

Am29C516A/Am29C517A

16 x 16-Bit CMOS Parallel Multipliers



Am29C516A/Am29C517A

Advanced Micro Devices

DISTINCTIVE CHARACTERISTICS

- 45-ns Clocked Multiply (Am29C516A/Am29C517A)
- 35-ns Clocked Multiply (Am29C516A-1/Am29C517A-1)
- Low-power 1.2 micron CMOS technology
- 16 x 16-Bit Parallel Multiplier with 32-Bit output
- Full product multiplexed at output
- Two's complement, unsigned, or mixed operands
- Output register may be made transparent
- Am29C516A pin and functionally compatible with CY7C516, WTL1516, IDT7216, MPY016, and Am29516
- TTL I/O and single +5 V supply
- Available in 64-pin plastic or ceramic DIPs and 68-pin ceramic leadless or plastic leaded chip carriers

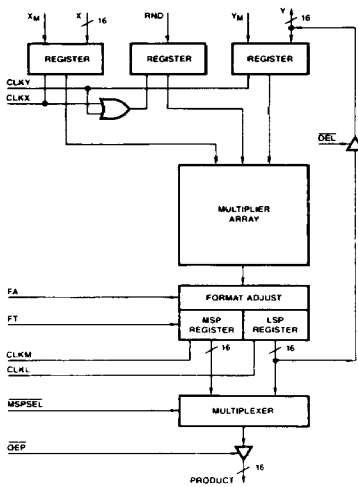
GENERAL DESCRIPTION

The Am29C516A/Am29C517A are high-speed, low-power, industry standard 16 x 16-bit parallel multipliers. They are widely used in array-processing and DSP applications. The 35-ns speed and 150-mW power dissipation provide fast multiplication and power savings. The Am29C516A has independent register clocks (CLKX, CLKY, CLKM, CLKL),

whereas the Am29C517A has a single clock and three register enables for use with microprogrammed systems. Applications for the Am29C516A/Am29C517A include digital filtering, graphics, speech recognition, radar, accelerators, FFT, and floating-point processors.

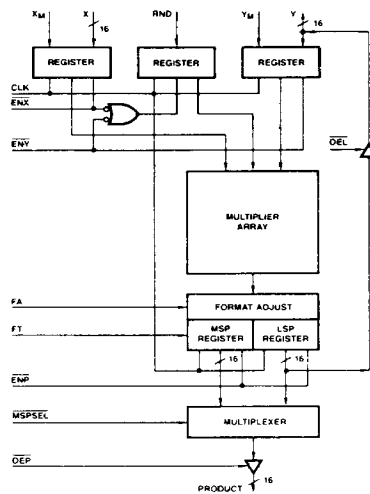
BLOCK DIAGRAMS

Am29C516A



BD002840

Am29C517A



BD002850

Publication #	Rev.	Amendment
09130	C	/0
Issue Date: July 1989		

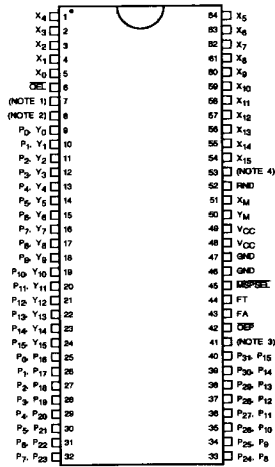
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RELATED AMD PRODUCTS

Part No.	Description
Am29C01	CMOS Four-Bit Microprocessor Slice
Am2903A	Four-Bit Bipolar Microprocessor Slice
Am2909A	Microprogram Sequencer
Am29C101	16-Bit CMOS Microprocessor Slice
Am29C10A	CMOS Microprogram Controller
Am2911A	Microprogram Sequencer
Am29C111	CMOS 16-Bit Microprogram Sequencer
Am29C116	16-Bit CMOS Microprocessor
Am29C117	16-Bit CMOS Microprocessor (with separate I/O)
Am29CPL151	CMOS Field-Programmable Controller
Am29CPL152	CMOS Field-Programmable Controller
Am29CPL154	CMOS Field-Programmable Controller
Am29C331	CMOS 16-Bit Microprogram Sequencer
Am29C332	CMOS 32-Bit Arithmetic Logic Unit
Am29C334	CMOS Four-Port Dual-Access Register File
Am29C52A	CMOS Eight-Bit Bidirectional I/O Port
Am29705A	16-Word by 4-Bit Two-Port RAM

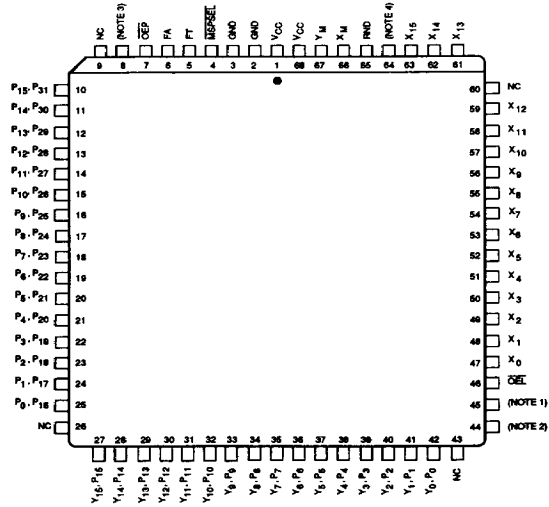
CONNECTION DIAGRAMS Top View

DIPs



CD010621

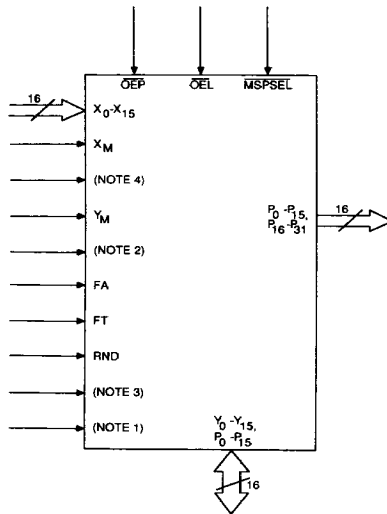
PLCC



CD011220

Note: Pin 1 is marked for orientation.

LOGIC SYMBOL

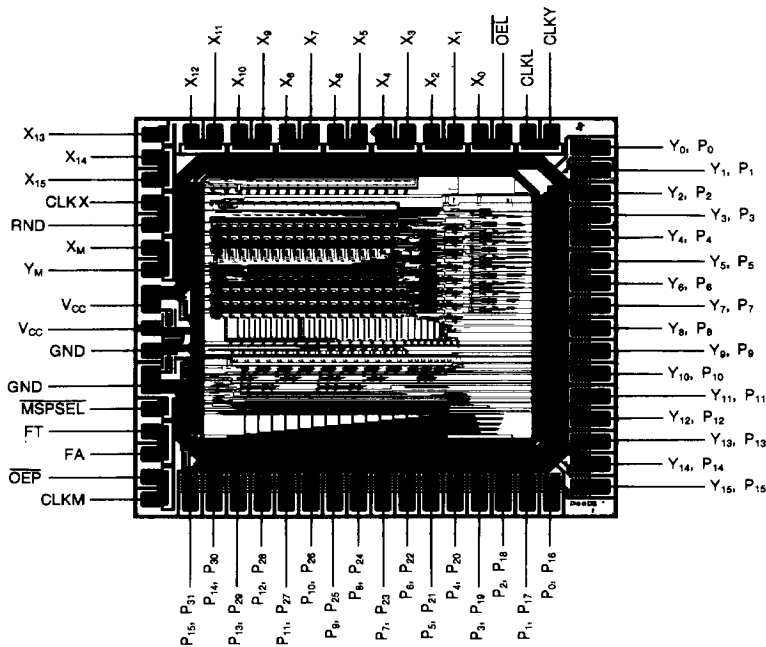


LS003000

Notes:

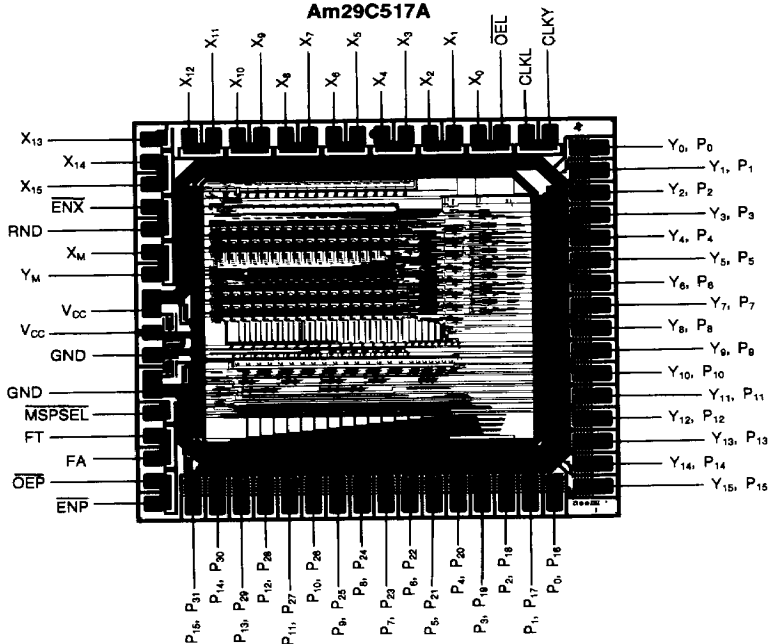
	Am29C516A	Am29C517A
1	CLKL	CLK
2	CLKY	ENY
3	CLKM	ENP
4	CLKX	ENX

METALLIZATION AND PAD LAYOUT Am29C516A



Approx. Component Count: 13000
Die Size: 256 x 253 Mils

Am29C517A



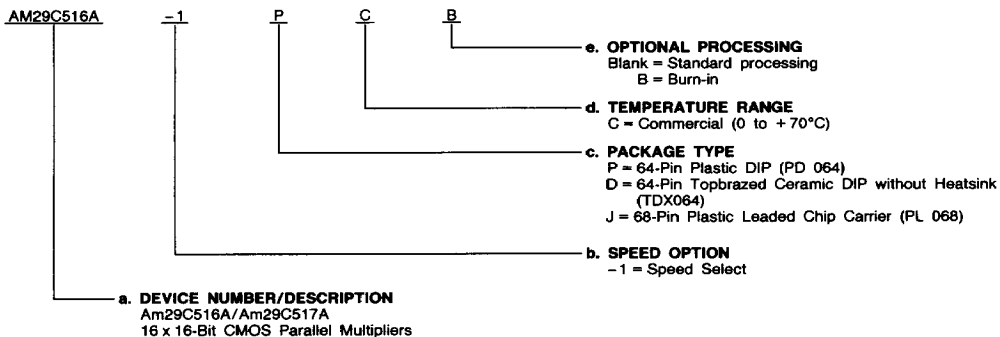
Approx. Component Count: 13000
Die Size: 256 x 253 Mils

ORDERING INFORMATION

Standard Products

AMD standard 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**



Valid Combinations	
AM29C516A	PC, DC, DCB, JC
AM29C517A	PC, DC, DCB, JC
AM29C516A-1	PC, DC, DCB, JC
AM29C517A-1	PC, DC, DCB, JC

Valid Combinations

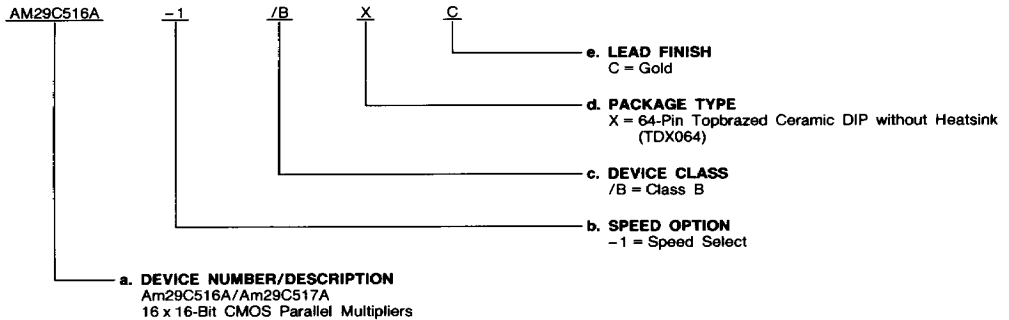
Valid Combinations list configurations planned to be supported in volume for this device. Consult the local AMD sales office to confirm availability of specific valid combinations, to check on newly released combinations, and to obtain additional data on AMD's standard military grade products.

MILITARY ORDERING INFORMATION

APL Products

AMD products for Aerospace and Defense applications are available in several packages and operating ranges. APL (Approved Products List) products are fully compliant with MIL-STD-883C requirements. The order number (Valid Combination) is formed by a combination of:

- a. **Device Number**
- b. **Speed Option** (if applicable)
- c. **Device Class**
- d. **Package Type**
- e. **Lead Finish**



Valid Combinations	
AM29C516A	/BXC
AM29C516A-1	
AM29C517A	
AM29C517A-1	

Valid Combinations

Valid Combinations list configurations planned to be supported in volume for this device. Consult the local AMD sales office to confirm availability of specific valid combinations or to check for newly released valid combinations.

Group A Tests

Group A tests consist of Subgroups 1, 2, 3, 7, 8, 9, 10, 11.

PIN DESCRIPTION

Am29C516A/Am29C517A

FA (RS*) Format Adjust (Input; Active HIGH)

Format Adjust control selects either a full 32-bit product (HIGH) or a left-shifted 31-bit product with the sign bit replicated in the Least Significant Product (LSP) (LOW). This control is normally HIGH, except for certain fractional two's-complement applications (see Multiplier output formats table).

FT Feedthrough (Input; Active HIGH)

Feedthrough control (HIGH) makes both MSP and LSP registers transparent.

MSPSEL Product Select (Input; Active LOW)

Selects either MSP (LOW) or LSP (HIGH) to be available at the product output port.

OEL (TRIL*) Output Enable LSP (Input; Active LOW)

Three-state enable for routing LSP through Y input/output port.

OEP (TRIM*) Output Enable Product (Input; Active LOW)

Three-state enable for product output port.

P₀-P₁₅ Data (Output)

LSP product port when MSPSEL is HIGH.

P₁₆-P₃₁ Data (Output)

MSP product port when MSPSEL is LOW.

RND Round Control (Input; Active HIGH)

Control for rounding the MSP. Adds a binary one to the most-significant bit of the LSP for two's-complement and unsigned numbers. Format adjust occurs before rounding.

X₀-X₁₅ Data (Input)

Multiplicand data inputs.

X_M, Y_M, (TCX, TCY*) Mode Control (Input)

Mode control inputs for each data word; LOW for unsigned data and HIGH for two's-complement data.

Y₀-Y₁₅ Data (Input/Output)

Multiplier data inputs or LSP output.

Am29C516A Only

CLKL LSP Register Clock (Input)

CLKM MSP Register Clock (Input)

CLKX Register Clock, X₀-X₁₅, RND (Input)

CLKY Register Clock, Y₀-Y₁₅, RND (Input)

Am29C517A Only

CLK Clock, All Registers (Input)

ENP Data (Input; Active LOW)

Register Enable MSP, LSP.

ENX Data (Input; Active LOW)

Register Enable X₀-X₁₅, X_M, RND.

ENY Data (Input; Active LOW)

Register Enable, Y₀-Y₁₅, Y_M, RND.

*TRW MPY 16HJ pin designation.

FUNCTIONAL DESCRIPTION

The Am29C516A and Am29C517A are high-speed parallel 16 x 16-bit CMOS multipliers that generate a 32-bit product. Two 17-bit input registers are provided for the X and Y operands and their associated mode controls, X_M and Y_M . These mode controls are used to specify each operand as either two's-complement or unsigned numbers. When one operand is two's complement and the other is unsigned, the product will be two's complement.

Two 16-bit output registers are provided to hold the most- and least-significant halves of the product (MSP and LSP). For asynchronous operation, these registers may be made transparent by taking the Feedthrough (FT) control HIGH.

The two halves of the product may be routed to a 16-bit output port (P) via a multiplexer. The multiplexer control (\overline{MSPSEL}) uses a pin which is a supply ground in the TRW MPY16HJ. When this control is LOW, the MSP appears on the P port, thus allowing full compatibility with the MPY16HJ. When this control is HIGH, the LSP appears on the P port. In addition, the LSP is connected to the bidirectional Y port through a separate three-state buffer controlled by \overline{OEL} .

In two's-complement notation, the acceptable range of values for a given word size is not the same for positive and negative numbers. The largest negative number is one LSB larger than the largest positive number. This is true for either fractional or

integer notation. In fractional notation, however, a problem can arise when the largest representable negative number is multiplied by itself. This should give a positive number of the same magnitude; however, the largest representable positive number is one LSB less than this value. As a result, this product cannot be correctly represented without using one additional output bit. The Am29C516A/Am29C517A has a Format Adjust (FA) control that permits shifting of the result to provide a correct answer for every two's-complement multiplication. When FA is LOW, the value of the MSP is doubled (i.e., shifted left one bit), which provides the capability of representing the largest possible product. The effects of this control are illustrated in the Format tables. Note that for unsigned-magnitude operation, the FA control must be HIGH.

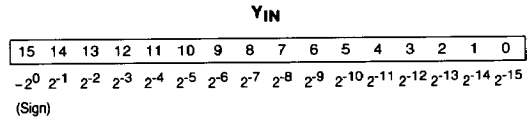
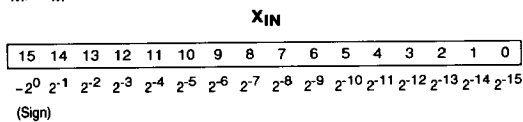
A Round control (RND) allows rounding of the MSP by adding a 1 to the MSB of the LSP. This control is registered, and is entered whenever either input register is clocked. Format Adjust takes place on a product before it is rounded.

The Am29C516A X, Y, MSP, and LSP registers have independent clocks (CLKX, CLKY, CLKM, CLKL). The Am29C517A differs in that it has a single clock input (CLK) and three register enables (\overline{ENX} , \overline{ENY} , \overline{ENP}) for the two input registers and the entire product, respectively. This facilitates the use of the part in microprogrammed systems. In both parts, data is entered into the registers on the positive edge of the clock.

INPUT FORMATS (All Devices)

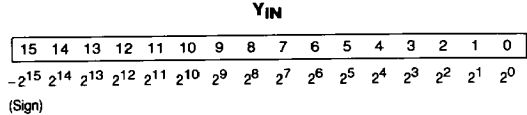
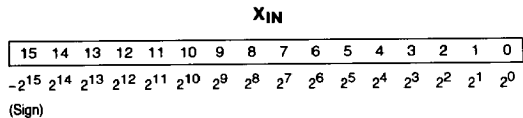
Fractional Two's-Complement Input Format

$X_M, Y_M = 1$



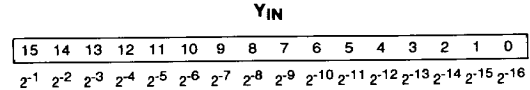
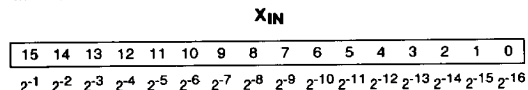
Integer Two's-Complement Input Format

$X_M, Y_M = 1$



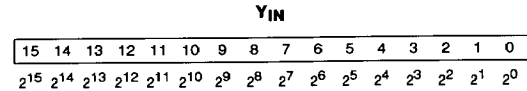
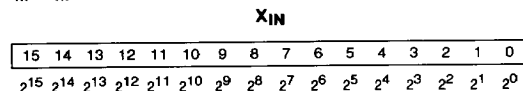
Unsigned Fractional Input Format

$X_M, Y_M = 0$



Unsigned Integer Input Format

$X_M, Y_M = 0$



OUTPUT FORMATS (All Devices)

Fractional Two's-Complement (Shifted)* Output

FA = 0

MSP

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

(Sign)

LSP

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

(Sign)

Fractional Two's-Complement Output

FA = 1

MSP

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

(Sign)

LSP

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

Integer Two's-Complement Output

FA = 1

MSP

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
2^{-31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}

(Sign)

LSP

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

Unsigned Fractional Output

FA = 1

MSP

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

LSP

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
2^{-17}	2^{-18}	2^{-19}	2^{-20}	2^{-21}	2^{-22}	2^{-23}	2^{-24}	2^{-25}	2^{-26}	2^{-27}	2^{-28}	2^{-29}	2^{-30}	2^{-31}	2^{-32}

Unsigned Integer Output

FA = 1

MSP

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}

LSP

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

*In this format an overflow occurs in the attempted multiplication of the two's complement number 1.000...(-1) with itself, yielding a product of 1.000... or -1.

ABSOLUTE MAXIMUM RATINGS

Storage Temperature	-65 to +150°C
Ambient Temperature under Bias (T _A)	-55 to +125°C
Supply Voltage to Ground Potential Continuous	-0.5 to +7.0 V
DC Voltage Applied to Outputs For High Output State	-0.3 to +V _{CC} +0.3 V
DC Input Voltage	-0.3 to +V _{CC} +0.3 V
DC Output Current, Into LOW Outputs	30 mA
DC Input Current	-10 to +10 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	
Ambient Temperature (T _A)	0°C to +70°C
Supply Voltage (V _{CC})	+4.50 to +5.50 V
Military* (M) Devices	
Ambient Temperature (T _A)	-55 to +125°C
Supply Voltage (V _{CC})	+4.5 to +5.5 V

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

*Military Product 100% tested at T_A = +25°C, +125°C, and -55°C.

DC CHARACTERISTICS over operating range unless otherwise specified (for APL Products, Group A, Subgroups 1, 2, 3 are tested unless otherwise noted)

Parameter Symbol	Parameter Description	Test Conditions (Note 1)		Min.	Max.	Unit	
V _{OH}	Output HIGH Voltage	V _{CC} = Min., V _{IN} = V _{IH} or V _{IL}	I _{OH} = -0.4 mA	2.4		V	
V _{OL}	Output LOW Voltage	V _{CC} = Min., V _{IN} = V _{IH} or V _{IL}	I _{OL} = 4 mA		0.5	V	
V _{IH}	Guaranteed Input Logical-HIGH Voltage (Note 2)			2.0		V	
V _{IL}	Guaranteed Input Logical-LOW Voltage (Note 2)				0.8	V	
I _{IL}	Input LOW Current	V _{CC} = Max., V _{IN} = 0.5 V			-10	μA	
I _{IH}	Input HIGH Current	V _{CC} = Max., V _{IN} = 5.0 V			10	μA	
I _{OZH}	Off State (High Impedance) Output Current	V _{CC} = Max.	V _O = 2.4 V		10	μA	
I _{OZL}			V _O = 0.5 V		-10		
I _{CC}	Static Power-Supply Current	V _{CC} = Max., I _O = 0 μA (Note 4)	COM'L T _A = 0 to 70°C	CMOS V _{IN} = V _{OL} or GND		15	mA
				TTL V _{IN} = 0.5 V or 2.4 V		30	
			MIL T _A = -55° to +125°C	CMOS V _{IN} = V _{OL} or GND		15	
				TTL V _{IN} = 0.5 V or 2.4 V		30	

- Notes: 1. V_{CC} conditions shown as Min. or Max. refer to the commercial (±10%) V_{CC} limits.
 2. These input levels provide zero noise immunity and should only be statically tested in a noise-free environment (not functionally tested).
 3. C_{PD} determines the no-load dynamic current consumption:

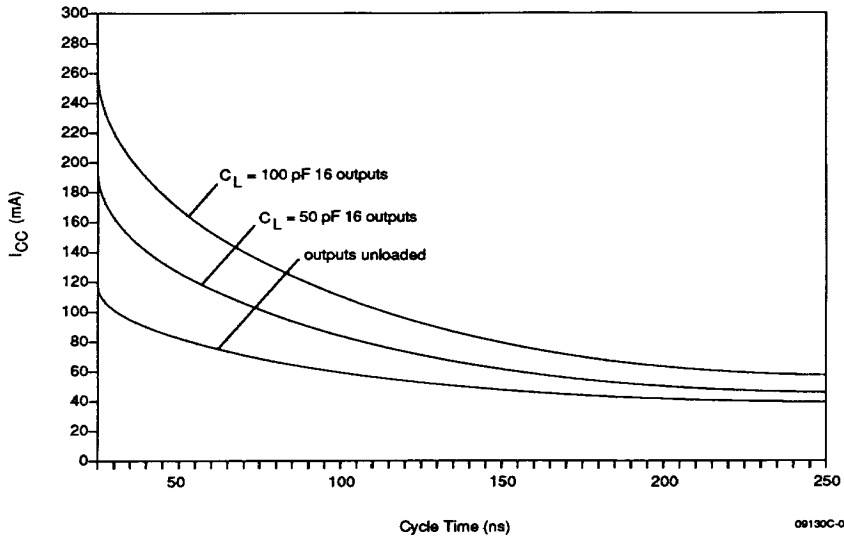
$$I_{CC}(\text{Total}) = I_{CC}(\text{Static}) + (C_{PD} + nC_L) V_{CC} \left(\frac{f}{2}\right)$$
 where f is the clock frequency of the C_L output load capacitance, and n number of loads.
 4. Use CMOS I_{CC} when the device is driven by CMOS circuits and TTL I_{CC} when the device is driven by TTL circuits.

CAPACITANCE*

Parameter Symbol	Parameter Description	Test Conditions (Note 1)	Min.	Max.	Unit
C _I	Input Capacitance	f = 1 MHz T _A = -55°C to 125°C V _{CC} = 4.5 V to 5.5 V			pF
C _O	Output Capacitance				
C _{PD}	Power Dissipation Capacitance (Note 3)	V _{CC} = 5.0 V, T _A = +25°C, No Load	950 pF Typical		

*These capacitances are tested on a sample basis.

Am39C516A/Am29C517A I_{CC} vs Cycle Time



09130C-001A

OP002740

Note: Values are calculated as typical total I_{CC} at $V_{CC} = 5.5$ V

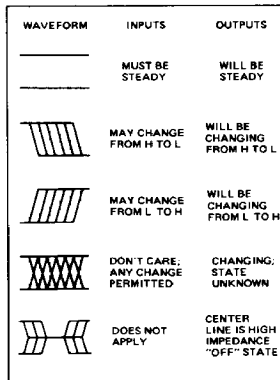
SWITCHING CHARACTERISTICS over operating range unless otherwise specified (for APL Products, Group A, Subgroups 9, 10, 11 are tested unless otherwise noted) (Note 1)

Parameter Symbol	Parameter Description	Test Conditions	COM'L				MIL				Unit
			29C516A/29C517A		29C516A-1/29C517A-1		29C516A/29C517A		29C516A-1/29C517A-1		
			Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
t _{MUC}	Unlocked Multiply Time	Load 1		55		49		70		55	ns
t _{MC}	Clocked Multiply Time			45		35		50		42	ns
t _S	X _i , Y _i , RND Setup Time		12		12		15		13		ns
t _H	X _i , Y _i , Hold Time		0		0		0		0		ns
	RND Hold Time		0		0		0		0		ns
t _{PWH}	Clock Pulse Width HIGH		15		15		15		15		ns
t _{PWL}	Clock Pulse Width LOW		15		15		15		15		ns
t _{PDSEL}	MSPSEL to Product Out			18		17		25		18	ns
t _{PDP}	Output Clock to P			20		19		25		21	ns
t _{PDY}	Output Clock to Y			22		21		25		22	ns
t _{PHZ}	OEP Disable Time	HIGH to Z		20		20		25		17	ns
t _{PLZ}		LOW to Z		20		20		25		17	ns
t _{PZH}	OEP Enable Time	Z to HIGH		21		21		25		21	ns
t _{PZL}		Z to LOW		21		21		25		21	ns
t _{PHZ}	OEL Disable Time	HIGH to Z		20		20		25		19	ns
t _{PLZ}		LOW to Z		20		20		25		19	ns
t _{PZH}	OEL Enable Time	Z to HIGH		25		25		27		24	ns
t _{PZL}		Z to LOW		25		25		27		24	ns
t _S	Clock Enable Setup Time (Am29C517A Only)	Load 1	15		15		20		20		ns
t _H	Clock Enable Hold Time (Am29C517A Only)		0		0		0		0		ns
t _{HCL}	Clock LOW Hold Time CLKXY Relative to CLKML (Am29C516A Only)		0		0		0		0		ns

Notes: 1. To ensure that the correct product is entered in the output registers, new data may not be entered into the input registers before the output registers have been clocked.

SWITCHING WAVEFORMS

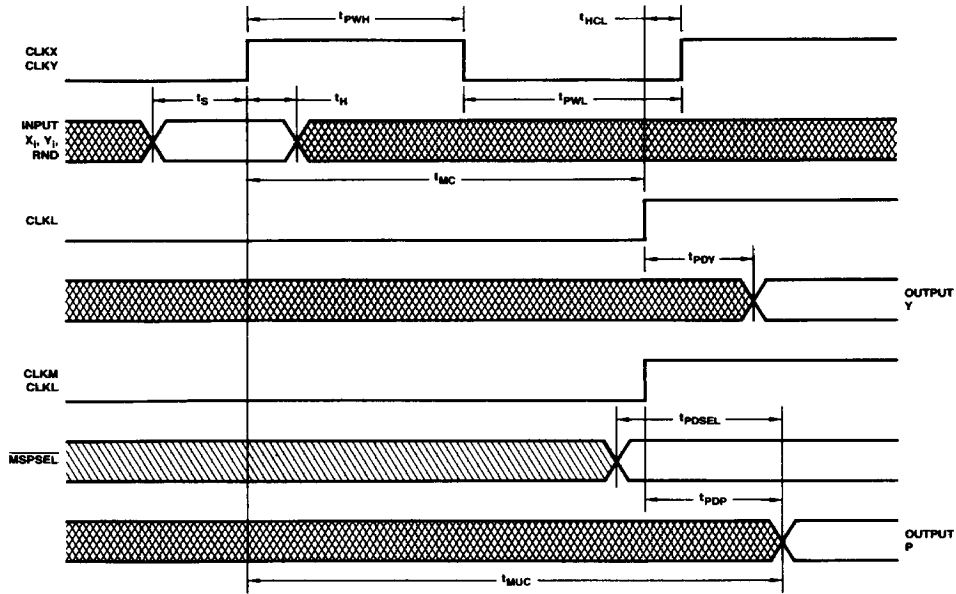
KEY TO SWITCHING WAVEFORMS



KS000010

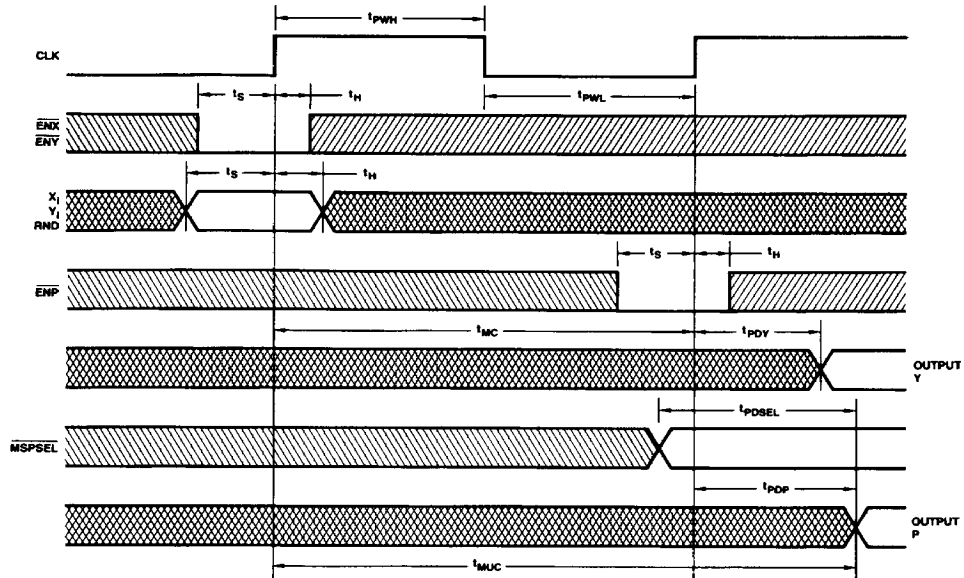
SWITCHING WAVEFORMS

Am29C516A/Am29C516A-1



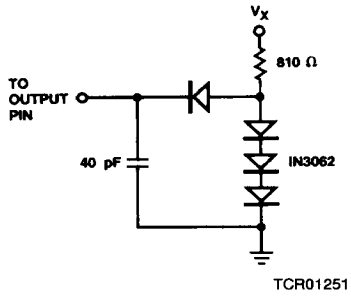
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Am29C517A/Am29C517A-1

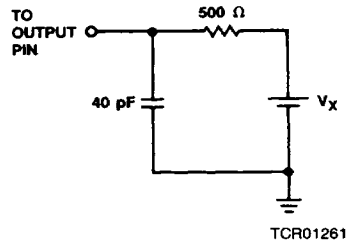


WFR02751

SWITCHING TEST CIRCUITS



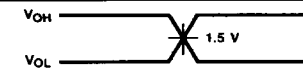
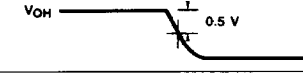
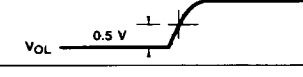
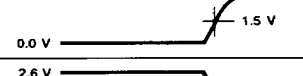

A. Normal Load (Load 1)



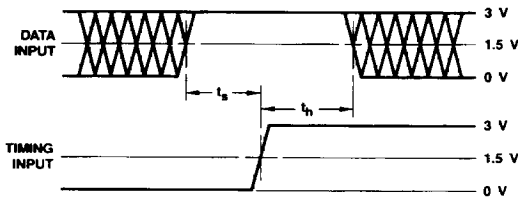
B. Three-State Delay Load (Load 2)

SWITCHING TEST WAVEFORMS

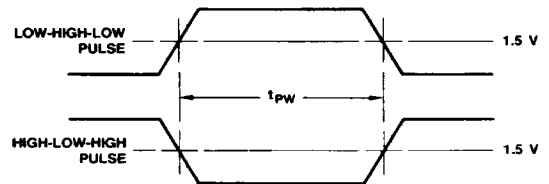
(All Devices)

Test	V_x	Output Waveform – Measurement Level
All t_{pDS}	V_{CC}	
t_{PHZ}	0.0 V	
t_{PLZ}	2.6 V	
t_{PZH}	0.0 V	
t_{PZL}	2.6 V	

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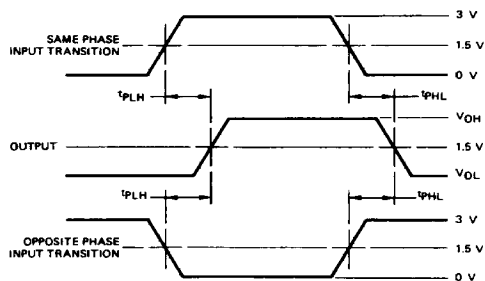
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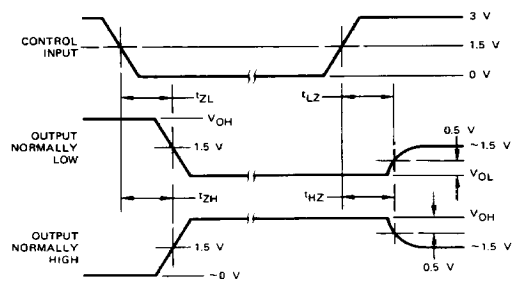
- Notes: 1. Diagram shown for HIGH data only.
Output transition may be opposite sense.
2. Cross hatched area is don't care condition.

Setup, Hold, and Release Times



WFR02980

Pulse Width



WFR02662

- Notes: 1. Diagram shown for Input Control Enable-LOW and Input Control Disable-HIGH.

Propagation Delay

Enable and Disable Times

TEST PHILOSOPHY AND METHODS

The following eight points describe AMD's philosophy for high volume, high speed automatic testing.

1. Ensure the part is adequately decoupled at the test head. Large changes in V_{CC} current as the device switches may cause erroneous function failures 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 output transition, ground current may change by as much as 400 mA in 5-8 ns. Inductance in the ground cable may allow the ground pin at the device to rise by hundreds 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 that 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. Capacitive Loading for AC Testing

Automatic testers and their associated hardware have stray capacitance that varies from one type of tester to another but is generally around 50 pF. This, of course, makes it impossible to make direct measurements of parameters which call for a smaller capacitive load than the associated stray capacitance. Typical examples of this are the so-called "float delays," which measure the propagation delays into the high-impedance state and are usually specified at a load capacitance of 5.0 pF. In these cases, the test is performed at the higher load capacitance (typically 50 pF), and engineering correlations based on data taken with a bench setup are used to predict the result at the lower capacitance.

Similarly, a product may be specified at more than one

capacitive load. Since the typical automatic tester is not capable of switching loads in mid-test, it is impossible to make measurements at both capacitances even though they may both be greater than the stray capacitance. In these cases, a measurement is made at one of the two capacitances. The result at the other capacitance is predicted from engineering correlations based on data taken with a bench setup and the knowledge that certain DC measurements (I_{OH} , I_{OL} , for example) have already been taken and are within spec. In some cases, special DC tests are performed in order to facilitate this correlation.

7. Threshold Testing

The noise associated with automatic testing (due to the long inductive cables), and the high gain of the tested device when in the vicinity of the actual device threshold, frequently give rise to oscillations when testing high speed circuits. These oscillations are not indicative of a reject device, but instead, of an overtaxed test system. To minimize this problem, thresholds are tested at least once for each input pin. Thereafter, "hard" high and low levels are used for other tests. Generally this means that function and AC testing are performed at "hard" input levels rather than at V_{IL} Max. and V_{IH} Min.

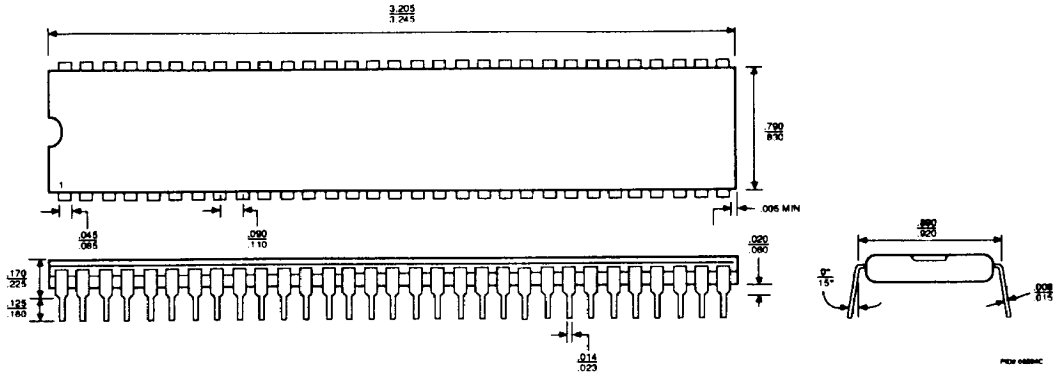
8. AC Testing

Occasionally parameters are specified that cannot be measured directly on automatic testers because of tester limitations. Data input hold times often fall into this category. In these cases, the parameter in question is guaranteed by correlating these tests with other AC tests that have been performed. These correlations are arrived at by the cognizant engineer using data from precise bench measurements in conjunction with the knowledge that certain DC parameters have already been measured and are within spec.

In some cases, certain AC tests are redundant, since they can be shown to be predicted by other tests which have already been performed. In these cases, the redundant tests are not performed.

PHYSICAL DIMENSIONS*

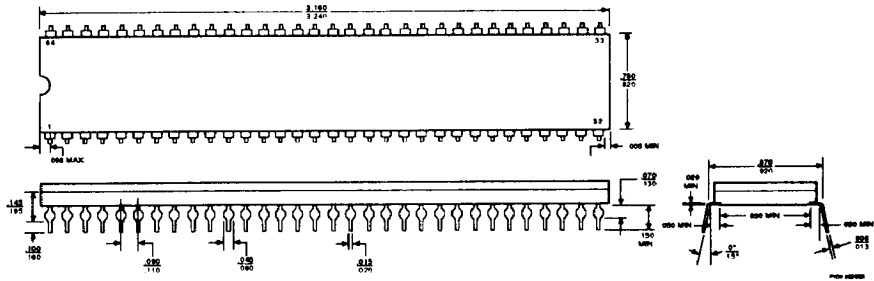
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*For reference only. All dimensions are measured in inches. BSC is an ANSI standard for Basic Space Centering.

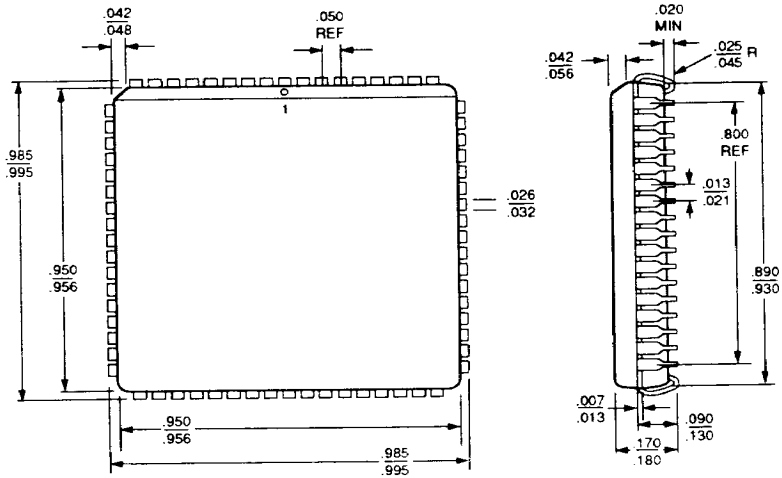
PHYSICAL DIMENSIONS (Cont'd.)

TDX064



PHYSICAL DIMENSIONS (Cont'd.)

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