Am29510/L510

16 X 16 Multiplier Accumulator

DISTINCTIVE CHARACTERISTICS

- Uses two's complement or unsigned inputs and
- Round control
- Output register preload
- 35-bit product accumulator result
  - 32-bit product
  - 3-bit extended product
- IMOX™ processing
  - ECL internal circuitry for speed
  - TTL I/O, Single 5V Supply
- FAST
  - High speed version multiply accumulate time 80ns
  - Low power version multiply accumulate time 110ns

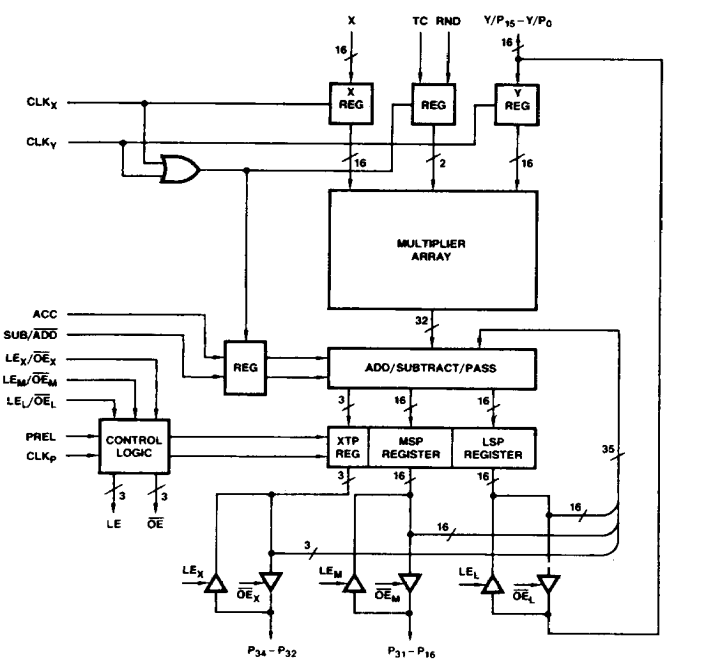
GENERAL DESCRIPTION

The Am29510 is a high-speed 16 x 16-bit multiplier/accumulator (MAC). The X and Y input registers accept 16-bit inputs in either two's complement or unsigned magnitude format. A third register stores the Two's Complement (TC), Round (RND), Accumulator (ACC), and Subtraction/Addition (SUB/$\overline{\text{ADD}}$) control bits. This register is clocked whenever the X or Y input registers are clocked.

The 35-bit accumulator/output register contains the full 32-bit multiplier output which is sign extended or zero-filled based on the TC control bit. The accumulator can also be preloaded from an external source through the bidirectional P port. The operation of the accumulator is controlled by the signals ACC, (Accumulator), SUB/$\overline{\text{ADD}}$ (Subtraction/Addition), and PREL (Preload). Each of the input registers and the output register has independent clocks.

The Am29L510 is a low-power version of the Am29510. The Am29L510 consumes only one-half the power of its standard power counterpart while maintaining nearly two-thirds the speed.

BLOCK DIAGRAM



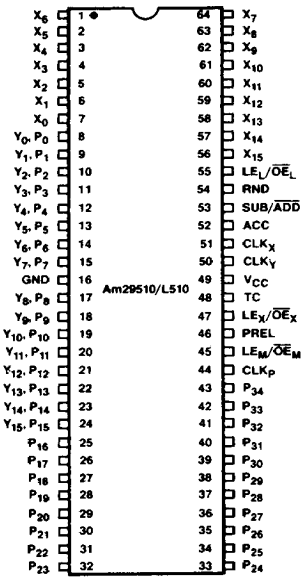
BDR02280

IMOX is a trademark of Advanced Micro Devices, Inc.

03563B

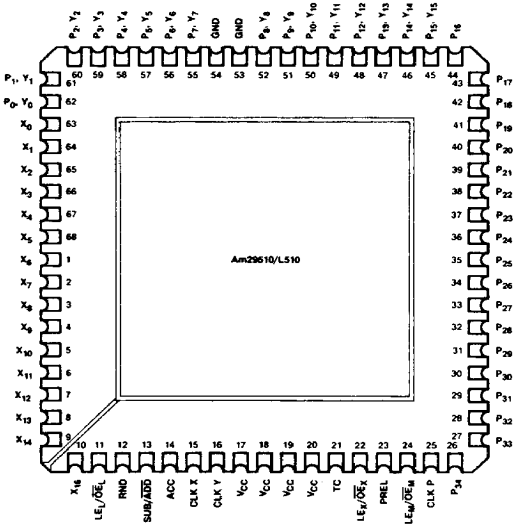
CONNECTION DIAGRAM
Top View

Dual In-Line



CDR04440

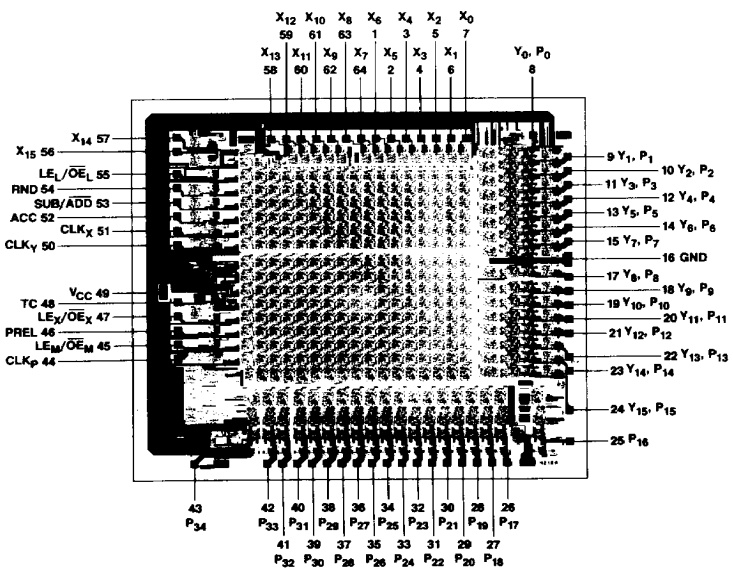
Leadless Chip Carrier



CDR04430

Note: Pin 1 is marked for orientation

METALLIZATION AND PAD LAYOUT



DIE SIZE: .291" x .258"

03563B

Refer to Page 13-1 for Essential Information on Military Devices

ORDERING INFORMATION

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

Am29510/L510 **P** **C** **B**

- **B** — Screening Option
  - Blank – Standard Processing
  - B – Burn-in (Note 1)
- **C** — Temperature (See Operating Ranges)
  - C – Commercial (0 to +70°C)
  - M – Military (–55 to +125°C)
- **P** — Package Code
  - L = 68-Pin Leadless Chip Carrier
  - D = 64-Pin Top-Brazed with Heat Sink or 64-Pin Top-Brazed without Heat Sink
  - P = 64-Pin Molded DIP*
- **Am29510/L510** — Device Type
  - Multiplier Accumulator

Note 1. 160-hour burn-in —
Heat sink parts: $T_A = 125°C$
Non-heat sink parts: $T_A = 85°C$

Valid Combinations	
Am29510	DC, DCB, DMB, LC, LMB, PC*, PCB*
Am29L510	

Valid Combinations

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

PIN DESCRIPTION

*Pin No.	Name	I/O	Description
54	RND	I	Round When RND is High, a bit with a weight of P_{15} is added to the multiplier product. RND is loaded on the rising edge of CLK_X or CLK_Y.
48	TC	I	Two's Complement When High, the X and Y inputs are defined as two's complement data, or as unsigned data when Low. The TC control is loaded on the rising edge of CLK_X or CLK_Y.
46	PREL	I	Preload When High, data is preloaded into the specific output register when its respective Load Enable is High. When Low, the accumulator register is available at the P-port when the Output Enables are Low.
47	$LE_X/\overline{OE}_X$	I	Load Enable Extended/Output Enable Extended Active High Load Enable for the XTP port during preloading. Active Low three-state control for the XTP port during normal operation (see Preload Function). (TSX)**
45	$LE_M/\overline{OE}_M$	I	Load Enable Most/Output Enable Most Active High Load Enable for the MSP port during preloading. Active Low three-state control for the MSP port during normal operation (see Preload Function). (TSM)**
55	$LE_L/\overline{OE}_L$	I	Load Enable Least/Output Enable Least Active High Load Enable for the LSP port during preloading. Active Low three-state control for the LSP port during normal operation (see Preload Function). (TSL)**
51, 50	CLK_X, CLK_Y	I	CLOCKS Load X and Y data respectively and TC, RND, ACC and SUB/$\overline{ADD}$ on the rising edge.
44	CLK_P	I	CLOCK Loads data into the XTP, MSP and LSP registers on the rising edge.
1-7, 56-64	X_{15}-X_0	I	Multiplier Data Input Data is loaded into the X register on the rising edge of CLK_X.
8-15, 17-24	Y_{15}-Y_0 P_{15}-P_0	I/O	Bidirectional Port Data is loaded into the Y register on the rising edge of CLK_Y. Product output for Least Significant Product (LSP) and input to preload LSP register.
41-43	P_{34}-P_{32}	I/O	Bidirectional Port Product output for Extended Product (XTP) and input to preload XTP register.
25-40	P_{31}-P_{16}	I/O	Bidirectional Port Product output for the Most Significant Product (MSP) and input to preload MSP register.
52	ACC	I	Accumulate When High, the multiplier product is accumulated in the accumulator. When Low, the multiplier product is written into the accumulator (see Accumulator Function Table). The ACC control is loaded on the rising edge of CLK_X or CLK_Y.
53	SUB/$\overline{ADD}$	I	Subtraction/Addition When High, the accumulator contents are subtracted from the multiplier product and the result written back into the accumulator. When Low, the multiplier product is added into the accumulator (see Accumulator Function Table). The SUB/$\overline{ADD}$ control is loaded on the rising edge of CLK_X or CLK_Y.

*DIP Configuration
**TRW TDC1010 Pin Designation

PRELOAD FUNCTION

PREL	$LE_X/\overline{OE}_X$	$LE_M/\overline{OE}_M$	$LE_L/\overline{OE}_L$	Output Register		
				XTP	MSP	LSP
0	0	0	0	Q	Q	Q
0	0	0	1	Q	Q	Z
0	0	1	0	Q	Z	Q
0	0	1	1	Q	Z	Z
0	1	0	0	Z	Q	Q
0	1	0	1	Z	Q	Z
0	1	1	0	Z	Z	Q
0	1	1	1	Z	Z	Z
1	0	0	0	Z	Z	Z
1	0	0	1	Z	Z	PL
1	0	1	0	Z	PL	Z
1	0	1	1	Z	PL	PL
1	1	0	0	PL	Z	Z
1	1	0	1	PL	Z	PL
1	1	1	0	PL	PL	Z
1	1	1	1	PL	PL	PL

Z = output buffers at High impedance (disabled).
Q = output buffers at Low impedance. Contents of output register available through output ports.
PL = output disabled. Preload data supplied to the output pins will be loaded into the output register at the rising edge of CLKp.

ACCUMULATOR FUNCTION TABLE

PREL	ACC	SUB/$\overline{ADD}$	P	OPERATION
L	L	X	Q	Load
L	H	L	Q	Add
L	H	H	Q	Subtract
H	X	X	PL	Preload

DETAILED DESCRIPTION

The Am29510 is a high-speed 16 x 16-bit multiplier/accumulator (MAC). It comprises a 16-bit parallel multiplier followed by a 35-bit accumulator. Two 16-bit input registers are provided for the X and Y operands. A third register stores two control bits, TC and RND. TC selects either a two's complement or an unsigned magnitude format for both data inputs. The RND control, when High, causes a bit to be added to the multiplier product with the weight of P_{15}. This causes the most significant 16-bits of the product to be rounded to the value nearest to the full 32-bit product. Using the RND control once during an accumulation causes the most significant 19-bits of the accumulator to be rounded to the value nearest the full 35-bit accumulation. The TC/RND register is clocked whenever the X or Y input registers are clocked.

The 32-bit multiplier output is zero-filled or sign-extended as appropriate to provide a 35-bit input to the accumulator. The accumulator has four functions: the product may be loaded into the accumulator, the product may be added into the accumulator value, the previous accumulator value may be subtracted from the product and the result stored in the accumulator or the accumulator may be preloaded from an external source. The operation of the accumulator is controlled by the signals ACC, SUB/$\overline{\text{ADD}}$ and PREL. ACC and SUB/$\overline{\text{ADD}}$ are stored in a register clocked whenever the X or Y registers are clocked. ACC in conjunction with SUB/$\overline{\text{ADD}}$ selects one of the first three accumulator functions (see Accumulator Function Table). For output and preloading purposes the accumulator is considered in three sections: Extended Product (XTP, P_{34}-P_{32}) controlled by $LE_X/\overline{OE}_X$, Most Significant Product (MSP, P_{31}-P_{16}) controlled by $LE_M/\overline{OE}_M$ and Least Significant Product (LSP, P_{15}-P_0) controlled by $LE_L/\overline{OE}_L$. When PREL is Low these controls are active-Low Output Enables for three-state output buffers. When PREL is High the output buffers automatically become high impedance, and the controls operate as active-High Load Enables to the three sections of the accumulator to permit preloading of data applied to the bidirectional P port. The P-port has 35 bits, the least significant 16 of which share pins with the Y input.

Am29510/L510 INPUT FORMATS

Fractional Two's Complement Input

X_{IN}

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
-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)

Y_{IN}

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
-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)

Integer Two's Complement Input

X_{IN}

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

(Sign)

Y_{IN}

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

(Sign)

Unsigned Fractional Input

X_{IN}

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	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}	2^{-16}

Y_{IN}

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	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}	2^{-16}

Unsigned Integer Input

X_{IN}

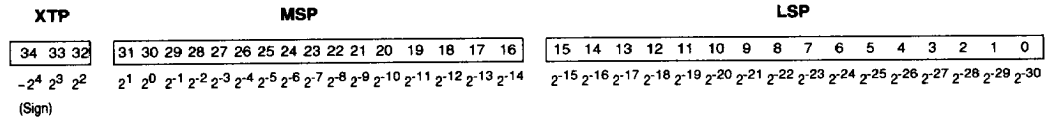
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

Y_{IN}

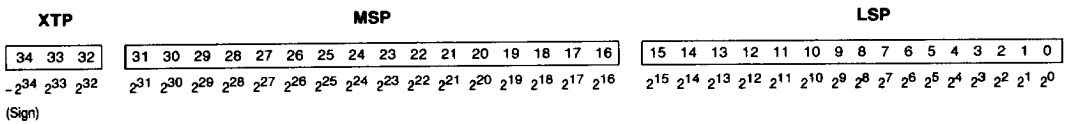
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

Am29510/L510
OUTPUT FORMATS

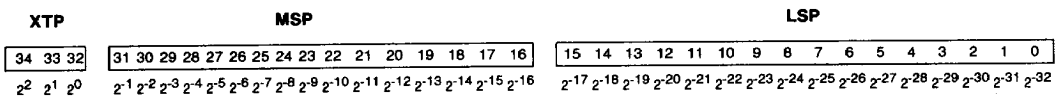
Two's Complement Fractional Output



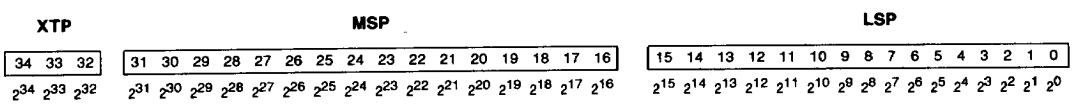
Two's Complement Integer Output



Unsigned Fractional Output



Unsigned Integer Output



ABSOLUTE MAXIMUM RATINGS

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

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

OPERATING RANGES

Commercial (C) Devices
Temperature
DIPs ..... T_A = 0 to +70°C
Chip Carriers ..... T_C = 0 to +85°C
Supply Voltage ..... 4.75V to 5.25V

Military (M) Devices
Temperature ..... T_C = −55°C to +125°C
Supply Voltage ..... 4.5V to 5.5V

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

DC CHARACTERISTICS over operating range unless otherwise specified

Am29510

Parameters	Description	Test Conditions (Note 1)			Min	Typ (Note 2)	Max	Units
V_{OH}	Output HIGH Voltage	V_{CC} = MIN, V_{IN} = V_{IH} or V_{IL}	I_{OH} = −0.4mA		2.4	2.7		Volts
V_{OL}	Output LOW Voltage	V_{CC} = MIN, V_{IN} = V_{IH} or V_{IL}	I_{OL} = 4.0mA			.3	.5	Volts
V_{IH}	Input HIGH Level	Guaranteed input logical HIGH voltage for all inputs			2.0			Volts
V_{IL}	Input LOW level	Guaranteed input logical LOW voltage for all inputs					.8	Volts
V_I	Input Clamp Voltage	V_{CC} = MIN, I_{IN} = −18mA					−1.5	Volts
I_{IL}	Input LOW Current	V_{CC} = MAX, V_{IN} = 0.4V					−0.4	mA
I_{IH}	Input HIGH Current	V_{CC} = MAX, V_{IN} = 2.4V					75	μA
I_I	Input HIGH Current	V_{CC} = MAX, V_{IN} = 5.5V					1	mA
I_{OZH}	Off State (High Impedance) Output Current	V_{CC} = MAX	Y, Product	V_O = 2.4V			25	μA
I_{OZL}				V_O = 0.4V			−25	
I_{SC}	Output Short Circuit Current (Note 3)	V_{CC} = MAX	Y, Product	V_O = 0V	−3		−30	mA
I_{CC}	Power Supply Current	COM'L and MIL		T_A = 25°C		750		mA
		COM'L Only V_{CC} = Max		T_A = 0 to +70°C (Note 4)			900	
				T_A = +70°C (Note 4)			725	
		MIL Only V_{CC} = Max		T_{CC} = −55 to +125°C			1000	
				T_{CC} = +125°C			750	

Notes: 1. For conditions shown as MIN or MAX, use the appropriate value specified under Operating Ranges for the applicable device type.
2. Typical limits are at V_{CC} = 5.0V, 25°C ambient and maximum loading.
3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.
4. Chip Carriers: T_A = 85°C.

03563B

Refer to Page 13-1 for Essential Information on Military Devices

DC CHARACTERISTICS over operating range unless otherwise specified

Am29L510

Parameters	Description	Test Conditions (Note 1)			Min	Typ (Note 2)	Max	Units
V_{OH}	Output HIGH Voltage	V_{CC} = MIN, V_{IN} = V_{IH} or V_{IL}	I_{OH} = −0.4mA		2.4	2.7		Volts
V_{OL}	Output LOW Voltage	V_{CC} = MIN, V_{IN} = V_{IH} or V_{IL}	I_{OL} = 4.0mA			.3	.5	Volts
V_{IH}	Input HIGH Level	Guaranteed input logical HIGH voltage for all inputs			2.0			Volts
V_{IL}	Input LOW Level	Guaranteed input logical LOW voltage for all inputs					.8	Volts
				COM'L			.8	
V_I	Input Clamp Voltage	V_{CC} = MIN, I_{IN} = −18mA					−1.5	Volts
I_{IL}	Input LOW Current	V_{CC} = MAX, V_{IN} = 0.4V					−0.4	mA
I_{IH}	Input HIGH Current	V_{CC} = MAX, V_{IN} = 2.4V					75	μA
I_I	Input HIGH Current	V_{CC} = MAX, V_{IN} = 5.5V					1	mA
I_{OZH}	Off State (High Impedance) Output Current	V_{CC} = MAX	Product	V_O = 2.4V			25	μA
I_{OZL}				V_O = 0.4V			−25	
I_{SC}	Output Short Circuit Current (Note 3)	V_{CC} = MAX	Y	V_O = 0V	−3		−30	mA
			Product	V_O = 0V	−3		−30	
I_{CC}	Power Supply Current	COM'L and MIL		T_A = 25°C		330		mA
		COM'L Only V_{CC} = Max		T_A = 0 to +70°C (Note 4)			450	
				T_A = +70°C (Note 4)			350	
		MIL Only V_{CC} = Max		T_{CC} = −55 to +125°C			535	
				T_{CC} = +125°C			375	

Notes: 1. For conditions shown as MIN or MAX, use the appropriate value specified under Operating Ranges for the applicable device type.
2. Typical limits are at V_{CC} = 5.0V, 25°C ambient and maximum loading.
3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.
4. Chip Carriers, T_C = 85°C.

7

03563B

Refer to Page 13-1 for Essential Information on Military Devices

SWITCHING CHARACTERISTICS over operating range unless otherwise specified

Parameters	Description		Test Conditions	Typ (Note 1)	COMMERCIAL 29510 Min	COMMERCIAL 29510 Max	MILITARY 29510 Min	MILITARY 29510 Max	Units
t_{MA}	Multiply Accumulate Time			50		80		90	ns
t_S	X_i, Y_i, RND, TC, ACC, SUB/$\overline{ADD}$ Set-up Time			12	25		30		ns
t_H	X_i, Y_i, RND, TC, ACC, SUB/$\overline{ADD}$ Hold Time			0	5		5		ns
t_S	PREL Setup Time			10	25		30		ns
t_H	PREL Hold Time			0	0		2		ns
t_{PWH}	Clock Pulse Width High			10	20		25		ns
t_{PWL}	Clock Pulse Width Low			10	20		25		ns
t_{PDP}	Output Clock to P			25		40		40	ns
t_{PDY}	Output Clock to Y			25		40		40	ns
t_{PHZ}	$LE_X/\overline{OE}_X$, $LE_M/\overline{OE}_M$ to P, $LE_L/\overline{OE}_L$ to Y Disable Time	High to Z		21		35		40	ns
t_{PLZ}		Low to Z		20		35		40	ns
t_{PZH}	$LE_X/\overline{OE}_X$, $LE_M/\overline{OE}_M$ to P, $LE_L/\overline{OE}_L$ to Y Enable Time	Z to High		28		40		40	ns
t_{PZL}		Z to Low		24		40		40	ns
t_{HCL}	Relative Hold Time				0		0		ns

SWITCHING CHARACTERISTICS over operating range unless otherwise specified*

Parameters	Description		Test Conditions	Typ (Note 1)	COMMERCIAL 29L510 Min	COMMERCIAL 29L510 Max	MILITARY 29L510 Min	MILITARY 29L510 Max	Units
t_{MA}	Multiply Accumulate Time			70		110		120	ns
t_S	X_i, Y_i, RND, TC, ACC, SUB/$\overline{ADD}$ Set-up Time			20	40		45		ns
t_H	X_i, Y_i, RND, TC, ACC, SUB/$\overline{ADD}$ Hold Time			-3	0		0		ns
t_S	PREL Set-up Time			15	27		35		ns
t_H	PREL Hold Time			-5	0		0		ns
t_{PWH}	Clock Pulse Width High			15	25		30		ns
t_{PWL}	Clock Pulse Width Low			15	25		30		ns
t_{PDP}	Output Clock to P			35		45		50	ns
t_{PDY}	Output Clock to Y			35		45		50	ns
t_{PHZ}	$LE_X/\overline{OE}_X$, $LE_M/\overline{OE}_M$ to P, $LE_L/\overline{OE}_L$ to Y Disable Time	High to Z		24		35		40	ns
t_{PLZ}		Low to Z		25		35		40	ns
t_{PZH}	$LE_X/\overline{OE}_X$, $LE_M/\overline{OE}_M$ to P, $LE_L/\overline{OE}_L$ to Y Enable Time	Z to High		38		45		50	ns
t_{PZL}		Z to Low		32		40		45	ns
t_{HCL}	Relative Hold Time				0		0		ns

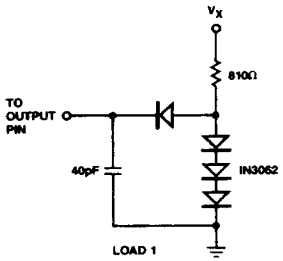
Note: 1. Typical limits are $V_{CC} = 5V$ and $T_A = 25°C$.

03563B

Refer to Page 13-1 for Essential Information on Military Devices

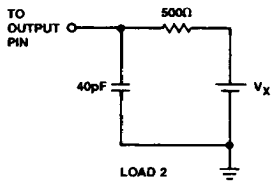
SWITCHING TEST CIRCUIT

Normal Load



TCR01270

Three-State Delay Load



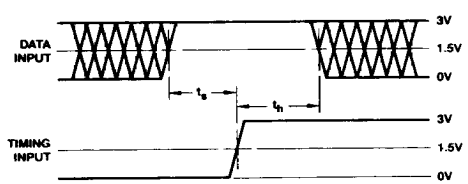
TCR01280

SWITCHING TEST WAVEFORMS

Test	V_X	Output Waveform – Measurement Level
All t_{PD}s	V_{CC}	V_{OH}, V_{OL}, 1.5V
t_{PHZ}	0.0V	V_{OH}, 0.5V, 0.0V
t_{PLZ}	2.6V	2.6V, V_{OL}, 0.5V
t_{PZH}	0.0V	V_{OH}, .5V, 0.0V
t_{PZL}	2.6V	2.6V, .5V, V_{OL}

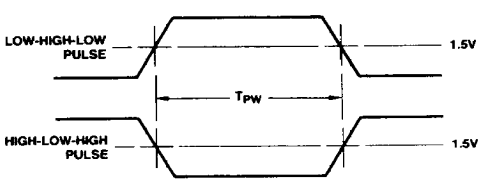
WFR02810

SET-UP AND HOLD TIME



WFR02970

PULSE WIDTH

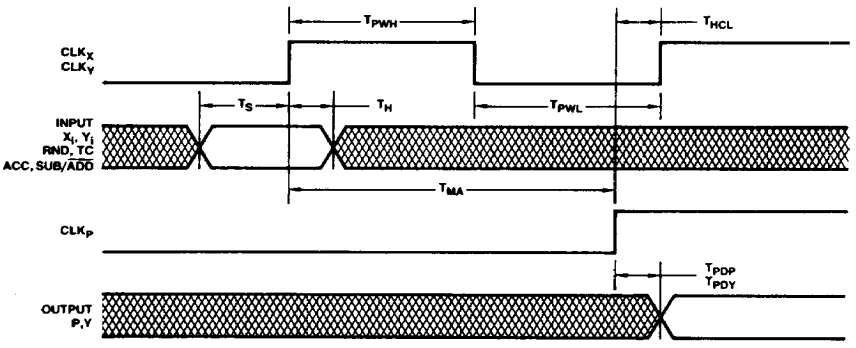


WFR02850

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

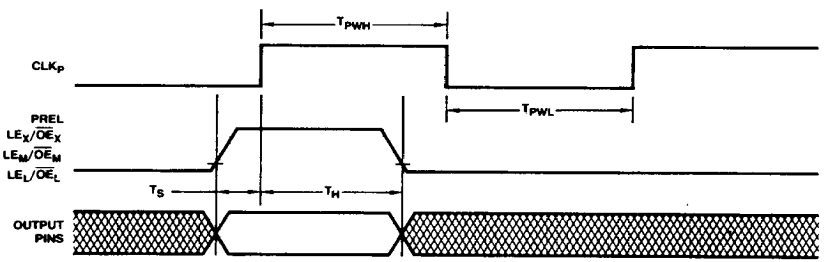
03563B

Am29510/L510
TIMING DIAGRAMS



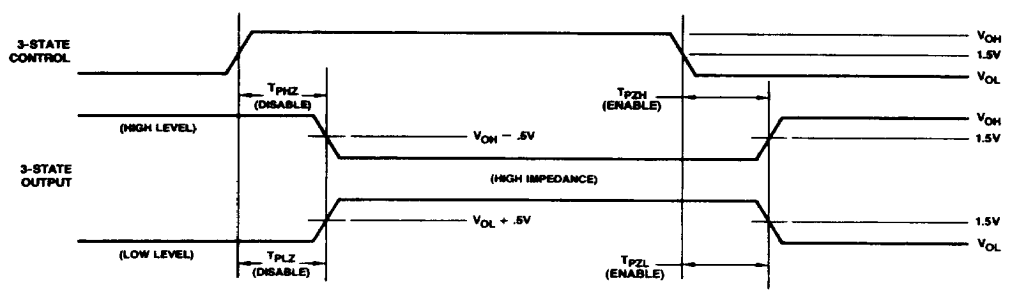
WFR02820

Am29510/L510
PRELOAD TIMING DIAGRAM



WFR02830

Am29510/L510
THREE-STATE
TIMING DIAGRAM

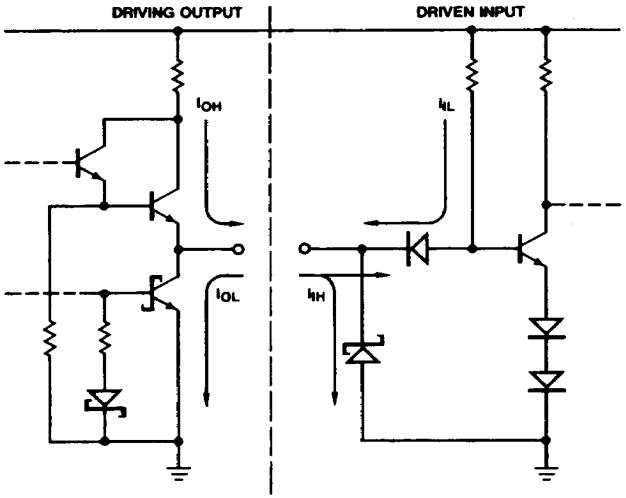


WFR02840

03563B

Refer to Page 13-1 for Essential Information on Military Devices

INPUT/OUTPUT CURRENT INTERFACE CONDITIONS



ICR00490

RELATED PRODUCTS

Part No.	Description
Am29526/527	High speed Sine function generator
Am29528/529	High Speed Cosine function generator
Am29540	Programmable FFT address sequencer
Am29520/21	Multilevel pipeline registers

03563B