



# THE DATASHEET OF TIBPAL16L8-12MJB



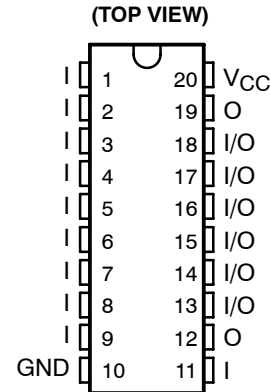
# TIBPAL16L8-10C, TIBPAL16R4-10C, TIBPAL16R6-10C, TIBPAL16R8-10C TIBPAL16L8-12M, TIBPAL16R4-12M, TIBPAL16R6-12M, TIBPAL16R8-12M HIGH-PERFORMANCE *IMPACT-X*™ PAL® CIRCUITS

SRPS017A – D3023, MAY 1987 – REVISED DECEMBER 2010

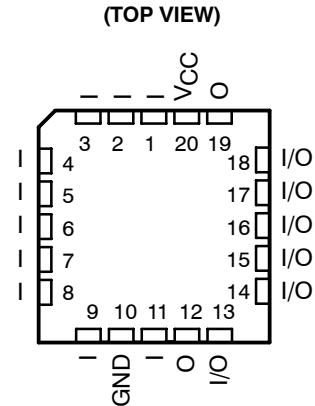
- **High-Performance Operation:**
  - $f_{max}$  (w/o feedback)
    - TIBPAL16R'-10C Series . . . 62.5 MHz Min
    - TIBPAL16R'-12M Series . . . 56 MHz Min
  - $f_{max}$  (with feedback)
    - TIBPAL16R'-10C Series . . . 55.5 MHz Min
    - TIBPAL16R'-12M Series . . . 48 MHz Min
  - Propagation Delay
    - 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

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

## description

These programmable array logic devices feature high speed and functional equivalency when compared with currently available devices. These *IMPACT-X*™ 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.

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.



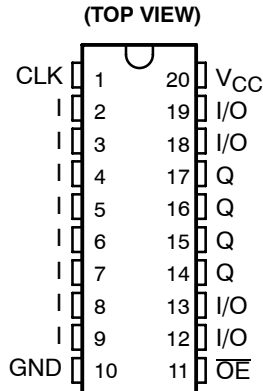
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

Copyright © 2010, Texas Instruments Incorporated

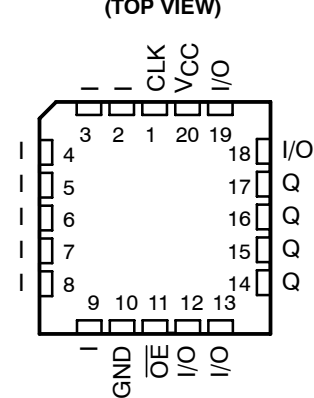
# TIBPAL16R4-10C, TIBPAL16R6-10C, TIBPAL16R8-10C TIBPAL16R4-12M, TIBPAL16R6-12M, TIBPAL16R8-12M HIGH-PERFORMANCE *IMPACT-X*™ PAL® CIRCUITS

SRPS017A - D3023, MAY 1987 - REVISED DECEMBER 2010

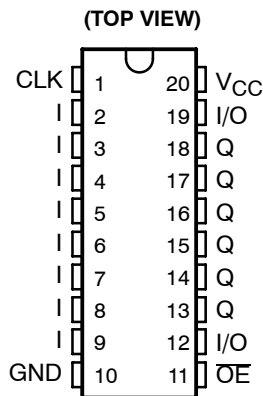
**TIBPAL16R4'**  
C SUFFIX . . . J OR N PACKAGE  
M SUFFIX . . . J PACKAGE



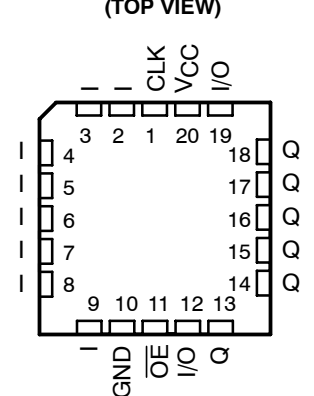
**TIBPAL16R4'**  
C SUFFIX . . . FN PACKAGE  
M SUFFIX . . . FK PACKAGE



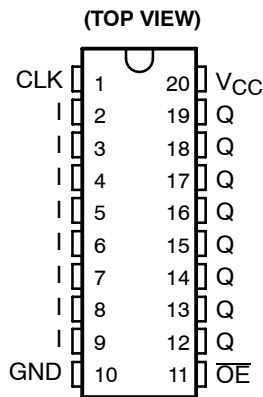
**TIBPAL16R6'**  
C SUFFIX . . . J OR N PACKAGE  
M SUFFIX . . . J PACKAGE



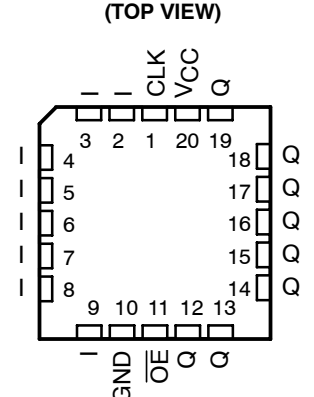
**TIBPAL16R6'**  
C SUFFIX . . . FN PACKAGE  
M SUFFIX . . . FK PACKAGE



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



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



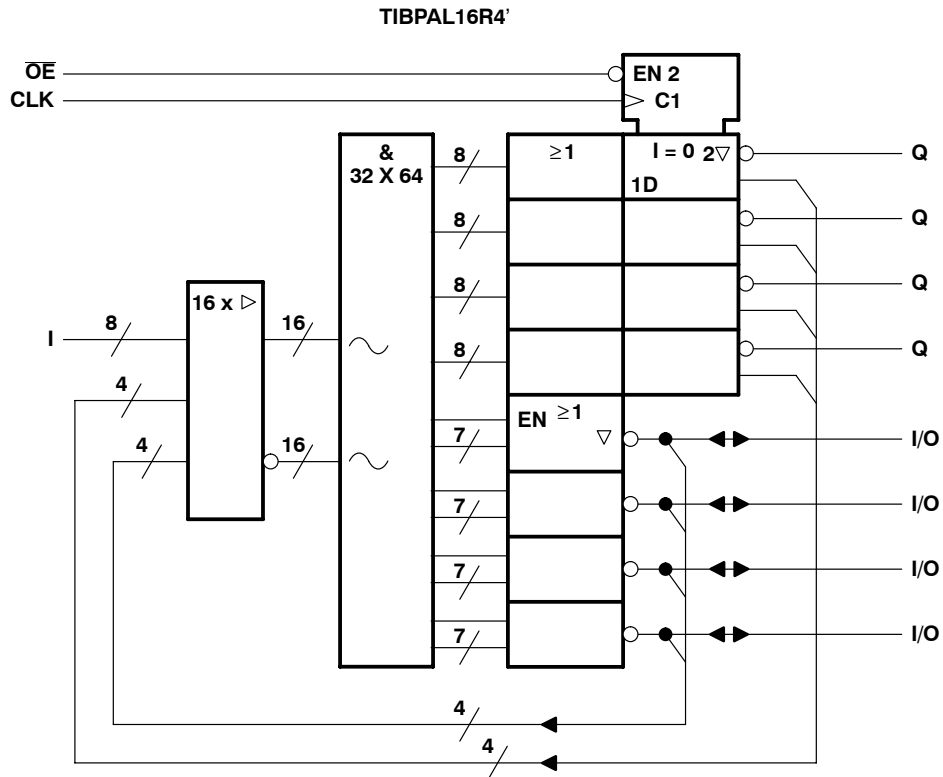
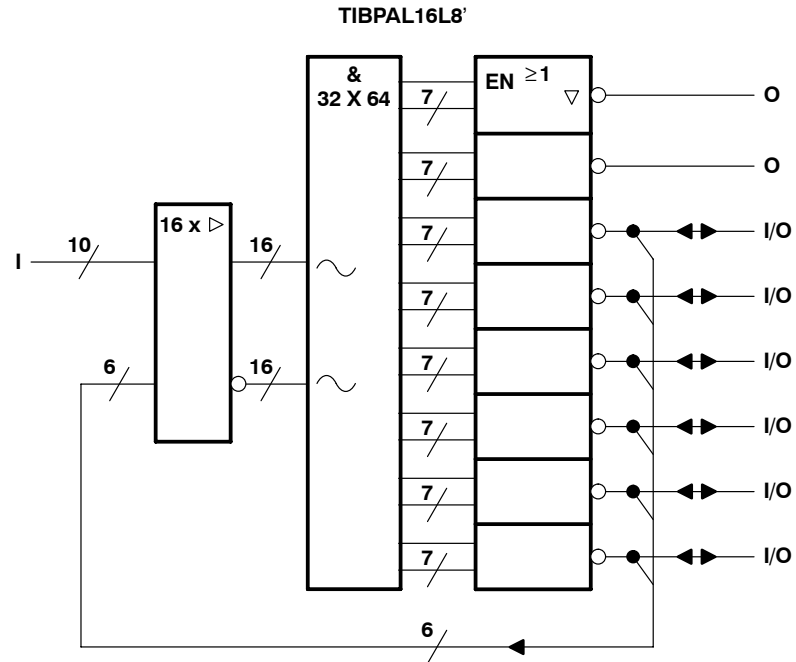
Pin assignments in operating mode



# TIBPAL16L8-10C, TIBPAL16R4-10C TIBPAL16L8-12M, TIBPAL16R4-12M HIGH-PERFORMANCE *IMPACT-X*™ PAL® CIRCUITS

SRPS017A - D3023, MAY 1987 - REVISED DECEMBER 2010

## functional block diagrams (positive logic)

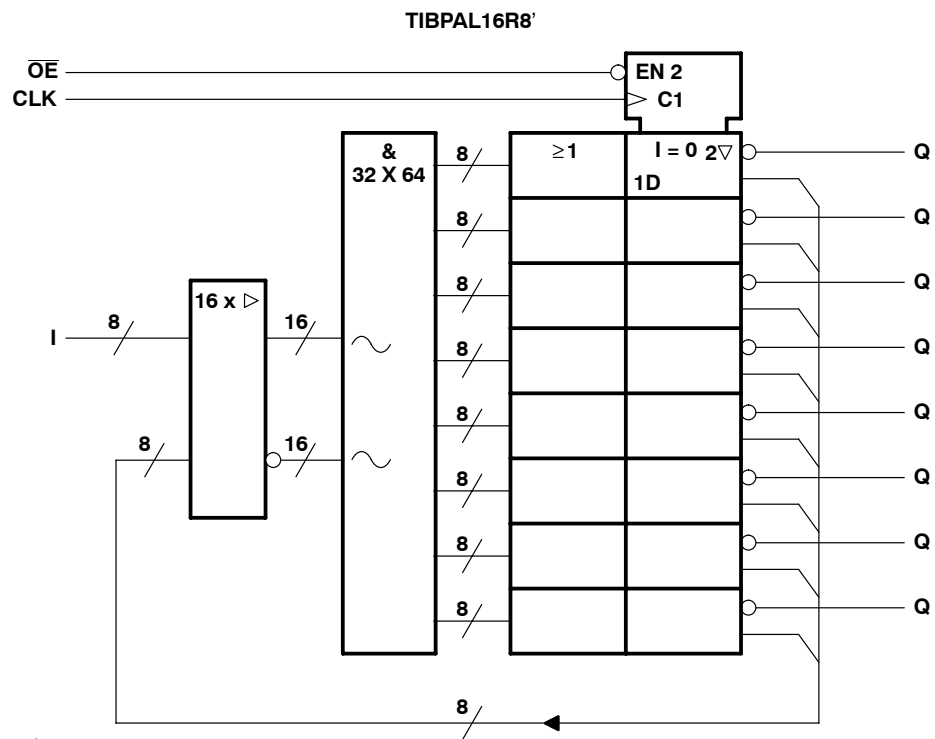
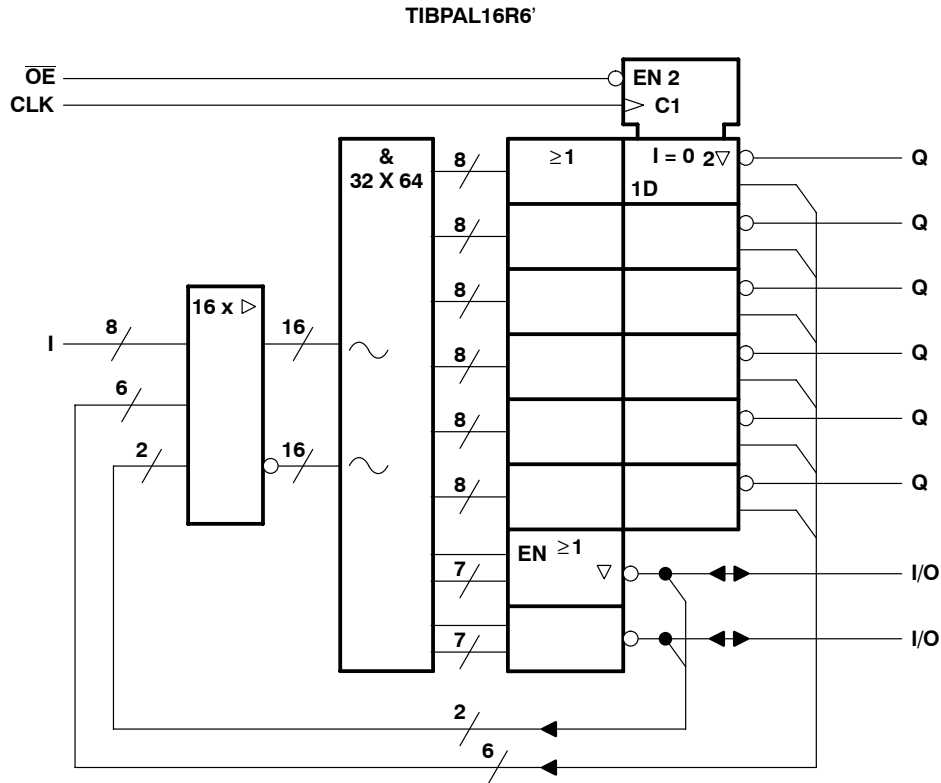


~ denotes fused inputs

# TIBPAL16R6-10C, TIBPAL16R8-10C TIBPAL16R6-12M, TIBPAL16R8-12M HIGH-PERFORMANCE *IMPACT-X*™ PAL® CIRCUITS

SRPS017A - D3023, MAY 1987 - REVISED DECEMBER 2010

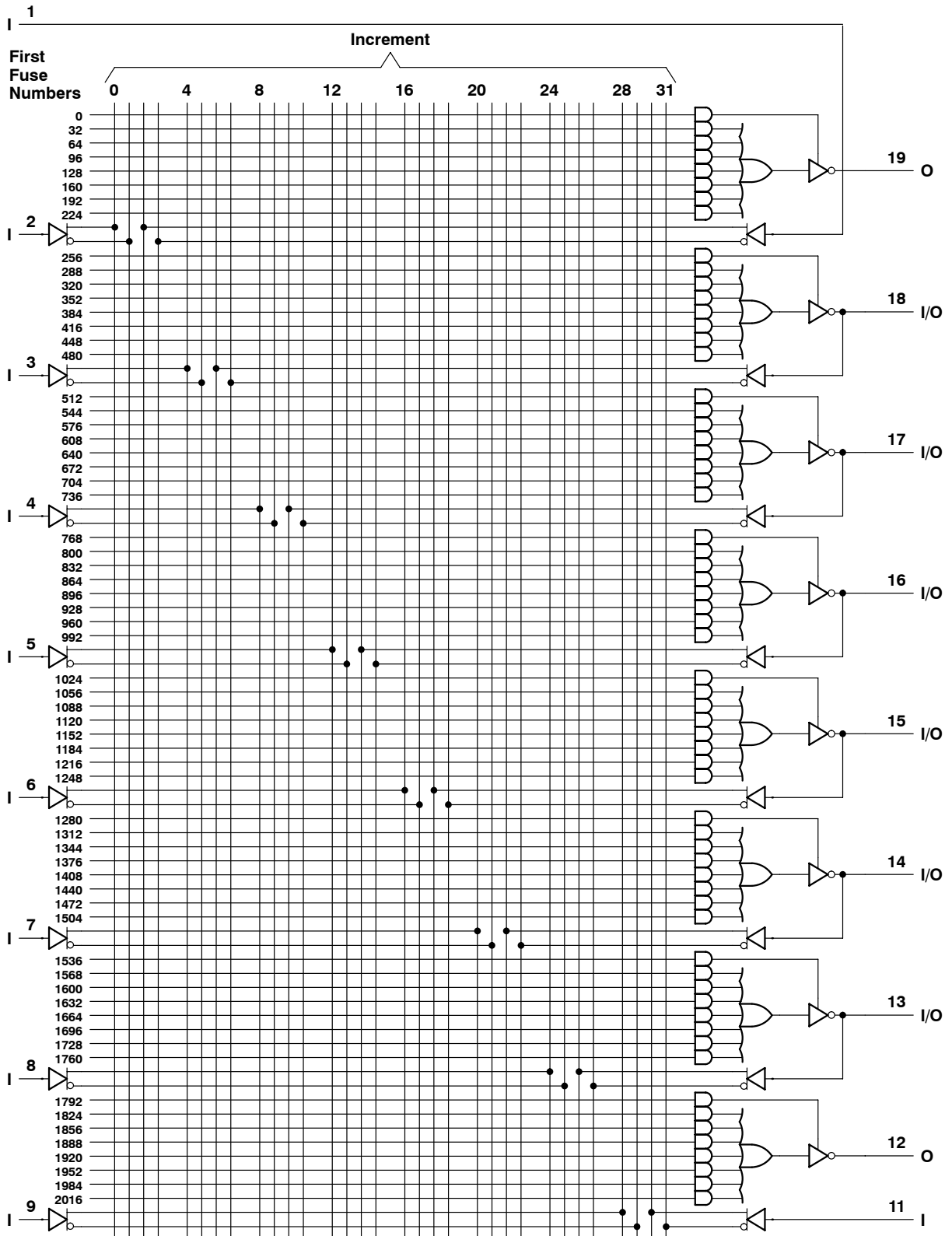
## functional block diagrams (positive logic)



# TIBPAL16L8-10C TIBPAL16L8-12M HIGH-PERFORMANCE *IMPACT-X*™ PAL® CIRCUITS

SRPS017A - D3023, MAY 1987 - REVISED DECEMBER 2010

## logic diagram (positive logic)



Fuse number = First fuse number + Increment

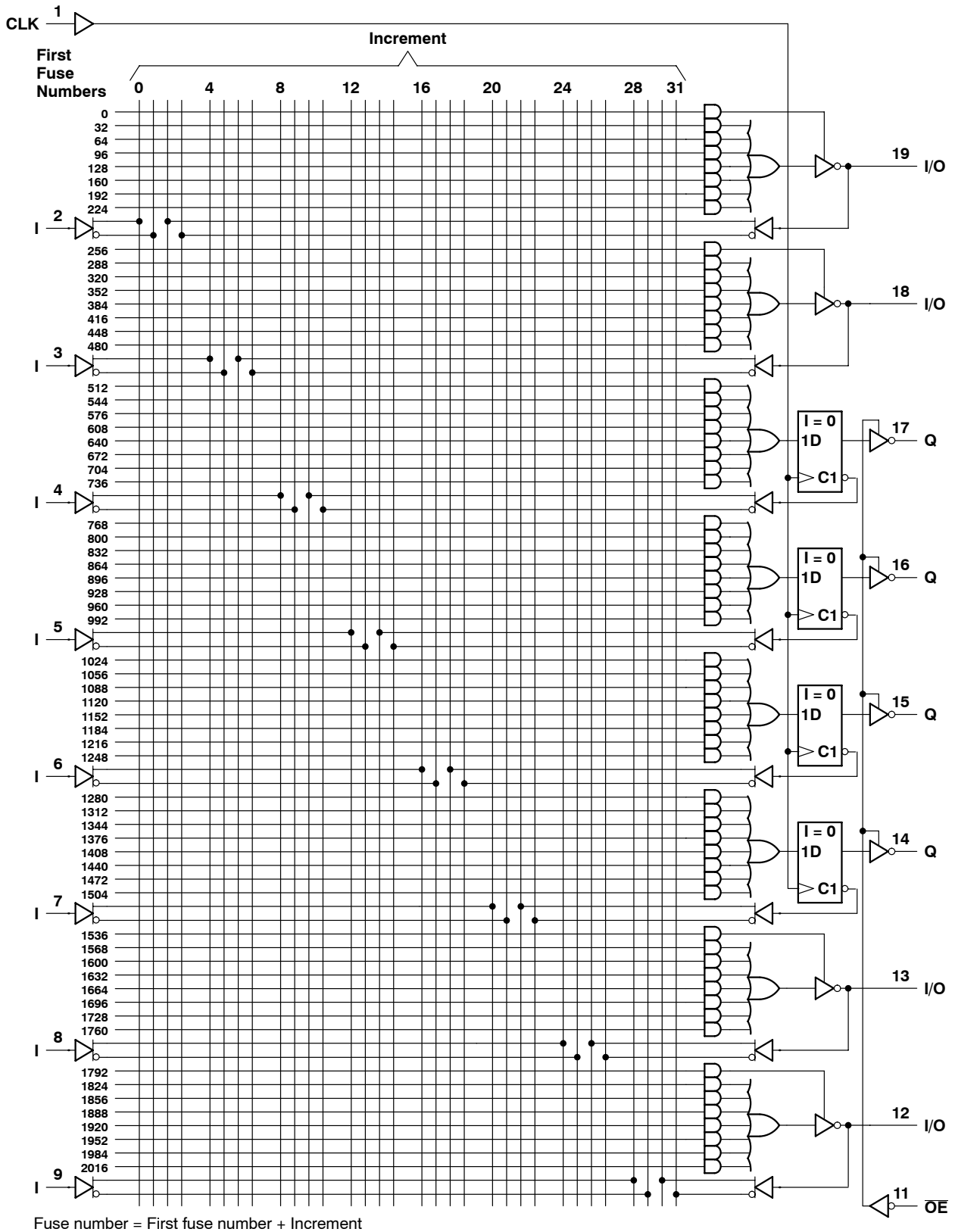


# TIBPAL16R4-10C TIBPAL16R4-12M

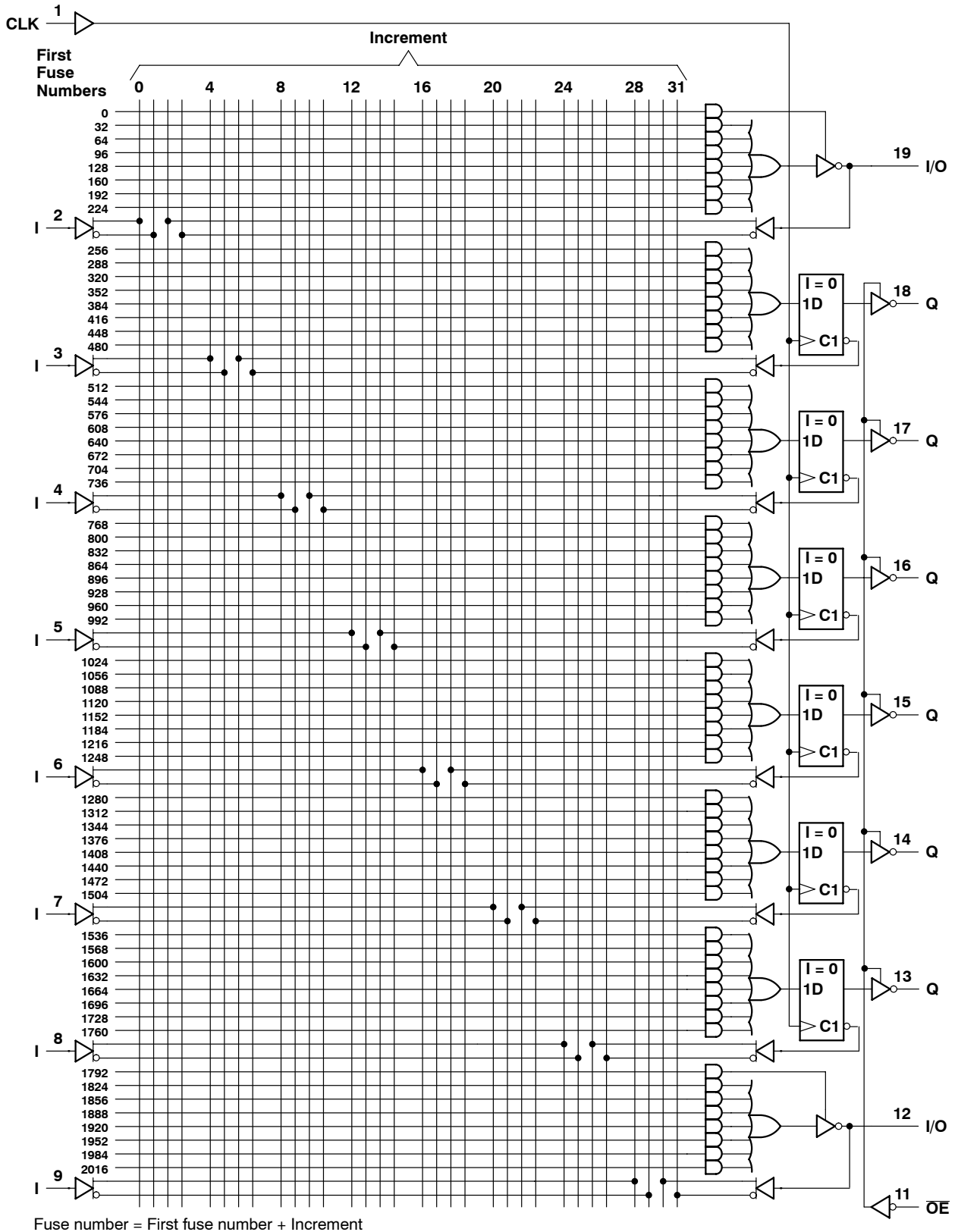
## HIGH-PERFORMANCE *IMPACT-X*™ PAL® CIRCUITS

SRPS017A - D3023, MAY 1987 - REVISED DECEMBER 2010

### logic diagram (positive logic)



**logic diagram (positive logic)**



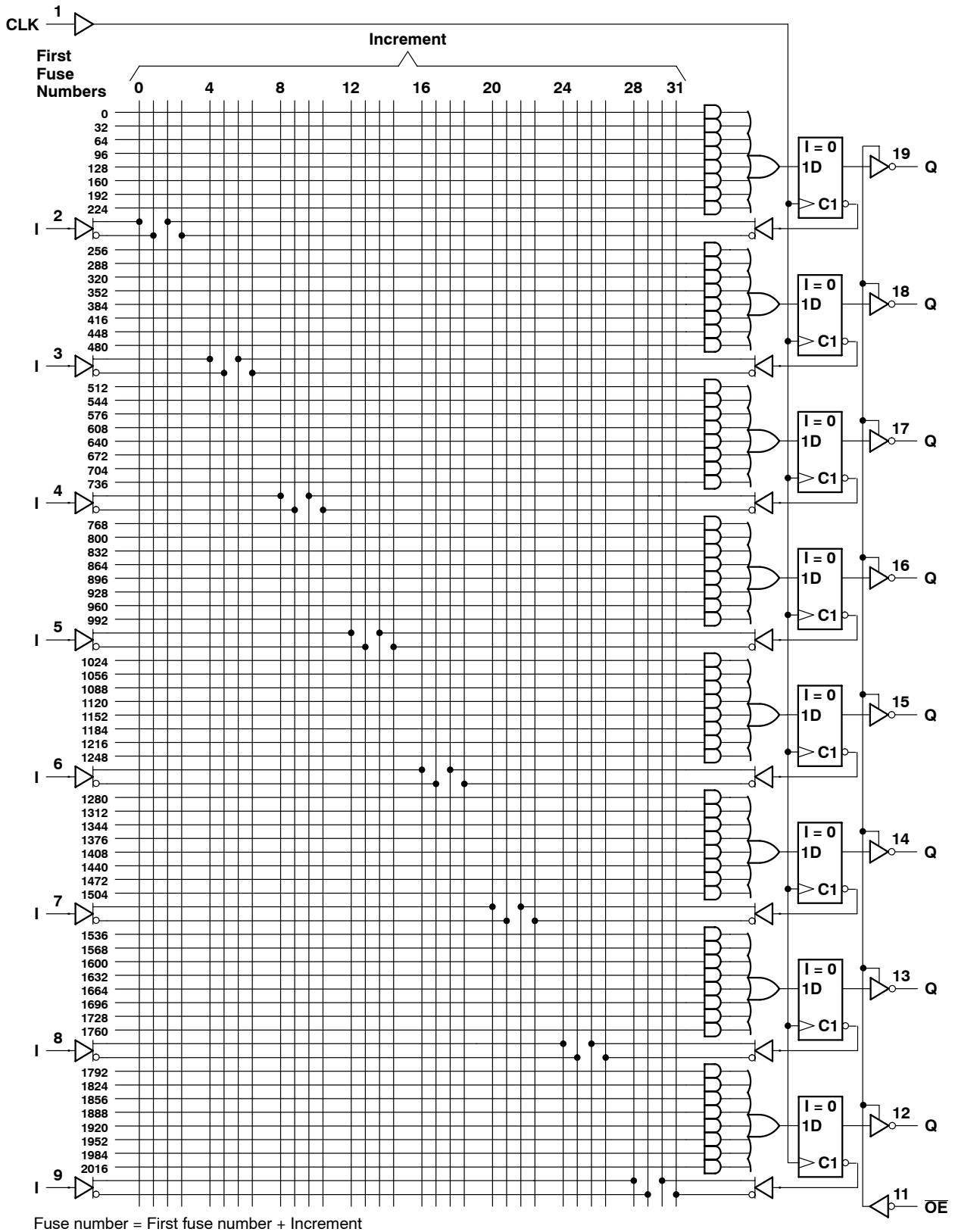
# TIBPAL16R8-10C

# TIBPAL16R8-12M

## HIGH-PERFORMANCE *IMPACT-X*™ PAL® CIRCUITS

SRPS017A - D3023, MAY 1987 - REVISED DECEMBER 2010

### logic diagram (positive logic)



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

SRPS017A – D3023, MAY 1987 – REVISED DECEMBER 2010

## 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

SRPS017A – D3023, MAY 1987 – REVISED DECEMBER 2010

**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 <sub>max</sub>	With feedback		R1 = 200 Ω, R2 = 390 Ω, See Figure 3	55.5	80		MHz
	Without feedback			62.5	85		
t <sub>pd</sub>	I, I/O	O, I/O		3	7	10	ns
t <sub>pd</sub>	CLK↑	Q		2	5	8	ns
t <sub>en</sub>	OE↓	Q		1	4	10	ns
t <sub>dis</sub>	OE↑	Q		1	4	10	ns
t <sub>en</sub>	I, I/O	O, I/O		3	8	10	ns
t <sub>dis</sub>	I, I/O	O, I/O		3	8	10	ns

† All typical values are at V<sub>CC</sub> = 5 V, T<sub>A</sub> = 25°C.

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

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

SRPS017D – D3023, MAY 1987 – REVISED DECEMBER 2010

## 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	$\mu$ A
$I_{OZL}^{\ddagger}$	$V_{CC} = 5.5$ V,	$V_O = 0.4$ V			-100	$\mu$ A
$I_I$	$V_{CC} = 5.5$ V,	$V_I = 5.5$ V			0.2	mA
$I_{IH}^{\ddagger}$	$V_{CC} = 5.5$ V,	$V_I = 2.4$ V			25	$\mu$ A
$I_{IL}^{\ddagger}$	$V_{CC} = 5.5$ 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,  $T_A = 25^\circ\text{C}$ . $\ddagger$  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

SRPS017D – D3023, MAY 1987 – REVISED DECEMBER 2010

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 <sub>max</sub>	With feedback		R1 = 390 Ω, R2 = 750 Ω, See Figure 3	48	80		MHz
	Without feedback			56	85		
t <sub>pd</sub>	I, I/O	O, I/O		3	7	12	ns
t <sub>pd</sub>	CLK↑	Q		2	5	10	ns
t <sub>en</sub>	OE↓	Q		1	4	10	ns
t <sub>dis</sub>	OE↑	Q		1	4	10	ns
t <sub>en</sub>	I, I/O	O, I/O		3	8	14	ns
t <sub>dis</sub>	I, I/O	O, I/O		2	8	12	ns

† All typical values are at V<sub>CC</sub> = 5 V, T<sub>A</sub> = 25°C.

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

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

SRPS017A – D3023, MAY 1987 – REVISED DECEMBER 2010

**programming information**

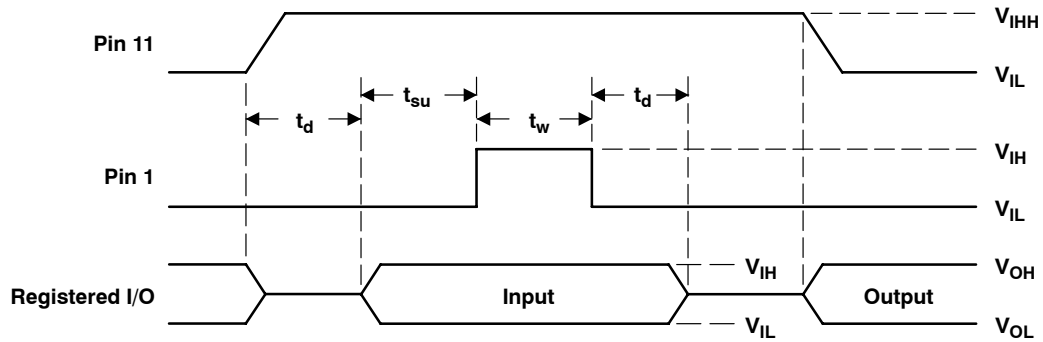
Texas Instruments programmable logic devices can be programmed using widely available software and inexpensive device programmers.

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**

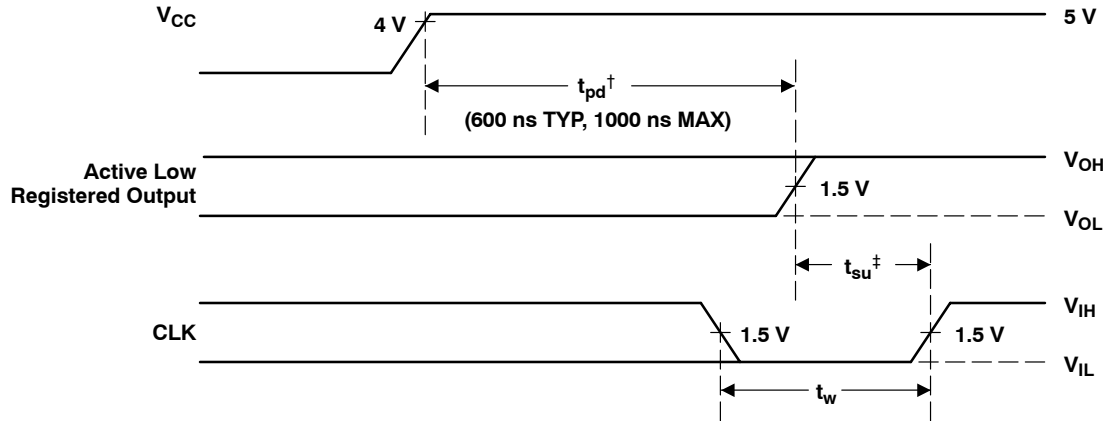
NOTE 3:  $t_d = t_{su} = t_h = 100 \text{ ns to } 1000 \text{ ns}$   $V_{IHH} = 10.25 \text{ V to } 10.75 \text{ v}$

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

SRPS017A – D3023, MAY 1987 – REVISED DECEMBER

**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.

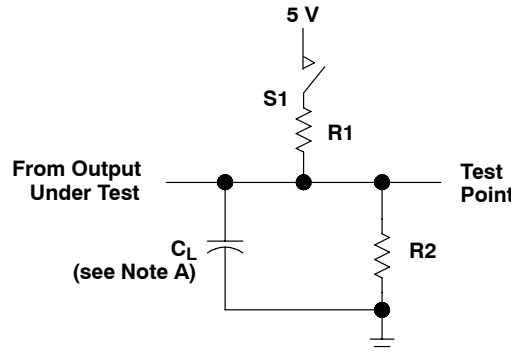
‡ This is the setup time for input or feedback.

**Figure 2. Power-Up Reset Waveforms**

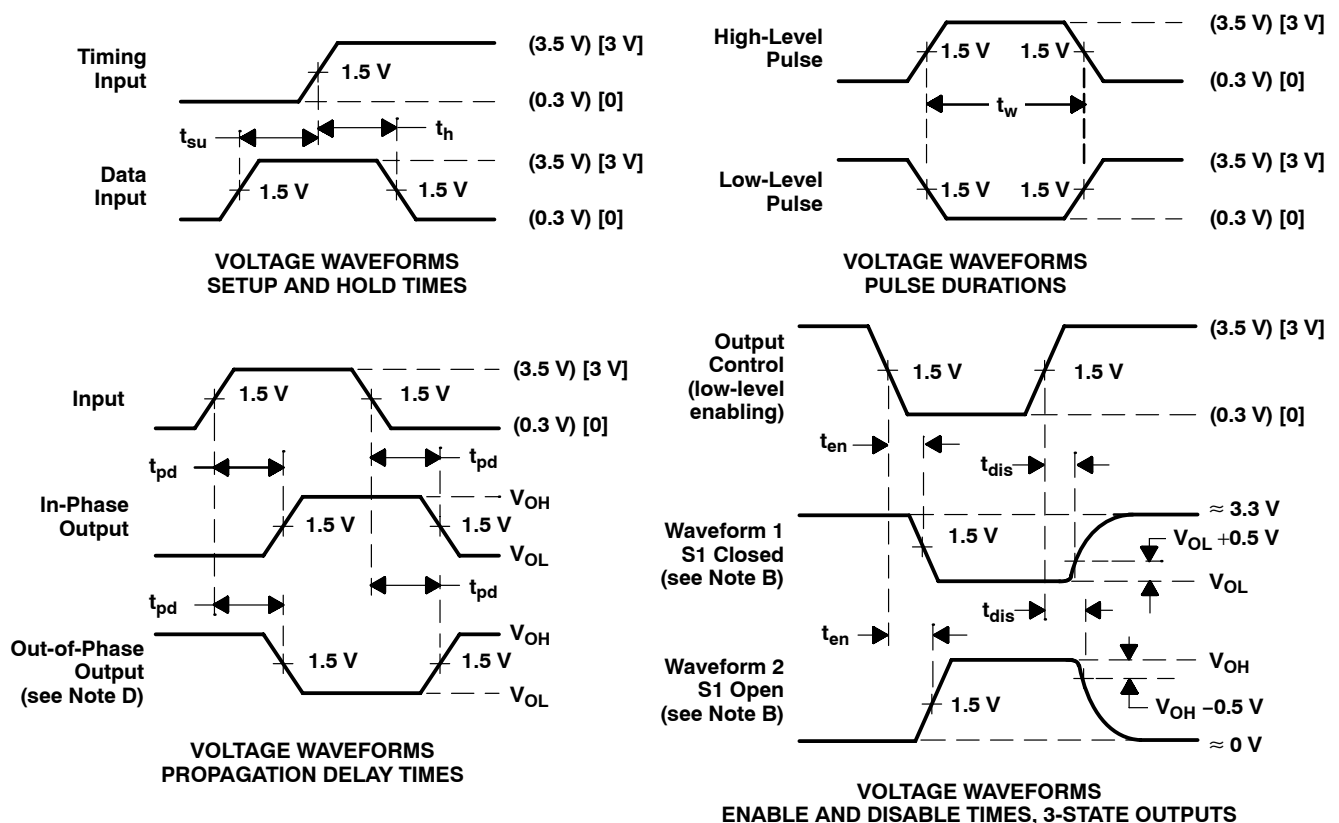
# TIBPAL16L8-10C, TIBPAL16R4-10C, TIBPAL16R6-10C, TIBPAL16R8-10C TIBPAL16L8-12M, TIBPAL16R4-12M, TIBPAL16R6-12M, TIBPAL16R8-12M HIGH-PERFORMANCE *IMPACT-X*™ *PAL*® CIRCUITS

SRPS017A – D3023, MAY 1987 – REVISED DECEMBER 2010

## 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 low except when disabled by the output control. Waveform 2 is for an output with internal conditions such that the output is high 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

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

SRPS017 – D3023, MAY 1987 – REVISED DECEMBER 2010

## 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  $\Delta t$  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 ( $\Delta t$ ) after SCLK. The exclusive OR gate detects the occurrence of a failure and increments the failure counter.

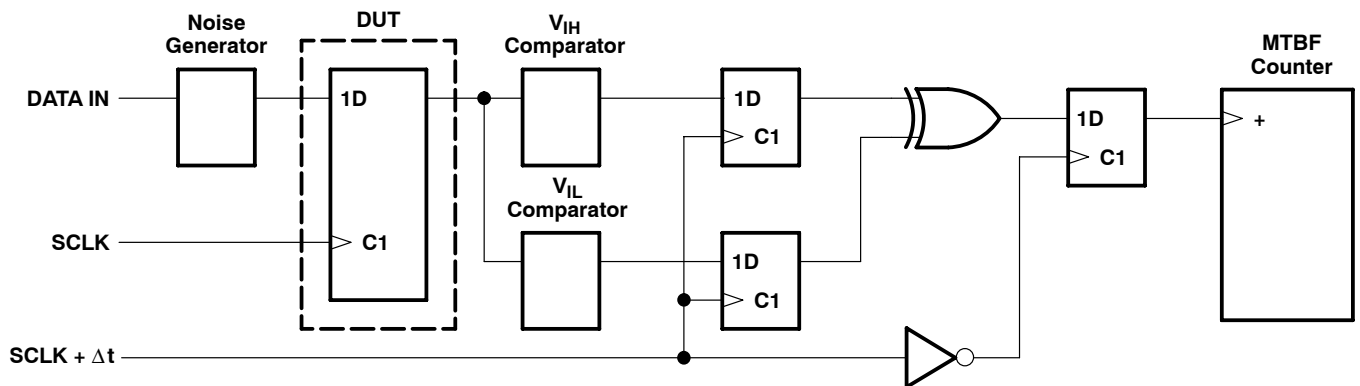


Figure 4. Metastable Evaluation Test Circuit

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.

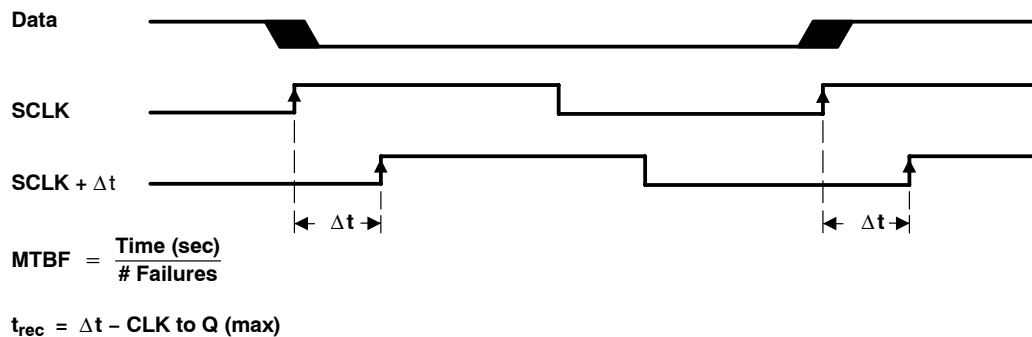
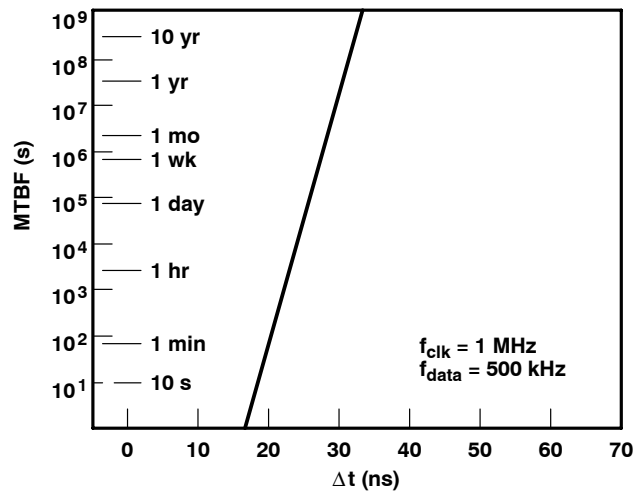


Figure 5. Timing Diagram

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

SRPS017A – D3023, MAY 1987 – REVISED DECEMBER 2010

By using the described test circuit, MTBF can be determined for several different values of  $\Delta t$  (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:  $\frac{1}{\text{MTBF}} = f_{\text{SCLK}} \times f_{\text{data}} \times C1 e^{-C2 \times \Delta t}$

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

Therefore

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

## 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.

**$f_{\text{SCLK}}$  (system clock frequency):** Actual clock frequency for the DUT.

**$f_{\text{data}}$  (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.

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

**$\Delta t$ :** The time difference (ns) from when the synchronizing flip-flop is clocked to when its output is sampled.

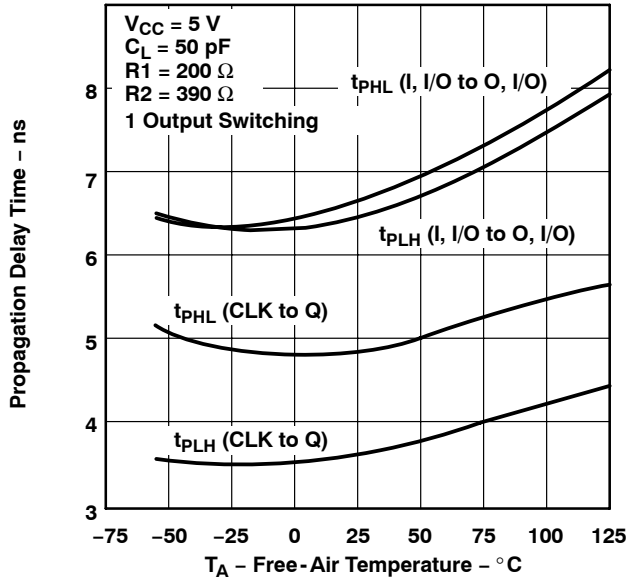
The test described above has shown the metastable characteristics of the TIBPAL16R4/R6/R8-10C series. For additional information on metastable characteristics of Texas Instruments logic circuits, please refer to TI Applications publication SDAA004, "Metastable Characteristics, Design Considerations for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

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

SRPS017A – D3023, MAY 1987 – REVISED DECEMBER 2010

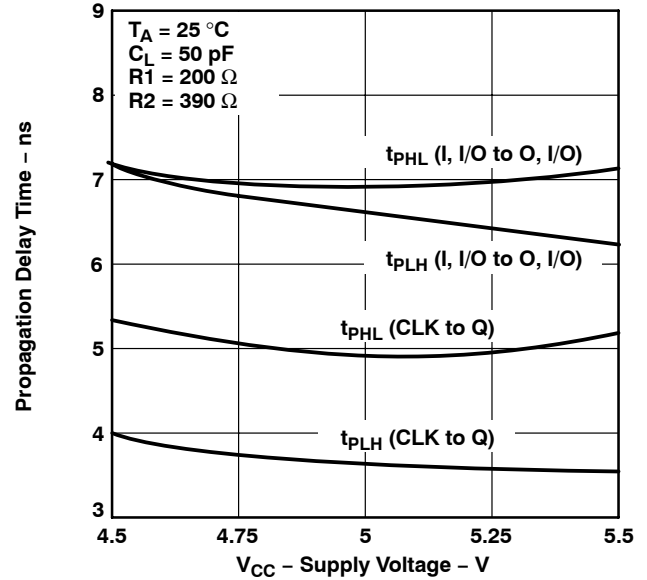
**TYPICAL CHARACTERISTICS**

**PROPAGATION DELAY TIME**  
**vs**  
**FREE-AIR TEMPERATURE**



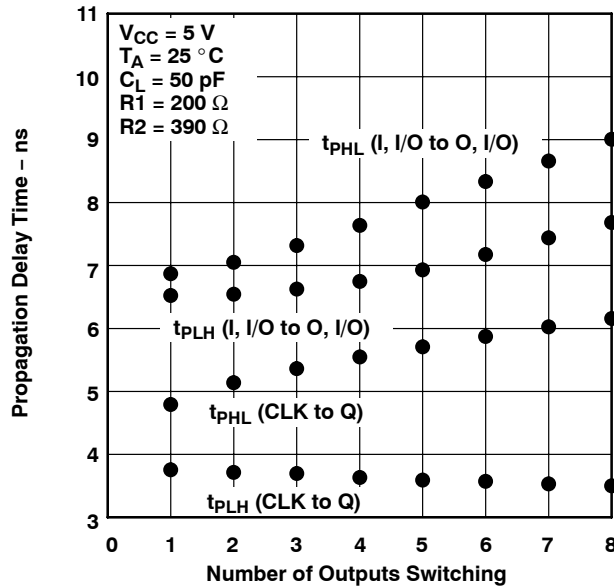
**Figure 7**

**PROPAGATION DELAY TIME**  
**vs**  
**SUPPLY VOLTAGE**



**Figure 8**

**PROPAGATION DELAY TIME**  
**vs**  
**NUMBER OF OUTPUTS SWITCHING**



**Figure 9**

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

SRPS017A - D3023, MAY 1987 - REVISED DECEMBER 2010

## TYPICAL CHARACTERISTICS

PROPAGATION DELAY TIME  
vs  
LOAD CAPACITANCE

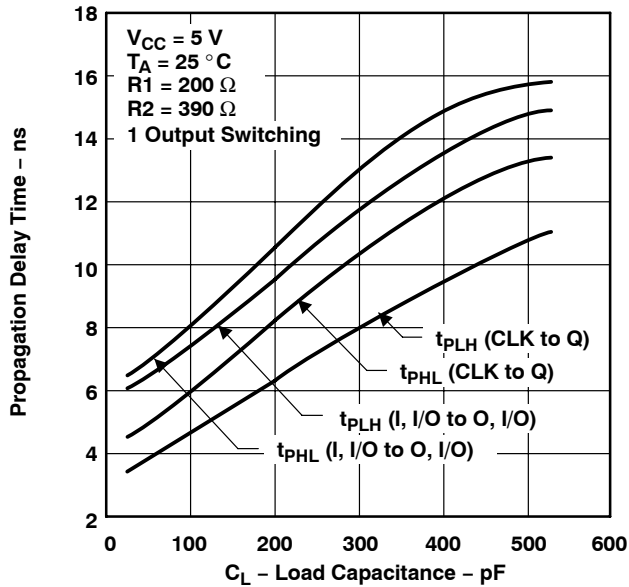


Figure 10

POWER DISSIPATION  
vs  
FREQUENCY  
8-BIT COUNTER MODE

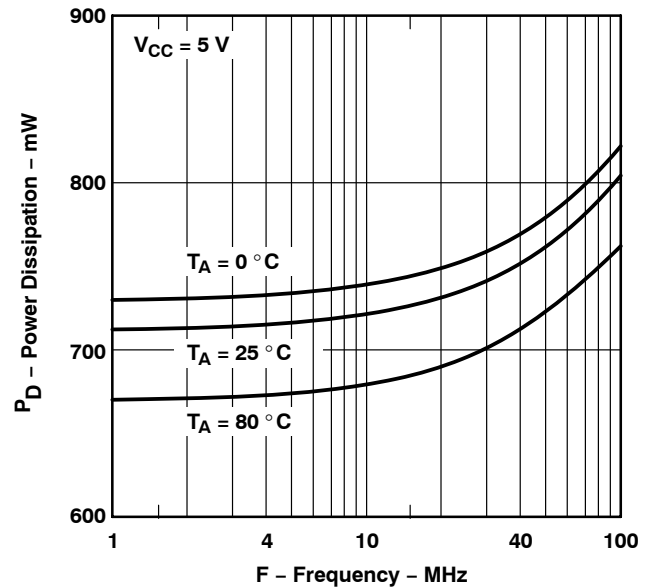


Figure 11

SUPPLY CURRENT  
vs  
FREE-AIR TEMPERATURE

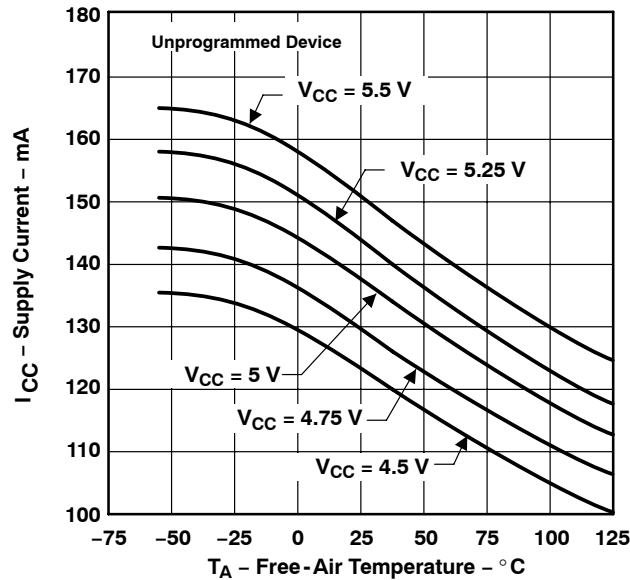


Figure 12

# 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) 430-9477; 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



**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
5962-85155152A	NRND	LCCC	FK	20	55	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	5962- 85155152A TIBPAL16 R6-12MFKB	
5962-8515515RA	NRND	CDIP	J	20	20	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	5962-8515515RA TIBPAL16R6-12M JB	
5962-85155162A	NRND	LCCC	FK	20	55	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	5962- 85155162A TIBPAL16 R4-12MFKB	
5962-8515516RA	NRND	CDIP	J	20	20	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	5962-8515516RA TIBPAL16R4-12M JB	
TIBPAL16R4-12MFKB	NRND	LCCC	FK	20	55	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	5962- 85155162A TIBPAL16 R4-12MFKB	
TIBPAL16R4-12MJ	NRND	CDIP	J	20	20	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	TIBPAL16R4-12M J	
TIBPAL16R4-12MJB	NRND	CDIP	J	20	20	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	5962-8515516RA TIBPAL16R4-12M JB	
TIBPAL16R6-12MFKB	NRND	LCCC	FK	20	55	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	5962- 85155152A TIBPAL16 R6-12MFKB	
TIBPAL16R6-12MJB	NRND	CDIP	J	20	20	Non-RoHS & Green	SNPB	N / A for Pkg Type	-55 to 125	5962-8515515RA TIBPAL16R6-12M JB	

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of  $\leq 1000$ ppm threshold. Antimony trioxide based flame retardants must also meet the  $\leq 1000$ ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

**Important Information and Disclaimer:** The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

**TUBE**


\*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (μm)	B (mm)
5962-85155152A	FK	LCCC	20	55	506.98	12.06	2030	NA
5962-85155162A	FK	LCCC	20	55	506.98	12.06	2030	NA
TIBPAL16R4-12MFKB	FK	LCCC	20	55	506.98	12.06	2030	NA
TIBPAL16R6-12MFKB	FK	LCCC	20	55	506.98	12.06	2030	NA

## GENERIC PACKAGE VIEW

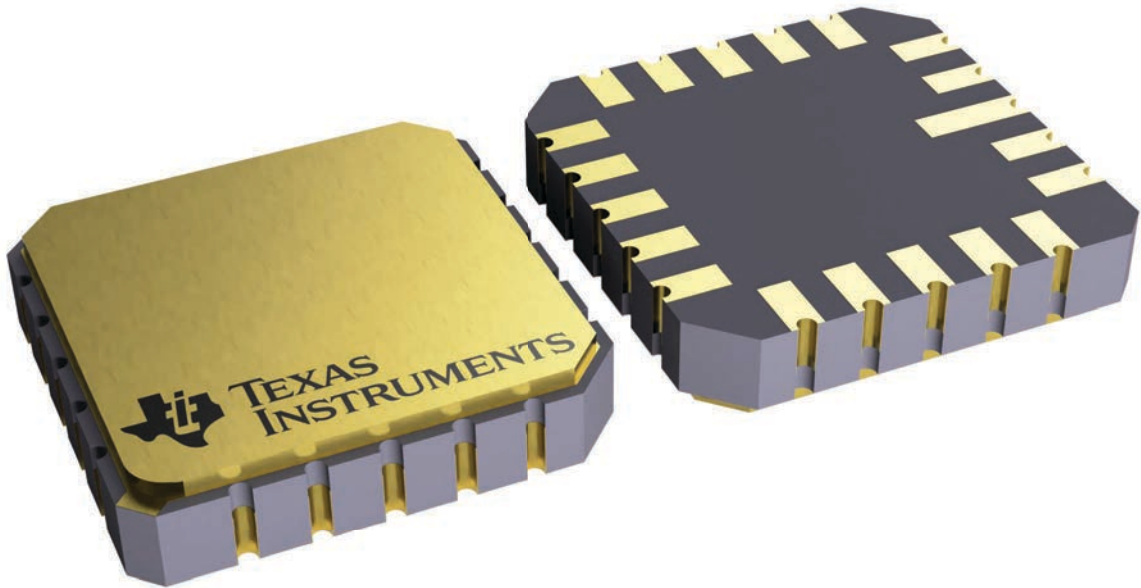
**FK 20**

**LCCC - 2.03 mm max height**

8.89 x 8.89, 1.27 mm pitch

LEADLESS CERAMIC CHIP CARRIER

This image is a representation of the package family, actual package may vary.  
Refer to the product data sheet for package details.

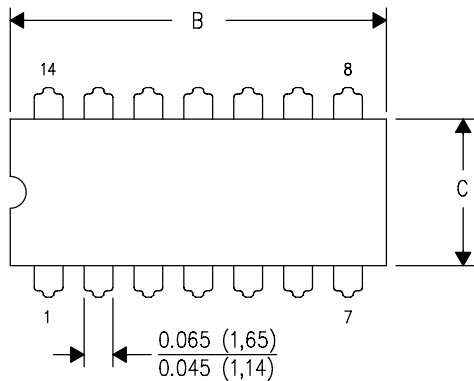


4229370VA\

J (R-GDIP-T\*\*)

14 LEADS SHOWN

CERAMIC DUAL IN-LINE PACKAGE



DIM \ PINS **	14	16	18	20
A	0.300 (7,62) BSC	0.300 (7,62) BSC	0.300 (7,62) BSC	0.300 (7,62) BSC
B MAX	0.785 (19,94)	.840 (21,34)	0.960 (24,38)	1.060 (26,92)
B MIN	—	—	—	—
C MAX	0.300 (7,62)	0.300 (7,62)	0.310 (7,87)	0.300 (7,62)
C MIN	0.245 (6,22)	0.245 (6,22)	0.220 (5,59)	0.245 (6,22)



4040083/F 03/03

- NOTES:
- All linear dimensions are in inches (millimeters).
  - This drawing is subject to change without notice.
  - This package is hermetically sealed with a ceramic lid using glass frit.
  - Index point is provided on cap for terminal identification only on press ceramic glass frit seal only.
  - Falls within MIL STD 1835 GDIP1-T14, GDIP1-T16, GDIP1-T18 and GDIP1-T20.

## IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2024, Texas Instruments Incorporated


## Looking for pricing, stock, or lifecycle information?

Click below to explore more details on WIN SOURCE:

 [View TIBPAL16L8-12MJB on WIN SOURCE](#)

 [Texas Instruments](#) Information

## Optimize Your Supply Chain with WIN SOURCE Solutions

-  Global Sourcing Solution
-  Obsolete Management
-  Cost Control Management
-  Shortage Management
-  Alternative Solution
-  Excess Inventory Management