

# Am29117

A High-Performance 16-Bit Bipolar Microprocessor

PRELIMINARY

## DISTINCTIVE CHARACTERISTICS

- **Optimized for High-Performance Controllers**  
Architecture and instruction set optimized for high-performance, intelligent controllers
- **Flow-Through Architecture**  
Separate input and output ports avoid bus turnaround for higher throughput
- **32 Working Registers**  
Contains 32 working registers with latched outputs
- **Fast**  
Supports 100 ns microcycle time/10 MHz 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
- **68-Pin Pin Grid Array Package**

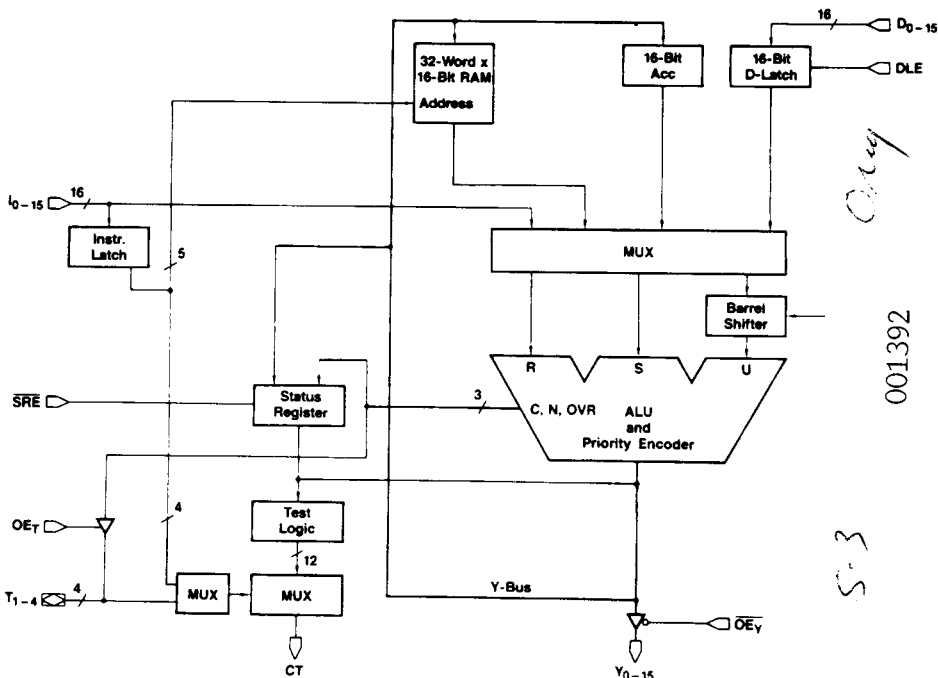
## GENERAL DESCRIPTION

The Am29117 is a microprogrammable 16-bit bipolar microprocessor whose architecture and instruction set are identical to the Am29116's except for the I/O bus structure. Since the device has separate input and output ports, designers can avoid quick bus turnaround requirements.

The architecture and instruction set are not only optimized for high-performance peripheral controllers, but also suitable for microprogrammed processor applications when combined with the Am29517A 16 x 16 Multiplier.

The instruction set contains unique functions besides ordinary logic and arithmetic functions: bit manipulation instructions (set, reset and test), rotate merge/compare instructions, prioritize instruction and CRC instruction.

## BLOCK DIAGRAM



BD001972

Am29117

Advanced Micro Devices

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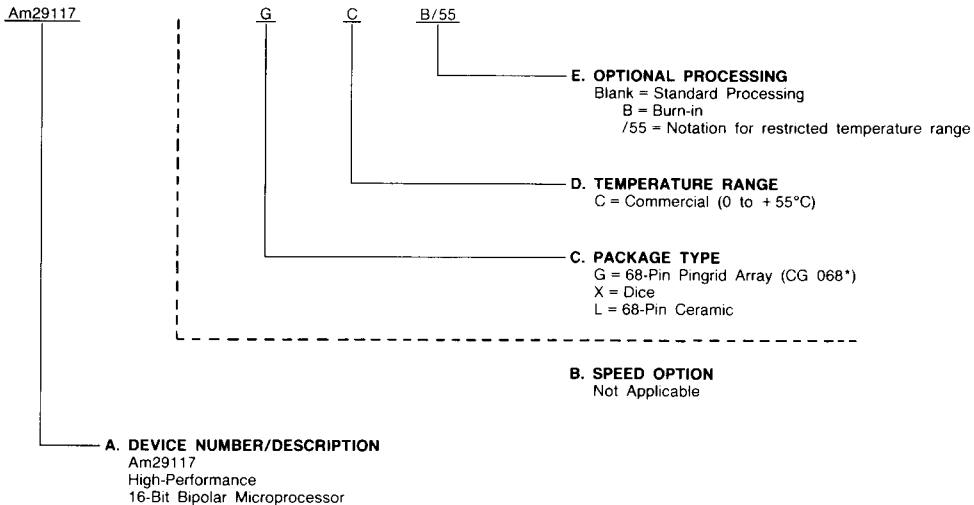


# ORDERING INFORMATION

## Standard Products

AMD products are available in several packages and operating ranges. The order number (Valid Combination) is formed by a combination of:

- A. Device Number**
- B. Speed Option** (if applicable)
- C. Package Type**
- D. Temperature Range**
- E. Optional Processing**



\*Preliminary. Subject to Change.

Valid Combinations	
Am29117	GC/55, LC/55 GCB/55, XC/55

### Valid Combinations

Consult the local AMD sales office to confirm availability of specific valid combinations, to check on newly released valid combinations, and to obtain additional data on AMD's standard military grade products.

## PIN DESCRIPTION

### **D<sub>0</sub> - D<sub>15</sub> Bidirectional Data (Input)**

Data Input Lines, D<sub>0</sub> - D<sub>15</sub>, are used as external data inputs which allow data to be directly loaded into the 16-bit data latch.

### **Y<sub>0</sub> - Y<sub>15</sub> General Output (Output)**

Data Output lines. When  $\overline{OE}_Y$  is HIGH, the 16-bit Y outputs are disabled (high impedance); having  $\overline{OE}_Y$  LOW allows the ALU data to be output on Y<sub>0</sub> - Y<sub>15</sub>.

### **DLE Data Latch Enable (Input)**

When  $\overline{OE}_Y$  is HIGH, the 16-bit data latch is transparent and is latched when DLE is LOW.

### **$\overline{OE}_Y$ Output Enable (Input)**

When  $\overline{OE}_Y$  is HIGH, the 16-bit Y outputs are disabled (high impedance); when  $\overline{OE}_Y$  is LOW, the 16-bit Y outputs are enabled (HIGH or LOW).

### **I<sub>0</sub> - I<sub>15</sub> Instruction Inputs (Input)**

Sixteen Instruction inputs, used to select the operation to be performed in the Am29117. Also used as data inputs while performing immediate instructions.

### **$\overline{IEN}$ Instruction Enable (Input)**

When  $\overline{IEN}$  is LOW, data can be written into RAM when the clock is LOW. The Accumulator can accept data during the LOW-to-HIGH transition of the clock. Having  $\overline{IEN}$  LOW, the Status Register can be updated when  $\overline{SRE}$  is LOW. With  $\overline{IEN}$  is HIGH, the conditional test output, CT, is disabled as a function of the instruction inputs.

### **$\overline{SRE}$ Status Register Enable (Input)**

When  $\overline{SRE}$  and  $\overline{IEN}$  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  $\overline{SRE}$  or  $\overline{IEN}$  HIGH will inhibit the Status Register from changing.

### **CP Clock Pulse (Input)**

The clock input to the Am29117. 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  $\overline{IEN}$  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-to-HIGH transition of the clock if  $\overline{IEN}$  is also LOW. The instruction latch becomes transparent when it exits an immediate instruction mode during a LOW-to-HIGH transition of the clock.

### **T<sub>1</sub> - T<sub>4</sub> Test I/O Pins (Input/Output)**

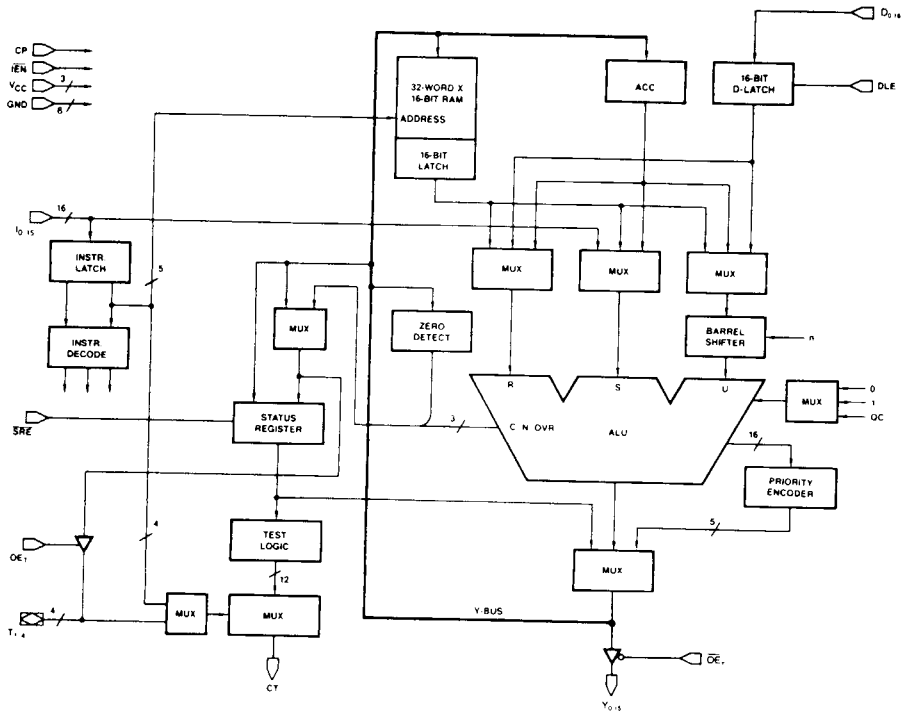
Under the control of  $OE_T$ , the four lower status bits, Z, C, N and OVR become outputs on T<sub>1</sub> - T<sub>4</sub>, respectively, when  $OE_T$  goes HIGH. When  $OE_T$  is LOW, T<sub>1</sub> - T<sub>4</sub> are used as inputs to generate the CT output.

### **$OE_T$ Output Enable (Output)**

When  $OE_T$  is LOW, 4-bit T outputs are disabled (high impedance); when  $OE_T$  is HIGH, the 4-bit T outputs are enabled (HIGH or LOW).

### **CT Conditional Test (Output)**

The condition code multiplexer selects one of the twelve condition code signals and places it on the CT output. A HIGH on the CT output indicates a passed condition and a LOW indicates a failed condition.



BD001961

Figure 1. Detailed Block Diagram

## FUNCTIONAL DESCRIPTION

### Architecture of the Am29117

The Am29117 is a high-performance, microprogrammable 16-bit bipolar microprocessor.

As shown in the Detailed 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
- Arithmetic Logic Unit (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  $\overline{IEN}$  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  $\overline{IEN}$  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 Am29117 on the D 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 Am29117 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, ( $\overline{SRE}$ ) input LOW and the  $\overline{IEN}$  input LOW, the Status Register is updated at the end of all instructions except NO-OP, Save-Status and Test-Status instructions.  $\overline{SRE}$  going HIGH or  $\overline{IEN}$  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  $\overline{SRE}$  LOW and  $\overline{IEN}$  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 T<sub>1-4</sub> 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, I<sub>0-4</sub>, have priority over T<sub>1-4</sub>, for testing status.

### Three-State Output Buffers

There are two sets of Three-State Output Buffers in the Am29117. One set controls the 16-bit Y bus. These outputs are enabled by placing a LOW on the  $\overline{OE}_Y$  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 Am29117. 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 Am29117 is very powerful. In addition to the single and two operand logical and arithmetic instructions, the Am29117 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.

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 Am29117 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. 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)		RAM
	ACC		ACC
	D		Y Bus
	D(0E)		Status
	D(SE)		ACC and Status
	I		
	0		
Two Operand	Source (R)	Source (S)	Destination
	RAM	ACC	RAM
	RAM	I	ACC
	D	RAM	Y Bus
	D	ACC	Status
	ACC	I	ACC and Status
	D	I	Status
Single Bit Shift	Source (U)		Destination
	RAM		RAM
	ACC		ACC
	ACC		Y Bus
	D		RAM
	D		ACC
	D		Y Bus
Rotate n Bits	Source (U)		Destination
	RAM		RAM
	ACC		ACC
	D		Y Bus
Bit Oriented	Source (R/S)		Destination
	RAM		RAM
	ACC		ACC
	D		Y Bus
Rotate and Merge	Rotated		Non-Rotated
	Source (U)	Mask (S)	Source/ Destination (R)
	D	I	ACC
	D	RAM	ACC
	D	I	RAM
	D	ACC	RAM
	ACC	I	RAM
	RAM	I	ACC
Rotate and Compare	Rotated		Non-Rotated
	Source (U)	Mask (S)	Source/ Destination (R)
	D	I	
	D	I	RAM
	D	ACC	RAM
	RAM	I	ACC

Instruction Type	Operand Combinations (Note 1)		
	Source (R)	Mask (S)	Destination
Prioritize (Note 3)	RAM	RAM	RAM
	ACC	ACC	ACC
	D	I	Y Bus
Cyclic Redundancy Check	Data In	Destination	Polynomial
	QLINK	RAM	ACC
No Operation	-		
Set Reset Status	Bits Affected		
	OVR, N, C, Z		
	LINK		
	Flag1		
	Flag2		
	Flag3		
Store Status	Source		Destination
	Status		RAM
			ACC
			Y Bus
Status Load	Source (R)	Source (S)	Destination
	D	ACC	Status
	ACC	I	Status and ACC
	D	I	
Test Status	Test Condition (CT)		
	$(N \oplus OVR) + Z$		
	$N \oplus OVR$		
	Z		
	OVR		
	Low		
	C		
	$Z + \bar{C}$		
	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 Am29117 is capable of extending sign bit (D(SE)) or binary zero (D(0E)) 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

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

SONR	B/W		Quad		Opcode		SRC	Dest
------	-----	--	------	--	--------	--	-----	------

### SINGLE OPERAND INSTRUCTION

Instruction <sup>1</sup>	B/W <sup>2</sup>	Quad <sup>3</sup>	Opcode	R/S <sup>4</sup> Dest <sup>4</sup>	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(0E) RAM		
			1010 SOSER D(SE) RAM		
			1011 SORR RAM RAM		
Instruction	B/W	Quad	Opcode	R/S <sup>4</sup>	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 <sup>5</sup>
			1111 NEG SRC + 1 ..Dest	1000 SOZ 0	00101 NRAS ACC, Status <sup>5</sup>
				1001 SOZE D(0E)	
			1010 SOSE D(SE)		

Notes: 1. The instruction mnemonic designates different instruction formats used in the Am29117. They are useful in assembly microcode with the System 29 AMDASM<sup>TM</sup> 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
SONR	COMP	SRC ..Dest	1 = W	Y - SRC	NC	NC	NC	NC	0	U	0	U
	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

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## 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 <sup>1</sup>	S <sup>1</sup>	Dest <sup>1</sup>	Opcode	RAM Address					
TOR1	0 = B 1 = W	00	0000	TORAA	RAM	ACC	0000	SUBR S minus R	00000	R00	RAM Reg 00	
			0010	TORIA	RAM	I	ACC	0001	SUBRC <sup>2</sup> 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 <sup>2</sup> 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 <sup>2</sup> S minus R	...	...	...
	0101	TODIR	D	I	RAM		with carry	11111	R31	RAM Reg 31		
						0010	SUBS R minus S					
						0011	SUBSC <sup>2</sup> 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						

- Notes: 1. R = Source  
 S = Source  
 Dest = Destination  
 2. During subtraction the carry is interpreted as borrow.

## TWO OPERAND INSTRUCTIONS

Instruction	B/W	Quad	R <sup>1</sup>	S <sup>1</sup>	Opcode	Destination						
TONR	0 = B 1 = W	11	0001	TODA	D	ACC	0000	SUBR	S minus R	00000	NRY	Y Bus
	0010		TOAI	ACC	I	0001	SUBRC <sup>3</sup>	S minus R with carry	00001	NRA	ACC	
	0101		TODI	D	I	0010	SUBS	R minus S	00100	NRS	Status <sup>2</sup>	
	0111		SUBSC <sup>3</sup>	R minus S with carry	00101	NRAS	ACC, Status <sup>2</sup>					
	0100		ADD	R plus S								
	0101		ADDC	R plus S with carry								
	0110		AND	R·S								
	0111		NAND	$\overline{R \cdot S}$								
	1000		EXOR	$R \oplus S$								
	1001		NOR	$\overline{R + S}$								
	1010		OR	$R + S$								
	1011		EXNOR	$\overline{R \oplus S}$								

- Notes: 1. R = Source  
S = Source  
2. When status is destination,  
Status i. Y<sub>i</sub> 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	$Y_{i-1} - S + \overline{R} + 1$	NC	NC	NC	NC	U	U	U	U
	SUBRC	S minus R with carry	1 = w	$Y_{i-1} - S + \overline{R} + QC$	NC	NC	NC	NC	U	U	U	U
	SUBS	R minus S		$Y_{i-1} - R + \overline{S} + 1$	NC	NC	NC	NC	U	U	U	U
	SUBSC	R minus S with carry		$Y_{i-1} - R + \overline{S} + QC$	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	$R \cdot S$		$Y_{i-1} - R_i \text{ AND } S_i$	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	$R \oplus S$		$Y_{i-1} - R_i \text{ EXOR } S_i$	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

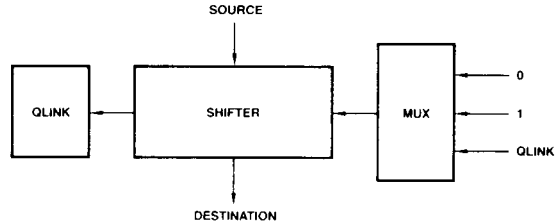
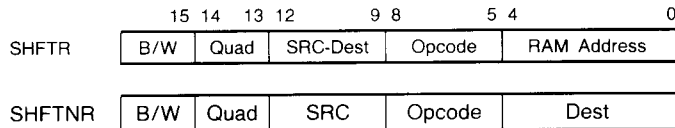
- U = Update  
NC = No Change  
0 = Reset  
1 = Set  
i = 0 to 15 when not specified

## 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,

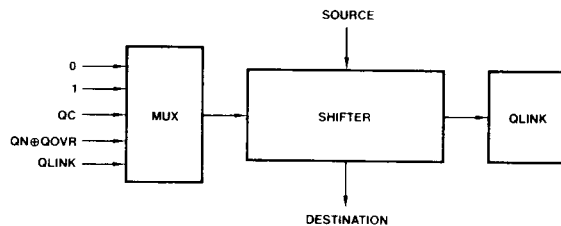
or the Link-Status bit (QLINK). The MSB is loaded into the Link-Status bit as shown in Figure 2. On a shift-down instruction, the MSB may be loaded with ZERO, ONE, the contents of the Status Carry flip-flop, (QC), the Exclusive-OR of the Negative-Status bit and the Overflow-Status bit (QN  $\oplus$  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  $\oplus$  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 <sup>1</sup>			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 <sup>1</sup>			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 SHUP1 SHUPL	Up 0 Up 1 Up QLINK	1 = W	Y <sub>i</sub> - SRC <sub>i-1</sub> , i = 1 to 15; Y <sub>0</sub> - Shift Input	NC	NC	NC	SRC <sub>15</sub> *	0	SRC <sub>14</sub>	0	U
			0 = B	Y <sub>i</sub> - SRC <sub>i-1</sub> , i = 1 to 7; Y <sub>0</sub> - Shift Input; Y <sub>8</sub> - SRC <sub>7</sub> , Y <sub>i</sub> - SRC <sub>i-8</sub> for i = 9 to 15	NC	NC	NC	SRC <sub>7</sub> *	0	SRC <sub>6</sub>	0	U
	SHDNZ SHDN1 SHDNL SHDNC SHCNOV	Down 0 Down 1 Down QLINK Down QC Down QN⊕QOVR	1 = W	Y <sub>i</sub> - SRC <sub>i+1</sub> , i = 0 to 14; Y <sub>15</sub> - Shift Input	NC	NC	NC	SRC <sub>0</sub> *	0	Shift Input	0	U
			0 = B	Y <sub>i</sub> - SRC <sub>i+1</sub> , i = 0 to 6; Y <sub>i</sub> - SRC <sub>i-7</sub> , i = 8 to 14; Y <sub>7,15</sub> - Shift Input	NC	NC	NC	SRC <sub>0</sub> *	0	Shift Input	0	U

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

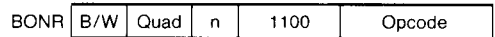
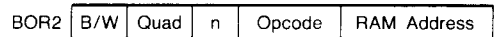
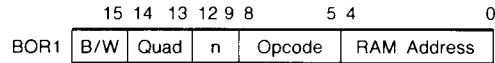
\*Shifted Output is loaded into the QLINK.

## 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  $n^{\text{th}}$  bit to a ONE leaving other bits unchanged; Reset Bit n

which forces the  $n^{\text{th}}$  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	$Y_i \leftarrow \text{RAM}_i$ for $i \neq n$ ; $Y_n \leftarrow 1$	NC	NC	NC	NC	0	U	0	0	
	RSTNR	Reset RAM, Bit n		$Y_i \leftarrow \text{RAM}_i$ for $i \neq n$ ; $Y_n \leftarrow 0$	NC	NC	NC	NC	0	U	0	0	U
	TSTNR	Test Ram, Bit n		$Y_i \leftarrow 0$ for $i \neq n$ ; $Y_n \leftarrow \text{SRC}_n$	NC	NC	NC	NC	0	U	0	0	U
BOR2	LD2NR	$2^n \leftarrow \text{RAM}$		$Y_i \leftarrow 0$ for $i \neq n$ ; $Y_n \leftarrow 1$	NC	NC	NC	NC	0	U	0	0	0
	LDC2NR	$2^n \leftarrow \text{RAM}$		$Y_i \leftarrow 1$ for $i \neq n$ ; $Y_n \leftarrow 0$	NC	NC	NC	NC	0	U	0	0	0
	A2NR	$\text{RAM} + 2^n \leftarrow \text{RAM}$		$Y_i \leftarrow \text{RAM} + 2^n$	NC	NC	NC	NC	U	U	U	U	U
	S2NR	$\text{RAM} - 2^n \leftarrow \text{RAM}$		$Y_i \leftarrow \text{RAM} - 2^n$	NC	NC	NC	NC	U	U	U	U	U
BONR	TSTNA	Test ACC, Bit n		$Y_i \leftarrow 0$ for $i \neq n$ ; $Y_n \leftarrow \text{ACC}_n$	NC	NC	NC	NC	0	U	0	0	U
	RSTNA	Reset ACC, Bit n		$Y_i \leftarrow \text{ACC}_i$ for $i \neq n$ ; $Y_n \leftarrow 0$	NC	NC	NC	NC	0	U	0	0	U
	SETNA	Set ACC, Bit n		$Y_i \leftarrow \text{ACC}_i$ for $i \neq n$ ; $Y_n \leftarrow 1$	NC	NC	NC	NC	0	U	0	0	0
	A2NA	$\text{ACC} + 2^n \leftarrow \text{ACC}$		$Y_i \leftarrow \text{ACC} + 2^n$	NC	NC	NC	NC	U	U	U	U	U
	S2NA	$\text{ACC} - 2^n \leftarrow \text{ACC}$		$Y_i \leftarrow \text{ACC} - 2^n$	NC	NC	NC	NC	U	U	U	U	U
	LD2NA	$2^n \leftarrow \text{ACC}$		$Y_i \leftarrow 0$ for $i \neq n$ ; $Y_n \leftarrow 1$	NC	NC	NC	NC	0	U	0	0	0
	LDC2NA	$2^n \leftarrow \text{ACC}$		$Y_i \leftarrow 1$ for $i \neq n$ ; $Y_n \leftarrow 0$	NC	NC	NC	NC	0	U	0	0	0
	TSTND	Test D, Bit n		$Y_i \leftarrow 0$ for $i \neq n$ ; $Y_n \leftarrow D_n$	NC	NC	NC	NC	0	U	0	0	U
	RSTND	Reset D, Bit n*	$Y_i \leftarrow D_i$ for $i \neq n$ ; $Y_n \leftarrow 0$	NC	NC	NC	NC	0	U	0	0	U	
	SETND	Set D, Bit n*	$Y_i \leftarrow D_i$ for $i \neq n$ ; $Y_n \leftarrow 1$	NC	NC	NC	NC	0	U	0	0	0	
	A2NDY	$D + 2^n \leftarrow Y \text{ Bus}$	$Y \leftarrow D + 2^n$	NC	NC	NC	NC	U	U	U	U	U	
	S2NDY	$D - 2^n \leftarrow Y \text{ Bus}$	$Y \leftarrow D - 2^n$	NC	NC	NC	NC	U	U	U	U	U	
	LD2NY	$2^n \leftarrow Y \text{ Bus}$	$Y_i \leftarrow 0$ for $i \neq n$ ; $Y_n \leftarrow 1$	NC	NC	NC	NC	0	U	0	0	0	
	LDC2NY	$2^n \leftarrow Y \text{ Bus}$	$Y_i \leftarrow 1$ for $i \neq n$ ; $Y_n \leftarrow 0$	NC	NC	NC	NC	0	U	0	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

### ROTATE BY n BITS FIELD DEFINITIONS

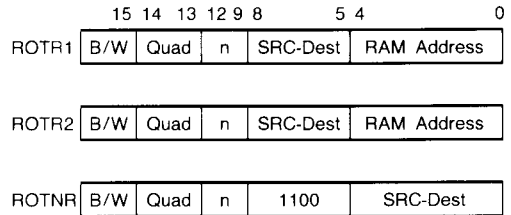


Figure 4. Rotate by n Example

### ROTATE BY n BITS INSTRUCTIONS

Instruction	B/W	Quad	n	U <sup>1</sup>		Dest <sup>1</sup>		RAM Address			
ROTR1	0 = B 1 = W	00	0 to 15	1100 1110 1111	RTRA RTRY RTRR	RAM RAM RAM	ACC Y Bus RAM	00000 . . 11111	R00 . . R31	RAM Reg 00 . . RAM Reg 31	
Instruction	B/W	Quad	n	U <sup>1</sup>		Dest <sup>1</sup>		RAM Address			
ROTR2	0 = B 1 = W	01	0 to 15	0000 0001	RTAR RTDR	ACC D	RAM RAM	00000 . . 11111	R00 . . R31	RAM Reg 00 . . RAM Reg 31	
Instruction	B/W	Quad	n	U <sup>1</sup>		Dest <sup>1</sup>		RAM Address			
ROTNR	0 = B 1 = W	11	0 to 15	1100				11000 11001 11100 11101	RTDY RTDA RTAY RTAA	D D ACC ACC	Y Bus ACC Y Bus 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	$Y_i - SRC_{(i-n) \bmod 16}$	NC	NC	NC	NC	0	SRC <sub>15-n</sub>	0	U
		0 = B	$Y_i - SRC_i + 8 = SRC_{(i-n) \bmod 8}$ for i = 0 to 7	NC	NC	NC	NC	0	SRC <sub>8-n</sub>	0	U

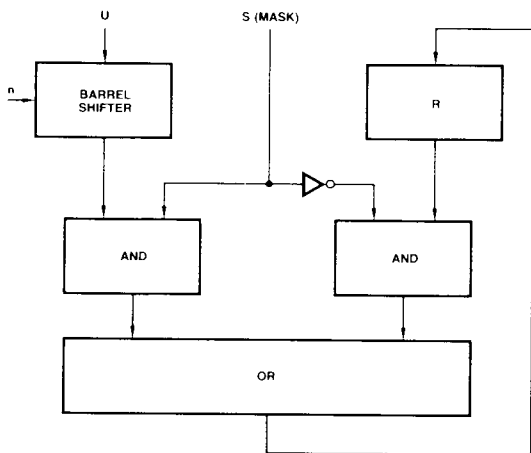
SRC = Source  
U = No Change  
0 = Reset  
1 = Set  
i = 0 to 15 when not specified



## 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  $i^{\text{th}}$  bit of the R input as the  $i^{\text{th}}$  output bit, while ONE in bit i will select the  $i^{\text{th}}$  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.



PF000630

Figure 5. Rotate and Merge Function

## 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

## ROTATE AND MERGE INSTRUCTION

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

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

## Y BUS AND STATUS - ROTATE AND MERGE INSTRUCTIONS

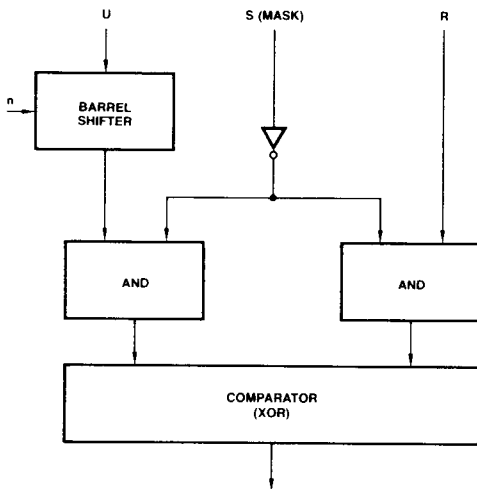
Instruction	Opcode	B/W	Y - Bus	Flag3	Flag2	Flag1	LINK	OVR	N	C	Z
ROTM		1=W	$Y_i - (\text{Non Rot Op})_i \cdot (\text{mask})_i + (\text{Rot Op})_{(i-n) \bmod 16} \cdot (\text{mask})_i$	NC	NC	NC	NC	0	U	0	U
		0=B	$Y_i - (\text{Non Rot Op})_i \cdot (\text{mask})_i + (\text{Rot Op})_{(i-n) \bmod 8} \cdot (\text{mask})_i$	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 in 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 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 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 <sup>1</sup>	R <sup>1</sup>	S <sup>1</sup>	RAM Address				
ROTC	0 = B 1 = W	01	0 to 15	0010	CDAI	D	ACC		00000	R00	RAM Reg 00
				0011	CDRI	D	RAM		...	...	...
				0100	CDRA	D	RAM	ACC	11111	R31	RAM Reg 31
				0101	CRAI	RAM	ACC				

U = Rotated Source  
R = Non-Rotated Source  
S = Mask

## Y BUS AND STATUS - ROTATE AND COMPARE INSTRUCTIONS

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

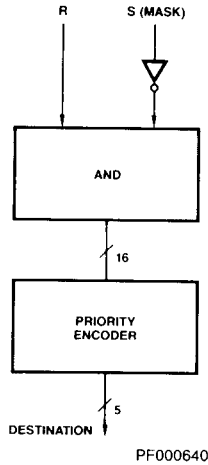


Figure 9. Prioritize Function

## PRIORITIZE 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 INSTRUCTIONS

Instruction	Opcode	B/W	Y - Bus	Flag3	Flag2	Flag1	LINK	OVR	N	C	Z
PRT1 PRT2		1 = W	$Y_i$ - CODE ( $SCR_n$ - $mask_n$ ); $Y_m$ . 0; $i = 0$ to 4 and $n = 0$ to 15 $m = 5$ to 15	NC	NC	NC	NC	0	U	0	U
PRT3 PRTNR		0 = B	$Y_i$ - CODE ( $SCR_n$ - $mask_n$ ); $Y_m$ . 0; $i = 0$ to 3 and $n = 0$ to 7 $m = 4$ to 15	NC	NC	NC	NC	0	U	0	U

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

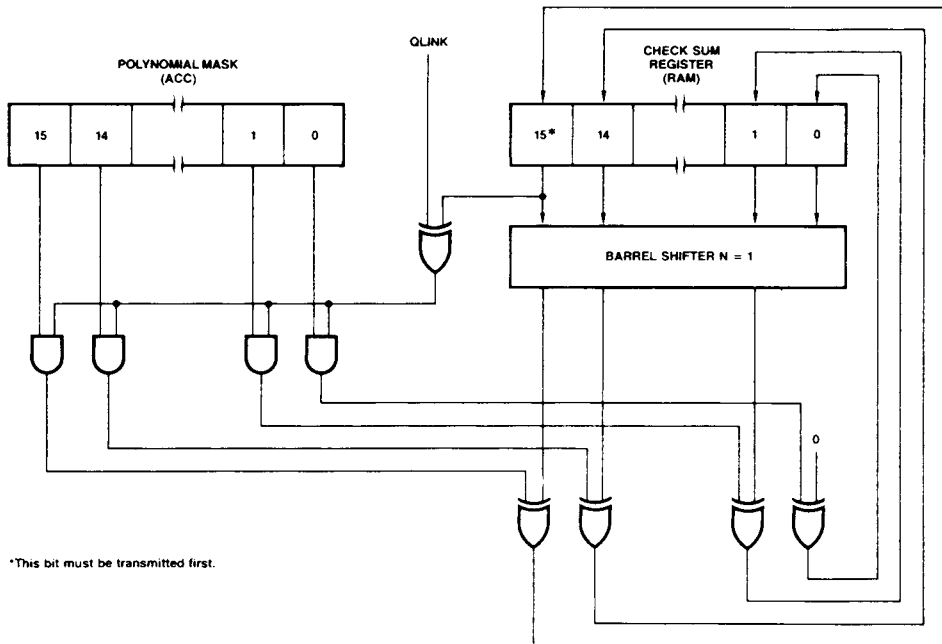
### Cyclic-Redundancy-Check Instruction

The Cyclic-Redundancy-Check (CRC) 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 CRC 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 check-sum register contains 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 FIELD DEFINITIONS:

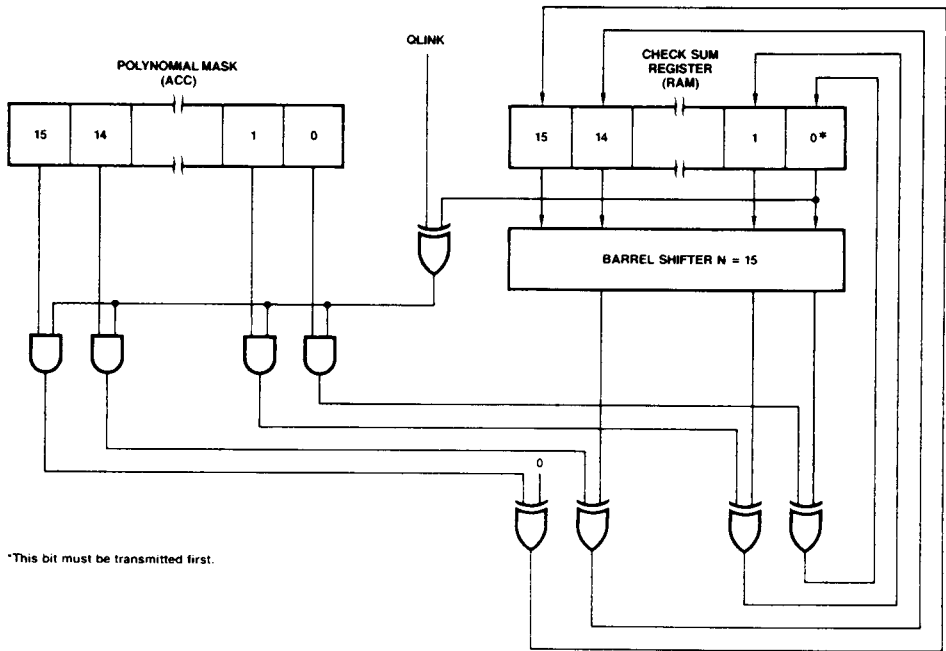
	15	14	13	12	9	8	5	4	0
CRCF	1	Quad	0110	0011	RAM Address				
CRCR	1	Quad	0110	1001	RAM Address				



\*This bit must be transmitted first.

PF000330

Figure 11. CRC Forward Function



PF000320

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**

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 <sub>15</sub> *	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 <sub>0</sub> *	0	U	0	U

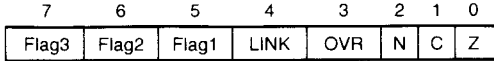
\*QLINK is loaded with the shifted out bit from the checksum register.

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).



MPR-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 + Q $\bar{C}$  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 I<sub>1</sub> to I<sub>4</sub> as shown below. Instruction lines I<sub>0</sub> - I<sub>4</sub> 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 <sub>4</sub> I <sub>4</sub>	T <sub>3</sub> I <sub>3</sub>	T <sub>2</sub> I <sub>2</sub>	T <sub>1</sub> I <sub>1</sub>	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 + $\bar{C}$
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 FIELD DEFINITIONS

	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
					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 00010 00100 00110 01000 01010 01100 01110 10000 10010 10100 10110	TNOZ TNO TZ TOVR TLOW TC TZC TN TL TF1 TF2 TF3	Test (N⊕OVR) + Z Test N⊕OVR Test Z Test OVR Test LOW Test C Test Z + $\bar{C}$ Test N Test LINK Test Flag1 Test Flag2 Test Flag3

Note:

## Y BUS AND STATUS - 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	NC
	SF1	Set Flag1			NC	NC	1	NC	NC	NC	NC	NC	NC
	SF2	Set Flag2			NC	1	NC	NC	NC	NC	NC	NC	NC
	SF3	Set Flag3			1	NC	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		
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

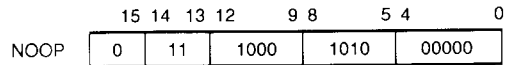
\*In byte mode only the lower byte from the Y bus is loaded into the RAM or ACC and in word mode all 16-bits from the Y bus are loaded into the RAM or ACC.

\*\*Y-Bus is Undefined.

### NO-OP Instruction

The NO-OP Instruction has a fixed 16-bit code. This instruction does not change any internal registers in the Am291176. It preserves the status register, RAM register and the ACC register.

### NO OPERATION FIELD DEFINITION



### NO-OP INSTRUCTION

Instruction	B/W	Quad			
<b>NOOP</b>	<b>0</b>	<b>11</b>	<b>1000</b>	<b>1010</b>	<b>00000</b>

### Y BUS AND STATUS - NO-OP INSTRUCTION

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

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
------	--

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

## ABSOLUTE MAXIMUM RATINGS

Storage Temperature	-65 to +150°C
Case Temperature Under Bias (T <sub>C</sub> )	-55 to +125°C
Supply Voltage to Ground Potential	-0.5 V to +7.0 V
DC Voltage Applied to Outputs For	
High Output State	-0.5 V to +V <sub>CC</sub> Max.
DC Input Voltage	-0.5 V to +5.5 V
DC Output Current, Into Outputs	30 mA
DC Input Current	-30 mA to +5.0 mA

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 (T <sub>A</sub> )	0 to +55°C
Supply Voltage	+4.75 V to +5.25 V
Air Velocity	300 linear feet per minute

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 1)		Min.	Max.	Units
V <sub>OH</sub>	Output HIGH Voltage	V <sub>CC</sub> = Min. V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	Y <sub>0-15</sub> T <sub>1-4</sub> CT	I <sub>OH</sub> = -1.6 mA	2.4	Volts
V <sub>OL</sub>	Output LOW Voltage	V <sub>CC</sub> = Min. V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	Y <sub>0-15</sub> T <sub>1-4</sub> CT	I <sub>OL</sub> = 16 mA	0.5	Volts
V <sub>IH</sub>	Guaranteed Input Logical HIGH Voltage (Note 5)		All Inputs	2.0		Volts
V <sub>IL</sub>	Guaranteed Input Logical LOW Voltage (Note 5)		All Inputs		0.8	Volts
V <sub>I</sub>	Input Clamp Voltage	V <sub>CC</sub> = Min.	All Inputs	I <sub>IN</sub> = -18 mA	-1.5	Volts
I <sub>IL</sub>	Input LOW Current	V <sub>CC</sub> = Max. V <sub>IN</sub> = 0.5 Volts (Note 3)	I <sub>EN</sub> SRE DLE I <sub>0-4</sub> I <sub>5-15</sub> OET OEY CP T <sub>1-4</sub> D <sub>0-15</sub>		-0.50 -0.50 -1.00 -1.00 -0.50 -0.50 -1.50 -0.55 -0.50	mA
I <sub>IH</sub>	Input HIGH Current	V <sub>CC</sub> = Max. V <sub>IN</sub> = 2.4 Volts (Note 3)	I <sub>EN</sub> SRE DLE I <sub>0-4</sub> I <sub>5-15</sub> OET OEY CP T <sub>1-4</sub> D <sub>0-15</sub>		50 50 100 100 50 50 50 150 100 50	μA
I <sub>I</sub>	Input HIGH Current	V <sub>CC</sub> = Max. V <sub>IN</sub> = 5.5 Volts	All Inputs		1.0	mA
I <sub>OZH</sub>	Off State (HIGH Impedance) Output Current	V <sub>CC</sub> = Max. V <sub>O</sub> = 2.4 Volts (Note 3)	T <sub>1-4</sub> (Note 3) Y <sub>0-15</sub>		100 50	μA
I <sub>OZL</sub>	Off State (HIGH Impedance) Output Current	V <sub>CC</sub> = Max. V <sub>O</sub> = 0.5 Volts (Note 4)	T <sub>1-4</sub> (Note 3) Y <sub>0-15</sub>		-550 -50	μA
I <sub>OS</sub>	Output Short Circuit Current	V <sub>CC</sub> = Max. + 0.5 Volts V <sub>O</sub> = 0.5 Volts (Note 2)			-30 -85	mA
I <sub>CC</sub>	Power Supply Current (Note 4)	V <sub>CC</sub> = Max.	COM'L	T <sub>AL</sub> = 0 to 55°C (Note 6) T <sub>A</sub> = 55°C	735 535	mA

- Notes: 1. For conditions shown as Min. or Max., use the appropriate value specified under Operating Ranges for the applicable device type.  
 2. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.  
 3. Y<sub>0-15</sub>, T<sub>1-4</sub> are three-state outputs internally connected to TTL inputs. Input characteristics are measured under conditions such that the outputs are in the OFF state.  
 4. Worst case I<sub>CC</sub> is at minimum temperature.  
 5. These input levels provide zero noise immunity and should be tested only in a static, noise-free environment.  
 6. Cold start.

## SWITCHING CHARACTERISTICS over operating range unless otherwise specified

( $T_A = 0$  to  $+55^\circ\text{C}$ ,  $V_{CC} = 4.75$  to  $5.25$  V,  $C_L = 50$  pF) (Note 7)

### A. Combinational Delays (nsec)

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

### B. Enable/Disable Times (nsec)




( $C_L = 5$  pF for disable only)

From Input	To Output	Enable		Disable	
		t <sub>pZH</sub>	t <sub>pZL</sub>	t <sub>pHZ</sub>	t <sub>pLZ</sub>
OE <sub>Y</sub>	Y <sub>0-15</sub>	20	20	20	20
OE <sub>T</sub>	T <sub>1-4</sub>	25	25	25	25

### C. Clock and Pulse Requirements (nsec)

Input	Min Low Time	Min High Time
CP	20	30
DLE	-	15
IEN	22	-

### 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 <sub>0-4</sub> (RAM ADDR)	CP	(t <sub>s1</sub> ) 24	(t <sub>h1</sub> ) 0	-	-	Single ADDR (Source)	
I <sub>0-4</sub> (RAM ADDR)	CP and IEN both LOW	(t <sub>s2</sub> ) 10	Do Not Change		(t <sub>h7</sub> ) 2	Two ADDR (Destination)	
I <sub>0-15</sub> (DATA)	CP	-	-	(t <sub>s8</sub> ) 65	(t <sub>h8</sub> ) 2		
I <sub>0-15</sub> (INSTR)	CP	(t <sub>s3</sub> ) 38†	(t <sub>h3</sub> ) † 17	(t <sub>s9</sub> ) 65	(t <sub>h9</sub> ) 2		
I <sub>0-15</sub> (INSTR)	IEN 	(t <sub>s16</sub> ) 6	(t <sub>h16</sub> ) 18	-	-	Two ADDR Immediate	
IEN 	CP 	-	-	-	(t <sub>h15</sub> ) 8	Two ADDR Immediate	
IEN HIGH	CP	(t <sub>s4</sub> ) 10	-	-	(t <sub>h10</sub> ) 1	Disable	
IEN LOW	CP	-	(t <sub>s5</sub> ) 20	(t <sub>h5</sub> )† 2	(t <sub>s11</sub> ) 22	(t <sub>h11</sub> )†† 1	Enable
SRE	CP	-	-	(t <sub>s12</sub> ) 17	(t <sub>h12</sub> ) 0		
D	CP	-	-	(t <sub>s13</sub> ) 44	(t <sub>h13</sub> ) 1		
D	DLE	(t <sub>s6</sub> ) 10	(t <sub>h6</sub> ) 6	-	-		
DLE	CP	-	-	(t <sub>s14</sub> ) 42	(t <sub>h14</sub> ) 0		

†Timing for immediate instruction for first cycle.

†† Status register and accumulator destination only.

### Notes on Testing

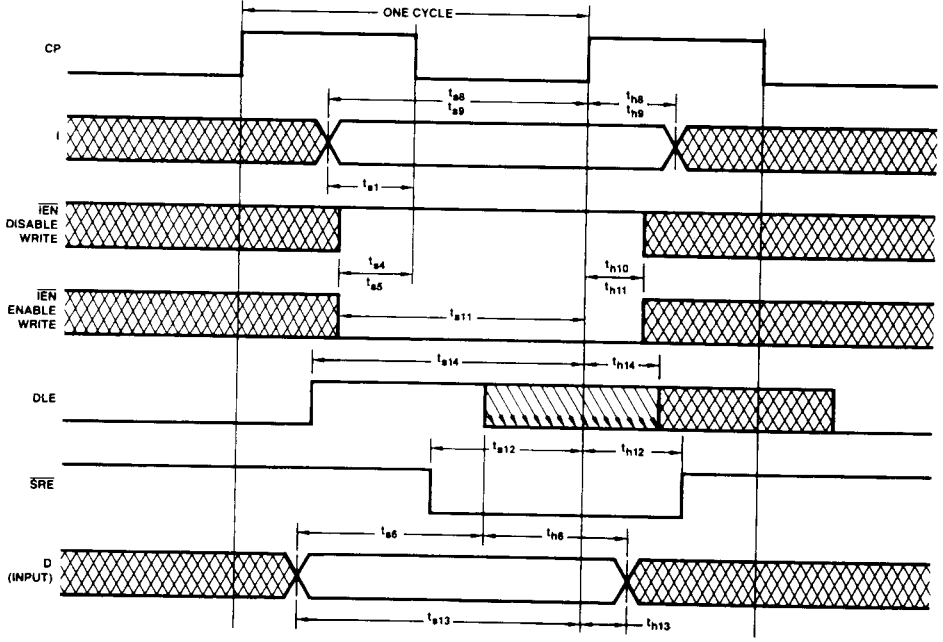
Incoming test procedures on this device should be careful planned, taking into account the high complexity and power levels of the part. The following notes may be useful:

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 5-8 ns. Inductance in the ground

cable may allow 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  $V_{IL} \leq 0$  V and  $V_{IH} \geq 3.0$  V 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.
7. At air velocity of 300 linear feet per minute.

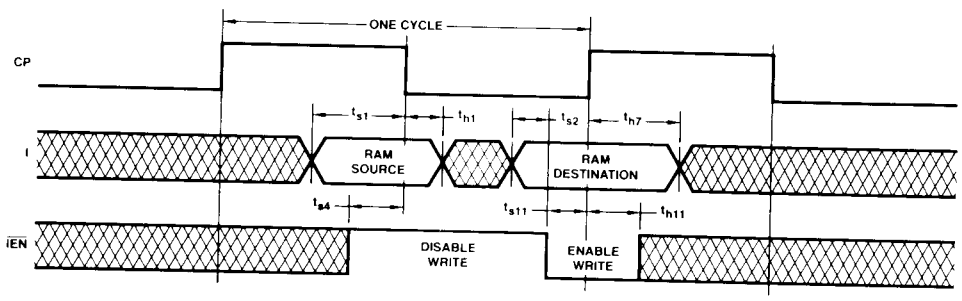
# SWITCHING WAVEFORMS



WF002561

## Single Address Access Timing

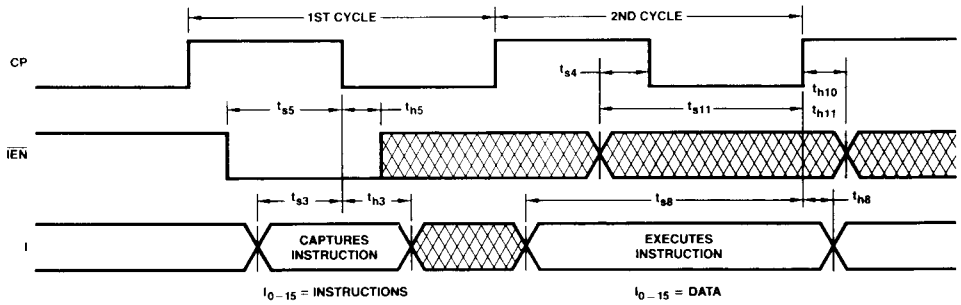
If  $t_{h6}$  is satisfied,  $t_{h13}$  need not be satisfied.



WF002540

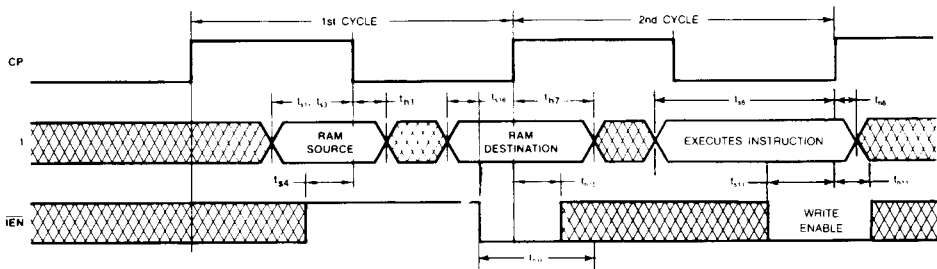
## Double Address Access Timing

## SWITCHING WAVEFORMS (Cont.)



WF002550

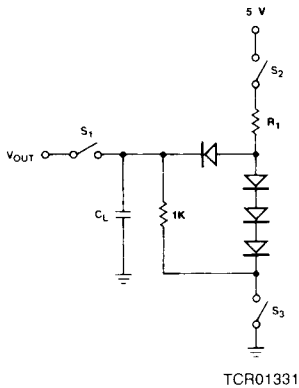
**One-Address Immediate Instruction Cycle Timing**



WF002542

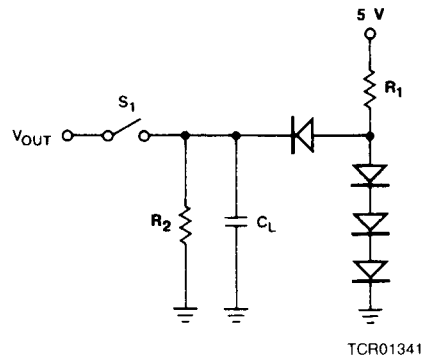
**Two-Address Immediate Instruction Timing**

## SWITCHING TEST CIRCUITS



**A. Three-State Outputs**

$$R_1 = 300 \Omega$$



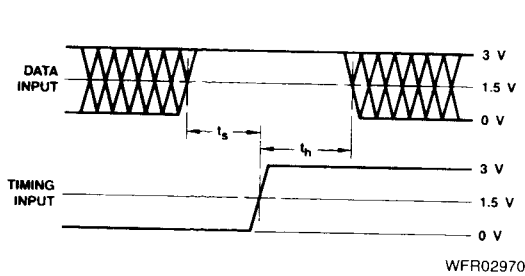
**B. Normal Outputs**

$$R_1 = 300 \Omega$$

$$R_2 = 3.0 \text{ k}\Omega$$

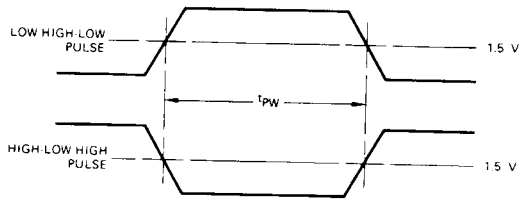
- Notes:
1.  $C_L = 50 \text{ pF}$  includes scope probe, wiring and stray capacitances without device in test fixture.
  2.  $S_1, S_2, S_3$  are closed during function tests and all AC tests except output enable tests.
  3.  $S_1$  and  $S_3$  are closed while  $S_2$  is open for  $t_{pZH}$  test.  
 $S_1$  and  $S_2$  are closed while  $S_3$  is open for  $t_{pZL}$  test.
  4.  $C_L = 5.0 \text{ pF}$  for output disable tests.

## SWITCHING TEST WAVEFORMS



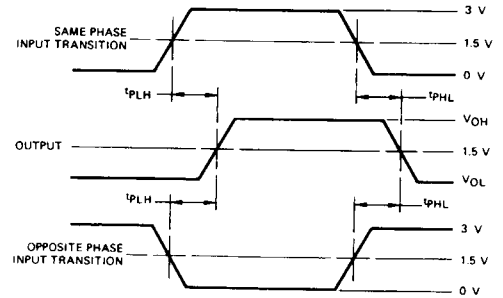
### Set-up, Hold, and Release Times

- Notes: 1. Diagram shown for HIGH data only. Output transition may be opposite sense.  
 2. Cross hatched area is don't care condition.

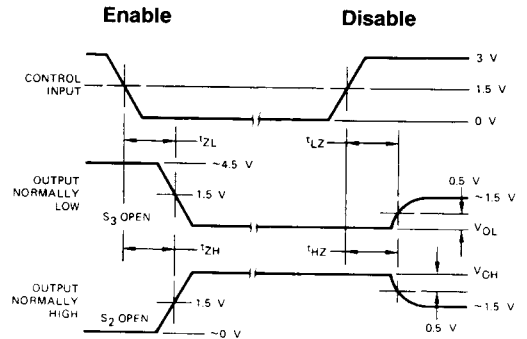


### Pulse Width

- Note: 1. Pulse generator for all pulses  
 Rate  $\leq 1.0$  MHz;  $Z_0 = 50 \Omega$ ;  
 $t_r \leq 2.5$  ns;  $t_f \leq 2.5$  ns.



### Propagation Delay

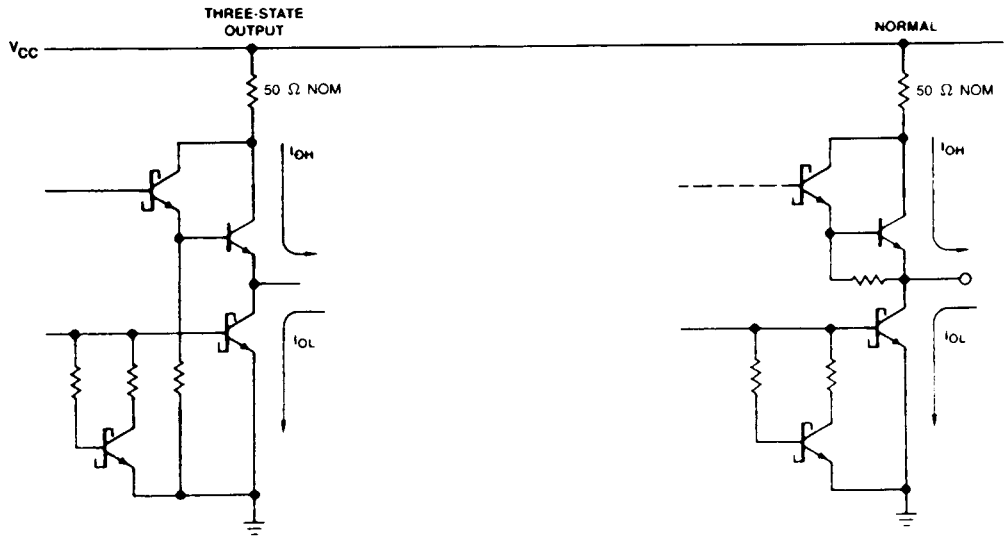


### Enable and Disable Times

- Notes: 1. Diagram shown for Input Control Enable-LOW and Input Control Disable-HIGH  
 2.  $S_1$ ,  $S_2$  and  $S_3$  of Load Circuit are closed except where shown.

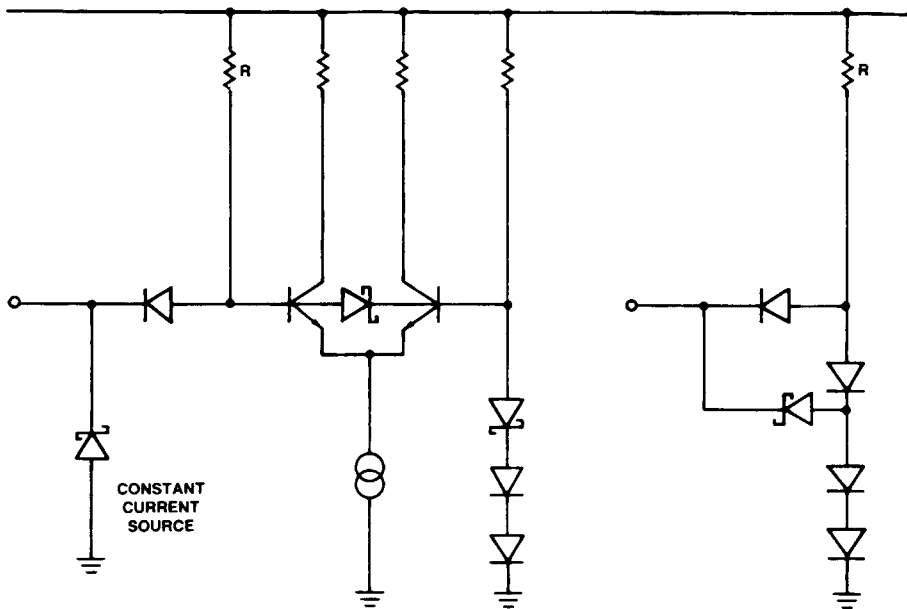
# INPUT/OUTPUT CURRENT INTERFACE

TTL



ICR00523

$C_O \cong 5.0$  pF, all outputs

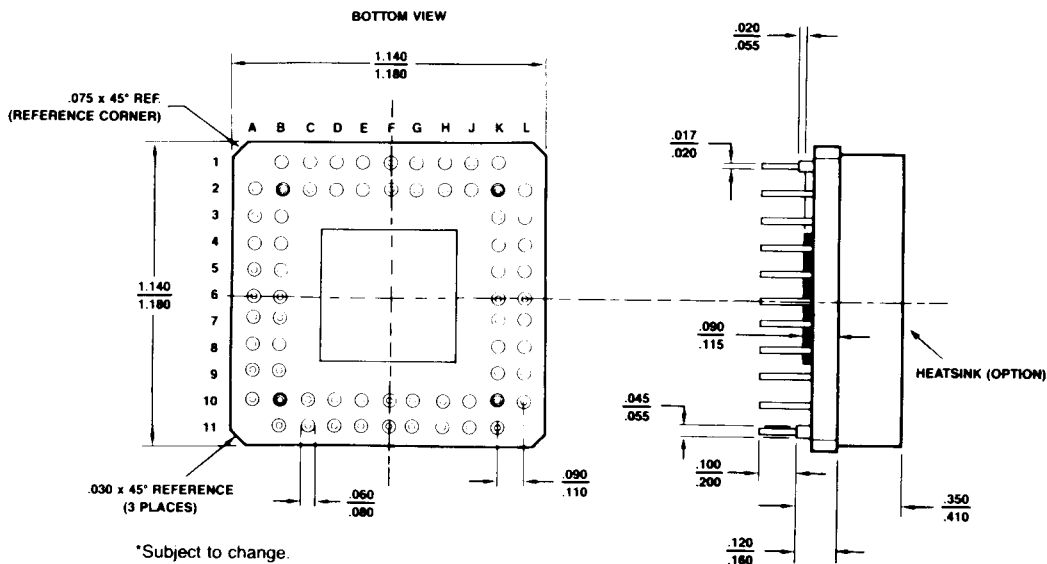


ICR00531



# PHYSICAL DIMENSIONS

## CG068



07547A

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