTRUCTIONS

Instruction	B/W	Quad	R ¹	S ¹	Dest ¹	Opcode	RAM Address		
TOR1	0 = B 1 = W	00	0000	TORAA	RAM	ACC	ACC	0000 SUBR S minus R	00000 R00 RAM Reg 00
			0010	TORIA	RAM	I	ACC	0001 SUBRC ² S minus R	.. .. .
			0011	TODRA	D	RAM	ACC	with carry	11111 R31 RAM Reg 31
			1000	TORAY	RAM	ACC	Y Bus	0010 SUBS R minus S	
			1010	TORIY	RAM	I	Y Bus	0011 SUBSC ² R minus S	
			1011	TODRY	D	RAM	Y Bus	with carry	
			1100	TORAR	RAM	ACC	RAM	0100 ADD R plus S	
			1110	TORIR	RAM	I	RAM	0101 ADDC R plus S	
			1111	TODRR	D	RAM	RAM	with carry	
								0110 AND R . S	
								0111 NAND R . S	
								1000 EXOR R ⊕ S	
								1001 NOR R + S	
					1010 OR R + S				
					1011 EXNOR R ⊕ S				
TOR2	0 = B 1 = W	10	0001	TODAR	D	ACC	RAM	0000 SUBR S minus R	00000 R00 RAM Reg 00
			0010	TOAIR	ACC	I	RAM	0001 SUBRC ² S minus R	.. .. .
			0101	TODIR	D	I	RAM	with carry	11111 R31 RAM Reg 31
								0010 SUBS R minus S	
								0011 SUBSC ² R minus S	
								with carry	
								0100 ADD R plus S	
					0101 ADDC R plus S				
					with carry				
					0110 AND R . S				
					0111 NAND R . S				
					1000 EXOR R ⊕ S				
					1001 NOR R + S				
					1010 OR R + S				
					1011 EXNOR R ⊕ S				

Note 1: R = Source

S = Source

Dest = Destination

Note 2: During subtraction the carry is interpreted as borrow.

TWO OPERAND INSTRUCTIONS

Instruction	B/W	Quad	R ¹	S ¹	Opcode			Destination				
TONR	0 = B	11	0001	TODA	D	ACC	0000	SUBR	S minus R	00000	NRY	Y Bus
	1 = W		0010	TOAI	ACC	I	0001	SUBRC	S minus R with carry	00001	NRA	ACC
			0101	TODI	D	I	0010	SUBS	R minus S	00100	NRS	Status ²
							0011	SUBSC	R minus S with carry	00101	NRAS	ACC, Status ²
							0100	ADD	R plus S			
							0101	ADDC	R plus S with carry			
							0110	AND	R _i S			
							0111	NAND	R _i S			
							1000	EXOR	R _i S			
							1001	NOR	R + S			
							1010	OR	R + S			
							1011	EXNOR	R _i S			

- Notes 1: R = Source
S = Source
2: When status is destination,
Status i...Y_i i = 0 to 3 (Byte mode)
i = 0 to 7 (Word mode)
3: During subtraction the carry is interpreted as borrow.

Y BUS AND STATUS CONTENTS - TWO OPERAND INSTRUCTIONS

Instruction	Opcode	Description	B/W	Y - Bus	Flag3	Flag2	Flag ₁	LINK	OVR	N	C	Z
TOR1 TOR2 TONR	SUBR	S minus R	0 = B	$Y_{i-1} - S + \bar{R} + 1$	NC	NC	NC	NC	U	U	U	U
	SUBRC	S minus R with carry	1 = w	$Y_{i-1} - S + \bar{R} + QC$	NC	NC	NC	NC	U	U	U	U
	SUBS	R minus S		$Y_{i-1} - R + \bar{S} + 1$	NC	NC	NC	NC	U	U	U	U
	SUBSC	R minus S with carry		$Y_{i-1} - R + \bar{S} + QC$	NC	NC	NC	NC	U	U	U	U
	ADD	R plus S		$Y_{i-1} - R + S$	NC	NC	NC	NC	U	U	U	U
	ADDC	R plus S with carry		$Y_{i-1} - R + S + QC$	NC	NC	NC	NC	U	U	U	U
	AND	R · S		$Y_{i-1} - R_i \text{ AND } S_i$	NC	NC	NC	NC	0	U	0	U
	NAND	$\overline{R \cdot S}$		$Y_{i-1} - R_i \text{ NAND } S_i$	NC	NC	NC	NC	0	U	0	U
	EXOR	R ⊕ S		$Y_{i-1} - R_i \text{ EXOR } S_i$	NC	NC	NC	NC	0	U	0	U
	NOR	$\overline{R + S}$		$Y_{i-1} - R_i \text{ NOR } S_i$	NC	NC	NC	NC	0	U	0	U
	OR	R + S		$Y_{i-1} - R_i \text{ OR } S_i$	NC	NC	NC	NC	0	U	0	U
	EXNOR	$\overline{R \oplus S}$		$Y_{i-1} - R_i \text{ EXNOR } S_i$	NC	NC	NC	NC	0	0	0	U

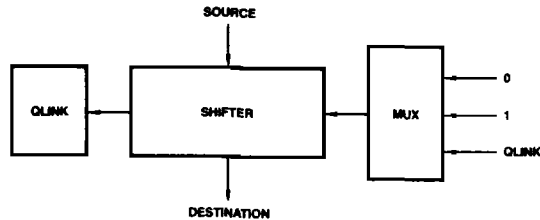
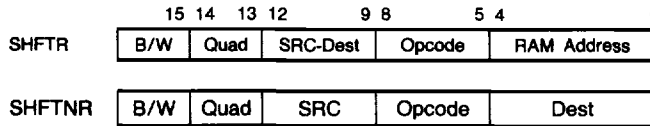
U = Update
NC = No Change
0 = Reset
1 = Set
i = 0 to 15 when not specified

SINGLE BIT SHIFT INSTRUCTIONS

The Single Bit Shift Instructions contain four indicators: byte or word mode, direction and shift linkage, source and destination. They are further subdivided into two types. The first type uses RAM as the source and/or destination and the second type does not use RAM as source or destination. Under the control of the instruction inputs, the desired shift function is performed on the specified source and the result is stored in the specified destination or placed on the Y-bus or both. The direction and shift linkage indicator defines the direction of the shift (up or down) as well as what will be shifted into the vacant bit. On a shift-up instruction, the LSB may be loaded with ZERO, ONE,

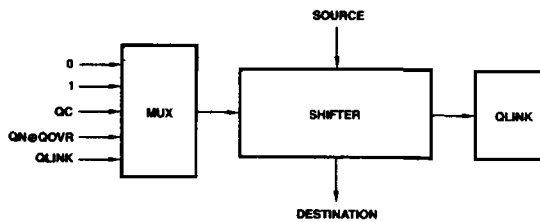
or the Link-Status bit (QLINK). The MSB is loaded into the Link-Status bit as shown in Figure 2. On a shift-down instruction, the MSB may be loaded with ZERO, ONE, the contents of the Status Carry flip-flop, (QC), the Exclusive-OR of the Negative-Status bit and the Overflow-Status bit (QN ⊕ QOVR) or the Link-Status bit. The LSB is loaded into the Link-Status bit as shown in Figure 3. The N and Z bits of the Status register are affected but the OVR and C bits are forced to ZERO. The Shift-Down with QN ⊕ QOVR is useful for Two's Complement multiplication.

SINGLE BIT SHIFT FIELD DEFINITIONS:



PF000360

Figure 2. Shift Up Function.



PF000350

Figure 3. Shift Down Function.

SINGLE BIT SHIFT INSTRUCTIONS

SINGLE BIT SHIFT

Instruction	B/W	Quad	U ¹		Dest ¹		Opcode				RAM Address		
SHFTR	0 - B	10	0110	SHRR	RAM	RAM	0000	SHUPZ	Up	0	00000	R00	RAM Reg 00
	1 - W		0111	SHDR	D	RAM	0001	SHUP1	Up	1	...	...	...
							0010	SHUPL	Up	QLINK	11111	R31	RAM Reg 31
							0100	SHDNZ	Down	0			
							0101	SHDN1	Down	1			
							0110	SHDNL	Down	QLINK			
							0111	SHDNC	Down	QC			
						1000	SHDNOV	Down	QN@QOVR				

Instruction	B/W	Quad	U ¹		Opcode				Destination				
SHFTNR	0 - B	11	0110	SHA	ACC	0000	SHUPZ	Up	0	00000	NRY	Y Bus	
	1 - W		0111	SHD	D	0001	SHUP1	Up	1	00001	NRA	ACC	
							0010	SHUPL	Up	QLINK			
							0100	SHDNZ	Down	0			
							0101	SHDN1	Down	1			
							0110	SHDNL	Down	QLINK			
							0111	SHDNC	Down	QC			
						1000	SHDNOV	Down	QN@QOVR				

Note 1. U = Source
Dest = Destination

Y BUS AND STATUS - SINGLE BIT SHIFT INSTRUCTIONS

Instruction	Opcode	Description	B/W	Y - Bus	Flag3	Flag2	Flag1	LINK	OVR	N	C	Z
SHR SHNR	SHUPZ	Up 0	1 - W	Y _i -SRC _i -1, i = 1 to 15;	NC	NC	NC	SRC ₁₅ *	0	SRC ₁₄	0	U
	SHUP1	Up 1		Y ₀ -Shift Input								
	SHUPL	Up QLINK	0 - B	Y _i -SRC _i -1, i = 1 to 7;	NC	NC	NC	SRC ₇ *	0	SRC ₆	0	U
				Y ₈ -SRC ₇ , Y _i -SRC _i -8 for i = 9 to 15								
	SHDNZ	Down 0	1 - W	Y _i -SRC _i +1, i = 0 to 14;	NC	NC	NC	SRC ₀ *	0	Shift Input	0	U
	SHDN1	Down 1		Y ₁₅ -Shift Input								
SHDNL	Down QLINK	0 - B	Y _i -SRC _i +1, i = 0 to 6;	NC	NC	NC	SRC ₀ *	0	Shift Input	0	U	
SHDNC	Down QC		Y _i -SRC _i -7, i = 8 to 14;									
SHCNOV	Down QN@QOVR		Y _{7,15} -Shift Input									

SRC = Source
U = Update
NC = No Change
0 = Reset
1 = Set
i = 0 to 15 when not specified

*Shifted Output is loaded into the QLINK.

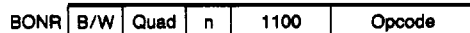
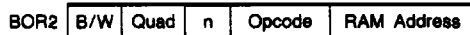
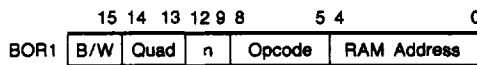
6

BIT ORIENTED INSTRUCTIONS

The Bit Oriented Instructions contain four indicators: byte or word mode, operation, source/destination, and the bit position of the bit to be operated on (Bit 0 is the least significant bit). They are further subdivided into two types. The first type uses the RAM as both source and destination and has two kinds of formats which differ only by quadrant. The second type does not use the RAM as a source or a destination. Under the control of the instruction inputs, the desired function is performed on the specified source and the result is stored in the specified destination or placed on the Y-bus or both. The operations which can be performed are: Set Bit n which forces the n^{th} bit to a ONE leaving other bits unchanged; Reset Bit n

which forces the n^{th} bit to ZERO leaving the other bits unchanged; Test Bit n , which sets the ZERO Status Bit depending on the state of bit n leaving all the bits unchanged; Load 2^n , which loads ONE in Bit position n and ZERO in all other bit positions; Load $\bar{2}^n$ which loads ZERO in bit position n and ONE in all other bit positions; increment by 2^n , which adds 2^n to the operand; and decrement by 2^n which subtracts 2^n from the operand. For all the Load, Set, Reset and Test instructions, the N and Z bits are affected and OVR and C bit of the Status register are forced to ZERO. For all arithmetic instructions the LSH (OVR, C, N, Z bits) of the Status register is affected.

BIT ORIENTED FIELD DEFINITIONS



BIT ORIENTED INSTRUCTIONS

Instruction	B/W	Quad	n	Opcode			RAM Address			
BOR1	0 = B 1 = W	11	0 to 15	1101	SETNR	Set RAM, bit n	00000	R00	RAM Reg 00	
				1110	RSTNR	Reset RAM, bit n	...	...	...
				1111	TSTNR	Test RAM, bit n	11111	R31	RAM Reg 31	
Instruction	B/W	Quad	n	Opcode			RAM Address			
BOR2	0 = B 1 = W	10	0 to 15	1100	LD2NR	2^n - RAM	00000	R00	RAM Reg 00	
				1101	LDC2NR	$\bar{2}^n$ - RAM	...	...	...
				1110	A2NR	RAM plus 2^n - RAM	11111	R31	RAM Reg 31	
				1111	S2NR	RAM minus 2^n - RAM				
Instruction	B/W	Quad	n	Opcode						
BONR	0 = B 1 = W	11	0 to 15	1100	00000	TSTNA	Test ACC, bit n			
					00001	RSTNA	Reset ACC, bit n			
					00010	SETNA	Set ACC, bit n			
					00100	A2NA	ACC plus 2^n - ACC			
					00101	S2NA	ACC minus 2^n - ACC			
					00110	LD2NA	2^n - ACC			
					00111	LDC2NA	$\bar{2}^n$ - ACC			
					10000	TSTND	Test D, bit n			
					10001	RSTND	Reset D, bit n			
					10010	SETND	Set D, bit n			
					10100	A2NDY	D plus 2^n - Y BUS			
					10101	S2NDY	D minus 2^n - Y BUS			
					10110	LS2NY	2^n - Y Bus			
10111	LDC2NY	$\bar{2}^n$ - Y Bus								

BIT ORIENTED INSTRUCTIONS

Y BUS AND STATUS - BIT ORIENTED INSTRUCTIONS

Instruction	Opcode	Description	B/W	Y - Bus	Flag3	Flag2	Flag1	LINK	OVR	N	C	Z
BOR1	SETNR	Set RAM Bit n	0 = B 1 = W	$Y_i \leftarrow RAM_j$ for $i \neq n$; $Y_n - 1$	NC	NC	NC	NC	0	U	0	0
	RSTNR	Reset RAM, Bit n		$Y_i \leftarrow RAM_j$ for $i \neq n$; $Y_n - 0$	NC	NC	NC	NC	0	U	0	0	U
	TSTNR	Test Ram, Bit n		$Y_i - 0$ for $i \neq n$; $Y_n - SRC_n$	NC	NC	NC	NC	0	U	0	U
BOR2	LD2NR	$2^n \leftarrow RAM$		$Y_i - 0$ for $i \neq n$; $Y_n - 1$	NC	NC	NC	NC	0	U	0	0
	LDC2NR	$2^n \leftarrow RAM$		$Y_i - 1$ for $i \neq n$; $Y_n - 0$	NC	NC	NC	NC	0	U	0	0
	A2NR	$RAM + 2^n \leftarrow RAM$		$Y_i \leftarrow RAM + 2^n$	NC	NC	NC	NC	U	U	U	U
	S2NR	$RAM - 2^n \leftarrow RAM$		$Y_i \leftarrow RAM - 2^n$	NC	NC	NC	NC	U	U	U	U
BONR	TSTNA	Test ACC, Bit n		$Y_i - 0$ for $i \neq n$; $Y_n - ACC_n$	NC	NC	NC	NC	0	U	0	U
	RSTNA	Reset ACC, Bit n		$Y_i - ACC_i$ for $i \neq n$; $Y_n - 0$	NC	NC	NC	NC	0	U	0	U
	SETNA	Set ACC, Bit n		$Y_i - ACC_i$ for $i \neq n$; $Y_n - 1$	NC	NC	NC	NC	0	U	0	0
	A2NA	$ACC + 2^n \leftarrow ACC$		$Y_i - ACC + 2^n$	NC	NC	NC	NC	U	U	U	U
	S2NA	$ACC - 2^n \leftarrow ACC$		$Y_i - ACC - 2^n$	NC	NC	NC	NC	U	U	U	U
	LD2NA	$2^n \leftarrow ACC$		$Y_i - 0$ for $i \neq n$; $Y_n - 1$	NC	NC	NC	NC	0	U	0	0
	LDC2NA	$2^n \leftarrow ACC$		$Y_i - 1$ for $i \neq n$; $Y_n - 0$	NC	NC	NC	NC	0	U	0	0
	TSTND	Test D, Bit n		$Y_i - 0$ for $i \neq n$; $Y_n - D_n$	NC	NC	NC	NC	0	U	0	U
	RSTND	Reset D, Bit n*		$Y_i - D_i$ for $i \neq n$; $Y_n - 0$	NC	NC	NC	NC	0	U	0	U
	SETND	Set D, Bit n*		$Y_i - D_i$ for $i \neq n$; $Y_n - 1$	NC	NC	NC	NC	0	U	0	0
	A2NDY	$D + 2^n \leftarrow Y$ Bus		$Y - D + 2^n$	NC	NC	NC	NC	U	U	U	U
	S2NDY	$D - 2^n \leftarrow Y$ Bus		$Y - D - 2^n$	NC	NC	NC	NC	U	U	U	U
	LD2NY	$2^n \leftarrow Y$ Bus		$Y_i - 0$ for $i \neq n$; $Y_n - 1$	NC	NC	NC	NC	0	U	0	0
	LDC2NY	$2^n \leftarrow Y$ Bus		$Y_i - 1$ for $i \neq n$; $Y_n - 0$	NC	NC	NC	NC	0	U	0	0

SRC = Source

U = Update

NC = No Change

0 = Reset

1 = Set

i = 0 to 15 when not specified

*Destination is not D Latch but Y Bus.

ROTATE BY n BITS INSTRUCTIONS

The Rotate by n Bits Instructions contain four indicators: byte or word mode, source, destination and the number of places the source is to be rotated. They are further subdivided into two types. The first type uses RAM as a source and/or a destination and the second type does not use RAM as a source or destination. The first type has two different formats and the only difference is in the quadrant. The second type has only one format as shown in the table. Under the control of instruction inputs, the n indicator specifies the number of bit positions the source is to be rotated up (0 to 15), and the result

is either stored in the specified destination or placed on the Y-bus or both. An example of this instruction is given in Figure 4. In the Word mode, all 16-bits are rotated up while in the Byte mode, only lower 8-bits (0-7) are rotated up. In the Word mode, a rotate up by n bits is equivalent to a rotate down by (16-n) bits. Similarly, in the Byte mode a rotate up by n bits is equivalent to a rotate down by (8-n) bits. The N and Z bits of the Status Register are affected and OVR and C bits are forced to ZERO.

EXAMPLE: n = 4, Word Mode

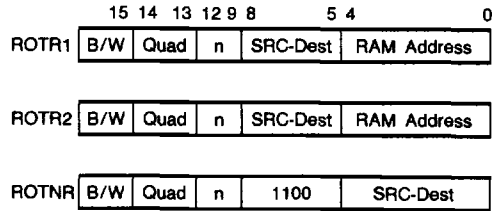
Source	0001	0011	0111	1111
Destination	0011	0111	1111	0001

EXAMPLE: n = 4, Byte Mode

Source	0001	0011	0111	1111
Destination	0001	0011	1111	0111

Figure 4. Rotate by n Example

ROTATE BY n BITS FIELD DEFINITIONS



ROTATE BY n BITS INSTRUCTIONS

Instruction	B/W	Quad	n	U ¹	Dest ¹	RAM Address
ROTR1	0 = B	00	0 to 15	1100	RTRA	RAM ACC
	1 = W			1110	RTRY	RAM Y Bus
				1111	RTRR	RAM RAM
				00000	R00	RAM Reg 00
				11111	R31	RAM Reg 31

Instruction	B/W	Quad	n	U ¹	Dest ¹	RAM Address
ROTR2	0 = B	01	0 to 15	0000	RTAR	ACC RAM
	1 = W			0001	RTDR	D RAM
				00000	R00	RAM Reg 00
				11111	R31	RAM Reg 31

Instruction	B/W	Quad	n	U ¹	Dest ¹	
ROTNR	0 = B 1 = W	11	0 to 15	1100	11000	RTDY D Y Bus
					11001	RTDA D ACC
					11100	RTAY ACC Y Bus
					11101	RTAA ACC ACC

Note 1: U = Source
Dest = Destination

Y BUS AND STATUS - ROTATE BY n BITS INSTRUCTIONS

Instruction	Op-code	B/W	Y - Bus	Flag3	Flag2	Flag1	LINK	OVR	N	C	Z
ROTR1 ROTR2 ROTNR		1 = W	$Y_i \leftarrow SRC_{(i-n) \bmod 16}$	NC	NC	NC	NC	0	SRC_{15-n}	0	U
		0 = B	$Y_i \leftarrow SRC_{i+8} = SRC_{(i-n) \bmod 8}$ for $i = 0$ to 7	NC	NC	NC	NC	0	SRC_{8-n}	0	U

SRC = Source
U = No Change
0 = Reset
1 = Set
i = 0 to 15 when not specified

ROTATE AND MERGE INSTRUCTION

The Rotate and Merge Instructions contain five indicators: byte or word mode, rotated source, non-rotated source/destination, mask and the number of bit positions a source is to be rotated. The function performed by the Rotate and Merge instruction is illustrated in Figure 5. The rotated source, U, is rotated up by the Barrel Shifter n places. The mask input then selects, on a bit by bit basis, the rotated U input or R

input. A ZERO in bit i of the mask will select the i^{th} bit of the R input as the i^{th} output bit, while ONE in bit i will select the i^{th} rotated U input as the output bit. The output word is stored in the non-rotated operand location. The N and Z bits are affected. The OVR and C bits of the Status register are forced to ZERO. An example of this instruction is given in Figure 6.

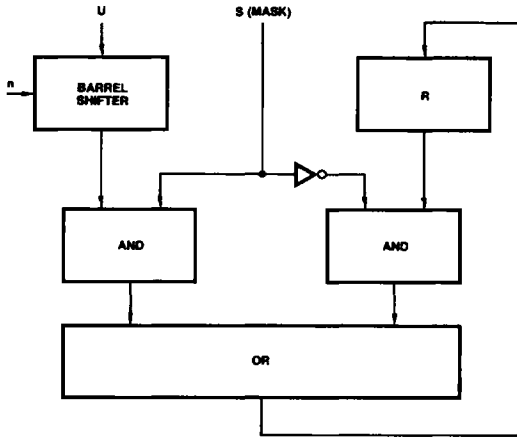
ROTATE AND MERGE FIELD DEFINITIONS:

	15	14	13	12	9	8	5	4	0
ROTM	B/W		Quad	n	ROT SRC- Non ROT SRC- Mask		RAM Address		

EXAMPLE: n = 4, Word Mode

U	0011	0001	0101	0110
Rotated U	0001	0101	0110	0011
R	1010	1010	1010	1010
Mask (S)	0000	1111	0000	1111
Destination	1010	0101	1010	0011

Figure 6. Rotate and Merge Example.



PF000630

Figure 5. Rotate and Merge Function.

ROTATE AND MERGE INSTRUCTION

Instruction	B/W	Quad	n	U ¹ R/Dest ¹ S ¹			RAM Address					
ROTM	0 = B 1 = W	01	0 to 15	0111	MDAI	D	ACC	I	00000	R00	RAM Reg 00	
				1000	MDAR	D	ACC	RAM			...	...
				1001	MDRI	D	RAM	I			...	...
				1010	MDRA	D	RAM	ACC			...	...
				1100	MARI	ACC	RAM	I			11111	R31	RAM Reg 31
1110	MRAI	RAM	ACC	I								

Note 1. U = Rotated Source
R/Dest = Non-Rotated Source and Destination
S = Mask

Y BUS AND STATUS - ROTATED MERGE

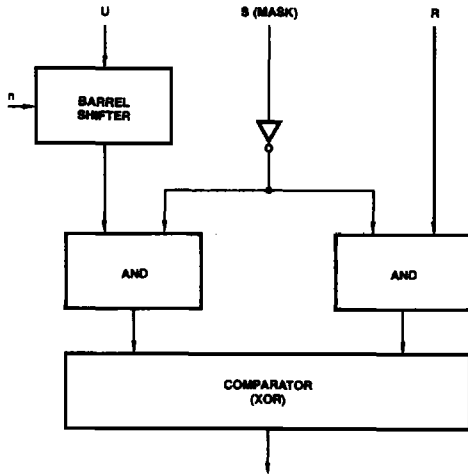
Instruction	Opcode	B/W	Y - Bus	Flag3	Flag2	Flag1	LINK	OVR	N	C	Z
ROTM		1=W	$Y_i = (\text{Non Rot Op})_i \cdot (\text{mask})_i + (\text{Rot Op})_{(i-n) \bmod 16} \cdot (\text{mask})_i$	NC	NC	NC	NC	0	U	0	U
		0=B	$Y_i = (\text{Non Rot Op})_i \cdot (\text{mask})_i + (\text{Rot Op})_{(i-n) \bmod 8} \cdot (\text{mask})_i$	NC	NC	NC	NC	0	U	0	U

U = Update
NC = No Change
0 = Reset
1 = Set
i = 0 to 15 when not specified

ROTATE AND COMPARE INSTRUCTIONS

The Rotate and Compare Instructions contain five indicators: byte or word mode, rotated source, non-rotated source, mask, and the number of bit positions the rotated source is to be rotated up. Under the control of instruction inputs, the function performed by the Rotate and Compare instruction is illustrated in Figure 7. The rotated operand is rotated by the Barrel Shifter n places. The mask is inverted and ANDed on a bit-by-bit basis

with the output of the Barrel Shifter and R input. Thus, a ONE in the mask input eliminates that bit from the comparison. A ZERO allows the comparison. If the comparison passes, the Zero flag is set. If it fails, the Zero flag is reset. The N and Z bit are affected. The OVR and C bits of the Status register are forced to ZERO. An example of this instruction is given in Figure 8.



PF000650

Figure 7. Rotate and Compare Function.

ROTATE AND COMPARE FIELD DEFINITIONS

	15	14	13	12	9	8		5	4		0
ROTC	B/W		Quad		n	Rot Src- Non Rot Src- Mask		RAM Address			

EXAMPLE: n = 4, Word Mode

U	0011	0001	0101	0110
U Rotated	0001	0101	0110	0011
R	0001	0101	1111	0000
Mask (S)	0000	0000	1111	1111
Z (status) = 1				

Figure 8. Rotate and Compare Examples.

ROTATE AND COMPARE INSTRUCTIONS

Instruction	B/W	Quad	n	U ¹	R ¹	S ¹	RAM Address				
ROTC	0 = B 1 = W	01	0 to 15	0010	CDAI	D	ACC	1	00000	R00	RAM Reg 00
				0011	CDRI	D	RAM	1	...	...	...
				0100	CDRA	D	RAM	ACC	11111	R31	RAM Reg 31
				0101	CRAI	RAM	ACC	1			

Note 1. U = Rotated Source
R = Non-Rotated Source
S = Mask

Y BUS AND STATUS - ROTATE AND COMPARE

Instruction	Opcode	B/W	Y - Bus	Flag3	Flag2	Flag1	LINK	OVR	N	C	Z
ROTC		1 = W	$Y_i \leftarrow (\text{Non Rot Op})_i \cdot (\overline{\text{mask}})_i \oplus (\text{Rot Op})_{(i-n) \bmod 16} \cdot (\text{mask})_i$	NC	NC	NC	NC	0	U	0	U
		0 = B	$Y_i \leftarrow (\text{Non Rot Op})_i \cdot (\overline{\text{mask}})_i \oplus (\text{Rot Op})_{(i-n) \bmod 8} \cdot (\text{mask})_i$	NC	NC	NC	NC	0	U	0	U

U = Update
NC = No Change
0 = Reset
1 = Set
i = 0 to 15 when not specified

PRIORITIZE INSTRUCTION

The Prioritize Instructions contain four indicators: byte or word mode, operand source (R), mask source (S) and destination. They are further subdivided into two types. The function performed by the Prioritize instruction is shown in Figure 9. The R operand is ANDed with the complement of the Mask operand. A ZERO in the Mask operand allows the corresponding bit in the R operand to participate in the priority encoding function. A ONE in the Mask operand forces the corresponding bit in the R operand to a ZERO, eliminating it from participation in the priority encoding function.

The priority encoder accepts a 16-bit input and produces a 5-bit binary-weighted code indicating the bit position of the highest priority active bit. If none of the inputs are active, the output is ZERO. In the Word mode, if input bit 15 is active, the output is 1, etc. Figure 10 lists the output as a function of the highest-priority active-bit position in both the Word and Byte mode. The N and Z bits are affected and the OVR and C bits of the status register are forced to ZERO. The only limitation in this instruction is that the operand and the mask must be different sources.

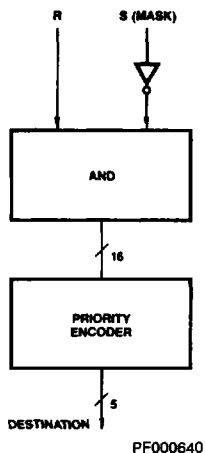


Figure 9. Prioritize Function.

PRIORITIZE INSTRUCTION FIELD DEFINITIONS

15 14 13 12		9 8		5 4		0
B/W	Quad	Destination	Source (R)	RAM Address/ Mask (S)		
B/W	Quad	Mask (S)	Destination	RAM Address/ Source (R)		
B/W	Quad	Mask (S)	Source (R)	RAM Address/ Destination		
B/W	Quad	Mask (S)	Source (R)	Destination		

WORD MODE BYTE MODE*

Highest Priority Active Bit	Encoder Output	Highest Priority Active Bit	Encoder Output
None	0	None	0
15	1	7	1
14	2	6	2
.	.	.	.
1	15	1	7
0	16	0	8

*Bits 8 through 15 do not participate.

Figure 10.

PRIORITIZE INSTRUCTION

Instruction	B/W	Quad	Destination			Source (R)			RAM Address/Mask (S)		
PRT1	0 = B 1 = W	10	1000	PRIA	ACC	0111	RPT1A	ACC	00000	R00	RAM Reg 00
			1010	PR1Y	Y Bus	1001	PR1D	D	...	...	...
			1011	PR1R	RAM				11111	R31	RAM Reg 31
Instruction	B/W	Quad	Mask (S)			Destination			RAM Address/Source (R)		
PRT2	0 = B 1 = W	10	1000	PRA	Acc	0000	PR2A	ACC	00000	R00	RAM Reg 00
			1010	PRZ	0	0010	PR2Y	Y Bus	...	...	...
			1011	PRI	I				11111	R31	RAM Reg 31
Instruction	B/W	Quad	Mask (S)			Source (R)			RAM Address/Dest		
PRT3	0 = B 1 = W	10	1000	PRA	ACC	0011	PR3R	RAM	00000	R00	RAM Reg 00
			1010	PRZ	0	0100	PR3A	ACC	...	...	...
			1011	PRI	I				0110	PR3D	D	11111	R31	RAM Reg 31
Instruction	B/W	Quad	Mask (S)			Source (R)			Destination		
PRTNR	0 = B 1 = W	11	1000	PRA	ACC	0100	PRTA	ACC	00000	NRY	Y Bus
			1010	PRZ	0	0110	PRTD	D	00001	NRA	ACC
			1011	PRI	I						

Y BUS AND STATUS - PRIORITIZE INSTRUCTION

Instruction	Opcode	B/W	Y - Bus	Flag3	Flag2	Flag1	LINK	OVR	N	C	Z
PRT1 PRT2		1 = W	$Y_i = \text{CODE} (\text{SCR}_n \cdot \text{mask}_n)$ $Y_{m-0}; i = 0 \text{ to } 4 \text{ and } n = 0 \text{ to } 15$ $m = 5 \text{ to } 15$	NC	NC	NC	NC	0	U	0	U
PRT3 PRTNR		0 = B	$Y_i = \text{CODE} (\text{SCR}_n \cdot \text{mask}_n)$ $Y_{m-0}; i = 0 \text{ to } 3 \text{ and } n = 0 \text{ to } 7$ $m = 4 \text{ to } 15$	NC	NC	NC	NC	0	U	0	U

SRC = Source
U = Update

NC = No Change
0 = Reset

1 = Set
i = 0 to 15 when not specified

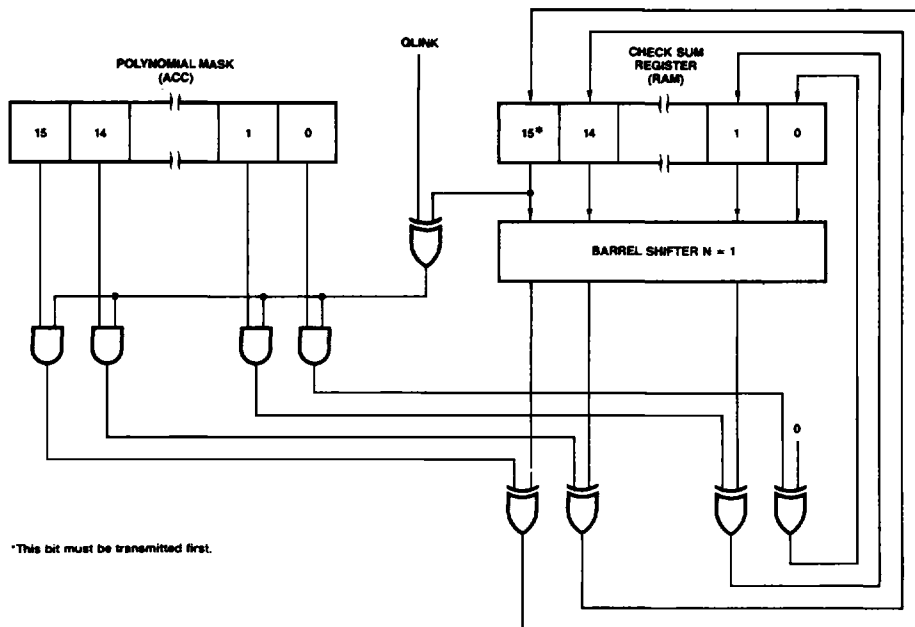
CRC INSTRUCTION

The CRC (Cyclic-Redundancy-Check) Instructions contain one indicator: address of a RAM register to use as the check sum register. The CRC instruction provides a method for generation of the check bits in a CRC calculation. Two CRC instructions are provided - CRC Forward and CRC Reverse. The reason for providing two instructions is that CRC standards do not specify which data bit is to be transmitted first, the LSB or the MSB, but they do specify which check bit must be transmitted first. Figure 11 illustrates the method used to generate these check bits for the CRC Forward function and

Figure 12 illustrates method used for the 2CRC Reverse function. The ACC serves as a polynomial mask to define the generating polynomial while the RAM register holds the partial result and eventually the calculated check sum. The LINK-bit is used as the serial input. The serial input combines with the MSB of the check-sum register, according to the polynomial defined by the polynomial mask register. When the last input bit has been processed, the CRC check bits. The LINK, N and Z bits are affected and the OVR and C bits of the Status register are forced to ZERO.

CYCLIC-REDUNDANCY-CHECK DEFINITIONS:

	15	14	13	12	9	8	5	4	0
CRCF	1	Quad	0110	0011	RAM Address				
CRCR	1	Quad	0110	1001	RAM Address				



PF000330

Figure 11. CRC Forward Function.

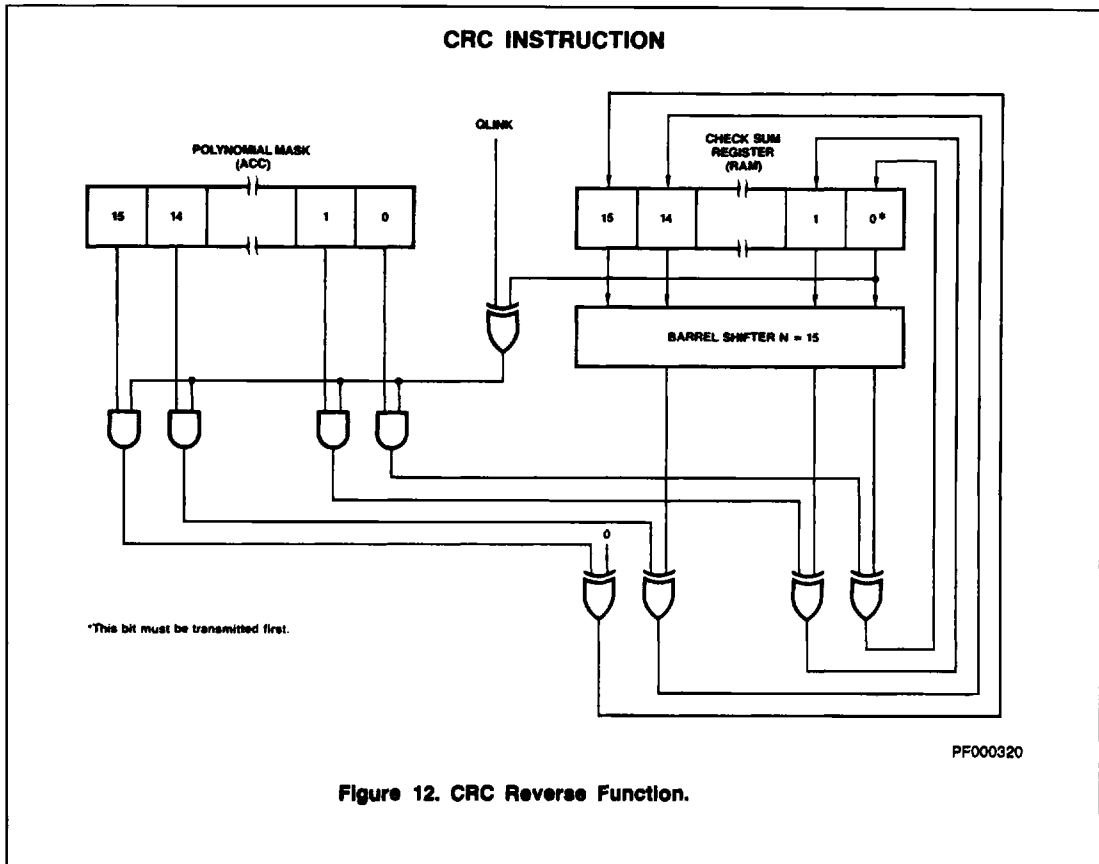


Figure 12. CRC Reverse Function.

CYCLIC REDUNDANCY CHECK

Instruction	B/W	Quad			RAM Address		
CRCF	1	10	0110	0011	00000	R00	RAM Reg 00
					11111	R31	RAM Reg 31
Instruction	B/W	Quad			RAM Address		
CRCR	1	10	0110	1001	00000	R00	RAM Reg 00
					11111	R31	RAM Reg 31

Y BUS AND STATUS - CYCLIC REDUNDANCY CHECK

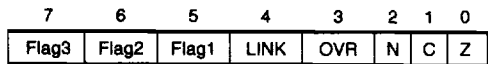
Instruction	Opcode	B/W	Y - Bus	Flag3	Flag2	Flag1	LINK	OVR	N	C	Z
CRCF		1 = W	$Y_i = [(QLINK \oplus RAM_{15}) \cdot ACC_i] \oplus RAM_{i-1}$ for $i = 15$ to 1 $Y_0 = [(QLINK \oplus RAM_{15}) \cdot ACC_0] \oplus 0$	NC	NC	NC	RAM_{15}^*	0	U	0	U
CRCR		1 = W	$Y_i = [(QLINK \oplus RAM_0) \cdot ACC_i] \oplus RAM_{i+1}$ for $i = 14$ to 0 $Y_{15} = [(QLINK \oplus RAM_0) \cdot ACC_{15}] \oplus 0$	NC	NC	NC	RAM_0^*	0	U	0	U

*QLINK is loaded with the shifted out bit from the checksum register.

U = Update
 NC = No Change
 0 = Reset
 1 = Set
 i = 0 to 15 when not specified

STATUS INSTRUCTIONS

Status Instructions – The Set Status Instruction contains a single indicator. This indicator specifies which bit or group of bits, contained in the status register (Figure 13), are to be set (forced to a ONE).



MPP-775

Figure 13. Status Byte.

The Reset Status Instruction contains a single indicator. This indicator specifies which bit or group of bits, contained in the status register, are to be reset (forced to ZERO).

The Store Status Instruction contains two indicators; byte/word and a second indicator that specifies the destination of the status register. The Store Status Instruction allows the status of the processor to be saved and restored later, which is an especially useful function for interrupt handling.

The status register is always stored in the lower byte of the RAM or the ACC register. Depending upon byte or word mode the upper byte is unchanged or loaded with all ZEROs respectively.

The Load Status instructions are included in the single operand and two operand instruction types.

The Test Status Instructions contain a single indicator which specifies which one of the 12 possible test conditions are to be placed on the Conditional-Test output. Besides the eight bits in the Status register (QZ, QC, QN, QOVR, QLINK, QFlag1, QFlag 2, and QFlag3), four logical functions (QN ⊕ QOVR, (QN ⊕ QOVR) + QZ, QZ + Q̄C and LOW may also be selected. These functions are useful in testing results of Two's Complement and unsigned number arithmetic operations. The status register may also be tested via the bidirectional T bus. The code to test the status register via T bus is similar to the code used by instruction lines I₁ to I₄ as shown below. Instruction lines I₀ – 4 have priority over T bus for testing the

status register on CT output. See the discussion on the status register for a full description.

T ₄ I ₄	T ₃ I ₃	T ₂ I ₂	T ₁ I ₁	CT
0	0	0	0	(N ⊕ OVR) + Z
0	0	0	1	N ⊕ OVR
0	0	1	0	Z
0	0	1	1	OVR
0	1	0	0	LOW
0	1	0	1	C
0	1	1	0	Z + C̄
0	1	1	1	N
1	0	0	0	LINK
1	0	0	1	Flag1
1	0	1	0	Flag2
1	0	1	1	Flag3

STATUS

	15	14	13	12	9	8	5	4	0
SETST	0	Quad	1011	1010	Opcode				
RSTST	0	Quad	1010	1010	Opcode				
SVSTR	B/W	Quad	0111	1010	RAM Address/Dest				
SVSTNR	B/W	Quad	0111	1010	Destination				

STATUS INSTRUCTIONS

Instruction	B/W	Quad			Opcode		
SETST	0	11	1011	1010	00011 00101 00110 01001 01010	SONCZ SL SF1 SF2 SF3	Set OVR, N, C, Z Set LINK Set Flag1 Set Flag2 Set Flag3
Instruction	B/W	Quad			Opcode		
RSTST	0	11	1011	1010	00011 00101 00110 01001 01010	RONCZ RL RF1 RF2 RF3	Reset OVR, N, C, Z Reset LINK Set Flag1 Set Flag2 Set Flag3
Instruction	B/W	Quad			RAM Address/Dest		
SVSTR	0 = B 1 = W	10	0111	1010	00000 .. 11111	R00 .. R31	RAM Reg 00 RAM Reg 31
Instruction	B/W	Quad			Destination		
SVSTNR	0 = B 1 = W	11	0111	1010	00000 00001	NRY NRA	Y Bus ACC

STATUS INSTRUCTIONS

Instruction	B/W	Quad			Opcode (CT)		
Test	0	11	1001	1010	00000	TNOZ	Test (N⊕OVR) + Z
					00010	TNO	Test N⊕OVR
					00100	TZ	Test Z
					00110	TOVR	Test OVR
					01000	TLOW	Test LOW
					01010	TC	Test C
					01100	TZC	Test Z + \bar{C}
					01110	TN	Test N
					10000	TL	Test LINK
					10010	TF1	Test Flag1
					10100	TF2	Test Flag2
					10110	TF3	Test Flag3

Note: IEN - test status instruction has priority over T₁₋₄ instruction.

Y BUS AND STATUS - FOR STATUS INSTRUCTIONS

Instruction	Opcode	Description	B/W	Y - Bus	Flag3	Flag2	Flag1	LINK	OVR	N	C	Z
SETST	SONCZ	Set OVR, N, C, Z	0 = B	Y _{i-1} for i = 0 to 15	NC	NC	NC	NC	1	1	1	1
	SL	Set LINK			NC	NC	NC	1	NC	NC	NC	NC
	SF1	Set Flag1			NC	NC	1	NC	NC	NC	NC	NC
	SF2	Set Flag2			NC	1	NC	NC	NC	NC	NC	NC
	SF3	Set Flag3			1	NC	NC	NC	NC	NC	NC	NC
RSTST	RONCZ	Reset OVR, N, C, Z	0 = B	Y _{i-0} for i = 0 to 15	NC	NC	NC	NC	0	0	0	0
	RL	Reset LINK			NC	NC	NC	0	NC	NC	NC	NC
	RF1	Reset Flag1			NC	NC	0	NC	NC	NC	NC	NC
	RF2	Reset Flag2			NC	0	NC	NC	NC	NC	NC	NC
	RF3	Reset Flag3			0	NC	NC	NC	NC	NC	NC	NC
SVSTR SVSTNR		Save Status*	0 = B 1 = W	Y _{i-Status} for i = 0 to 7; Y _{i-0} for i = 8 to 15	NC	NC	NC	NC	NC	NC	NC	NC
Test	TNOZ	Test (N⊕OVR) + Z	0 = B	**	NC	NC	NC	NC	NC	NC	NC	NC
	TNO	Test N⊕OVR			NC	NC	NC	NC	NC	NC	NC	NC
	TZ	Test Z			NC	NC	NC	NC	NC	NC	NC	NC
	TOVR	Test OVR			NC	NC	NC	NC	NC	NC	NC	NC
	TLOW	Test LOW			NC	NC	NC	NC	NC	NC	NC	NC
	TC	Test C			NC	NC	NC	NC	NC	NC	NC	NC
	TZC	Test Z + \bar{C}			NC	NC	NC	NC	NC	NC	NC	NC
	TN	Test N			NC	NC	NC	NC	NC	NC	NC	NC
	TL	Test LINK			NC	NC	NC	NC	NC	NC	NC	NC
	TF1	Test Flag1			NC	NC	NC	NC	NC	NC	NC	NC
	TF2	Test Flag2			NC	NC	NC	NC	NC	NC	NC	NC
	TF3	Test Flag3			NC	NC	NC	NC	NC	NC	NC	NC

U = Update
 NC = No Change
 0 = Reset
 1 = Set
 i = 0 to 15 when not specified

*In byte mode only the lower byte from the Y bus is loaded into the RAM or ACC and in word mode all 16-bits from the Y bus are loaded into the RAM or ACC.

**Y-Bus is Undefined.

6

NO-OP INSTRUCTION

The NO-OP instruction has a fixed 16-bit code. This instruction does not change any internal registers in the Am29116. It preserves the status register, RAM register and the ACC register.

NO OPERATION FIELD DEFINITION

	15	14	13	12	9	8	5	4	0
NOOP	0	11	1000	1010	00000				

NO-OP INSTRUCTION

Instruction	B/W	Quad			
NOOP	0	11	1000	1010	00000

Y BUS AND STATUS - NO-OP INSTRUCTION

Instruction	Opcode	B/W	Y - Bus	Flag3	Flag2	Flag1	LINK	OVR	N	C	Z
NOOP		0 = B	*	NC	NC	NC	NC	NC	NC	NC	NC

SRC = Source
 U = Update
 NC = No Change
 0 = Reset
 1 = Set
 i = 0 to 15 when not specified
 *Y-Bus is undefined.

SUMMARY OF MNEMONICS

Instruction Type

SOR	Single Operand RAM
SONR	Single Operand Non-RAM
TOR1	Two Operand RAM (Quad 0)
TOR2	Two Operand RAM (Quad 2)
TONR	Two Operand Non-RAM
SHFTR	Single Bit Shift RAM
SHFTNR	Single Bit Shift Non-RAM
ROTR1	Rotate n Bits RAM (Quad 0)
ROTR2	Rotate n Bits RAM (Quad 1)
ROTNR	Rotate n Bits Non-RAM
BOR1	Bit Oriented RAM (Quad 3)
BOR2	Bit Oriented RAM (Quad 2)
BONR	Bit Oriented Non-RAM
ROTM	Rotate and Merge
ROTC	Rotate and Compare
PRT1	Prioritize RAM; Type 1
PRT2	Prioritize RAM; Type 2
PRT3	Prioritize RAM; Type 3
PRTNR	Prioritize Non-RAM
CRCF	Cyclic Redundancy Check Forward
CRCR	Cyclic Redundancy Check Reverse
NOOP	No Operation
SETST	Set Status
RSTST	Reset Status
SVSTR	Save Status RAM
SVSTNR	Save Status Non-RAM
TEST	Test Status

SOURCE AND DESTINATION

Single Operand

SORA	Single Operand RAM to ACC
SORY	Single Operand RAM to Y Bus
SORS	Single Operand RAM to Status
SOAR	Single Operand ACC to RAM
SODR	Single Operand D to RAM
SOIR	Single Operand I to RAM
SOZR	Single Operand 0 to RAM
SOZER	Single Operand D(0E) to RAM
SOSER	Single Operand D(SE) to RAM
SORR	Single Operand RAM to RAM
SOA	Single Operand ACC
SOD	Single Operand D
SOI	Single Operand I
SOZ	Single Operand 0
SOZE	Single Operand D(0E)
SOSE	Single Operand D(SE)
NRY	Non-RAM Y Bus
NRA	Non-RAM ACC
NRS	Non-RAM Status
NRAS	Non-RAM ACC, Status

Two Operand

TORAA	Two Operand RAM, ACC to ACC
TORIA	Two Operand RAM, I to ACC
TODRA	Two Operand D, RAM to ACC
TORAY	Two Operand RAM, ACC to Y Bus
TORIY	Two Operand RAM, I to Y Bus
TODRY	Two Operand D, RAM to Y Bus
TORAR	Two Operand RAM, ACC to RAM
TORIR	Two Operand RAM, I to RAM
TODRR	Two Operand D, RAM to RAM
TODAR	Two Operand D, ACC to RAM
TOAIR	Two Operand ACC, I to RAM
TODIR	Two Operand D, I to RAM
TODA	Two Operand D, ACC
TOAI	Two Operand ACC, I
TODI	Two Operand D, I

Single Bit Shift

SHRR	Shift RAM, Store in RAM
SHDR	Shift D, Store in RAM
SHA	Shift ACC
SHD	Shift D

Rotate n Bits

RTRA	Rotate RAM, Store in ACC
RTRY	Rotate RAM, Place on Y Bus
RTRR	Rotate RAM, Store in RAM
RTAR	Rotate ACC, Store in RAM
RTDR	Rotate D, Store in RAM
RTDY	Rotate D, Place on Y Bus
RTDA	Rotate D, Store in ACC
RTAY	Rotate ACC, Place on Y Bus
RTAA	Rotate ACC, Store in ACC

Rotate and Merge

MDAI	Merge Disjoint Bits of D and ACC Using I as Mask and Store in ACC
MDAR	Merge Disjoint Bits of D and ACC Using RAM as Mask and Store in ACC
MDRI	Merge Disjoint Bits of D and RAM Using I as Mask and Store in RAM
MDRA	Merge Disjoint Bits of D and RAM Using ACC as Mask and Store in RAM
MARI	Merge Disjoint Bits of ACC and RAM Using I as Mask and Store in RAM
MRAI	Merge Disjoint Bits of RAM and ACC Using I as Mask and Store in ACC

Rotate and Compare

CDAI	Compare Unmasked Bits of D and ACC Using I as Mask
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CDRI Compare Unmasked Bits of D and RAM Using I as Mask
 CDRA Compare Unmasked Bits of D and RAM Using ACC as Mask
 CRAI Compare Unmasked Bits of RAM and ACC Using I as Mask

Prioritize

PR1A ACC as Destination for Prioritize Type 1
 PR1Y Y Bus as Destination for Prioritize Type 1
 PR1R RAM as Destination for Prioritize Type 1
 PRT1A ACC as Source for Prioritize Type 1
 PR1D D as Source for Prioritize Type 1
 PR2A ACC as Destination for Prioritize Type 2
 PR2Y Y Bus as Destination for Prioritize Type 2
 PR3R RAM as Source for Prioritize Type 3
 PR3A ACC as Source for Prioritize Type 3
 PR3D D as Source for Prioritize Type 3
 PRTA ACC as source for Prioritize Type Non-RAM
 PRTD D as Source for Prioritize Type Non-RAM
 PRA ACC as Mask for Prioritize Type 2, 3, and Non-RAM
 PRZ Mask Equal to Zero for Prioritize Type 2, 3, and Non-RAM
 PRI I as Mask for Prioritize Type 2, 3, and Non-RAM

OPCODE**Addition**

ADD Add without Carry
 ADDC Add with Carry
 A2NA Add 2^n to ACC
 A2NR Add 2^n to RAM
 A2NDY Add 2^n to D, Place on Y Bus

Subtraction

SUBR Subtract R from S without Carry
 SUBRC Subtract R from S with Carry
 SUBS Subtract S from R without Carry
 SUBSC Subtract S from R with Carry
 S2NR Subtract 2^n from RAM
 S2NA Subtract 2^n from ACC
 S2NDY Subtract 2^n from D, Place on Y Bus

Logical Operations

AND Boolean AND
 NAND Boolean NAND
 EXOR Boolean EXOR
 NOR Boolean NOR
 OR Boolean OR
 EXNOR Boolean EXNOR

SHIFTS

SHUPZ Shift Up Towards MSB with 0 Insert
 SHUP1 Shift Up Towards MSB with 1 Insert
 SHUPL Shift Up Towards MSB with LINK Insert

SHDNZ Shift Down Towards LSB with 0 Insert
 SHDN1 Shift Down Towards LSB with 1 Insert
 SHDNL Shift Down Towards LSB with LINK Insert
 SHDNC Shift Down Towards LSB with Carry Insert
 SHDNOV Shift Down Towards LSB with Sign EXOR Overflow Insert

Loads

LD2NR Load 2^n into RAM
 LDC2NR Load 2^n into RAM
 LD2NA Load 2^n into ACC
 LDC2NA Load 2^n into ACC
 LD2NY Place 2^n on Y Bus
 LDC2NY Place 2^n on Y Bus

Bit Oriented

SETNR Set RAM, Bit n
 SETNA Set ACC, Bit n
 SETND Set D, Bit n
 SONCZ Set OVR, N, C, Z, in Status Register
 SL Set LINK Bit in Status Register
 SF1 Set Flag1 Bit in Status Register
 SF2 Set Flag2 Bit in Status Register
 SF3 Set Flag3 Bit in Status Register
 RSTNR Reset RAM, Bit n
 RSTNA Reset ACC, Bit n
 RSTND Reset D, Bit n
 RONCZ Reset OVR, N, C, Z, in Status Register
 RL Reset LINK Bit in Status Register
 RF1 Reset Flag1 Bit in Status Register
 RF2 Reset Flag2 Bit in Status Register
 RF3 Reset Flag3 Bit in Status Register
 TSTNR Test RAM, Bit n
 TSTNA Test ACC, Bit n
 TSTND Test D, Bit n

Arithmetic Operations

MOVE Move and Update Status
 COMP Complement (1's Complement)
 INC Increment
 NEG Two's Complement

Conditional Test

TNOZ Test $(N \oplus OVR) + Z$
 TNO Test $N \oplus OVR$
 TZ Test Zero Bit
 TOVR Test Overflow Bit
 TLOW Test for LOW
 TC Test Carry Bit
 TZC Test $Z + \bar{C}$
 TN Test Negative Bit
 TL Test LINK Bit
 TF1 Test Flag1 Bit
 TF2 Test Flag2 Bit
 TF3 Test Flag3 Bit

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ABSOLUTE MAXIMUM RATINGS

Storage Temperature	-65°C to +150°C
(Case) Temperature Under Bias	-55°C to +125°C
Supply Voltage to Ground Potential	-0.5V to +7.0V
DC Voltage Applied to Outputs For	
High Output State	-0.5V to +V _{CC} max
DC Input Voltage	-0.5V to +5.5V
DC Output Current, Into Outputs	30mA
DC Input Current	-30mA to +5.0mA

Stresses above those listed under ABSOLUTE MAXIMUM RATINGS may cause permanent device failure. Functionality at or above these limits is not implied. Exposure to absolute maximum ratings for extended periods may affect device reliability.

OPERATING RANGES

Commercial (C) Devices	
Temperature	0°C to +70°C
Supply Voltage	+4.75V to +5.25V
Military (M) Devices	
Temperature	-55°C to +125°C
Supply Voltage	+4.5V to +5.5V

Operating ranges define those limits over which the functionality of the device is guaranteed.

DC CHARACTERISTICS over operating range unless otherwise specified

Parameters	Description	Test Conditions (Note 2)		Min	Typ (Note 1)	Max	Units
V _{OH}	Output HIGH Voltage	V _{CC} = MIN V _{IN} = V _{IH} or V _{IL}	Y0-5 T1-4 CT	I _{OH} = -1.8mA/-1.2mA (COM'L/MIL)	2.4		Volts
V _{OL}	Output LOW Voltage	V _{CC} = MIN V _{IN} = V _{IH} or V _{IL}	Y0-15 T1-4 CT	I _{OL} = 16mA/12mA (COM'L/MIL)		0.5	Volts
V _{IH}	Guaranteed Input Logical HIGH Voltage (Note 6)		All Inputs		2.0		Volts
V _{IL}	Guaranteed Input Logical LOW Voltage (Note 6)		All Inputs			0.8	Volts
V _I	Input Clamp Voltage	V _{CC} = MIN	All Inputs	I _{IN} = 18mA		-1.5	Volts
I _{IL}	Input LOW Current	V _{CC} = MAX V _{IN} = 0.5 Volts (Note 4)	IEN SRE DLE IO-4 IS-15 OET OEY CP T1-4 Y0-15			-0.50 -0.50 -1.00 -1.00 -0.50 -0.50 -1.50 -0.55 -0.55	mA
I _{IH}	Input HIGH Current	V _{CC} = MAX V _{IN} = 2.4 Volts (Note 4)	IEN SRE DLE IO-4 IS-15 OET OEY CP T1-4 Y0-15			50 50 100 100 50 50 50 150 100 100	μA
I _I	Input HIGH Current	V _{CC} = MAX V _{IN} = 5.5 Volts	All Inputs			1.0	mA
I _{OZH}	Off State (HIGH Impedance) Output Current	V _{CC} = MAX V _O = 2.4 Volts (Note 4)	T1-4 Y0-15			100	μA
I _{OZL}	Off State (HIGH Impedance) Output Current	V _{CC} = MAX V _O = 0.5 Volts (Note 4)	T1-4 Y0-15			-550	μA
I _{OS}	Output Short Circuit Current	V _{CC} = MAX + 0.5 Volts V _O = 0.5 Volts (Note 3)			-30	-85	mA
I _{CC}	Power Supply Current (Note 5)	V _{CC} = MAX	COM'L	T _{AL} = 0 to 70°C (Note 7) T _A = 70°C		735 535	mA
			MIL	T _C = -55 to 125°C (Note 7) T _C = 125°C		745 485	

- Notes: 1. Typical limits are at V_{CC} = 5.0V, 25°C ambient and maximum loading.
 2. For conditions shown as MIN or MAX, use the appropriate value specified under Operating Ranges for the applicable device type.
 3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.
 4. Y0-15, T1-4 are three-state outputs internally connected to TTL inputs. Input characteristics are measured under conditions such that the outputs are in the OFF state.
 5. Worst case I_{CC} is at minimum temperature.
 6. These input levels provide zero noise immunity and should be tested only in a static, noise-free environment.
 7. Cold start.

SWITCHING CHARACTERISTICS

GUARANTEED CHARACTERISTICS OVER COMMERCIAL OPERATING RANGE

(T_A = 0 to +70°C, V_{CC} = 4.75 to 5.25V, C_L = 50pF)

A. Combinational Delays (nsec)

		Outputs		
		Y ₀₋₁₅	T ₁₋₄	CT
	I ₀₋₄ (ADDR)	79	84	-
	I ₀₋₁₅ (DATA)	79	84	-
	I ₀₋₁₅ (INSTR)	79	84	48
Input	DLE	58**	60	-
	T ₁₋₄	-	-	39
	CP	56	62	36
	Y ₀₋₁₅	62**	64*	-
	IEN	-	-	43

*Y₀₋₁₅ must be stored in the Data Latch and its source disabled before the delay to Y₀₋₁₅ as an output can be measured.

**Guaranteed indirectly by other tests.

B. Enable/Disable Times (nsec)

(C_L = 5pF for disable only)

From Input	To Output	Enable		Disable	
		t _{PZH}	t _{PZL}	t _{PZH}	t _{PLZ}
OE _Y	Y ₀₋₁₅	20	20	20	20
OE _T	T ₁₋₄	25	25	25	25

C. Clock and Pulse Requirements (nsec)

Input	Min Low Time	Min High Time
CP	20	30
DLE	-	15
IEN	-	-

D. Setup and Hold Times (nsec)

Input	With Respect To	High-to-Low Transition		Low-to-High Transition		Comment
		Set-up	Hold	Set-up	Hold	
I ₀₋₄ (RAM ADDR)	CP	(t _{s1}) 24	(t _{h1}) 0	-	-	Single ADDR (Source)
I ₀₋₄ (RAM ADDR)	CP and IEN both LOW	(t _{s2}) 10	-	Do Not Change		Two ADDR (Destination)
I ₀₋₅ (DATA)	CP	-	-	(t _{s3}) 65	(t _{h3}) 0	
I ₀₋₁₅ (INSTR)	CP	(t _{s3}) 38†	(t _{h3}) † 17	(t _{s3}) 65	(t _{h3}) 0	
IEN HIGH	CP	(t _{s4}) 10	-	-	(t _{h10}) 0	Disable
IEN LOW	CP	-	(t _{s5}) 20	(t _{s11}) 22	(t _{h11}) †† 0	Enable Immediate first cycle
SRE	CP	-	-	(t _{s12}) 17	(t _{h12}) 0	
Y	CP	-	-	(t _{s13}) 44	(t _{h13}) 0	
Y	DLE	(t _{s6}) 10	(t _{h6}) 6	-	-	
DLE	CP	-	-	(t _{s14}) 42	(t _{h14}) 0	

†Timing for immediate instruction for first cycle.

†† Status register and accumulator destination only.

Notes on Testing

Incoming test procedures on this device should be carefully planned, taking into account the high complexity and power levels of the part. The following notes may be useful:

1. Insure the part is adequately decoupled at the test head. Large changes in V_{CC} current as the device switches may cause erroneous function failure due to V_{CC} changes.
2. Do not leave inputs floating during any tests, as they may start to oscillate at high frequency.
3. Do not attempt to perform threshold tests at high speed. Following an input transition, ground current may change by as much as 400 mA in 5–8ns. Inductance in the ground

cable may allow the ground pin at the device to rise by 100s of millivolts momentarily.

4. Use extreme care in defining input levels for AC tests. Many inputs may be changed at once, so there will be significant noise at the device pins and they may not actually reach V_{IL} or V_{IH} until the noise has settled. AMD recommends using V_{IL} ≤ 0V and V_{IH} ≥ 3.0V for AC tests.
5. To simplify failure analysis, programs should be designed to perform DC, Function, and AC tests as three distinct groups of tests.
6. To assist in testing, AMD offers complete documentation on our test procedures and, in most cases, can provide Fairchild Sentry programs, under license.

SWITCHING CHARACTERISTICS (Cont.)

GUARANTEED CHARACTERISTICS OVER MILITARY OPERATING RANGE

($T_C = -55$ to $+125^\circ\text{C}$, $V_{CC} = 4.5$ to 5.5V , $C_L = 50\text{pF}$)

A. Combinational Delays (nsec)

	Inputs	Outputs		
		Y_{0-15}	T_{1-4}	CT
	I_{0-4} (ADDR)	100	103	-
	I_{0-15} (DATA)	100	103	-
	I_{0-15} (INSTR)	100	103	50
Input	DLE	68	70	-
	T_{1-4}	-	-	46
	CP	70	73	43
	Y_{0-15}	70	72	-
	$\overline{\text{IEN}}$	-	-	50

B. Enable/Disable Times (nsec)

($C_L = 5\text{pF}$ for disable only)

From Input	To Output	Enable		Disable	
		tpZH	tpZL	tpHZ	tpLZ
OE_Y	Y_{0-15}	25	25	25	25
OE_T	T_{1-4}	26	26	30	30

C. Clock and Pulse Requirements (nsec)

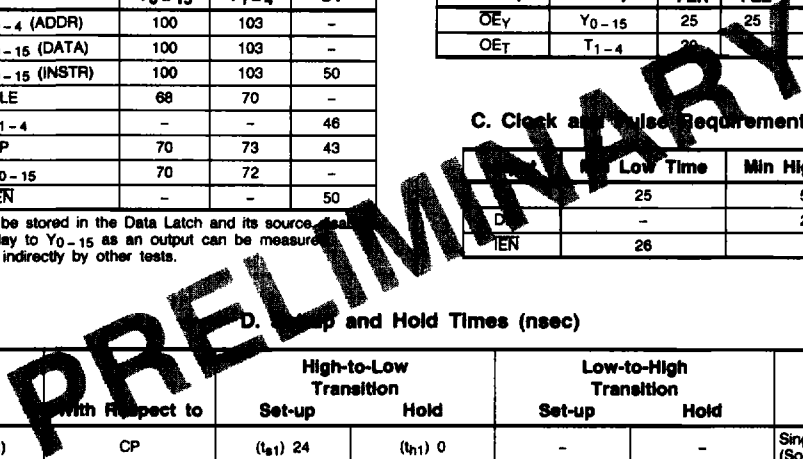
Signal	Low Time	Min High Time
D	25	50
$\overline{\text{IEN}}$	-	20
$\overline{\text{IEN}}$	26	-

* Y_{0-15} must be stored in the Data Latch and its source, read before the delay to Y_{0-15} as an output can be measured.
 **Guaranteed indirectly by other tests.

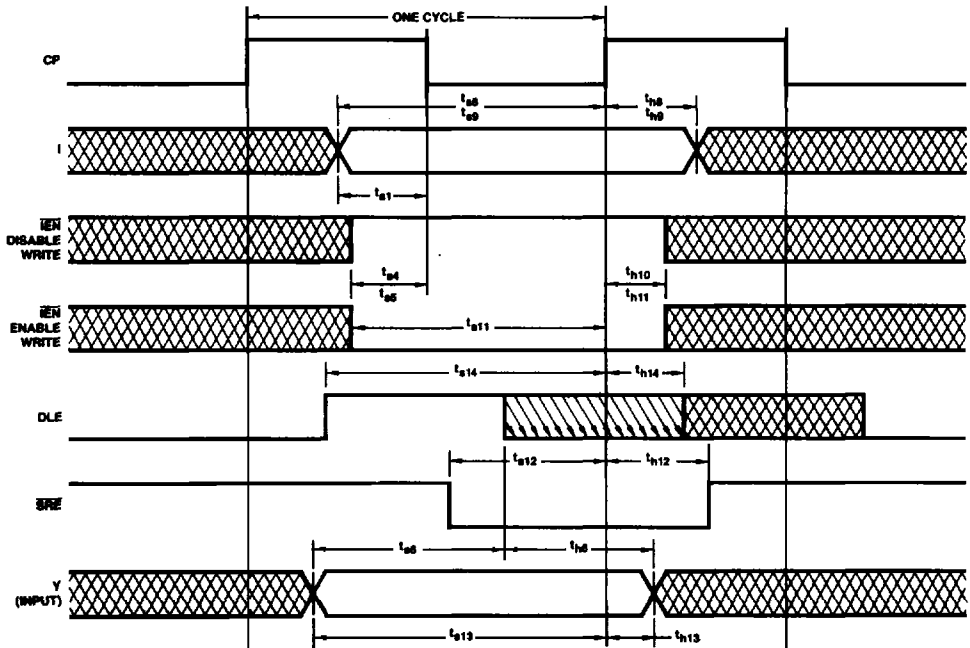
D. Setup and Hold Times (nsec)

Input	With Respect to	High-to-Low Transition		Low-to-High Transition		Comment	
		Set-up	Hold	Set-up	Hold		
I_{0-4} (RAM ADDR)	CP	(t _{s1}) 24	(t _{h1}) 0	-	-	Single ADDR (Source)	
I_{0-4} (RAM ADDR)	CP and $\overline{\text{IEN}}$ both LOW	(t _{s2}) 10	Do Not Change		(t _{h7}) 0	Two ADDR (Destination)	
I_{0-15} (DATA)	CP	-	-	(t _{s8}) 78	(t _{h8}) 3		
I_{0-15} (INSTR)	CP	(t _{s3})† 57	(t _{h3})† 17	(t _{s9}) 78	(t _{h9}) 3		
$\overline{\text{IEN}}$ HIGH	CP	(t _{s4}) 10	-	-	(t _{h10}) 1	Disable	
$\overline{\text{IEN}}$ LOW	CP	-	(t _{s5}) 20	(t _{h5})† 3	(t _{s11}) 28	Enable	Immediate first cycle
SRE	CP	-	-	(t _{s12}) 19	(t _{h12}) 0		
Y	CP	-	-	(t _{s13}) 50	(t _{h13}) 2		
Y	DLE	(t _{s6}) 11	(t _{h6}) 7	-	-		
DLE	CP	-	-	(t _{s14}) 50	(t _{h14}) 0		

†Timing for immediate instruction for first cycle.
 †† Status register and accumulator destination only.



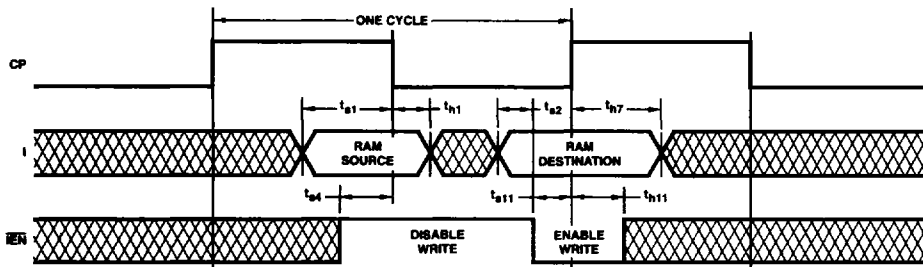
Am29116 SINGLE ADDRESS ACCESS TIMING



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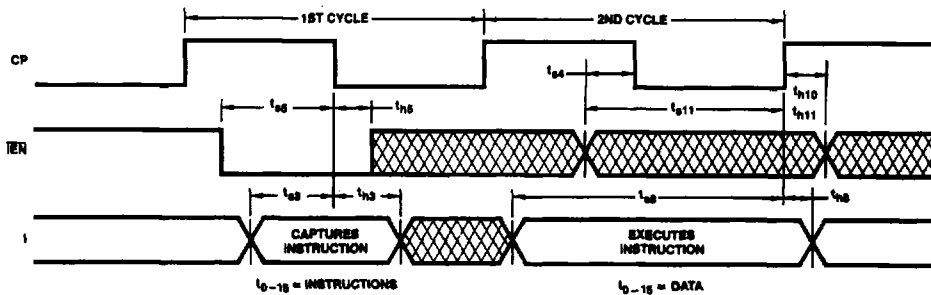
If t_{h6} is satisfied, t_{h13} need not be satisfied.

DOUBLE ADDRESS ACCESS TIMING



WF002540

IMMEDIATE INSTRUCTION CYCLE TIMING



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