

**TIBPAL16L8-10C, TIBPAL16R4-10C, TIBPAL16R6-10C, TIBPAL16R8-10C
TIBPAL16L8-12M, TIBPAL16R4-12M, TIBPAL16R6-12M, TIBPAL16R8-12M
HIGH-PERFORMANCE *IMPACT-X*TM *PAL*[®] CIRCUITS**

SRPS017 – D3023, MAY 1987 – REVISED MARCH 1992

- **High-Performance Operation:**
 - f_{max} (w/o feedback)
 - TIBPAL16R'-10C Series . . . 62.5 MHz Min
 - TIBPAL16R'-12M Series . . . 56 MHz Min
 - f_{max} (with feedback)
 - TIBPAL16R'-10C Series . . . 55.5 MHz Min
 - TIBPAL16R'-12M Series . . . 48 MHz Min
 - Propagation Delay**
 - TIBPAL16L'-10C Series . . . 10 ns Max
 - TIBPAL16L'-12M Series . . . 12 ns Max
- **Functionally Equivalent, but Faster than, Existing 20-Pin PLDs**
- **Preload Capability on Output Registers Simplifies Testing**
- **Power-Up Clear on Registered Devices (All Register Outputs are Set Low, but Voltage Levels at the Output Pins Go High)**
- **Package Options Include Both Plastic and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs**
- **Security Fuse Prevents Duplication**
- **Dependable Texas Instruments Quality and Reliability**

DEVICE	I INPUTS	3-STATE O OUTPUTS	REGISTERED Q OUTPUTS	I/O PORTS
PAL16L8	10	2	0	6
PAL16R4	8	0	4 (3-state buffers)	4
PAL16R6	8	0	6 (3-state buffers)	2
PAL16R8	8	0	8 (3-state buffers)	0

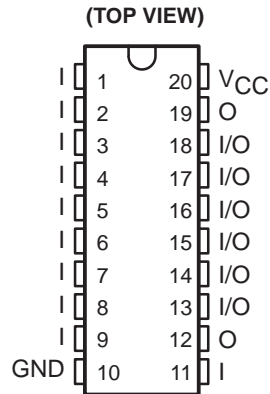
description

These programmable array logic devices feature high speed and functional equivalency when compared with currently available devices. These *IMPACT-X*TM circuits combine the latest Advanced Low-Power Schottky technology with proven titanium-tungsten fuses to provide reliable, high-performance substitutes for conventional TTL logic. Their easy programmability allows for quick design of custom functions and typically results in a more compact circuit board. In addition, chip carriers are available for further reduction in board space.

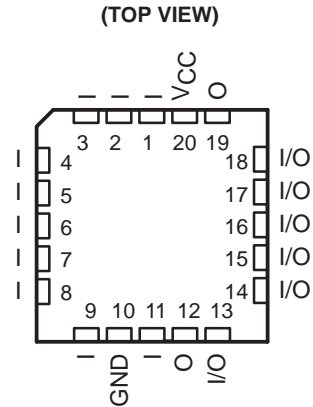
All of the register outputs are set to a low level during power up. Extra circuitry has been provided to allow loading of each register asynchronously to either a high or low state. This feature simplifies testing because the registers can be set to an initial state prior to executing the test sequence.

The TIBPAL16' C series is characterized from 0°C to 75°C. The TIBPAL16' M series is characterized for operation over the full military temperature range of -55°C to 125°C.

TIBPAL16L8'
C SUFFIX . . . J OR N PACKAGE
M SUFFIX . . . J PACKAGE



TIBPAL16L8'
C SUFFIX . . . FN PACKAGE
M SUFFIX . . . FK PACKAGE



Pin assignments in operating mode

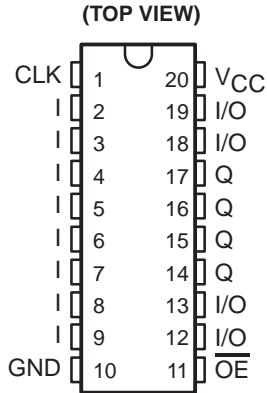
These devices are covered by U.S. Patent 4,410,987.
IMPACT-X is a trademark of Texas Instruments Incorporated.
PAL is a registered trademark of Advanced Micro Devices Inc.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

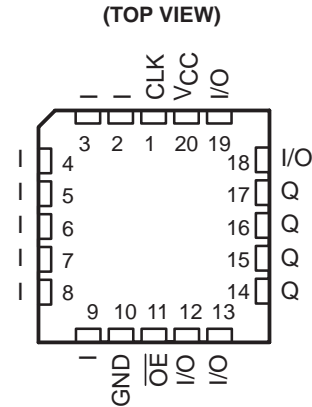


TIBPAL16R4-10C, TIBPAL16R6-10C, TIBPAL16R8-10C
 TIBPAL16R4-12M, TIBPAL16R6-12M, TIBPAL16R8-12M
 HIGH-PERFORMANCE *IMPACT-X*™ PAL® CIRCUITS
 SRPS017 – D3023, MAY 1987 – REVISED MARCH 1992

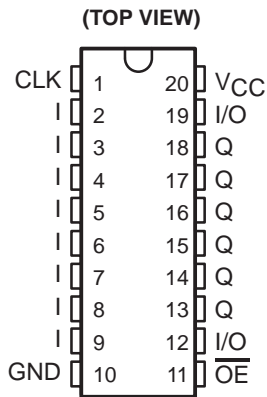
TIBPAL16R4'
 C SUFFIX ... J OR N PACKAGE
 M SUFFIX ... J PACKAGE



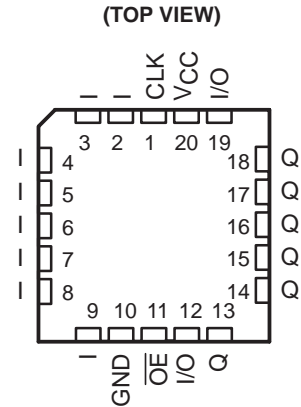
TIBPAL16R4'
 C SUFFIX ... FN PACKAGE
 M SUFFIX ... FK PACKAGE



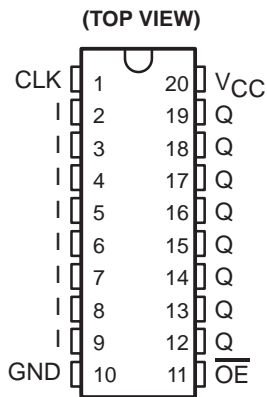
TIBPAL16R6'
 C SUFFIX ... J OR N PACKAGE
 M SUFFIX ... J PACKAGE



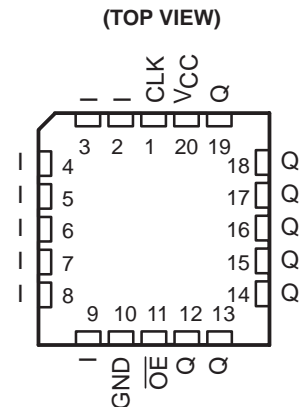
TIBPAL16R6'
 C SUFFIX ... FN PACKAGE
 M SUFFIX ... FK PACKAGE



TIBPAL16R8'
 C SUFFIX ... J OR N PACKAGE
 M SUFFIX ... J PACKAGE

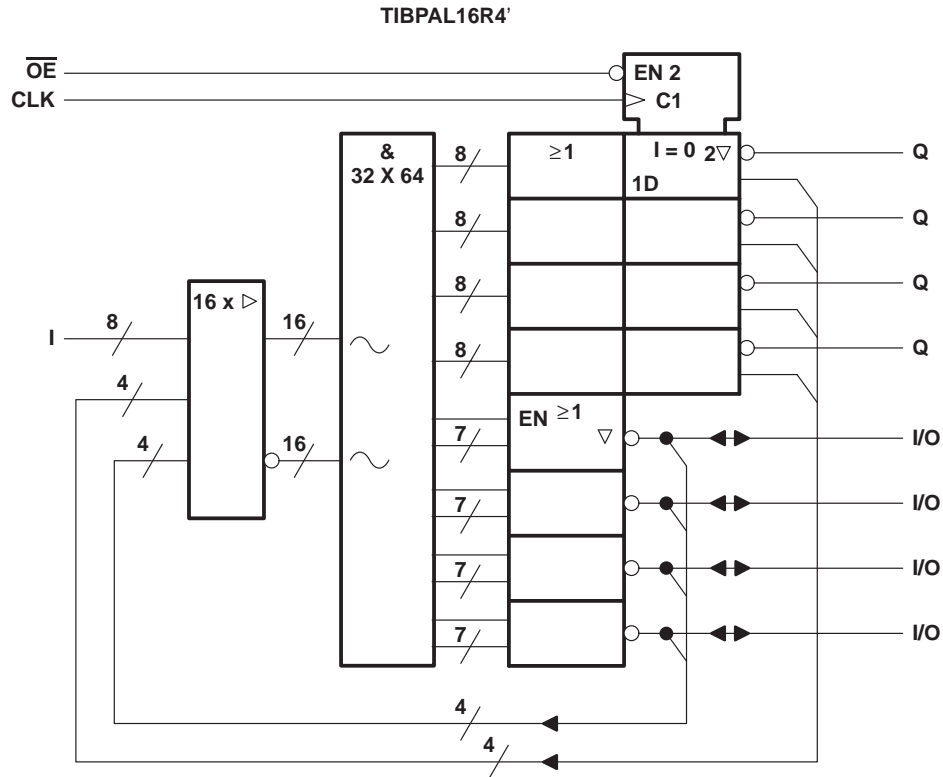
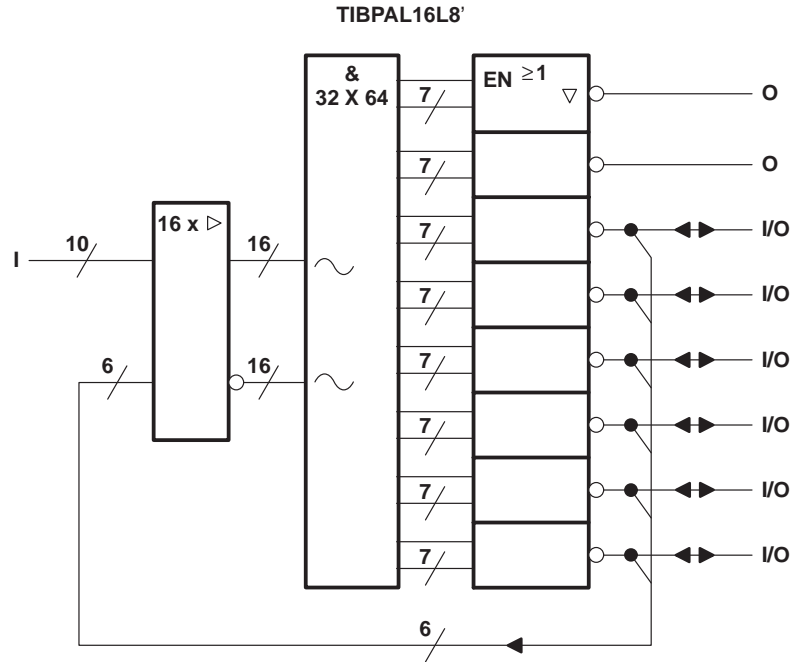


TIBPAL16R8'
 C SUFFIX ... FN PACKAGE
 M SUFFIX ... FK PACKAGE



Pin assignments in operating mode

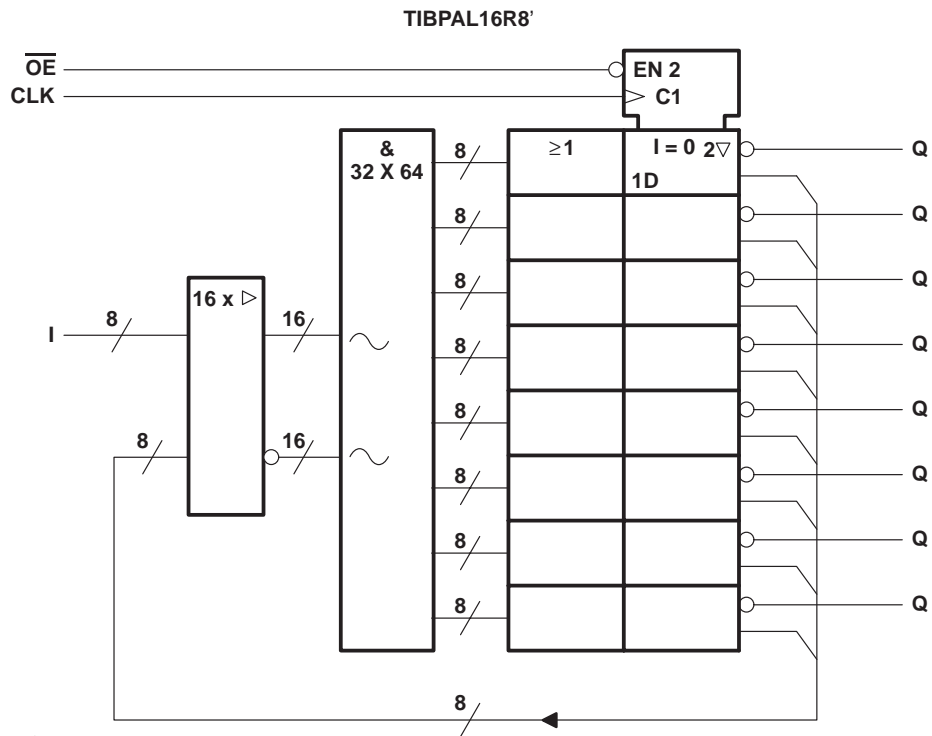
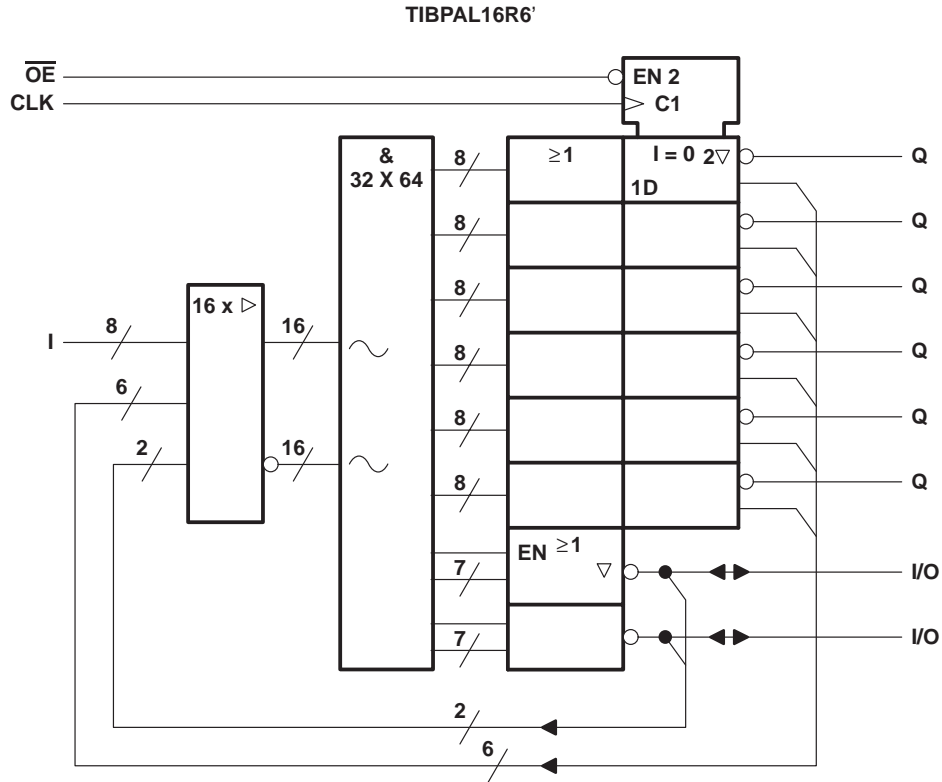
functional block diagrams (positive logic)



~ denotes fused inputs

TIBPAL16R6-10C, TIBPAL16R8-10C
 TIBPAL16R6-12M, TIBPAL16R8-12M
 HIGH-PERFORMANCE *IMPACT-X*™ PAL® CIRCUITS
 SRPS017 – D3023, MAY 1987 – REVISED MARCH 1992

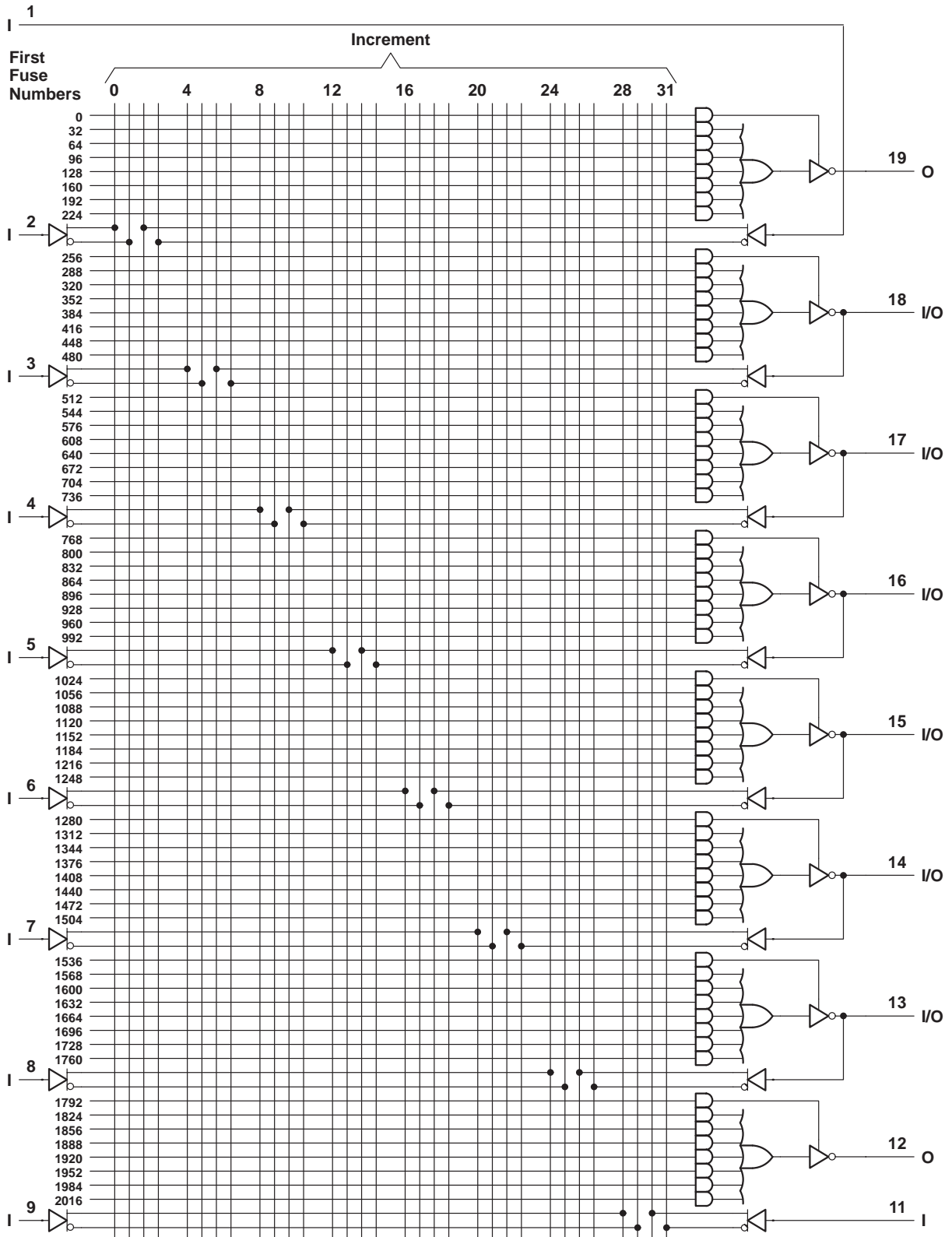
functional block diagrams (positive logic)



~ denotes fused inputs

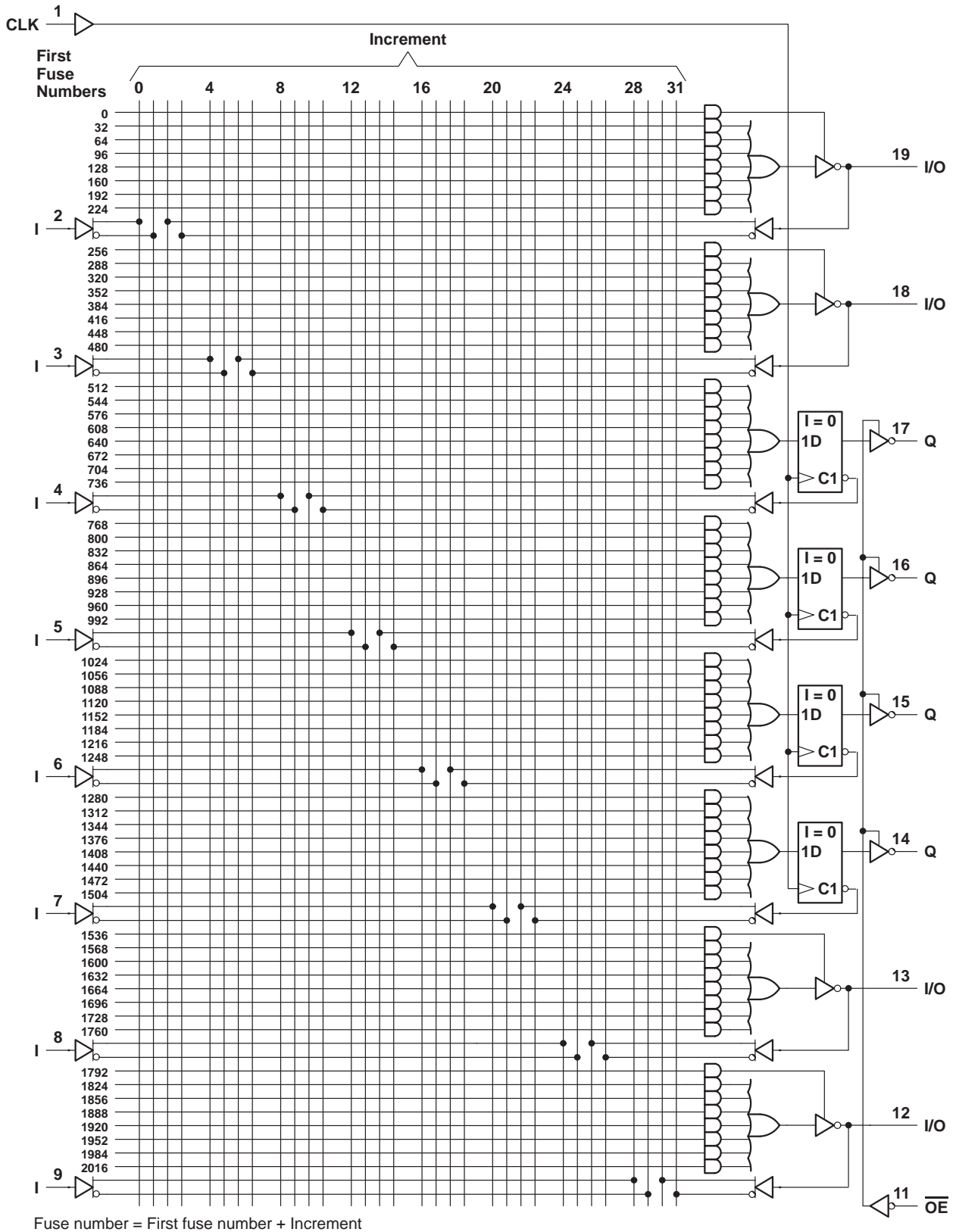


logic diagram (positive logic)

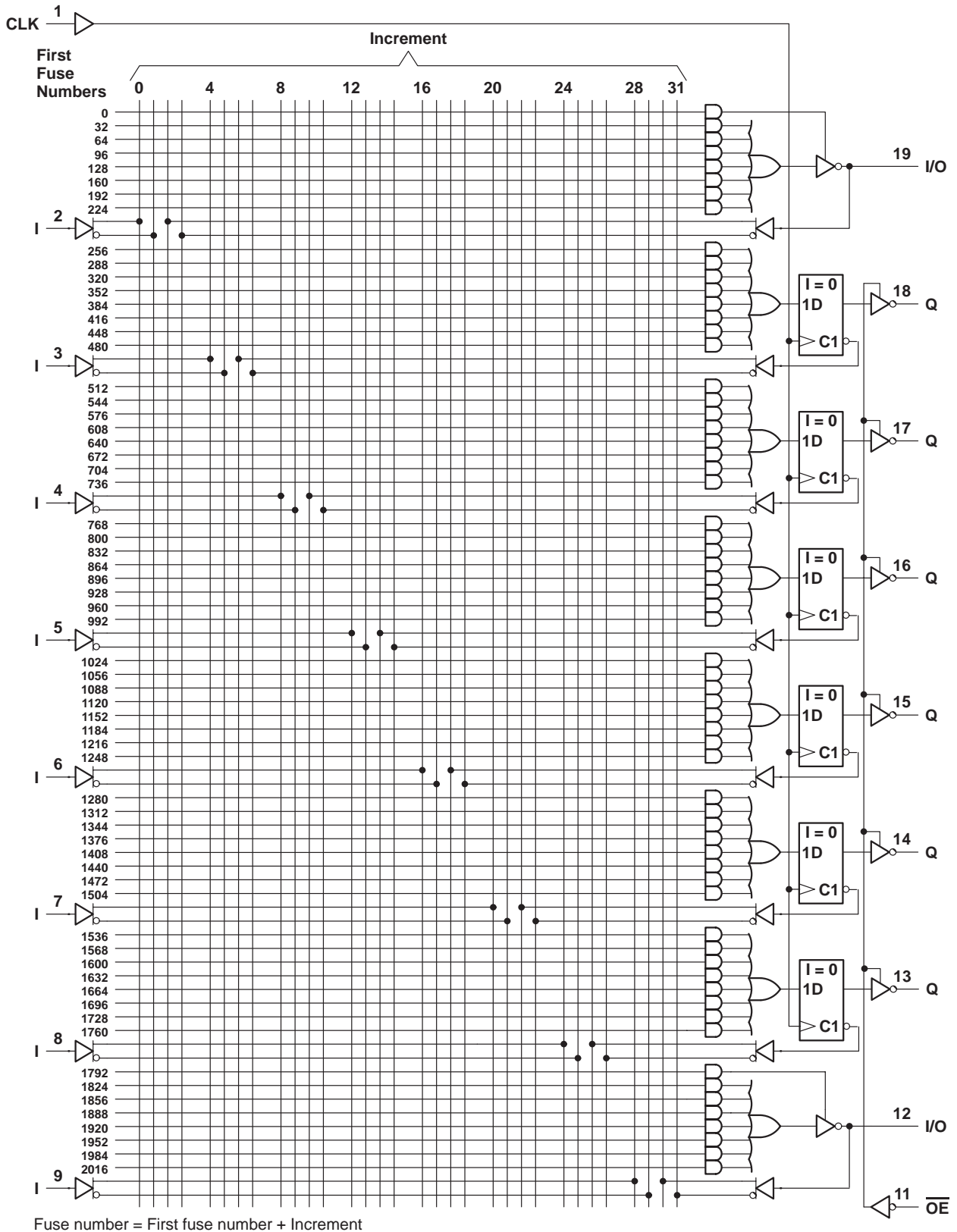


Fuse number = First fuse number + Increment

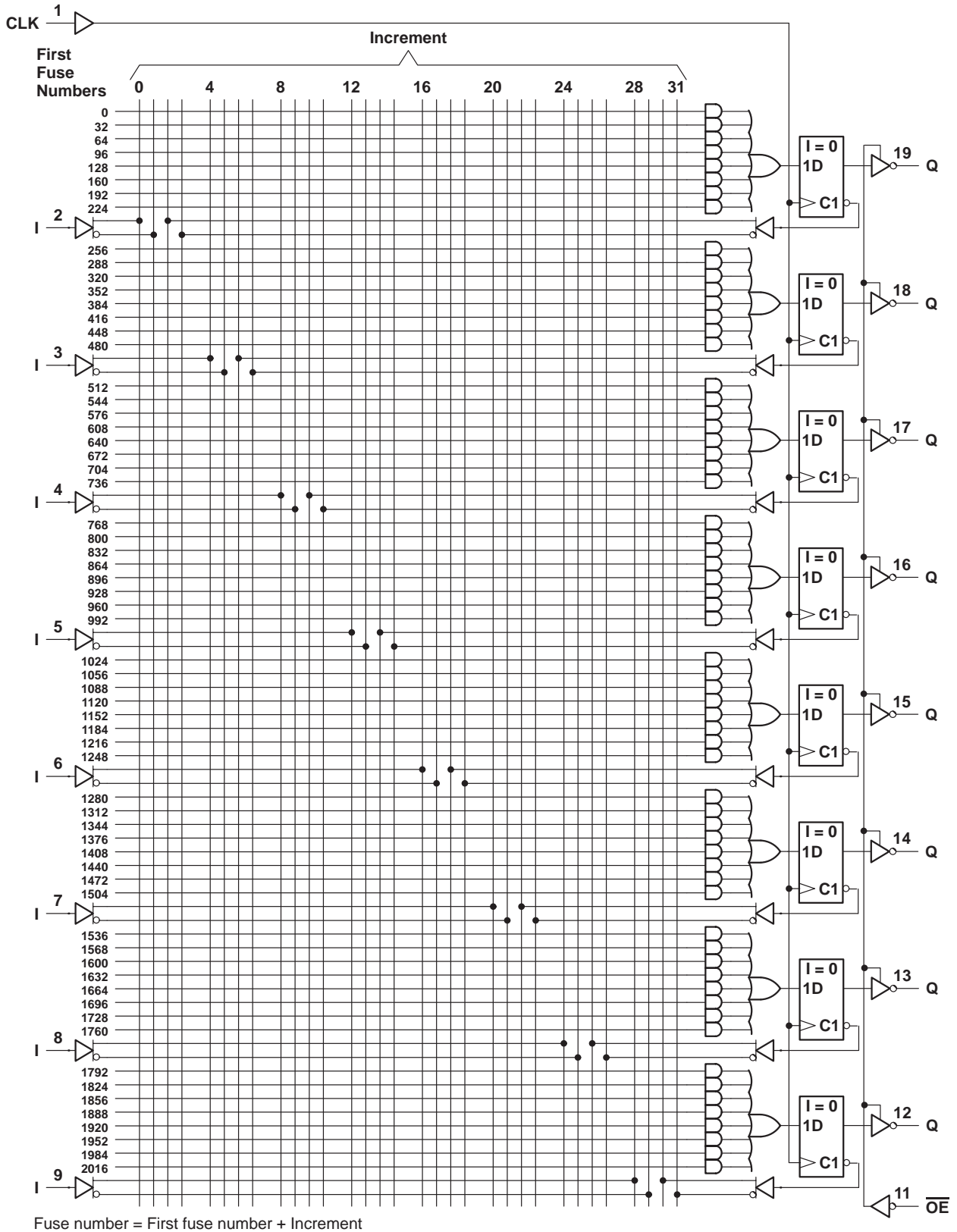
logic diagram (positive logic)



logic diagram (positive logic)



logic diagram (positive logic)



TIBPAL16L8-10C, TIBPAL16R4-10C, TIBPAL16R6-10C, TIBPAL16R8-10C HIGH-PERFORMANCE *IMPACT-X*[™] PAL[®] CIRCUITS

SRPS017 – D3023, MAY 1987 – REVISED MARCH 1992

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Supply voltage, V_{CC} (see Note 1)	7 V
Input voltage (see Note 1)	5.5 V
Voltage applied to disabled output (see Note 1)	5.5 V
Operating free-air temperature range	0°C to 75°C
Storage temperature range	–65°C to 150°C

NOTE 1: These ratings apply except for programming pins during a programming cycle.

recommended operating conditions

		MIN	NOM	MAX	UNIT
V_{CC}	Supply voltage	4.75	5	5.25	V
V_{IH}	High-level input voltage (see Note 2)	2		5.5	V
V_{IL}	Low-level input voltage (see Note 2)			0.8	V
I_{OH}	High-level output current			–3.2	mA
I_{OL}	Low-level output current			24	mA
f_{clock}	Clock frequency	0		62.5	MHz
t_w	Pulse duration, clock (see Note 2)	High		8	ns
		Low		8	
t_{su}	Setup time, input or feedback before clock [†]	10			ns
t_h	Hold time, input or feedback after clock [†]	0			ns
T_A	Operating free-air temperature	0	25	75	°C

NOTE 2: These are absolute voltage levels with respect to the ground pin of the device and include all overshoots due to system and/or tester noise. Testing these parameters should not be attempted without suitable equipment.

electrical characteristics over recommended operating free-air temperature range

PARAMETER	TEST CONDITIONS		MIN	TYP [†]	MAX	UNIT
V_{IK}	$V_{CC} = 4.75$ V,	$I_I = -18$ mA		–0.8	–1.5	V
V_{OH}	$V_{CC} = 4.75$ V,	$I_{OH} = -3.2$ mA	2.4	3.2		V
V_{OL}	$V_{CC} = 4.75$ V,	$I_{OL} = 24$ mA		0.3	0.5	V
I_{OZH}^{\ddagger}	$V_{CC} = 5.25$ V,	$V_O = 2.4$ V			100	μA
I_{OZL}^{\ddagger}	$V_{CC} = 5.25$ V,	$V_O = 0.4$ V			–100	μA
I_I	$V_{CC} = 5.25$ V,	$V_I = 5.5$ V			0.2	mA
I_{IH}^{\ddagger}	$V_{CC} = 5.25$ V,	$V_I = 2.4$ V			25	μA
I_{IL}^{\ddagger}	$V_{CC} = 5.25$ V,	$V_I = 0.4$ V		–0.08	–0.25	mA
I_{OS}^{\S}	$V_{CC} = 5.25$ V,	$V_O = 0$	–30	–70	–130	mA
I_{CC}	$V_{CC} = 5.25$ V,	$V_I = 0$, Outputs open		140	180	mA
C_i	$f = 1$ MHz,	$V_I = 2$ V		5		pF
C_o	$f = 1$ MHz,	$V_O = 2$ V		6		pF
$C_{i/o}$	$f = 1$ MHz,	$V_{I/O} = 2$ V		7.5		pF
C_{clk}	$f = 1$ MHz,	$V_{CLK} = 2$ V		6		pF

[†] All typical values are at $V_{CC} = 5$ V, $T_A = 25^\circ\text{C}$.

[‡] I/O leakage is the worst case of I_{OZL} and I_{IL} or I_{OZH} and I_{IH} respectively.

[§] Not more than one output should be shorted at a time, and the duration of the short circuit should not exceed one second.



TIBPAL16L8-10C, TIBPAL16R4-10C, TIBPAL16R6-10C, TIBPAL16R8-10C HIGH-PERFORMANCE *IMPACT-X*[™] *PAL*[®] CIRCUITS

SRPS017 – D3023, MAY 1987 – REVISED MARCH 1992

switching characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	TEST CONDITION	MIN	TYP†	MAX	UNIT
f _{max}	With feedback		R1 = 200 Ω, R2 = 390 Ω, See Figure 3	55.5	80		MHz
	Without feedback			62.5	85		
t _{pd}	I, I/O	O, I/O		3	7	10	ns
t _{pd}	CLK↑	Q		2	5	8	ns
t _{en}	OE↓	Q		1	4	10	ns
t _{dis}	OE↑	Q		1	4	10	ns
t _{en}	I, I/O	O, I/O		3	8	10	ns
t _{dis}	I, I/O	O, I/O		3	8	10	ns

† All typical values are at V_{CC} = 5 V, T_A = 25°C.

$$\ddagger f_{\max}(\text{with feedback}) = \frac{1}{t_{\text{su}} + t_{\text{pd}}(\text{CLK to Q})}, \quad f_{\max}(\text{without feedback}) = \frac{1}{t_{\text{w high}} + t_{\text{w low}}}$$

TIBPAL16L8-12M, TIBPAL16R4-12M, TIBPAL16R6-12M, TIBPAL16R8-12M HIGH-PERFORMANCE *IMPACT-X*™ PAL® CIRCUITS

SRPS017 – D3023, MAY 1987 – REVISED MARCH 1992

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Supply voltage, V_{CC} (see Note 1)	7 V
Input voltage (see Note 1)	5.5 V
Voltage applied to disabled output (see Note 1)	5.5 V
Operating free-air temperature range	–55°C to 125°C
Storage temperature range	–65°C to 150°C

NOTE 1: These ratings apply except for programming pins during a programming cycle.

recommended operating conditions

		MIN	NOM	MAX	UNIT
V_{CC}	Supply voltage	4.5	5	5.5	V
V_{IH}	High-level input voltage	2		5.5	V
V_{IL}	Low-level input voltage			0.8	V
I_{OH}	High-level output current			–2	mA
I_{OL}	Low-level output current			12	mA
f_{clock}^{\dagger}	Clock frequency	0		56	MHz
t_w	Pulse duration, clock (see Note 2)	High		9	ns
		Low		9	
t_{su}^{\dagger}	Setup time, input or feedback before clock \uparrow	11			ns
t_h^{\dagger}	Hold time, input or feedback after clock \uparrow	0			ns
T_A	Operating free-air temperature	–55	25	125	°C

NOTE 2: These are absolute voltage levels with respect to the ground pin of the device and include all overshoots due to system and/or tester noise. Testing these parameters should not be attempted without suitable equipment.

electrical characteristics over recommended operating free-air temperature range

PARAMETER	TEST CONDITIONS		MIN	TYP \dagger	MAX	UNIT
V_{IK}	$V_{CC} = 4.5 V,$	$I_I = -18 mA$		–0.8	–1.5	V
V_{OH}	$V_{CC} = 4.5 V,$	$I_{OH} = -2 mA$	2.4	3.2		V
V_{OL}	$V_{CC} = 4.5 V,$	$I_{OL} = 12 mA$		0.3	0.5	V
I_{OZH}^{\ddagger}	$V_{CC} = 5.5 V,$	$V_O = 2.4 V$			100	μA
I_{OZL}^{\ddagger}	$V_{CC} = 5.5 V,$	$V_O = 0.4 V$			–100	μA
I_I	$V_{CC} = 5.5 V,$	$V_I = 5.5 V$			0.2	mA
I_{IH}^{\ddagger}	$V_{CC} = 5.5 V,$	$V_I = 2.4 V$			25	μA
I_{IL}^{\ddagger}	$V_{CC} = 5.5 V,$	$V_I = 0.4 V$		–0.08	–0.25	mA
I_{OS}^{\S}	$V_{CC} = 5.5 V,$	$V_O = 0.5 V$	–30	–70	–250	mA
I_{CC}	$V_{CC} = 5.5 V,$	$V_I = GND,$ Outputs open		140	220	mA
C_i	$f = 1 MHz,$	$V_I = 2 V$		5		pF
C_o	$f = 1 MHz,$	$V_O = 2 V$		6		pF
$C_{i/o}$	$f = 1 MHz,$	$V_{I/O} = 2 V$		7.5		pF
C_{clk}	$f = 1 MHz,$	$V_{CLK} = 2 V$		6		pF

\dagger All typical values are at $V_{CC} = 5 V, T_A = 25^\circ C$.

\ddagger I/O leakage is the worst case of I_{OZL} and I_{IL} or I_{OZH} and I_{IH} respectively.

\S Not more than one output should be shorted at a time, and the duration of the short circuit should not exceed one second. V_O is set at 0.5 V to avoid test problems caused by test equipment ground degradation.



TIBPAL16L8-12M, TIBPAL16R4-12M, TIBPAL16R6-12M, TIBPAL16R8-12M HIGH-PERFORMANCE *IMPACT-X*[™] *PAL*[®] CIRCUITS

SRPS017 – D3023, MAY 1987 – REVISED MARCH 1992

switching characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	TEST CONDITION	MIN	TYP†	MAX	UNIT
f _{max}	With feedback		R1 = 390 Ω, R2 = 750 Ω, See Figure 3	48	80		MHz
	Without feedback			56	85		
t _{pd}	I, I/O	O, I/O		3	7	12	ns
t _{pd}	CLK↑	Q		2	5	10	ns
t _{en}	OE↓	Q		1	4	10	ns
t _{dis}	OE↑	Q		1	4	10	ns
t _{en}	I, I/O	O, I/O		3	8	14	ns
t _{dis}	I, I/O	O, I/O		2	8	12	ns

† All typical values are at V_{CC} = 5 V, T_A = 25°C.

$$\ddagger f_{\max(\text{with feedback})} = \frac{1}{t_{\text{su}} + t_{\text{pd}} (\text{CLK to Q})} \quad f_{\max(\text{without feedback})} = \frac{1}{t_{\text{w high}} + t_{\text{w low}}}$$

programming information

Texas Instruments programmable logic devices can be programmed using widely available software and inexpensive device programmers.

Complete programming specifications, algorithms, and the latest information on hardware, software, and firmware are available upon request. Information on programmers capable of programming Texas Instruments programmable logic is also available, upon request, from the nearest TI field sales office, local authorized TI distributor, or by calling Texas Instruments at (214) 997-5666.

preload procedure for registered outputs (see Figure 1 and Note 3)

The output registers can be preloaded to any desired state during device testing. This permits any state to be tested without having to step through the entire state-machine sequence. Each register is preloaded individually by following the steps given below.

- Step 1. With V_{CC} at 5 volts and Pin 1 at V_{IL} , raise Pin 11 to V_{IHH} .
- Step 2. Apply either V_{IL} or V_{IH} to the output corresponding to the register to be preloaded.
- Step 3. Pulse Pin 1, clocking in preload data.
- Step 4. Remove output voltage, then lower Pin 11 to V_{IL} . Preload can be verified by observing the voltage level at the output pin.

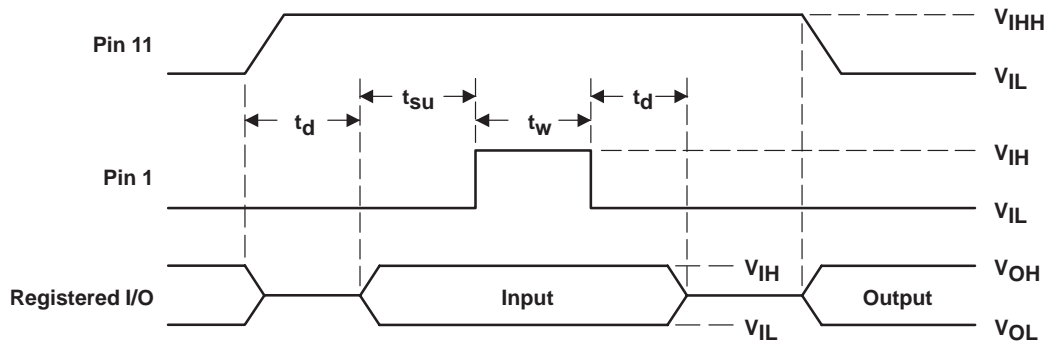
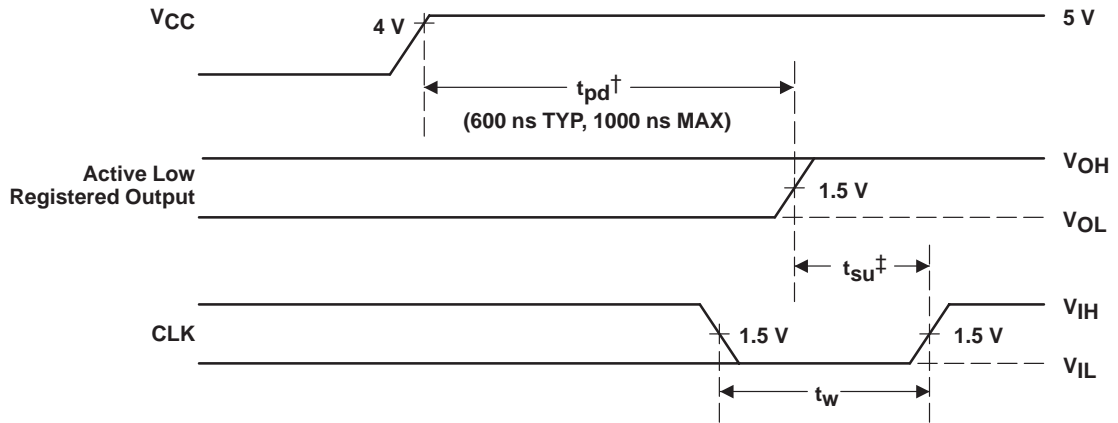


Figure 1. Preload Waveforms

NOTE 3: $t_d = t_{su} = t_h = 100$ ns to 1000 ns $V_{IHH} = 10.25$ V to 10.75 v

power-up reset (see Figure 2)

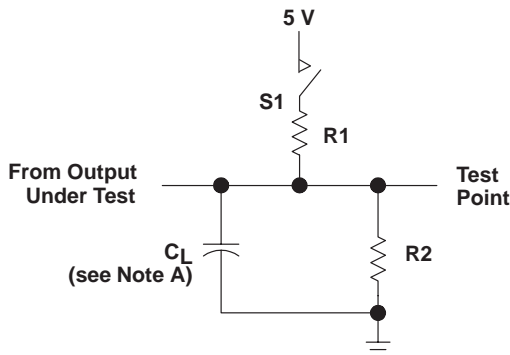
Following power up, all registers are reset to zero. This feature provides extra flexibility to the system designer and is especially valuable in simplifying state-machine initialization. To ensure a valid power-up reset, it is important that the rise of V_{CC} be monotonic. Following power-up reset, a low-to-high clock transition must not occur until all applicable input and feedback setup times are met.



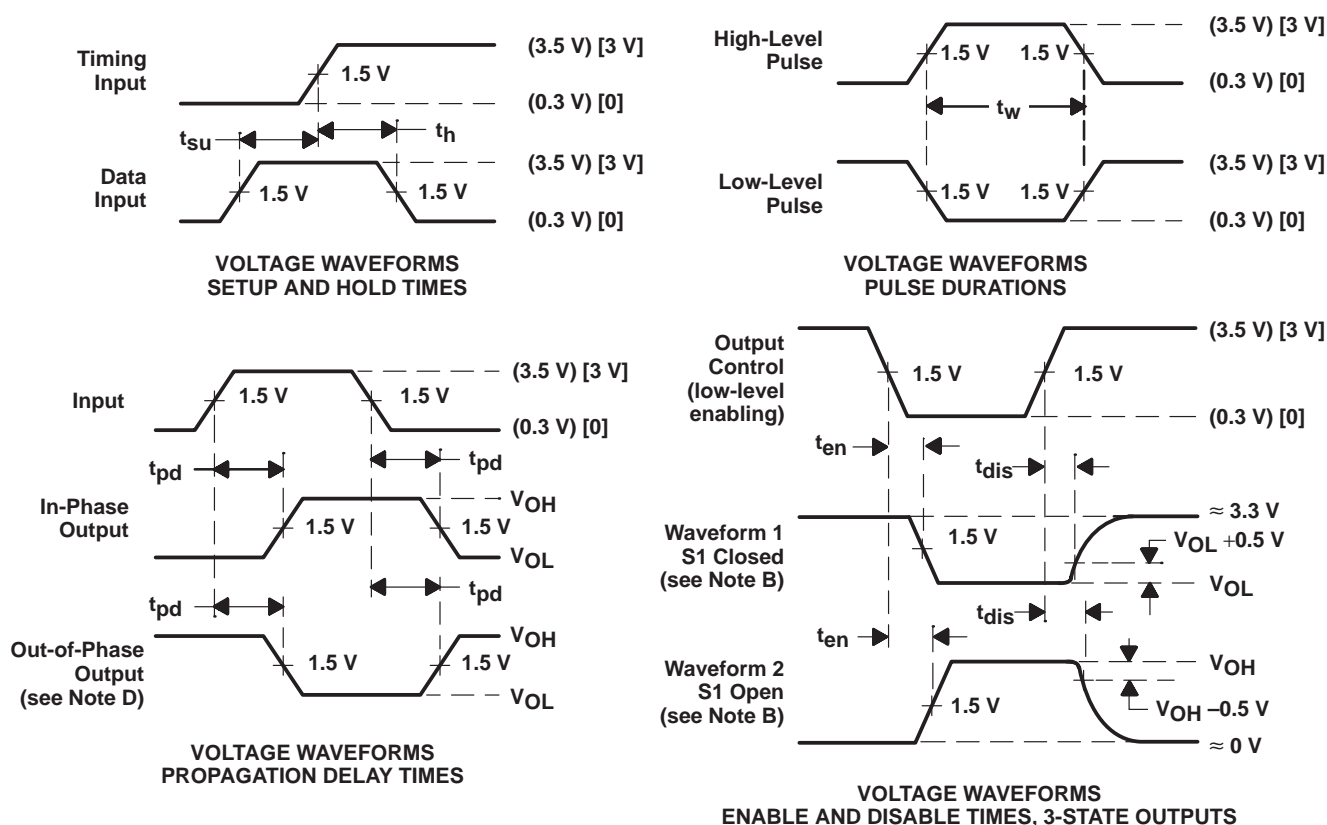
† This is the power-up reset time and applies to registered outputs only. The values shown are from characterization data.
 ‡ This is the setup time for input or feedback.

Figure 2. Power-Up Reset Waveforms

PARAMETER MEASUREMENT INFORMATION



LOAD CIRCUIT FOR 3-STATE OUTPUTS



- NOTES: A. C_L includes probe and jig capacitance and is 50 pF for t_{pd} and t_{en} , 5 pF for t_{dis} .
 B. Waveform 1 is for an output with internal conditions such that the output is high except when disabled by the output control. Waveform 2 is for an output with internal conditions such that the output is low except when disabled by the output control.
 C. All input pulses have the following characteristics: For C suffix, use the voltage levels indicated in parentheses (), $PRR \leq 1$ MHz, $t_r = t_f = 2$ ns, duty cycle = 50%; For M suffix, use the voltage levels indicated in brackets [], $PRR \leq 10$ MHz, t_r and $t_f \leq 2$ ns, duty cycle = 50%.
 D. When measuring propagation delay times of 3-state outputs, switch S1 is closed.
 E. Equivalent loads may be used for testing.

Figure 3. Load Circuit and Voltage Waveforms

metastable characteristics of TIBPAL16R4-10C, TIBPAL16R6-10C, and TIBPAL16R8-10C

At some point a system designer is faced with the problem of synchronizing two digital signals operating at two different frequencies. This problem is typically overcome by synchronizing one of the signals to the local clock through use of a flip-flop. However, this solution presents an awkward dilemma since the setup and hold time specifications associated with the flip-flop are sure to be violated. The metastable characteristics of the flip-flop can influence overall system reliability.

Whenever the setup and hold times of a flip-flop are violated, its output response becomes uncertain and is said to be in the metastable state if the output hangs up in the region between V_{IL} and V_{IH} . This metastable condition lasts until the flip-flop falls into one of its two stable states, which takes longer than the specified maximum propagation delay time (CLK to Q max).

From a system engineering standpoint, a designer cannot use the specified data sheet maximum for propagation delay time when using the flip-flop as a data synchronizer – how long to wait after the specified data sheet maximum must be known before using the data in order to guarantee reliable system operation.

The circuit shown in Figure 4 can be used to evaluate MTBF (Mean Time Between Failure) and Δt for a selected flip-flop. Whenever the Q output of the DUT is between 0.8 V and 2 V, the comparators are in opposite states. When the Q output of the DUT is higher than 2 V or lower than 0.8 V, the comparators are at the same logic level. The outputs of the two comparators are sampled a selected time (Δt) after SCLK. The exclusive OR gate detects the occurrence of a failure and increments the failure counter.

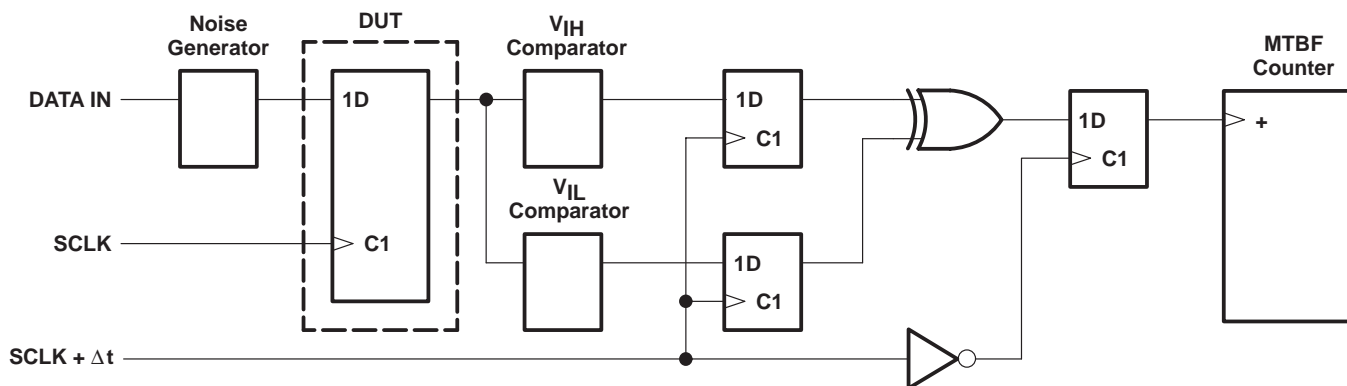


Figure 4. Metastable Evaluation Test Circuit

In order to maximize the possibility of forcing the DUT into a metastable state, the input data signal is applied so that it always violates the setup and hold time. This condition is illustrated in the timing diagram in Figure 5. Any other relationship of SCLK to data will provide less chance for the device to enter into the metastable state.

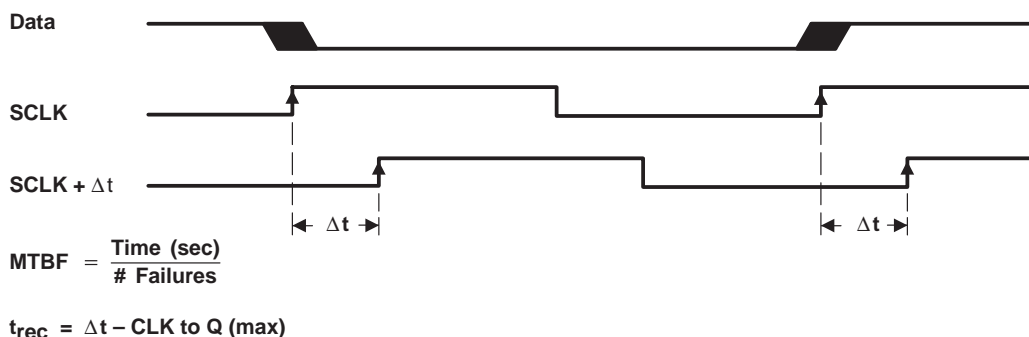


Figure 5. Timing Diagram

By using the described test circuit, MTBF can be determined for several different values of Δt (see Figure 4). Plotting this information on semilog scale demonstrates the metastable characteristics of the selected flip-flop. Figure 6 shows the results for the TIBPAL16'-10C operating at 1 MHz.

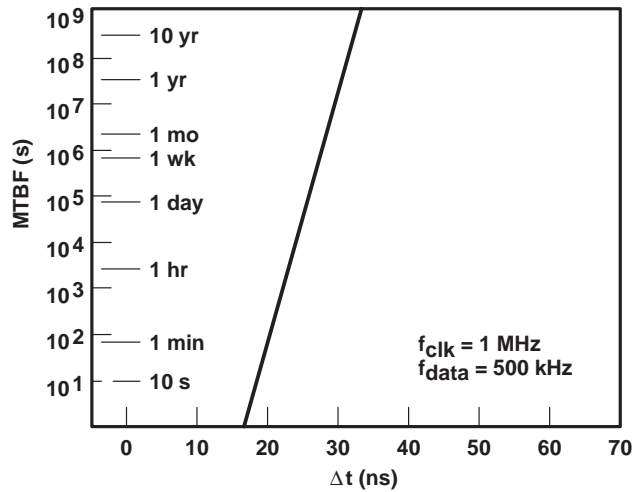


Figure 6. Metastable Characteristics

From the data taken in the above experiment, an equation can be derived for the metastable characteristics at other clock frequencies.

The metastable equation: $\frac{1}{\text{MTBF}} = f_{\text{SCLK}} \times f_{\text{data}} \times C1 \times e^{-C2 \times \Delta t}$

The constants C1 and C2 describe the metastable characteristics of the device. From the experimental data, these constants can be solved for: C1 = 9.15×10^{-7} and C2 = 0.959

Therefore

$$\frac{1}{\text{MTBF}} = f_{\text{SCLK}} \times f_{\text{data}} \times 9.15 \times 10^{-7} \times e^{-0.959 \times \Delta t}$$

definition of variables

DUT (Device Under Test): The DUT is a 10-ns registered PLD programmed with the equation $Q := D$.

MTBF (Mean Time Between Failures): The average time (s) between metastable occurrences that cause a violation of the device specifications.

f_{SCLK} (system clock frequency): Actual clock frequency for the DUT.

f_{data} (data frequency): Actual data frequency for a specified input to the DUT.

C1: Calculated constant that defines the magnitude of the curve.

C2: Calculated constant that defines the slope of the curve.

t_{rec} (metastability recovery time): Minimum t_{rec} required to guarantee recovery from metastability, at a given MTBF failure rate. $t_{\text{rec}} = \Delta t - t_{\text{pd}}$ (CLK to Q, max)

Δt : The time difference (ns) from when the synchronizing flip-flop is clocked to when its output is sampled.

The test described above has shown the metastable characteristics of the TIBPAL16R4/R6/R8-10C series. For additional information on metastable characteristics of Texas Instruments logic circuits, please refer to TI Applications publication SDAA004, "Metastable Characteristics, Design Considerations for ALS, AS, and LS Circuits."

TYPICAL CHARACTERISTICS

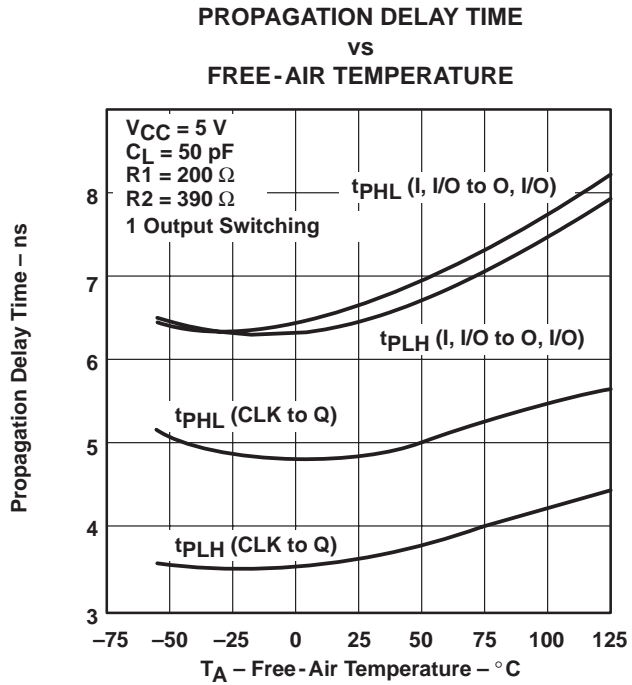


Figure 7

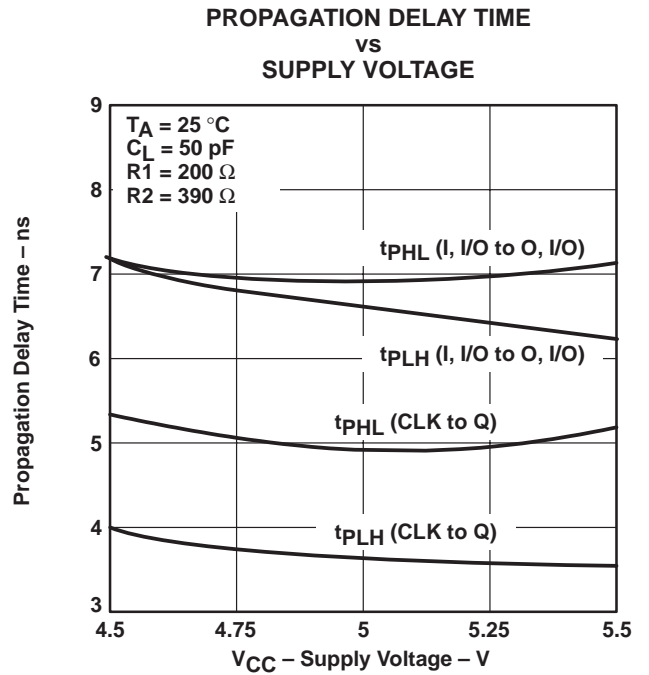


Figure 8

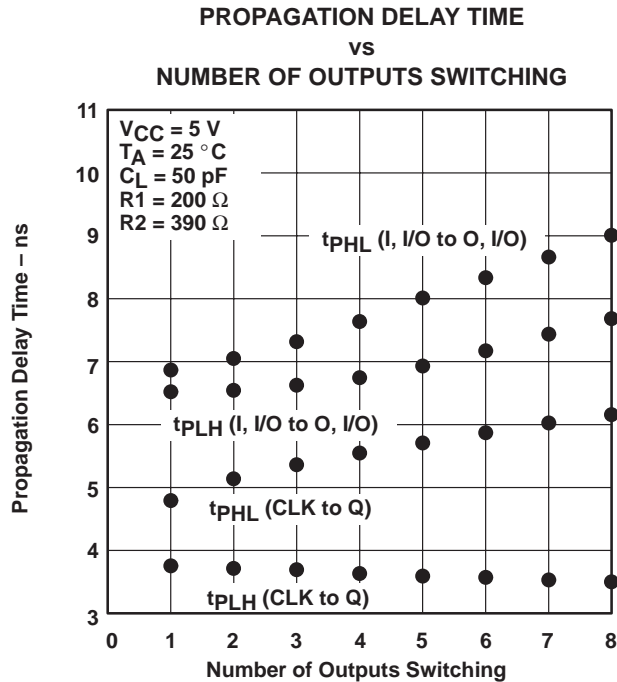


Figure 9

TYPICAL CHARACTERISTICS

PROPAGATION DELAY TIME
 vs
 LOAD CAPACITANCE

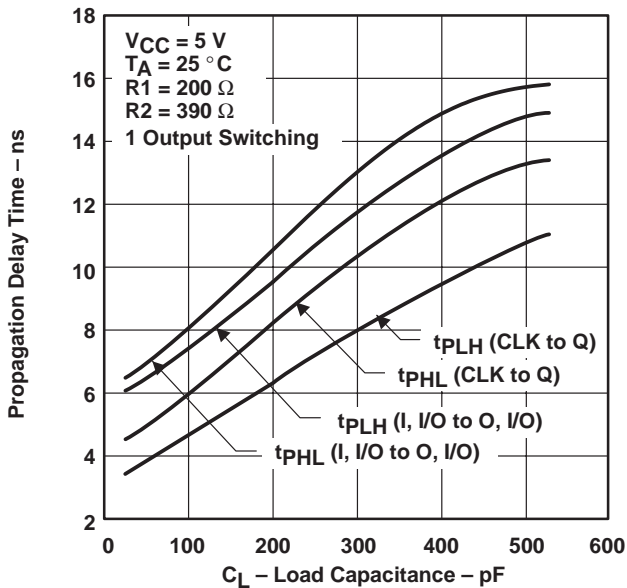


Figure 10

POWER DISSIPATION
 vs
 FREQUENCY
 8-BIT COUNTER MODE

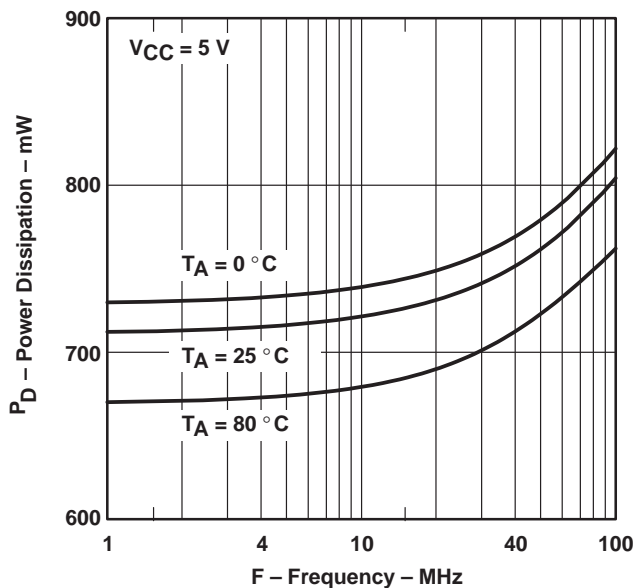


Figure 11

SUPPLY CURRENT
 vs
 FREE-AIR TEMPERATURE

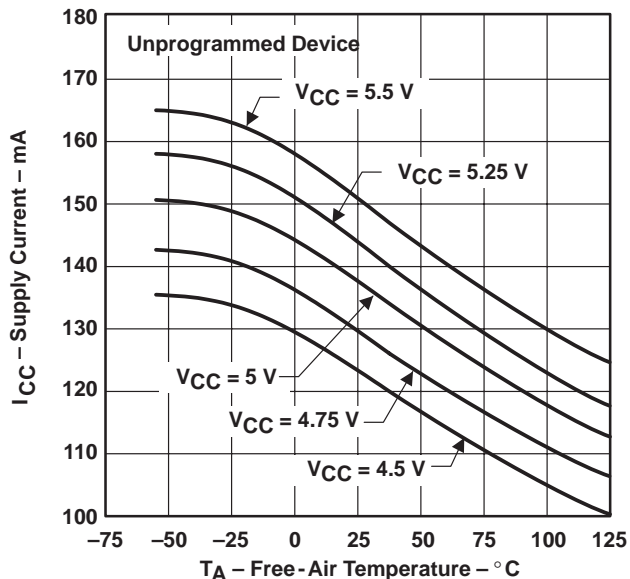


Figure 12

TI North American Sales Offices

ALABAMA: Huntsville: (205) 837-7530
ARIZONA: Phoenix: (602) 995-1007
CALIFORNIA: Irvine: (714) 660-1200
 San Diego: (619) 278-9600
 Santa Clara: (408) 980-9000
 Woodland Hills: (818) 704-8100
COLORADO: Aurora: (303) 368-8000
CONNECTICUT: Wallingford: (203) 269-0074
FLORIDA: Altamonte Springs: (407) 260-2116
 Fort Lauderdale: (305) 973-8502
 Tampa: (813) 885-7588
GEORGIA: Norcross: (404) 662-7967
ILLINOIS: Arlington Heights: (708) 640-3000
INDIANA: Carmel: (317) 573-6400
 Fort Wayne: (219) 489-4697
KANSAS: Overland Park: (913) 451-4511
MARYLAND: Columbia: (410) 964-2003
MASSACHUSETTS: Waltham: (617) 895-9100
MICHIGAN: Farmington Hills: (313) 553-1581
MINNESOTA: Eden Prairie: (612) 828-9300
MISSOURI: St. Louis: (314) 821-8400
NEW JERSEY: Iselin: (908) 750-1050
NEW MEXICO: Albuquerque: (505) 345-2555
NEW YORK: East Syracuse: (315) 463-9291
 Fishkill: (914) 897-2900
 Melville: (516) 454-6600
 Pittsford: (716) 385-6770
NORTH CAROLINA: Charlotte: (704) 527-0930
 Raleigh: (919) 876-2725
OHIO: Beachwood: (216) 765-7258
 Beavercreek: (513) 427-6200
OREGON: Beaverton: (503) 643-6758
PENNSYLVANIA: Blue Bell: (215) 825-9500
PUERTO RICO: Hato Rey: (809) 753-8700
TEXAS: Austin: (512) 250-6769
 Dallas: (214) 917-1264
 Houston: (713) 778-6592
 Midland: (915) 561-7137
UTAH: Salt Lake City: (801) 466-8972
WISCONSIN: Waukesha: (414) 798-1001
CANADA: Nepean: (613) 726-1970
 Richmond Hill: (416) 884-9181
 St. Laurent: (514) 335-8392

TI Regional Technology Centers

CALIFORNIA: Irvine: (714) 660-8140
 Santa Clara: (408) 748-2222
GEORGIA: Norcross: (404) 662-7945
ILLINOIS: Arlington Heights: (708) 640-2909
INDIANA: Indianapolis: (317) 573-6400
MASSACHUSETTS: Waltham: (617) 895-9196
MEXICO: Mexico City: 491-70834
MINNESOTA: Minneapolis: (612) 828-9300
TEXAS: Dallas: (214) 917-3881
CANADA: Nepean: (613) 726-1970

Customer Response Center

TOLL FREE: (800) 336-5236
OUTSIDE USA: (214) 995-6611
 (8:00 a.m. – 5:00 p.m. CST)

TI Authorized North American Distributors

Alliance Electronics, Inc. (military product only)
 Almac/Arrow
 Anthem Electronics
 Arrow/Schweber
 Future Electronics (Canada)
 GRS Electronics Co., Inc.
 Hall-Mark Electronics
 Marshall Industries
 Newark Electronics
 Rochester Electronics, Inc.
 (obsolete product only) (508) 462-9332)
 Wyle Laboratories
 Zeus Components

TI Distributors

ALABAMA: Arrow/Schweber (205) 837-6955; Hall-Mark (205) 837-8700; Marshall (205) 881-9235.
ARIZONA: Anthem (602) 966-6600; Arrow/Schweber (602) 437-0750; Hall-Mark (602) 431-0030; Marshall (602) 496-0290; Wyle (602) 437-2088.
CALIFORNIA: Los Angeles/Orange County: Anthem (818) 775-1333, (714) 768-4444; Arrow/Schweber (818) 380-9686, (714) 838-5422; Hall-Mark (818) 773-4500, (714) 727-6000; Marshall (818) 878-7000, (714) 458-5301; Wyle (818) 880-9000, (714) 863-9953; Zeus (714) 921-9000, (818) 889-3838;
 Sacramento: Anthem (916) 624-9744; Hall-Mark (916) 624-9781; Marshall (916) 635-9700; Wyle (916) 638-5282;
 San Diego: Anthem (619) 453-9005; Arrow/Schweber (619) 565-4800; Hall-Mark (619) 268-1201; Marshall (619) 578-9600; Wyle (619) 565-9171; Zeus (619) 277-9681.
 San Francisco Bay Area: Anthem (408) 453-1200; Arrow/Schweber (408) 441-9700, (510) 490-9477; Hall-Mark (408) 432-4000; Marshall (408) 942-4600; Wyle (408) 727-2500; Zeus (408) 629-4789.
COLORADO: Anthem (303) 790-4500; Arrow/Schweber (303) 799-0258; Hall-Mark (303) 790-1662; Marshall (303) 451-8383; Wyle (303) 457-9953.
CONNECTICUT: Anthem (203) 575-1575; Arrow/Schweber (203) 265-7741; Hall-Mark (203) 271-2844; Marshall (203) 265-3822.
FLORIDA: Fort Lauderdale: Arrow/Schweber (305) 429-8200; Hall-Mark (305) 971-9280; Marshall (305) 977-4880.
 Orlando: Arrow/Schweber (407) 333-9300; Hall-Mark (407) 830-5855; Marshall (407) 767-8585; Zeus (407) 788-9100.
 Tampa: Hall-Mark (813) 541-7440; Marshall (813) 573-1399.
GEORGIA: Arrow/Schweber (404) 497-1300; Hall-Mark (404) 623-4400; Marshall (404) 923-5750.
ILLINOIS: Anthem (708) 884-0200; Arrow/Schweber (708) 250-0500; Hall-Mark (312) 860-3800; Marshall (708) 490-0155; Newark (312) 784-5100.
INDIANA: Arrow/Schweber (317) 299-2071; Hall-Mark (317) 872-8875; Marshall (317) 297-0483.
IOWA: Arrow/Schweber (319) 395-7230.
KANSAS: Arrow/Schweber (913) 541-9542; Hall-Mark (913) 888-4747; Marshall (913) 492-3121.
MARYLAND: Anthem (301) 995-6640; Arrow/Schweber (301) 596-7800; Hall-Mark (301) 988-9800; Marshall (301) 622-1118; Zeus (301) 997-1118.
MASSACHUSETTS: Anthem (508) 657-5170; Arrow/Schweber (508) 658-0900; Hall-Mark (508) 667-0902; Marshall (508) 658-0810; Wyle (617) 272-7300; Zeus (617) 246-8200.

MICHIGAN: Detroit: Arrow/Schweber (313) 462-2290; Hall-Mark (313) 416-5800; Marshall (313) 525-5850; Newark (313) 967-0600.
MINNESOTA: Anthem (612) 944-5454; Arrow/Schweber (612) 941-5280; Hall-Mark (612) 881-2600; Marshall (612) 559-2211.
MISSOURI: Arrow/Schweber (314) 567-6888; Hall-Mark (314) 291-5350; Marshall (314) 291-4650.
NEW JERSEY: Anthem (201) 227-7960; Arrow/Schweber (201) 227-7880, (609) 596-8000; Hall-Mark (201) 515-3000, (609) 235-1900; Marshall (201) 882-0320, (609) 234-9100.
NEW MEXICO: Alliance (505) 292-3360.
NEW YORK: Long Island: Anthem (516) 864-6600; Arrow/Schweber (516) 231-1000; Hall-Mark (516) 737-0600; Marshall (516) 273-2424; Zeus (914) 937-7400.
Rochester: Arrow/Schweber (716) 427-0300; Hall-Mark (716) 425-3300; Marshall (716) 235-7620.
Syracuse: Marshall (607) 785-2345.
NORTH CAROLINA: Arrow/Schweber (919) 876-3132; Hall-Mark (919) 872-0712; Marshall (919) 878-9882.
OHIO: Cleveland: Arrow/Schweber (216) 248-3990; Hall-Mark (216) 349-4632; Marshall (216) 248-1788.
Columbus: Hall-Mark (614) 888-3313.
Dayton: Arrow/Schweber (513) 435-5563; Marshall (513) 898-4480; Zeus (513) 293-6162.
OKLAHOMA: Arrow/Schweber (918) 252-7537; Hall-Mark (918) 254-6110.
OREGON: Almac/Arrow (503) 629-8090; Anthem (503) 643-1114; Marshall (503) 644-5050; Wyle (503) 643-7900.
PENNSYLVANIA: Anthem (215) 443-5150; Arrow/Schweber (215) 928-1800; GRS (215) 922-7037; (609) 964-8560; Marshall (412) 788-0441.
TEXAS: Austin: Arrow/Schweber (512) 835-4180; Hall-Mark (512) 258-8848; Marshall (512) 837-1991; Wyle (512) 345-8853;
 Dallas: Anthem (214) 238-7100; Arrow/Schweber (214) 380-6464; Hall-Mark (214) 553-4300; Marshall (214) 233-5200; Wyle (214) 235-9953; Zeus (214) 783-7010;
 Houston: Arrow/Schweber (713) 530-4700; Hall-Mark (713) 781-6100; Marshall (713) 467-1666; Wyle (713) 879-9953.
UTAH: Anthem (801) 973-8555; Arrow/Schweber (801) 973-6913; Marshall (801) 973-2288; Wyle (801) 974-9953.
WASHINGTON: Almac/Arrow (206) 643-9992; Anthem (206) 483-1700; Marshall (206) 486-5747; Wyle (206) 881-1150.
WISCONSIN: Arrow/Schweber (414) 792-0150; Hall-Mark (414) 797-7844; Marshall (414) 797-8400.
CANADA: Calgary: Future (403) 235-5325;
 Edmonton: Future (403) 438-2858;
 Montreal: Arrow/Schweber (514) 421-7411; Future (514) 694-7710; Marshall (514) 694-8142
 Ottawa: Arrow/Schweber (613) 226-6903; Future (613) 820-8313.
 Quebec: Future (418) 897-6666.
 Toronto: Arrow/Schweber (416) 670-7769; Future (416) 612-9200; Marshall (416) 458-8046.
 Vancouver: Arrow/Schweber (604) 421-2333; Future (604) 294-1166.

TI Die Processors

Chip Supply (407) 298-7100
 Elmo Semiconductor (818) 768-7400
 Minco Technology Labs (512) 834-2022



D0892

IMPORTANT NOTICE

Texas Instruments and its subsidiaries (TI) reserve the right to make changes to their products or to discontinue any product or service without notice, and advise customers to obtain the latest version of relevant information to verify, before placing orders, that information being relied on is current and complete. All products are sold subject to the terms and conditions of sale supplied at the time of order acknowledgement, including those pertaining to warranty, patent infringement, and limitation of liability.

TI warrants performance of its semiconductor products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are utilized to the extent TI deems necessary to support this warranty. Specific testing of all parameters of each device is not necessarily performed, except those mandated by government requirements.

CERTAIN APPLICATIONS USING SEMICONDUCTOR PRODUCTS MAY INVOLVE POTENTIAL RISKS OF DEATH, PERSONAL INJURY, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE ("CRITICAL APPLICATIONS"). TI SEMICONDUCTOR PRODUCTS ARE NOT DESIGNED, AUTHORIZED, OR WARRANTED TO BE SUITABLE FOR USE IN LIFE-SUPPORT DEVICES OR SYSTEMS OR OTHER CRITICAL APPLICATIONS. INCLUSION OF TI PRODUCTS IN SUCH APPLICATIONS IS UNDERSTOOD TO BE FULLY AT THE CUSTOMER'S RISK.

In order to minimize risks associated with the customer's applications, adequate design and operating safeguards must be provided by the customer to minimize inherent or procedural hazards.

TI assumes no liability for applications assistance or customer product design. TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right of TI covering or relating to any combination, machine, or process in which such semiconductor products or services might be or are used. TI's publication of information regarding any third party's products or services does not constitute TI's approval, warranty or endorsement thereof.