

MACH210A-7/10/12**MACH210-12/15/20****MACH210AQ-12/15/20****High-Density EE CMOS Programmable Logic****Lattice/Vantis****DISTINCTIVE CHARACTERISTICS**

- 44 Pins
- 64 Macrocells
- 7.5 ns t_{PD} Commercial
12 ns t_{PD} Industrial
- 133 MHz f_{CNT}
- 38 Inputs; 210A Inputs have built-in pull-up resistors
- Peripheral Component Interconnect (PCI) compliant
- 32 Outputs
- 64 Flip-flops; 2 clock choices
- 4 "PAL22V16" blocks with buried macrocells
- Pin-compatible with MACH110, MACH111, MACH211, and MACH215

GENERAL DESCRIPTION

The MACH210 is a member of the high-performance EE CMOS MACH 2 device family. This device has approximately six times the logic macrocell capability of the popular PAL22V10 without loss of speed.

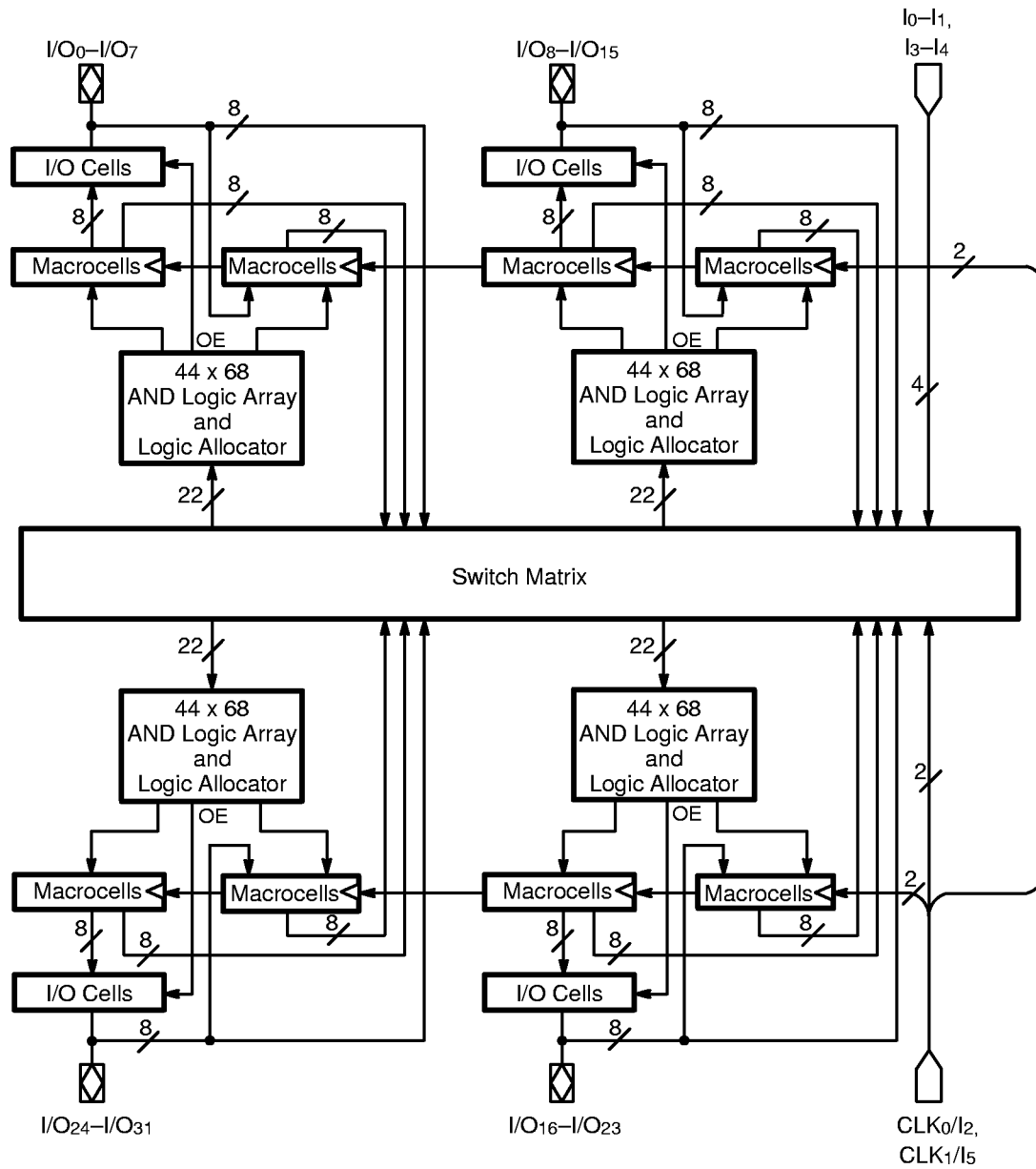
The MACH210 consists of four PAL blocks interconnected by a programmable switch matrix. The four PAL blocks are essentially "PAL22V16" structures complete with product-term arrays and programmable macrocells, including additional buried macrocells. The switch matrix connects the PAL blocks to each other and to all input pins, providing a high degree of connectivity between the fully-connected PAL blocks. This allows designs to be placed and routed efficiently.

The MACH210 has two kinds of macrocell: output and buried. The MACH210 output macrocell provides regis-

tered, latched, or combinatorial outputs with programmable polarity. If a registered configuration is chosen, the register can be configured as D-type or T-type to help reduce the number of product terms. The register type decision can be made by the designer or by the software. All output macrocells can be connected to an I/O cell. If a buried macrocell is desired, the internal feedback path from the macrocell can be used, which frees up the I/O pin for use as an input.

The MACH210 has dedicated buried macrocells which, in addition to the capabilities of the output macrocell, also provide input registers or latches for use in synchronizing signals and reducing setup time requirements.

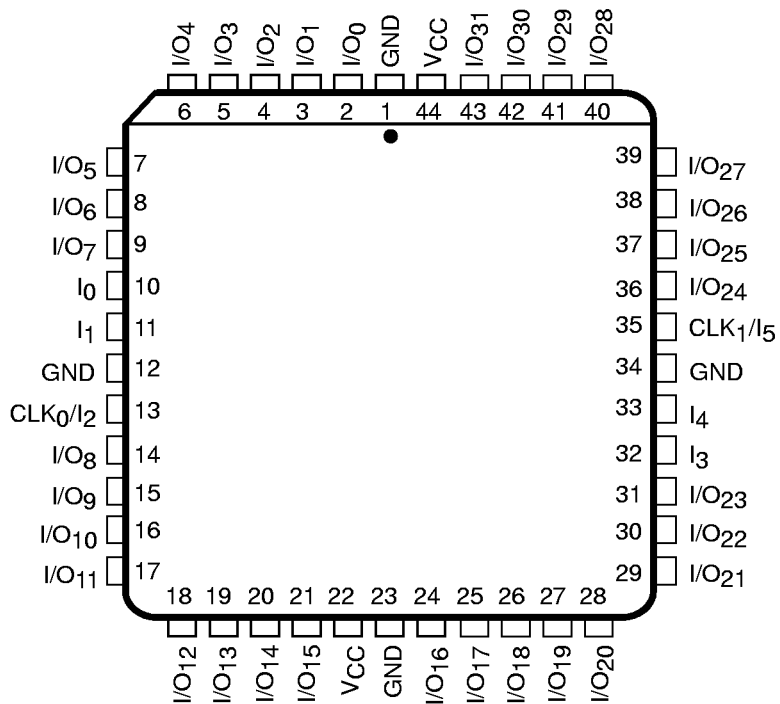
BLOCK DIAGRAM



141281-1

CONNECTION DIAGRAM
Top View

PLCC

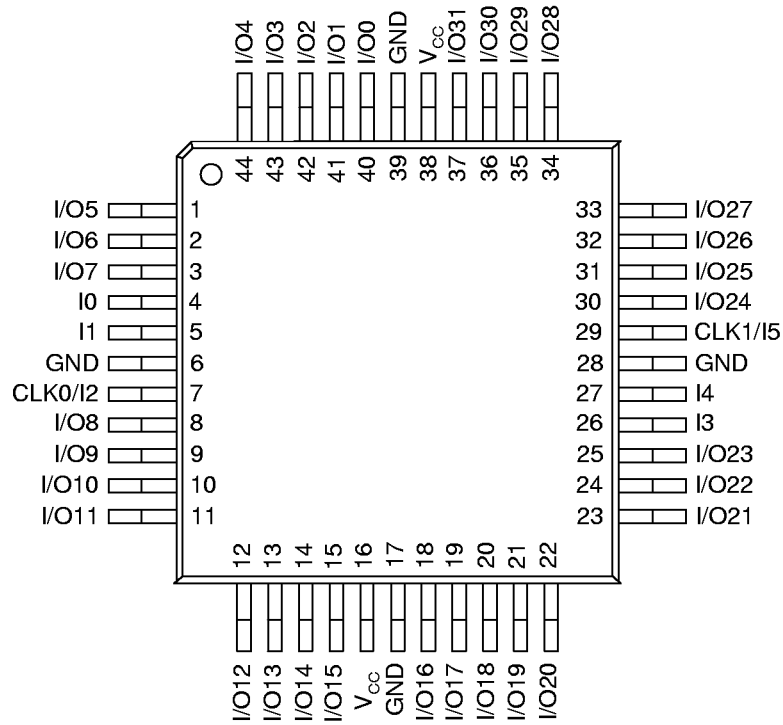


14128I-2

Note:
Pin-compatible with MACH110, MACH111, MACH211, and MACH215.

CONNECTION DIAGRAM
Top View

TQFP



Note:
Pin-compatible with MACH111 and MACH211.

141281-3

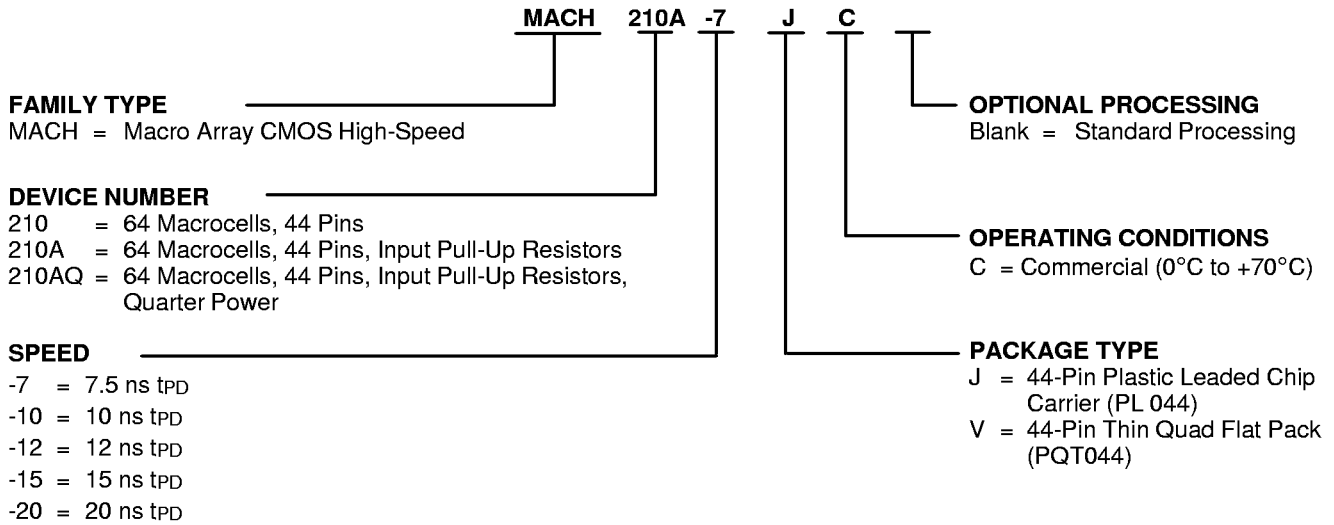
PIN DESIGNATIONS

- CLK/I = Clock or Input
- GND = Ground
- I = Input
- I/O = Input/Output
- V_{cc} = Supply Voltage

ORDERING INFORMATION

Commercial Products

Programmable logic products for commercial applications are available with several ordering options. The order number (Valid Combination) is formed by a combination of:



| Valid Combinations | |
|--------------------|--------|
| MACH210A-7 | JC, VC |
| MACH210A-10 | |
| MACH210A-12 | |
| MACH210-12 | JC |
| MACH210-15 | |
| MACH210-20 | |
| MACH210AQ-12 | |
| MACH210AQ-15 | |
| MACH210AQ-20 | |

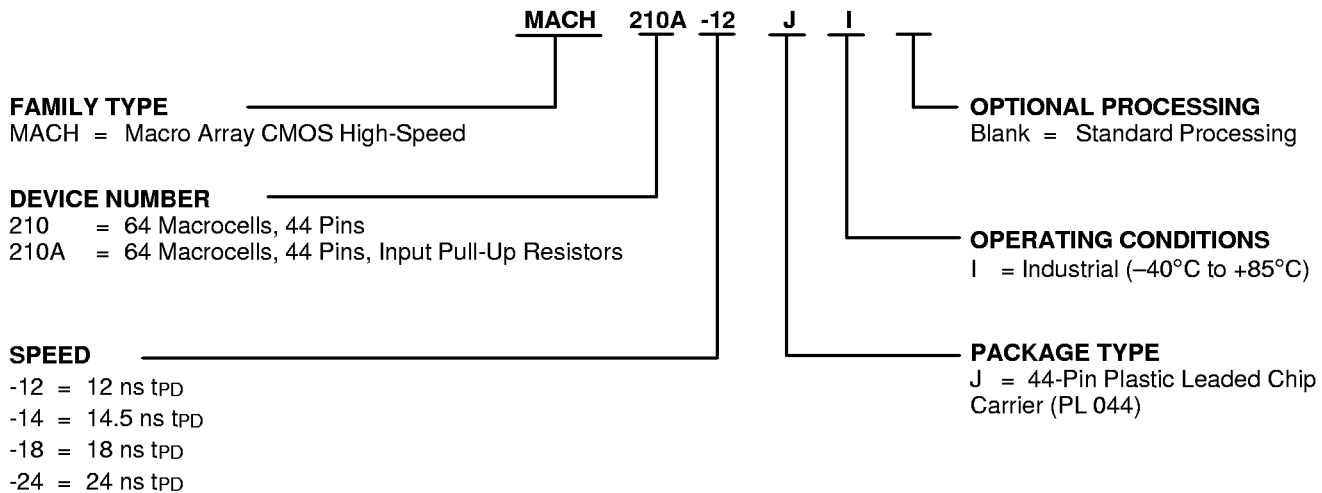
Valid Combinations

The Valid Combinations table lists configurations planned to be supported in volume for this device. Consult your local sales office to confirm availability of specific valid combinations or to check on newly released combinations.

ORDERING INFORMATION

Industrial Products

Programmable logic products for industrial applications are available with several ordering options. The order number (Valid Combination) is formed by a combination of:



| Valid Combinations | |
|--------------------|----|
| MACH210A-12 | JI |
| MACH210A-14 | |
| MACH210-14 | |
| MACH210-18 | |
| MACH210-24 | |

Valid Combinations

The Valid Combinations table lists configurations planned to be supported in volume for this device. Consult your local sales office to confirm availability of specific valid combinations or to check on newly released combinations.

FUNCTIONAL DESCRIPTION

The MACH210 consists of four PAL blocks connected by a switch matrix. There are 32 I/O pins and 4 dedicated input pins feeding the switch matrix. These signals are distributed to the four PAL blocks for efficient design implementation. There are two clock pins that can also be used as dedicated inputs.

The MACH210A inputs and I/O pins have built-in pull-up resistors. While it is always a good design practice to tie unused pins high, the 210A pull-up resistors provide design security and stability in the event that unused pins are left disconnected.

The PAL Blocks

Each PAL block in the MACH210 (Figure 1) contains a 64-product-term logic array, a logic allocator, 8 output macrocells, 8 buried macrocells, and 8 I/O cells. The switch matrix feeds each PAL block with 22 inputs. This makes the PAL block look effectively like an independent "PAL22V16" with 8 buried macrocells.

In addition to the logic product terms, two output enable product terms, an asynchronous reset product term, and an asynchronous preset product term are provided. One of the two output enable product terms can be chosen within each I/O cell in the PAL block. All flip-flops within the PAL block are initialized together.

The Switch Matrix

The MACH210 switch matrix is fed by the inputs and feedback signals from the PAL blocks. Each PAL block provides 16 internal feedback signals and 8 I/O feedback signals. The switch matrix distributes these signals back to the PAL blocks in an efficient manner that also provides for high performance. The design software automatically configures the switch matrix when fitting a design into the device.

The Product-term Array

The MACH210 product-term array consists of 64 product terms for logic use, and 4 special-purpose product terms. Two of the special-purpose product terms provide programmable output enable; one provides asynchronous reset, and one provides asynchronous preset.

The Logic Allocator

The logic allocator in the MACH210 takes the 64 logic product terms and allocates them to the 16 macrocells as needed. Each macrocell can be driven by up to 16 product terms. The design software automatically configures the logic allocator when fitting the design into the device.

Table 1 illustrates which product term clusters are available to each macrocell within a PAL block. Refer to Figure 1 for cluster and macrocell numbers.

Table 1. Logic Allocation

| Macrocell | | Available Clusters |
|-----------------|-----------------|--|
| Output | Buried | |
| M ₀ | M ₁ | C ₀ , C ₁ , C ₂ C ₀ , C ₁ , C ₂ , C ₃ |
| M ₂ | M ₃ | C ₁ , C ₂ , C ₃ , C ₄ C ₂ , C ₃ , C ₄ , C ₅ |
| M ₄ | M ₅ | C ₃ , C ₄ , C ₅ , C ₆ C ₄ , C ₅ , C ₆ , C ₇ |
| M ₆ | M ₇ | C ₅ , C ₆ , C ₇ , C ₈ C ₆ , C ₇ , C ₈ , C ₉ |
| M ₈ | M ₉ | C ₇ , C ₈ , C ₉ , C ₁₀ C ₈ , C ₉ , C ₁₀ , C ₁₁ |
| M ₁₀ | M ₁₁ | C ₉ , C ₁₀ , C ₁₁ , C ₁₂ C ₁₀ , C ₁₁ , C ₁₂ , C ₁₃ |
| M ₁₂ | M ₁₃ | C ₁₁ , C ₁₂ , C ₁₃ , C ₁₄ C ₁₂ , C ₁₃ , C ₁₄ , C ₁₅ |
| M ₁₄ | M ₁₅ | C ₁₃ , C ₁₄ , C ₁₅ C ₁₄ , C ₁₅ |

The Macrocell

The MACH210 has two types of macrocell: output and buried. The output macrocells can be configured as either registered, latched, or combinatorial, with programmable polarity. The macrocell provides internal feedback whether configured with or without the flip-flop. The registers can be configured as D-type or T-type, allowing for product-term optimization.

The flip-flops can individually select one of two clock/gate pins, which are also available as data inputs. The registers are clocked on the LOW-to-HIGH transition of the clock signal. The latch holds its data when the gate input is HIGH, and is transparent when the gate input is LOW. The flip-flops can also be asynchronously initialized with the common asynchronous reset and preset product terms.

The buried macrocells are the same as the output macrocells if they are used for generating logic. In that case, the only thing that distinguishes them from the output macrocells is the fact that there is no I/O cell connection, and the signal is only used internally. The buried macrocell can also be configured as an input register or latch.

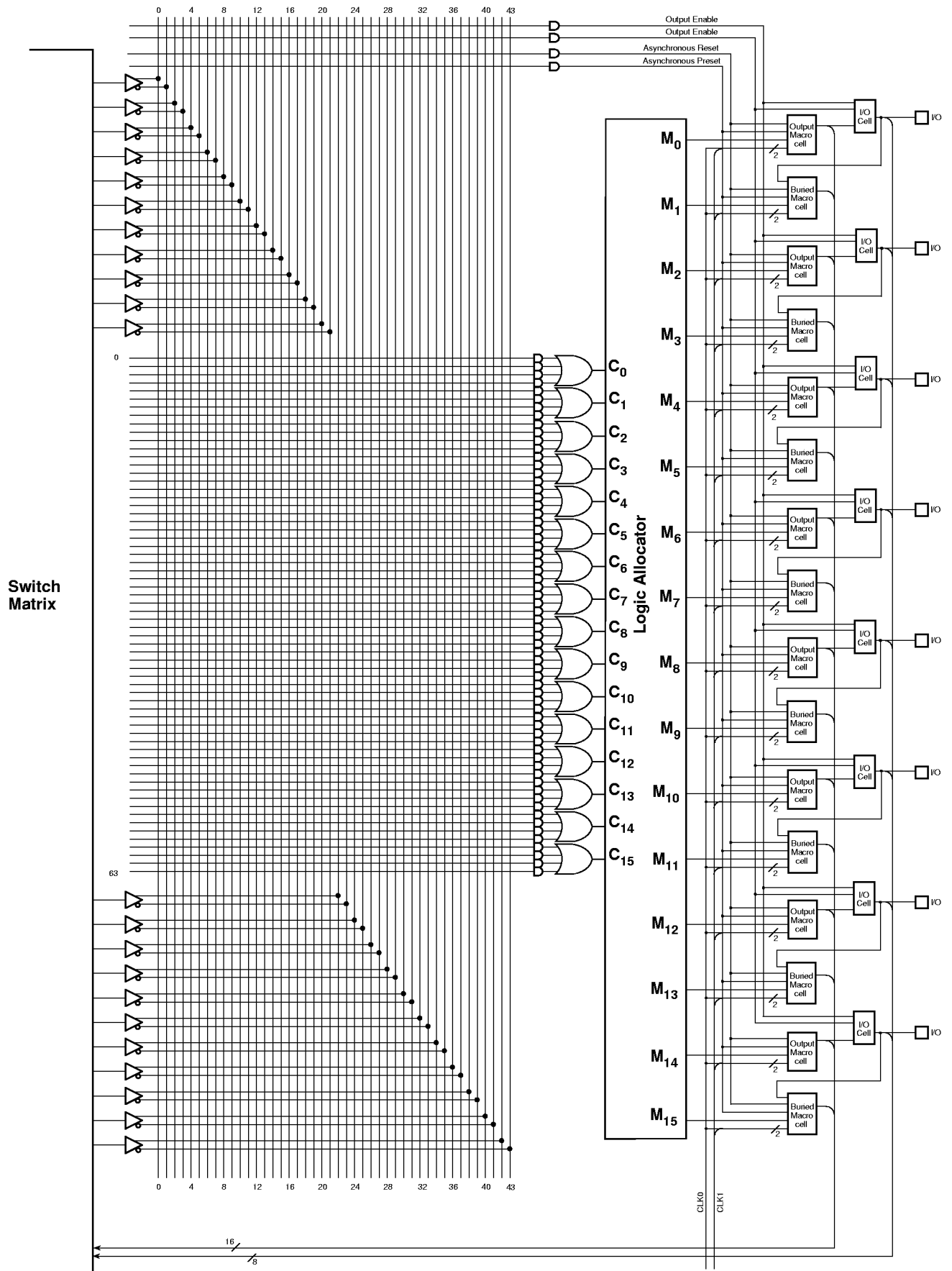
The I/O Cell

The I/O cell in the MACH210 consists of a three-state output buffer. The three-state buffer can be configured in one of three ways: always enabled, always disabled, or controlled by a product term. If product term control is chosen, one of two product terms may be used to provide the control. The two product terms that are available are common to all I/O cells in a PAL block.

These choices make it possible to use the macrocell as an output, an input, a bidirectional pin, or a three-state output for use in driving a bus.

PCI Compliance

The MACH210A-7/10 is fully compliant with the *PCI Local Bus Specification* published by the PCI Special Interest Group. The MACH210A-7/10's predictable timing ensures compliance with the PCI AC specifications independent of the design. On the other hand, in CPLD and FPGA architectures without predictable timing, PCI compliance is dependent upon routing and product term distribution.



141281-4

Figure 1. MACH210 PAL Block

ABSOLUTE MAXIMUM RATINGS

| | |
|--|----------------------------|
| Storage Temperature | −65°C to +150°C |
| Ambient Temperature with Power Applied | −55°C to +125°C |
| Supply Voltage with Respect to Ground | −0.5 V to +7.0 V |
| DC Input Voltage | −0.5 V to $V_{CC} + 0.5$ V |
| DC Output or I/O Pin Voltage | −0.5 V to $V_{CC} + 0.5$ V |
| Static Discharge Voltage | 2001 V |
| Latchup Current ($T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$) | 200 mA |

Stresses above those listed under Absolute Maximum Ratings may cause permanent device failure. Functionality at or above these limits is not implied. Exposure to Absolute Maximum Ratings for extended periods may affect device reliability. Programming conditions may differ.

OPERATING RANGES

Commercial (C) Devices

| | |
|--|--------------------|
| Temperature (T_A) Operating in Free Air | 0°C to +70°C |
| Supply Voltage (V_{CC}) with Respect to Ground | +4.75 V to +5.25 V |

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

DC CHARACTERISTICS over COMMERCIAL operating ranges unless otherwise specified

| Parameter Symbol | Parameter Description | Test Conditions | Min | Typ | Max | Unit |
|------------------|---------------------------------------|---|-----|-----|------|---------------|
| V_{OH} | Output HIGH Voltage | $I_{OH} = -3.2$ mA, $V_{CC} = \text{Min}$ $V_{IN} = V_{IH}$ or V_{IL} | 2.4 | | | V |
| V_{OL} | Output LOW Voltage | $I_{OL} = 16$ mA, $V_{CC} = \text{Min}$ $V_{IN} = V_{IH}$ or V_{IL} | | | 0.5 | V |
| V_{IH} | Input HIGH Voltage | Guaranteed Input Logical HIGH Voltage for all Inputs (Note 1) | 2.0 | | | V |
| V_{IL} | Input LOW Voltage | Guaranteed Input Logical LOW Voltage for all Inputs (Note 1) | | | 0.8 | V |
| I_{IH} | Input HIGH Leakage Current | $V_{IN} = 5.25$ V, $V_{CC} = \text{Max}$ (Note 2) | | | 10 | μA |
| I_{IL} | Input LOW Leakage Current | $V_{IN} = 0$ V, $V_{CC} = \text{Max}$ (Note 2) | | | −100 | μA |
| I_{OZH} | Off-State Output Leakage Current HIGH | $V_{OUT} = 5.25$ V, $V_{CC} = \text{Max}$ $V_{IN} = V_{IH}$ or V_{IL} (Note 2) | | | 10 | μA |
| I_{OZL} | Off-State Output Leakage Current LOW | $V_{OUT} = 0$ V, $V_{CC} = \text{Max}$ $V_{IN} = V_{IH}$ or V_{IL} (Note 2) | | | −100 | μA |
| I_{SC} | Output Short-Circuit Current | $V_{OUT} = 0.5$ V, $V_{CC} = \text{Max}$ (Note 3) | −30 | | −160 | mA |
| I_{CC} | Supply Current | $V_{IN} = 0$ V, Outputs Open ($I_{OUT} = 0$ mA) $V_{CC} = 5.0$ V, $f = 25$ MHz, $T_A = 25^\circ\text{C}$ (Note 4) | | 130 | | mA |

Notes:

- These are absolute values with respect to device ground and all overshoots due to system or tester noise are included.
- I/O pin leakage is the worst case of I_{IL} and I_{OZL} (or I_{IH} and I_{OZH}).
- Not more than one output should be shorted at a time and duration of the short-circuit should not exceed one second. $V_{OUT} = 0.5$ V has been chosen to avoid test problems caused by tester ground degradation.
- This parameter is measured with a 16-bit up/down counter pattern. This pattern is programmed in each PAL block and capable of being loaded, enabled, and reset.

CAPACITANCE (Note 1)

| Parameter Symbol | Parameter Description | Test Conditions | | Typ | Unit |
|------------------|-----------------------|--------------------------|--|-----|------|
| C _{IN} | Input Capacitance | V _{IN} = 2.0 V | V _{CC} = 5.0 V, T _A = 25°C, f = 1 MHz | 6 | pF |
| C _{OUT} | Output Capacitance | V _{OUT} = 2.0 V | | 8 | pF |

SWITCHING CHARACTERISTICS over COMMERCIAL operating ranges

| Parameter Symbol | Parameter Description | | -7 | | Unit |
|--------------------|--|---------------------------------------|--------|-------|------|
| | | | Min | Max | |
| t _{PD} | Input, I/O, or Feedback to Combinatorial Output | | | 7.5 | ns |
| t _s | Setup Time from Input, I/O or Feedback to Clock | | D-Type | 5.5 | ns |
| | | | T-Type | 6.5 | ns |
| t _H | Register Data Hold Time | | 0 | | ns |
| t _{CO} | Clock to Output | | | 5 | ns |
| t _{WL} | Clock Width | | LOW | 3 | ns |
| t _{WH} | | | HIGH | 3 | ns |
| f _{MAX} | Maximum Frequency | External Feedback | D-Type | 100 | MHz |
| | | Internal Feedback (f _{CNT}) | T-Type | 91 | MHz |
| | D-Type | | 133 | MHz | |
| | T-Type | | 125 | MHz | |
| | No Feedback | | | 166.7 | MHz |
| t _{SL} | Setup Time from Input, I/O, or Feedback to Gate | | 5.5 | | ns |
| t _{HL} | Latch Data Hold Time | | 0 | | ns |
| t _{GO} | Gate to Output | | | 6 | ns |
| t _{GWL} | Gate Width LOW | | 3 | | ns |
| t _{PDL} | Input, I/O, or Feedback to Output Through Transparent Input or Output Latch | | | 9.5 | ns |
| t _{SIR} | Input Register Setup Time | | 2 | | ns |
| t _{HIR} | Input Register Hold Time | | 2 | | ns |
| t _{ICO} | Input Register Clock to Combinatorial Output | | | 11 | ns |
| t _{ICS} | Input Register Clock to Output Register Setup | | D-Type | 9 | ns |
| | | | T-Type | 10 | ns |
| t _{WICL} | Input Register Clock Width | | LOW | 3 | ns |
| t _{WICH} | | | HIGH | 3 | ns |
| f _{MAXIR} | Maximum Input Register Frequency | | 166.7 | | MHz |
| t _{SIL} | Input Latch Setup Time | | 2 | | ns |
| t _{HIL} | Input Latch Hold Time | | 2 | | ns |
| t _{I GO} | Input Latch Gate to Combinatorial Output | | | 12 | ns |
| t _{I GOL} | Input Latch Gate to Output Through Transparent Output Latch | | | 14 | ns |
| t _{SLL} | Setup Time from Input, I/O, or Feedback Through Transparent Input Latch to Output Latch Gate | | 7.5 | | ns |

SWITCHING CHARACTERISTICS over COMMERCIAL operating ranges (continued)

| Parameter Symbol | Parameter Description | -7 | | Unit |
|------------------|--|-----|------|------|
| | | Min | Max | |
| tIGS | Input Latch Gate to Output Latch Setup | 10 | | ns |
| twIGL | Input Latch Gate Width LOW | 3 | | ns |
| tpDLL | Input, I/O, or Feedback to Output Through Transparent Input and Output Latches | | 11.5 | ns |
| tAR | Asynchronous Reset to Registered or Latched Output | | 12 | ns |
| tARW | Asynchronous Reset Width | 8 | | ns |
| tARR | Asynchronous Reset Recovery Time | 8 | | ns |
| tAP | Asynchronous Preset to Registered or Latched Output | | 12 | ns |
| tAPW | Asynchronous Preset Width | 8 | | ns |
| tAPR | Asynchronous Preset Recovery Time | 8 | | ns |
| tEA | Input, I/O, or Feedback to Output Enable | | 7.5 | ns |
| tER | Input, I/O, or Feedback to Output Disable | | 7.5 | ns |

Note:

1. These parameters are not 100% tested, but are evaluated at initial characterization and at any time the design is modified where capacitance may be affected.

ABSOLUTE MAXIMUM RATINGS

| | |
|--|----------------------------|
| Storage Temperature | −65°C to +150°C |
| Ambient Temperature with Power Applied | −55°C to +125°C |
| Supply Voltage with Respect to Ground | −0.5 V to +7.0 V |
| DC Input Voltage | −0.5 V to $V_{CC} + 0.5$ V |
| DC Output or I/O Pin Voltage | −0.5 V to $V_{CC} + 0.5$ V |
| Static Discharge Voltage | 2001 V |
| Latchup Current ($T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$) | 200 mA |

Stresses above those listed under Absolute Maximum Ratings may cause permanent device failure. Functionality at or above these limits is not implied. Exposure to Absolute Maximum Ratings for extended periods may affect device reliability. Programming conditions may differ.

OPERATING RANGES

Commercial (C) Devices

| | |
|--|--------------------|
| Temperature (T_A) Operating in Free Air | 0°C to +70°C |
| Supply Voltage (V_{CC}) with Respect to Ground | +4.75 V to +5.25 V |

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

DC CHARACTERISTICS over COMMERCIAL operating ranges unless otherwise specified

| Parameter Symbol | Parameter Description | Test Conditions | Min | Typ | Max | Unit |
|------------------|---------------------------------------|---|-----|-----|------|---------------|
| V_{OH} | Output HIGH Voltage | $I_{OH} = -3.2$ mA, $V_{CC} = \text{Min}$ $V_{IN} = V_{IH}$ or V_{IL} | 2.4 | | | V |
| V_{OL} | Output LOW Voltage | $I_{OL} = 16$ mA, $V_{CC} = \text{Min}$ $V_{IN} = V_{IH}$ or V_{IL} | | | 0.5 | V |
| V_{IH} | Input HIGH Voltage | Guaranteed Input Logical HIGH Voltage for all Inputs (Note 1) | 2.0 | | | V |
| V_{IL} | Input LOW Voltage | Guaranteed Input Logical LOW Voltage for all Inputs (Note 1) | | | 0.8 | V |
| I_{IH} | Input HIGH Leakage Current | $V_{IN} = 5.25$ V, $V_{CC} = \text{Max}$ (Note 2) | | | 10 | μA |
| I_{IL} | Input LOW Leakage Current | $V_{IN} = 0$ V, $V_{CC} = \text{Max}$ (Note 2) | | | −100 | μA |
| I_{OZH} | Off-State Output Leakage Current HIGH | $V_{OUT} = 5.25$ V, $V_{CC} = \text{Max}$ $V_{IN} = V_{IH}$ or V_{IL} (Note 2) | | | 10 | μA |
| I_{OZL} | Off-State Output Leakage Current LOW | $V_{OUT} = 0$ V, $V_{CC} = \text{Max}$ $V_{IN} = V_{IH}$ or V_{IL} (Note 2) | | | −100 | μA |
| I_{SC} | Output Short-Circuit Current | $V_{OUT} = 0.5$ V, $V_{CC} = \text{Max}$ (Note 3) | −30 | | −160 | mA |
| I_{CC} | Supply Current (Typical) | $V_{CC} = 5$ V, $T_A = 25^\circ\text{C}$, $f = 25$ MHz (Note 4) | | 135 | | mA |

Notes:

- These are absolute values with respect to device ground and all overshoots due to system or tester noise are included.
- I/O pin leakage is the worst case of I_{IL} and I_{OZL} (or I_{IH} and I_{OZH}).
- Not more than one output should be shorted at a time and duration of the short-circuit should not exceed one second. $V_{OUT} = 0.5$ V has been chosen to avoid test problems caused by tester ground degradation.
- Measured with a 16-bit up/down counter pattern. This pattern is programmed in each PAL block and is capable of being loaded, enabled, and reset.

CAPACITANCE (Note 1)

| Parameter Symbol | Parameter Description | Test Conditions | | Typ | Unit |
|------------------|-----------------------|--------------------------|--|-----|------|
| C _{IN} | Input Capacitance | V _{IN} = 2.0 V | V _{CC} = 5.0 V, T _A = 25°C, f = 1 MHz | 6 | pF |
| C _{OUT} | Output Capacitance | V _{OUT} = 2.0 V | | 8 | pF |

SWITCHING CHARACTERISTICS over COMMERCIAL operating ranges (Note 2)

| Parameter Symbol | Parameter Description | | -10 | | -12 | | Unit |
|--------------------|--|--|---------------------------------------|--------|------|------|------|
| | | | Min | Max | Min | Max | |
| t _{PD} | Input, I/O, or Feedback to Combinatorial Output (Note 3) | | | 10 | | 12 | ns |
| t _S | Setup Time from Input, I/O, or Feedback to Clock | | D-Type | 6.5 | | 7 | ns |
| | | | T-Type | 7.5 | | 8 | ns |
| t _H | Register Data Hold Time | | 0 | | 0 | | ns |
| t _{CO} | Clock to Output (Note 3) | | | 6 | | 8 | ns |
| t _{WL} | Clock Width | | LOW | 5 | | 6 | ns |
| t _{WH} | | | HIGH | 5 | | 6 | ns |
| f _{MAX} | Maximum Frequency (Note 1) | External Feedback | 1/(t _S + t _{CO}) | D-Type | 80 | 66.7 | MHz |
| | | | T-Type | 74 | 62.5 | MHz | |
| | Internal Feedback (f _{CNT}) | D-Type | 100 | 83.3 | MHz | | |
| | | T-Type | 91 | 76.9 | MHz | | |
| No Feedback | 1/(t _S + t _H) | 100 | | 83.3 | MHz | | |
| t _{SL} | Setup Time from Input, I/O, or Feedback to Gate | | 6.5 | | 7 | | ns |
| t _{HL} | Latch Data Hold Time | | 0 | | 0 | | ns |
| t _{GO} | Gate to Output (Note 3) | | | 7 | | 10 | ns |
| t _{GWL} | Gate Width LOW | | 5 | | 6 | | ns |
| t _{PDL} | Input, I/O, or Feedback to Output Through Transparent Input or Output Latch | | | 12 | | 14 | ns |
| t _{SIR} | Input Register Setup Time | | 2 | | 2 | | ns |
| t _{HIR} | Input Register Hold Time | | 2 | | 2 | | ns |
| t _{ICO} | Input Register Clock to Combinatorial Output | | | 13 | | 15 | ns |
| t _{ICS} | Input Register Clock to Output Register Setup | | D-Type | 10 | | 12 | ns |
| | | | T-Type | 11 | | 13 | ns |
| t _{WICL} | Input Register Clock Width | | LOW | 5 | | 6 | ns |
| t _{WICH} | | | HIGH | 5 | | 6 | ns |
| f _{MAXIR} | Maximum Input Register Frequency | 1/(t _{WICL} + t _{WICH}) | 100 | | 83.3 | | MHz |
| t _{SIL} | Input Latch Setup Time | | 2 | | 2 | | ns |
| t _{HIL} | Input Latch Hold Time | | 2 | | 2 | | ns |
| t _{IGO} | Input Latch Gate to Combinatorial Output | | | 14 | | 17 | ns |
| t _{IGOL} | Input Latch Gate to Output Through Transparent Output Latch | | | 16 | | 19 | ns |
| t _{SLL} | Setup Time from Input, I/O, or Feedback Through Transparent Input Latch to Output Latch Gate | | 8.5 | | 9 | | ns |
| t _{IGS} | Input Latch Gate to Output Latch Setup | | 11 | | 13 | | ns |

**SWITCHING CHARACTERISTICS over COMMERCIAL operating ranges (Note 2)
(continued)**

| Parameter Symbol | Parameter Description | -10 | | -12 | | Unit |
|-------------------|--|-----|-----|-----|-----|------|
| | | Min | Max | Min | Max | |
| t _{WIGL} | Input Latch Gate Width LOW | 5 | | 6 | | ns |
| t _{PDLL} | Input, I/O, or Feedback to Output Through Transparent Input and Output Latches | | 14 | | 16 | ns |
| t _{AR} | Asynchronous Reset to Registered or Latched Output | | 25 | | 16 | ns |
| t _{ARW} | Asynchronous Reset Width (Note 1) | 10 | | 12 | | ns |
| t _{ARR} | Asynchronous Reset Recovery Time (Note 1) | 10 | | 8 | | ns |
| t _{AP} | Asynchronous Preset to Registered or Latched Output | | 15 | | 16 | ns |
| t _{APW} | Asynchronous Preset Width (Note 1) | 10 | | 12 | | ns |
| t _{APR} | Asynchronous Preset Recovery Time (Note 1) | 10 | | 8 | | ns |
| t _{EA} | Input, I/O, or Feedback to Output Enable (Note 3) | | 10 | | 12 | ns |
| t _{ER} | Input, I/O, or Feedback to Output Disable (Note 3) | | 10 | | 12 | ns |

Notes:

1. *These parameters are not 100% tested, but are evaluated at initial characterization and at any time the design is modified where capacitance may be affected.*
2. *See Switching Test Circuit, for test conditions.*
3. *Parameters measured with 16 outputs switching.*

ABSOLUTE MAXIMUM RATINGS

| | |
|--|----------------------------|
| Storage Temperature | −65°C to +150°C |
| Ambient Temperature with Power Applied | −55°C to +125°C |
| Supply Voltage with Respect to Ground | −0.5 V to +7.0 V |
| DC Input Voltage | −0.5 V to $V_{CC} + 0.5$ V |
| DC Output or I/O Pin Voltage | −0.5 V to $V_{CC} + 0.5$ V |
| Static Discharge Voltage | 2001 V |
| Latchup Current ($T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$) | 200 mA |

Stresses above those listed under Absolute Maximum Ratings may cause permanent device failure. Functionality at or above these limits is not implied. Exposure to Absolute Maximum Ratings for extended periods may affect device reliability. Programming conditions may differ.

INDUSTRIAL OPERATING RANGES

| | |
|---|------------------|
| Temperature (T_A) Operating in Free Air | −40°C to +85°C |
| Supply Voltage (V_{CC}) with Respect to Ground | +4.5 V to +5.5 V |

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

DC CHARACTERISTICS over COMMERCIAL operating ranges unless otherwise specified

| Parameter Symbol | Parameter Description | Test Conditions | Min | Typ | Max | Unit |
|------------------|---------------------------------------|---|-----|-----|------|---------------|
| V_{OH} | Output HIGH Voltage | $I_{OH} = -3.2$ mA, $V_{CC} = \text{Min}$ $V_{IN} = V_{IH}$ or V_{IL} | 2.4 | | | V |
| V_{OL} | Output LOW Voltage | $I_{OL} = 16$ mA, $V_{CC} = \text{Min}$ $V_{IN} = V_{IH}$ or V_{IL} | | | 0.5 | V |
| V_{IH} | Input HIGH Voltage | Guaranteed Input Logical HIGH Voltage for all Inputs (Note 1) | 2.0 | | | V |
| V_{IL} | Input LOW Voltage | Guaranteed Input Logical LOW Voltage for all Inputs (Note 1) | | | 0.8 | V |
| I_{IH} | Input HIGH Leakage Current | $V_{IN} = 5.25$ V, $V_{CC} = \text{Max}$ (Note 2) | | | 10 | μA |
| I_{IL} | Input LOW Leakage Current | $V_{IN} = 0$ V, $V_{CC} = \text{Max}$ (Note 2) | | | −100 | μA |
| I_{OZH} | Off-State Output Leakage Current HIGH | $V_{OUT} = 5.25$ V, $V_{CC} = \text{Max}$ $V_{IN} = V_{IH}$ or V_{IL} (Note 2) | | | 10 | μA |
| I_{OZL} | Off-State Output Leakage Current LOW | $V_{OUT} = 0$ V, $V_{CC} = \text{Max}$ $V_{IN} = V_{IH}$ or V_{IL} (Note 2) | | | −100 | μA |
| I_{SC} | Output Short-Circuit Current | $V_{OUT} = 0.5$ V, $V_{CC} = \text{Max}$ (Note 3) | −30 | | −160 | mA |
| I_{CC} | Supply Current (Typical) | $V_{CC} = 5$ V, $T_A = 25^\circ\text{C}$, $f = 25$ MHz (Note 4) | | 135 | | mA |

Notes:

- These are absolute values with respect to device ground and all overshoots due to system or tester noise are included.
- I/O pin leakage is the worst case of I_{IL} and I_{OZL} (or I_{IH} and I_{OZH}).
- Not more than one output should be shorted at a time and duration of the short-circuit should not exceed one second.
 $V_{OUT} = 0.5$ V has been chosen to avoid test problems caused by tester ground degradation.
- Measured with a 16-bit up/down counter pattern. This pattern is programmed in each PAL block and is capable of being loaded, enabled, and reset.

CAPACITANCE (Note 1)

| Parameter Symbol | Parameter Description | Test Conditions | | Typ | Unit |
|------------------|-----------------------|--------------------------|--|-----|------|
| C _{IN} | Input Capacitance | V _{IN} = 2.0 V | V _{CC} = 5.0 V, T _A = 25°C, f = 1 MHz | 6 | pF |
| C _{OUT} | Output Capacitance | V _{OUT} = 2.0 V | | 8 | pF |

SWITCHING CHARACTERISTICS over COMMERCIAL operating ranges (Note 2)

| Parameter Symbol | Parameter Description | | -12 | | -14 | | Unit | | |
|--------------------|--|--|---------------------------------------|--------|--------|------|------|-----|-----|
| | | | Min | Max | Min | Max | | | |
| t _{PD} | Input, I/O, or Feedback to Combinatorial Output (Note 3) | | | 12 | | 14.5 | ns | | |
| t _S | Setup Time from Input, I/O, or Feedback to Clock | | D-Type | | 8 | 8.5 | ns | | |
| | | | T-Type | | 9 | 10 | ns | | |
| t _H | Register Data Hold Time | | 0 | | 0 | | ns | | |
| t _{CO} | Clock to Output (Note 3) | | | 7.5 | | 10 | ns | | |
| t _{WL} | Clock Width | | LOW | | 6 | 7.5 | ns | | |
| t _{WH} | | | HIGH | | 6 | 7.5 | ns | | |
| f _{MAX} | Maximum Frequency (Note 1) | External Feedback | 1/(t _S + t _{CO}) | | D-Type | | 64 | 53 | MHz |
| | | | | | T-Type | | 59 | 50 | MHz |
| | | Internal Feedback (f _{CNT}) | | D-Type | | 80 | 61.5 | MHz | |
| | | | | T-Type | | 72.5 | 57 | MHz | |
| No Feedback | | 1/(t _S + t _H) | | 80 | 66.5 | MHz | | | |
| t _{SL} | Setup Time from Input, I/O, or Feedback to Gate | | 8 | | 8.5 | | ns | | |
| t _{HL} | Latch Data Hold Time | | 0 | | 0 | | ns | | |
| t _{GO} | Gate to Output (Note 3) | | | 8.5 | | 12 | ns | | |
| t _{GWL} | Gate Width LOW | | 6 | | 7.5 | | ns | | |
| t _{PDL} | Input, I/O, or Feedback to Output Through Transparent Input or Output Latch | | | 14.5 | | 17 | ns | | |
| t _{SIR} | Input Register Setup Time | | 2.5 | | 2.5 | | ns | | |
| t _{HIR} | Input Register Hold Time | | 3 | | 3 | | ns | | |
| t _{ICO} | Input Register Clock to Combinatorial Output | | | 16 | | 18 | ns | | |
| t _{ICS} | Input Register Clock to Output Register Setup | | D-Type | | 12 | 14.5 | ns | | |
| | | | T-Type | | 13 | 16 | ns | | |
| t _{WICL} | Input Register Clock Width | | LOW | | 6 | 7.5 | ns | | |
| t _{WICH} | | | HIGH | | 6 | 7.5 | ns | | |
| f _{MAXIR} | Maximum Input Register Frequency | 1/(t _{WICL} + t _{WICH}) | 80 | | 66.5 | | MHz | | |
| t _{SIL} | Input Latch Setup Time | | 2.5 | | 2.5 | | ns | | |
| t _{HIL} | Input Latch Hold Time | | 3 | | 3 | | ns | | |
| t _{IGO} | Input Latch Gate to Combinatorial Output | | | 17 | | 20.5 | ns | | |
| t _{IGOL} | Input Latch Gate to Output Through Transparent Output Latch | | | 19.5 | | 23 | ns | | |
| t _{SLL} | Setup Time from Input, I/O, or Feedback Through Transparent Input Latch to Output Latch Gate | | 10.5 | | 11 | | ns | | |
| t _{IGS} | Input Latch Gate to Output Latch Setup | | 13.5 | | 16 | | ns | | |

**SWITCHING CHARACTERISTICS over COMMERCIAL operating ranges (Note 2)
(continued)**

| Parameter Symbol | Parameter Description | -12 | | -14 | | Unit |
|-------------------|--|-----|------|------|------|------|
| | | Min | Max | Min | Max | |
| t _{WIGL} | Input Latch Gate Width LOW | 6 | | 7.5 | | ns |
| t _{PDLL} | Input, I/O, or Feedback to Output Through Transparent Input and Output Latches | | 17 | | 19.5 | ns |
| t _{AR} | Asynchronous Reset to Registered or Latched Output | | 19.5 | | 19.5 | ns |
| t _{ARW} | Asynchronous Reset Width (Note 1) | 12 | | 14.5 | | ns |
| t _{ARR} | Asynchronous Reset Recovery Time (Note 1) | 12 | | 10 | | ns |
| t _{AP} | Asynchronous Preset to Registered or Latched Output | | 18 | | 19.5 | ns |
| t _{APW} | Asynchronous Preset Width (Note 1) | 12 | | 14.5 | | ns |
| t _{APR} | Asynchronous Preset Recovery Time (Note 1) | 12 | | 10 | | ns |
| t _{EA} | Input, I/O, or Feedback to Output Enable (Note 3) | | 12 | | 14.5 | ns |
| t _{ER} | Input, I/O, or Feedback to Output Disable (Note 3) | | 12 | | 14.5 | ns |

Notes:

1. *These parameters are not 100% tested, but are evaluated at initial characterization and at any time the design is modified where capacitance may be affected.*
2. *See Switching Test Circuit, for test conditions.*
3. *Parameters measured with 16 outputs switching.*

ABSOLUTE MAXIMUM RATINGS

| | |
|--|----------------------------|
| Storage Temperature | −65°C to +150°C |
| Ambient Temperature with Power Applied | −55°C to +125°C |
| Supply Voltage with Respect to Ground | −0.5 V to +7.0 V |
| DC Input Voltage | −0.5 V to $V_{CC} + 0.5$ V |
| DC Output or I/O Pin Voltage | −0.5 V to $V_{CC} + 0.5$ V |
| Static Discharge Voltage | 2001 V |
| Latchup Current ($T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$) | 200 mA |

Stresses above those listed under Absolute Maximum Ratings may cause permanent device failure. Functionality at or above these limits is not implied. Exposure to Absolute Maximum Ratings for extended periods may affect device reliability. Programming conditions may differ.

OPERATING RANGES

Commercial (C) Devices

| | |
|--|--------------------|
| Temperature (T_A) Operating in Free Air | 0°C to +70°C |
| Supply Voltage (V_{CC}) with Respect to Ground | +4.75 V to +5.25 V |

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

DC CHARACTERISTICS over COMMERCIAL operating ranges unless otherwise specified

| Parameter Symbol | Parameter Description | Test Conditions | Min | Typ | Max | Unit |
|------------------|---------------------------------------|---|-----|-----|------|---------------|
| V_{OH} | Output HIGH Voltage | $I_{OH} = -3.2$ mA, $V_{CC} = \text{Min}$ $V_{IN} = V_{IH}$ or V_{IL} | | 2.4 | | V |
| V_{OL} | Output LOW Voltage | $I_{OL} = 16$ mA, $V_{CC} = \text{Min}$ $V_{IN} = V_{IH}$ or V_{IL} | | | 0.5 | V |
| V_{IH} | Input HIGH Voltage | Guaranteed Input Logical HIGH Voltage for all Inputs (Note 1) | 2.0 | | | V |
| V_{IL} | Input LOW Voltage | Guaranteed Input Logical LOW Voltage for all Inputs (Note 1) | | | 0.8 | V |
| I_{IH} | Input HIGH Leakage Current | $V_{IN} = 5.25$ V, $V_{CC} = \text{Max}$ (Note 2) | | | 10 | μA |
| I_{IL} | Input LOW Leakage Current | $V_{IN} = 0$ V, $V_{CC} = \text{Max}$ (Note 2) | | | −10 | μA |
| I_{OZH} | Off-State Output Leakage Current HIGH | $V_{OUT} = 5.25$ V, $V_{CC} = \text{Max}$ $V_{IN} = V_{IH}$ or V_{IL} (Note 2) | | | 10 | μA |
| I_{OZL} | Off-State Output Leakage Current LOW | $V_{OUT} = 0$ V, $V_{CC} = \text{Max}$ $V_{IN} = V_{IH}$ or V_{IL} (Note 2) | | | −10 | μA |
| I_{SC} | Output Short-Circuit Current | $V_{OUT} = 0.5$ V, $V_{CC} = \text{Max}$ (Note 3) | | −30 | −160 | mA |
| I_{CC} | Supply Current (Typical) | $V_{CC} = 5$ V, $T_A = 25^\circ\text{C}$, $f = 25$ MHz (Note 4) | | 120 | | mA |

Notes:

- These are absolute values with respect to device ground and all overshoots due to system or tester noise are included.
- I/O pin leakage is the worst case of I_{IL} and I_{OZL} (or I_{IH} and I_{OZH}).
- Not more than one output should be shorted at a time and duration of the short-circuit should not exceed one second.
 $V_{OUT} = 0.5$ V has been chosen to avoid test problems caused by tester ground degradation.
- Measured with a 16-bit up/down counter pattern. This pattern is programmed in each PAL block and is capable of being loaded, enabled, and reset.

CAPACITANCE (Note 1)

| Parameter Symbol | Parameter Description | Test Conditions | | Typ | Unit |
|------------------|-----------------------|--------------------------|--|-----|------|
| C _{IN} | Input Capacitance | V _{IN} = 2.0 V | V _{CC} = 5.0 V, T _A = 25°C, f = 1 MHz | 6 | pF |
| C _{OUT} | Output Capacitance | V _{OUT} = 2.0 V | | 8 | pF |

SWITCHING CHARACTERISTICS over COMMERCIAL operating ranges (Note 2)

| Parameter Symbol | Parameter Description | | -12 | | -15 | | -20 | | Unit | |
|--------------------|--|--|---------------------------------------|--------|------|------|------|------|------|-----|
| | | | Min | Max | Min | Max | Min | Max | | |
| t _{PD} | Input, I/O, or Feedback to Combinatorial Output (Note 3) | | | 12 | | 15 | | 20 | ns | |
| t _s | Setup Time from Input, I/O, or Feedback to Clock | | D-type | 7 | | 10 | | 13 | ns | |
| | | | T-type | 8 | | 11 | | 14 | ns | |
| t _H | Register Data Hold Time | | 0 | | 0 | | 0 | | ns | |
| t _{CO} | Clock to Output (Note 3) | | | 8 | | 10 | | 12 | ns | |
| t _{WL} | Clock Width | | LOW | 6 | | 6 | | 8 | ns | |
| t _{WH} | | | HIGH | 6 | | 6 | | 8 | ns | |
| f _{MAX} | Maximum Frequency (Note 1) | External Feedback | 1/(t _s + t _{CO}) | D-type | 66.7 | | 50 | | 40 | MHz |
| | | | T-type | 62.5 | | 47.6 | | 38.5 | MHz | |
| | | Internal Feedback (f _{CNT}) | D-type | 83.3 | | 66.6 | | 50 | MHz | |
| | | | T-type | 76.9 | | 62.5 | | 47.6 | MHz | |
| No Feedback | 1/(t _{WL} + t _{WH}) | 83.3 | | 83.3 | | 62.5 | MHz | | | |
| t _{SL} | Setup Time from Input, I/O, or Feedback to Gate | | 7 | | 10 | | 13 | | ns | |
| t _{HL} | Latch Data Hold Time | | 0 | | 0 | | 0 | | ns | |
| t _{GO} | Gate to Output (Note 3) | | | 10 | | 11 | | 12 | ns | |
| t _{GWL} | Gate Width LOW | | 6 | | 6 | | 8 | | ns | |
| t _{PDL} | Input, I/O, or Feedback to Output Through Transparent Input or Output Latch | | | 14 | | 17 | | 22 | ns | |
| t _{SIR} | Input Register Setup Time | | 2 | | 2 | | 2 | | ns | |
| t _{HIR} | Input Register Hold Time | | 2 | | 2.5 | | 3 | | ns | |
| t _{ICO} | Input Register Clock to Combinatorial Output | | | 15 | | 18 | | 23 | ns | |
| t _{ICS} | Input Register Clock to Output Register Setup | | D-type | 12 | | 15 | | 20 | ns | |
| | | | T-type | 13 | | 16 | | 21 | ns | |
| t _{WICL} | Input Register Clock Width | | LOW | 6 | | 6 | | 8 | ns | |
| t _{WICH} | | | HIGH | 6 | | 6 | | 8 | ns | |
| f _{MAXIR} | Maximum Input Register Frequency | 1/(t _{WICL} + t _{WICH}) | 83.3 | | 83.3 | | 62.5 | | MHz | |
| t _{SIL} | Input Latch Setup Time | | 2 | | 2 | | 2 | | ns | |
| t _{HIL} | Input Latch Hold Time | | 2 | | 2.5 | | 3 | | ns | |
| t _{IGO} | Input Latch Gate to Combinatorial Output | | | 17 | | 20 | | 25 | ns | |
| t _{IGOL} | Input Latch Gate to Output Through Transparent Output Latch | | | 19 | | 22 | | 27 | ns | |
| t _{SLL} | Setup Time from Input, I/O, or Feedback Through Transparent Input Latch to Output Latch Gate | | 9 | | 12 | | 15 | | ns | |
| t _{IGS} | Input Latch Gate to Output Latch Setup | | 13 | | 16 | | 21 | | ns | |

**SWITCHING CHARACTERISTICS over COMMERCIAL operating ranges (Note 2)
(continued)**

| Parameter Symbol | Parameter Description | -12 | | -15 | | -20 | | Unit |
|-------------------|--|-----|-----|-----|-----|-----|-----|------|
| | | Min | Max | Min | Max | Min | Max | |
| t _{WGL} | Input Latch Gate Width LOW | 6 | | 6 | | 8 | | ns |
| t _{PDLL} | Input, I/O, or Feedback to Output Through Transparent Input and Output Latches | | 16 | | 19 | | 24 | ns |
| t _{AR} | Asynchronous Reset to Registered or Latched Output | | 16 | | 20 | | 25 | ns |
| t _{ARW} | Asynchronous Reset Width (Note 1) | 12 | | 15 | | 20 | | ns |
| t _{ARR} | Asynchronous Reset Recovery Time (Note 1) | 8 | | 10 | | 15 | | ns |
| t _{AP} | Asynchronous Preset to Registered or Latched Output | | 16 | | 20 | | 25 | ns |
| t _{APW} | Asynchronous Preset Width (Note 1) | 12 | | 15 | | 20 | | ns |
| t _{APR} | Asynchronous Preset Recovery Time (Note 1) | 8 | | 10 | | 15 | | ns |
| t _{EA} | Input, I/O, or Feedback to Output Enable (Note 3) | | 12 | | 15 | | 20 | ns |
| t _{ER} | Input, I/O, or Feedback to Output Disable (Note 3) | | 12 | | 15 | | 20 | ns |

Notes:

1. *These parameters are not 100% tested, but are evaluated at initial characterization and at any time the design is modified where capacitance may be affected.*
2. *See Switching Test Circuit, for test conditions.*
3. *Parameters measured with 16 outputs switching.*

ABSOLUTE MAXIMUM RATINGS

| | |
|--|----------------------------|
| Storage Temperature | −65°C to +150°C |
| Ambient Temperature | |
| With Power Applied | −55°C to +125°C |
| Supply Voltage with Respect to Ground | −0.5 V to +7.0 V |
| DC Input Voltage | −0.5 V to $V_{CC} + 0.5$ V |
| DC Output or I/O Pin Voltage | −0.5 V to $V_{CC} + 0.5$ V |
| Static Discharge Voltage | 2001 V |
| Latchup Current ($T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$) | 200 mA |

Stresses above those listed under Absolute Maximum Ratings may cause permanent device failure. Functionality at or above these limits is not implied. Exposure to Absolute Maximum Ratings for extended periods may affect device reliability. Programming conditions may differ.

INDUSTRIAL OPERATING RANGES

| | |
|--|------------------|
| Ambient Temperature (T_A) | |
| Operating in Free Air | −40°C to +85°C |
| Supply Voltage (V_{CC}) with Respect to Ground | +4.5 V to +5.5 V |

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

DC CHARACTERISTICS over INDUSTRIAL operating ranges unless otherwise specified

| Parameter Symbol | Parameter Description | Test Conditions | Min | Typ | Max | Unit |
|------------------|---------------------------------------|---|-----|-----|------|---------------|
| V_{OH} | Output HIGH Voltage | $I_{OH} = -3.2$ mA, $V_{CC} = \text{Min}$ $V_{IN} = V_{IH}$ or V_{IL} | 2.4 | | | V |
| V_{OL} | Output LOW Voltage | $I_{OL} = 16$ mA, $V_{CC} = \text{Min}$ $V_{IN} = V_{IH}$ or V_{IL} | | | 0.5 | V |
| V_{IH} | Input HIGH Voltage | Guaranteed Input Logical HIGH Voltage for all Inputs (Note 1) | 2.0 | | | V |
| V_{IL} | Input LOW Voltage | Guaranteed Input Logical LOW Voltage for all Inputs (Note 1) | | | 0.8 | V |
| I_{IH} | Input HIGH Leakage Current | $V_{IN} = 5.25$ V, $V_{CC} = \text{Max}$ (Note 2) | | | 10 | μA |
| I_{IL} | Input LOW Leakage Current | $V_{IN} = 0$ V, $V_{CC} = \text{Max}$ (Note 2) | | | −10 | μA |
| I_{OZH} | Off-State Output Leakage Current HIGH | $V_{OUT} = 5.25$ V, $V_{CC} = \text{Max}$ $V_{IN} = V_{IH}$ or V_{IL} (Note 2) | | | 10 | μA |
| I_{OZL} | Off-State Output Leakage Current LOW | $V_{OUT} = 0$ V, $V_{CC} = \text{Max}$ $V_{IN} = V_{IH}$ or V_{IL} (Note 2) | | | −10 | μA |
| I_{SC} | Output Short-Circuit Current | $V_{OUT} = 0.5$ V, $V_{CC} = \text{Max}$ (Note 3) | −30 | | −160 | mA |
| I_{CC} | Supply Current (Typical) | $V_{CC} = 5$ V, $T_A = 25^\circ\text{C}$, $f = 25$ MHz (Note 4) | | 120 | | mA |

Notes:

- These are absolute values with respect to device ground and all overshoots due to system and/or tester noise are included.
- I/O pin leakage is the worst case of I_{IL} and I_{OZL} (or I_{IH} and I_{OZH}).
- Not more than one output should be shorted at a time. Duration of the short-circuit should not exceed one second. $V_{OUT} = 0.5$ V has been chosen to avoid test problems caused by tester ground degradation.
- Measured with a 16-bit up/down counter pattern. This pattern is programmed in each PAL block and is capable of being loaded, enabled, and reset.

CAPACITANCE (Note 1)

| Parameter Symbol | Parameter Description | Test Conditions | | Typ | Unit |
|------------------|-----------------------|--------------------------|--|-----|------|
| C _{IN} | Input Capacitance | V _{IN} = 2.0 V | V _{CC} = 5.0 V, T _A = 25°C, f = 1 MHz | 6 | pF |
| C _{OUT} | Output Capacitance | V _{OUT} = 2.0 V | | 8 | pF |

SWITCHING CHARACTERISTICS over INDUSTRIAL operating ranges (Note 2)

| Parameter Symbol | Parameter Description | | -14 | | -18 | | -24 | | Unit | |
|--------------------|--|--|---------------------------------------|--------|------|------|------|------|------|-----|
| | | | Min | Max | Min | Max | Min | Max | | |
| t _{PD} | Input, I/O, or Feedback to Combinatorial Output (Note 3) | | | 14.5 | | 18 | | 24 | ns | |
| t _S | Setup Time from Input, I/O, or Feedback to Clock | | D-type | 8.5 | | 12 | | 16 | ns | |
| | | | T-type | 10 | | 13.5 | | 17 | ns | |
| t _H | Register Data Hold Time | | 0 | | 0 | | 0 | | ns | |
| t _{CO} | Clock to Output (Note 3) | | | 10 | | 12 | | 14.5 | ns | |
| t _{WL} | Clock Width | | LOW | 7.5 | | 7.5 | | 10 | ns | |
| t _{WH} | | | HIGH | 7.5 | | 7.5 | | 10 | ns | |
| f _{MAX} | Maximum Frequency (Note 1) | External Feedback | 1/(t _S + t _{CO}) | D-type | 53 | | 40 | | 32 | MHz |
| | | | T-type | 50 | | 38 | | 30.5 | MHz | |
| | | Internal Feedback (f _{CNT}) | D-type | 61.5 | | 53 | | 38 | MHz | |
| | | | T-type | 57 | | 44 | | 34.5 | MHz | |
| No Feedback | 1/(t _{WL} + t _{WH}) | 66.5 | | 66.5 | | 50 | MHz | | | |
| t _{SL} | Setup Time from Input, I/O, or Feedback to Gate | | 8.5 | | 12 | | 16 | | ns | |
| t _{HL} | Latch Data Hold Time | | 0 | | 0 | | 0 | | ns | |
| t _{GO} | Gate to Output (Note 3) | | | 12 | | 13.5 | | 14.5 | ns | |
| t _{GWL} | Gate Width LOW | | 7.5 | | 7.5 | | 10 | | ns | |
| t _{PDL} | Input, I/O, or Feedback to Output Through Transparent Input or Output Latch | | | 17 | | 20.5 | | 26.5 | ns | |
| t _{SIR} | Input Register Setup Time | | 2.5 | | 2.5 | | 2.5 | | ns | |
| t _{HIR} | Input Register Hold Time | | 3 | | 3.5 | | 4 | | ns | |
| t _{ICO} | Input Register Clock to Combinatorial Output | | | 18 | | 22 | | 28 | ns | |
| t _{ICS} | Input Register Clock to Output Register Setup | | D-type | 14.5 | | 18 | | 24 | ns | |
| | | | T-type | 16 | | 19.5 | | 25.5 | ns | |
| t _{WICL} | Input Register Clock Width | | LOW | 7.5 | | 7.5 | | 10 | ns | |
| t _{WICH} | | | HIGH | 7.5 | | 7.5 | | 10 | ns | |
| f _{MAXIR} | Maximum Input Register Frequency | 1/(t _{WICL} + t _{WICH}) | 66.5 | | 66.5 | | 50 | | MHz | |
| t _{SIL} | Input Latch Setup Time | | 2.5 | | 2.5 | | 2.5 | | ns | |
| t _{HIL} | Input Latch Hold Time | | 3 | | 3.5 | | 4 | | ns | |
| t _{IGO} | Input Latch Gate to Combinatorial Output | | | 20.5 | | 24 | | 30 | ns | |
| t _{IGOL} | Input Latch Gate to Output Through Transparent Output Latch | | | 23 | | 26.5 | | 32.5 | ns | |
| t _{SLL} | Setup Time from Input, I/O, or Feedback Through Transparent Input Latch to Output Latch Gate | | 11 | | 14.5 | | 18 | | ns | |
| t _{IGS} | Input Latch Gate to Output Latch Setup | | 16 | | 19.5 | | 25.5 | | ns | |
| t _{WIGL} | Input Latch Gate Width LOW | | 7.5 | | 7.5 | | 10 | | ns | |
| t _{PDLL} | Input, I/O, or Feedback to Output Through Transparent Input and Output Latches | | | 19.5 | | 23 | | 29 | ns | |

**SWITCHING CHARACTERISTICS over INDUSTRIAL operating ranges (Note 2)
(continued)**

| Parameter Symbol | Parameter Description | -14 | | -18 | | -24 | | Unit |
|------------------|---|------|------|-----|-----|-----|-----|------|
| | | Min | Max | Min | Max | Min | Max | |
| t _{AR} | Asynchronous Reset to Registered or Latched Output | | 19.5 | | 24 | | 30 | ns |
| t _{ARW} | Asynchronous Reset Width (Note 1) | 14.5 | | 18 | | 24 | | ns |
| t _{ARR} | Asynchronous Reset Recovery Time (Note 1) | 10 | | 12 | | 18 | | ns |
| t _{AP} | Asynchronous Preset to Registered or Latched Output | | 19.5 | | 24 | | 30 | ns |
| t _{APW} | Asynchronous Preset Width (Note 1) | 14.5 | | 18 | | 24 | | ns |
| t _{APR} | Asynchronous Preset Recovery Time (Note 1) | 10 | | 12 | | 18 | | ns |
| t _{EA} | Input, I/O, or Feedback to Output Enable (Note 3) | | 14.5 | | 18 | | 24 | ns |
| t _{ER} | Input, I/O, or Feedback to Output Disable (Note 3) | | 14.5 | | 18 | | 24 | ns |

Notes:

1. These parameters are not 100% tested, but are evaluated at initial characterization and at any time the design is modified where capacitance may be affected.
2. See Switching Test Circuit, for test conditions.
3. Parameters measured with 16 outputs switching.

ABSOLUTE MAXIMUM RATINGS

| | |
|--|----------------------------|
| Storage Temperature | −65°C to +150°C |
| Ambient Temperature with Power Applied | −55°C to +125°C |
| Supply Voltage with Respect to Ground | −0.5 V to +7.0 V |
| DC Input Voltage | −0.5 V to $V_{CC} + 0.5$ V |
| DC Output or I/O Pin Voltage | −0.5 V to $V_{CC} + 0.5$ V |
| Static Discharge Voltage | 2001 V |
| Latchup Current ($T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$) | 200 mA |

Stresses above those listed under Absolute Maximum Ratings may cause permanent device failure. Functionality at or above these limits is not implied. Exposure to Absolute Maximum Ratings for extended periods may affect device reliability. Programming conditions may differ.

OPERATING RANGES

Commercial (C) Devices

| | |
|--|--------------------|
| Temperature (T_A) Operating in Free Air | 0°C to +70°C |
| Supply Voltage (V_{CC}) with Respect to Ground | +4.75 V to +5.25 V |

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

DC CHARACTERISTICS over COMMERCIAL operating ranges unless otherwise specified

| Parameter Symbol | Parameter Description | Test Conditions | Min | Typ | Max | Unit |
|------------------|---------------------------------------|---|-----|-----|------|---------------|
| V_{OH} | Output HIGH Voltage | $I_{OH} = -3.2$ mA, $V_{CC} = \text{Min}$ $V_{IN} = V_{IH}$ or V_{IL} | 2.4 | | | V |
| V_{OL} | Output LOW Voltage | $I_{OL} = 16$ mA, $V_{CC} = \text{Min}$ $V_{IN} = V_{IH}$ or V_{IL} | | | 0.5 | V |
| V_{IH} | Input HIGH Voltage | Guaranteed Input Logical HIGH Voltage for all Inputs (Note 1) | 2.0 | | | V |
| V_{IL} | Input LOW Voltage | Guaranteed Input Logical LOW Voltage for all Inputs (Note 1) | | | 0.8 | V |
| I_{IH} | Input HIGH Leakage Current | $V_{IN} = 5.25$ V, $V_{CC} = \text{Max}$ (Note 2) | | | 10 | μA |
| I_{IL} | Input LOW Leakage Current | $V_{IN} = 0$ V, $V_{CC} = \text{Max}$ (Note 2) | | | −100 | μA |
| I_{OZH} | Off-State Output Leakage Current HIGH | $V_{OUT} = 5.25$ V, $V_{CC} = \text{Max}$ $V_{IN} = V_{IH}$ or V_{IL} (Note 2) | | | 10 | μA |
| I_{OZL} | Off-State Output Leakage Current LOW | $V_{OUT} = 0$ V, $V_{CC} = \text{Max}$ $V_{IN} = V_{IH}$ or V_{IL} (Note 2) | | | −100 | μA |
| I_{SC} | Output Short-Circuit Current | $V_{OUT} = 0.5$ V, $V_{CC} = \text{Max}$ (Note 3) | −30 | | −160 | mA |
| I_{CC} | Supply Current (Typical) | $V_{CC} = 5$ V, $T_A = 25^\circ\text{C}$, $f = 25$ MHz (Note 4) | | 45 | | mA |

Notes:

- These are absolute values with respect to device ground and all overshoots due to system or tester noise are included.
- I/O pin leakage is the worst case of I_{IL} and I_{OZL} (or I_{IH} and I_{OZH}).
- Not more than one output should be shorted at a time and duration of the short-circuit should not exceed one second.
 $V_{OUT} = 0.5$ V has been chosen to avoid test problems caused by tester ground degradation.
- Measured with a 16-bit up/down counter pattern. This pattern is programmed in each PAL block and is capable of being loaded, enabled, and reset.

CAPACITANCE (Note 1)

| Parameter Symbol | Parameter Description | Test Conditions | | Typ | Unit |
|------------------|-----------------------|--------------------------|--|-----|------|
| C _{IN} | Input Capacitance | V _{IN} = 2.0 V | V _{CC} = 5.0 V, T _A = 25°C, f = 1 MHz | 6 | pF |
| C _{OUT} | Output Capacitance | V _{OUT} = 2.0 V | | 8 | pF |

SWITCHING CHARACTERISTICS over COMMERCIAL operating ranges (Note 2)

| Parameter Symbol | Parameter Description | | -12 | | Unit |
|--------------------|--|---------------------------------------|--------|------|------|
| | | | Min | Max | |
| t _{PD} | Input, I/O, or Feedback to Combinatorial Output | | | 12 | ns |
| t _s | Setup Time from Input, I/O, or Feedback to Clock | | D-type | 12 | ns |
| | | | T-type | 13 | ns |
| t _H | Register Data Hold Time | | 0 | | ns |
| t _{CO} | Clock to Output | | | 6 | ns |
| t _{WL} | Clock Width | | LOW | 6 | ns |
| t _{WH} | | | HIGH | 6 | ns |
| f _{MAX} | Maximum Frequency (Note 1) | External Feedback | D-type | 55.6 | MHz |
| | | | T-type | 52.6 | MHz |
| | | Internal Feedback (f _{CNT}) | D-type | 83.3 | MHz |
| | | | T-type | 76.9 | MHz |
| No Feedback | | | 83.3 | MHz | |
| t _{SL} | Setup Time from Input, I/O, or Feedback to Gate | | 12 | | ns |
| t _{HL} | Latch Data Hold Time | | 0 | | ns |
| t _{GO} | Gate to Output | | | 7 | ns |
| t _{GWL} | Gate Width LOW | | 6 | | ns |
| t _{PDL} | Input, I/O, or Feedback to Output Through Transparent Input or Output Latch | | | 14 | ns |
| t _{SIR} | Input Register Setup Time | | 2 | | ns |
| t _{HIR} | Input Register Hold Time | | 2.5 | | ns |
| t _{ICO} | Input Register Clock to Combinatorial Output | | | 17 | ns |
| t _{ICS} | Input Register Clock to Output Register Setup | | D-type | 15 | ns |
| | | | T-type | 16 | ns |
| t _{WICL} | Input Register Clock Width | | LOW | 6 | ns |
| t _{WICH} | | | HIGH | 6 | ns |
| f _{MAXIR} | Maximum Input Register Frequency | | 83.3 | | MHz |
| t _{SIL} | Input Latch Setup Time | | 2 | | ns |
| t _{HIL} | Input Latch Hold Time | | 2.5 | | ns |
| t _{IGO} | Input Latch Gate to Combinatorial Output | | | 19 | ns |
| t _{IGOL} | Input Latch Gate to Output Through Transparent Output Latch | | | 20 | ns |
| t _{SLL} | Setup Time from Input, I/O, or Feedback Through Transparent Input Latch to Output Latch Gate | | 13 | | ns |
| t _{IGS} | Input Latch Gate to Output Latch Setup | | 16 | | ns |

**SWITCHING CHARACTERISTICS over COMMERCIAL operating ranges (Note 2)
(continued)**

| Parameter Symbol | Parameter Description | -12 | | Unit |
|-------------------|--|-----|-----|------|
| | | Min | Max | |
| t _{WGL} | Input Latch Gate Width LOW | 6 | | ns |
| t _{PDLL} | Input, I/O, or Feedback to Output Through Transparent Input and Output Latches | | 18 | ns |
| t _{AR} | Asynchronous Reset to Registered or Latched Output | | 24 | ns |
| t _{ARW} | Asynchronous Reset Width (Note 1) | 19 | | ns |
| t _{ARR} | Asynchronous Reset Recovery Time (Note 1) | 19 | | ns |
| t _{AP} | Asynchronous Preset to Registered or Latched Output | | 24 | ns |
| t _{APW} | Asynchronous Preset Width (Note 1) | 19 | | ns |
| t _{APR} | Asynchronous Preset Recovery Time (Note 1) | 19 | | ns |
| t _{EA} | Input, I/O, or Feedback to Output Enable | | 12 | ns |
| t _{ER} | Input, I/O, or Feedback to Output Disable | | 12 | ns |

Notes:

1. These parameters are not 100% tested, but are evaluated at initial characterization and at any time the design is modified where capacitance may be affected.
2. See Switching Test Circuit, for test conditions.

ABSOLUTE MAXIMUM RATINGS

| | |
|--|----------------------------|
| Storage Temperature | −65°C to +150°C |
| Ambient Temperature with Power Applied | −55°C to +125°C |
| Supply Voltage with Respect to Ground | −0.5 V to +7.0 V |
| DC Input Voltage | −0.5 V to $V_{CC} + 0.5$ V |
| DC Output or I/O Pin Voltage | −0.5 V to $V_{CC} + 0.5$ V |
| Static Discharge Voltage | 2001 V |
| Latchup Current ($T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$) | 200 mA |

Stresses above those listed under Absolute Maximum Ratings may cause permanent device failure. Functionality at or above these limits is not implied. Exposure to Absolute Maximum Ratings for extended periods may affect device reliability. Programming conditions may differ.

OPERATING RANGES

Commercial (C) Devices

| | |
|--|--------------------|
| Temperature (T_A) Operating in Free Air | 0°C to +70°C |
| Supply Voltage (V_{CC}) with Respect to Ground | +4.75 V to +5.25 V |

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

DC CHARACTERISTICS over COMMERCIAL operating ranges unless otherwise specified

| Parameter Symbol | Parameter Description | Test Conditions | Min | Typ | Max | Unit |
|------------------|---------------------------------------|---|-----|-----|------|---------------|
| V_{OH} | Output HIGH Voltage | $I_{OH} = -3.2$ mA, $V_{CC} = \text{Min}$ $V_{IN} = V_{IH}$ or V_{IL} | 2.4 | | | V |
| V_{OL} | Output LOW Voltage | $I_{OL} = 16$ mA, $V_{CC} = \text{Min}$ $V_{IN} = V_{IH}$ or V_{IL} | | | 0.5 | V |
| V_{IH} | Input HIGH Voltage | Guaranteed Input Logical HIGH Voltage for all Inputs (Note 1) | 2.0 | | | V |
| V_{IL} | Input LOW Voltage | Guaranteed Input Logical LOW Voltage for all Inputs (Note 1) | | | 0.8 | V |
| I_{IH} | Input HIGH Leakage Current | $V_{IN} = 5.25$ V, $V_{CC} = \text{Max}$ (Note 2) | | | 10 | μA |
| I_{IL} | Input LOW Leakage Current | $V_{IN} = 0$ V, $V_{CC} = \text{Max}$ (Note 2) | | | −100 | μA |
| I_{OZH} | Off-State Output Leakage Current HIGH | $V_{OUT} = 5.25$ V, $V_{CC} = \text{Max}$ $V_{IN} = V_{IH}$ or V_{IL} (Note 2) | | | 10 | μA |
| I_{OZL} | Off-State Output Leakage Current LOW | $V_{OUT} = 0$ V, $V_{CC} = \text{Max}$ $V_{IN} = V_{IH}$ or V_{IL} (Note 2) | | | −100 | μA |
| I_{SC} | Output Short-Circuit Current | $V_{OUT} = 0.5$ V, $V_{CC} = \text{Max}$ (Note 3) | −30 | | −160 | mA |
| I_{CC} | Supply Current (Typical) | $V_{CC} = 5$ V, $T_A = 25^\circ\text{C}$, $f = 25$ MHz (Note 4) | | 45 | | mA |

Notes:

- These are absolute values with respect to device ground and all overshoots due to system or tester noise are included.
- I/O pin leakage is the worst case of I_{IL} and I_{OZL} (or I_{IH} and I_{OZH}).
- Not more than one output should be shorted at a time and duration of the short-circuit should not exceed one second. $V_{OUT} = 0.5$ V has been chosen to avoid test problems caused by tester ground degradation.
- Measured with a 16-bit up/down counter pattern. This pattern is programmed in each PAL block and is capable of being loaded, enabled, and reset.

CAPACITANCE (Note 1)

| Parameter Symbol | Parameter Description | Test Conditions | | Typ | Unit |
|------------------|-----------------------|--------------------------|--|-----|------|
| C _{IN} | Input Capacitance | V _{IN} = 2.0 V | V _{CC} = 5.0 V, T _A = 25°C, f = 1 MHz | 6 | pF |
| C _{OUT} | Output Capacitance | V _{OUT} = 2.0 V | | 8 | pF |

SWITCHING CHARACTERISTICS over COMMERCIAL operating ranges (Note 2)

| Parameter Symbol | Parameter Description | | | -15 | | -20 | | Unit |
|--------------------|--|--|---------------------------------------|--------|------|------|-----|------|
| | | | | Min | Max | Min | Max | |
| t _{PD} | Input, I/O, or Feedback to Combinatorial Output (Note 3) | | | | 15 | | 20 | ns |
| t _S | Setup Time from Input, I/O, or Feedback to Clock | | D-type | 13 | | 17 | | ns |
| | | | T-type | 14 | | 18 | | ns |
| t _H | Register Data Hold Time | | | 0 | | 0 | | ns |
| t _{CO} | Clock to Output (Note 3) | | | | 7 | | 8 | ns |
| t _{WL} | Clock Width | | LOW | 6 | | 8 | | ns |
| t _{WH} | | | HIGH | 6 | | 8 | | ns |
| f _{MAX} | Maximum Frequency (Note 1) | External Feedback | 1/(t _S + t _{CO}) | D-type | 50 | | 40 | MHz |
| | | | T-type | 47.6 | | 38.4 | MHz | |
| | Internal Feedback (f _{CNT}) | D-type | 58.8 | | 45.4 | MHz | | |
| | | T-type | 55.5 | | 43.4 | MHz | | |
| | No Feedback | 1/(t _S + t _H) | D-type | 76.9 | | 58.8 | MHz | |
| | | | T-type | 71.4 | | 55.5 | MHz | |
| t _{SL} | Setup Time from Input, I/O, or Feedback to Gate | | | 13 | | 17 | | ns |
| t _{HL} | Latch Data Hold Time | | | 0 | | 0 | | ns |
| t _{GO} | Gate to Output (Note 3) | | | | 8 | | 8 | ns |
| t _{GWL} | Gate Width LOW | | | 6 | | 8 | | ns |
| t _{PDL} | Input, I/O, or Feedback to Output Through Transparent Input or Output Latch | | | | 17 | | 22 | ns |
| t _{SIR} | Input Register Setup Time | | | 2 | | 2 | | ns |
| t _{HIR} | Input Register Hold Time | | | 2.5 | | 3 | | ns |
| t _{ICO} | Input Register Clock to Combinatorial Output | | | | 18 | | 23 | ns |
| t _{ICS} | Input Register Clock to Output Register Setup | | D-type | 17 | | 22 | | ns |
| | | | T-type | 18 | | 23 | | ns |
| t _{WICL} | Input Register Clock Width | | LOW | 6 | | 8 | | ns |
| t _{WICH} | | | HIGH | 6 | | 8 | | ns |
| f _{MAXIR} | Maximum Input Register Frequency | 1/(t _{WICL} + t _{WICH}) | | 83.3 | | 62.5 | | MHz |
| t _{SIL} | Input Latch Setup Time | | | 2 | | 2 | | ns |
| t _{HIL} | Input Latch Hold Time | | | 2.5 | | 3 | | ns |
| t _{IGO} | Input Latch Gate to Combinatorial Output | | | | 20 | | 25 | ns |
| t _{IGOL} | Input Latch Gate to Output Through Transparent Output Latch | | | | 22 | | 27 | ns |
| t _{SLL} | Setup Time from Input, I/O, or Feedback Through Transparent Input Latch to Output Latch Gate | | | 15 | | 19 | | ns |
| t _{IGS} | Input Latch Gate to Output Latch Setup | | | 18 | | 23 | | ns |

**SWITCHING CHARACTERISTICS over COMMERCIAL operating ranges (Note 2)
(continued)**

| Parameter Symbol | Parameter Description | -15 | | -20 | | Unit |
|-------------------|--|-----|-----|-----|-----|------|
| | | Min | Max | Min | Max | |
| t _{WIGL} | Input Latch Gate Width LOW | 6 | | 8 | | ns |
| t _{PDLL} | Input, I/O, or Feedback to Output Through Transparent Input and Output Latches | | 19 | | 24 | ns |
| t _{AR} | Asynchronous Reset to Registered or Latched Output | | 25 | | 30 | ns |
| t _{ARW} | Asynchronous Reset Width (Note 1) | 20 | | 25 | | ns |
| t _{ARR} | Asynchronous Reset Recovery Time (Note 1) | 20 | | 25 | | ns |
| t _{AP} | Asynchronous Preset to Registered or Latched Output | | 25 | | 30 | ns |
| t _{APW} | Asynchronous Preset Width (Note 1) | 20 | | 25 | | ns |
| t _{APR} | Asynchronous Preset Recovery Time (Note 1) | 20 | | 25 | | ns |
| t _{EA} | Input, I/O, or Feedback to Output Enable (Note 3) | | 15 | | 20 | ns |
| t _{ER} | Input, I/O, or Feedback to Output Disable (Note 3) | | 15 | | 20 | ns |

Notes:

1. These parameters are not 100% tested, but are evaluated at initial characterization and at any time the design is modified where capacitance may be affected.
2. See Switching Test Circuit, for test conditions.
3. Parameters measured with 16 outputs switching.

ABSOLUTE MAXIMUM RATINGS

| | |
|--|----------------------------|
| Storage Temperature | −65°C to +150°C |
| Ambient Temperature | |
| With Power Applied | −55°C to +125°C |
| Supply Voltage with Respect to Ground | −0.5 V to +7.0 V |
| DC Input Voltage | −0.5 V to $V_{CC} + 0.5$ V |
| DC Output or I/O Pin Voltage | −0.5 V to $V_{CC} + 0.5$ V |
| Static Discharge Voltage | 2001 V |
| Latchup Current ($T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$) | 200 mA |

Stresses above those listed under Absolute Maximum Ratings may cause permanent device failure. Functionality at or above these limits is not implied. Exposure to Absolute Maximum Ratings for extended periods may affect device reliability. Programming conditions may differ.

INDUSTRIAL OPERATING RANGES

| | |
|--|------------------|
| Ambient Temperature (T_A) | |
| Operating in Free Air | −40°C to +85°C |
| Supply Voltage (V_{CC}) with Respect to Ground | +4.5 V to +5.5 V |

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

DC CHARACTERISTICS over INDUSTRIAL operating ranges unless otherwise specified

| Parameter Symbol | Parameter Description | Test Conditions | Min | Typ | Max | Unit |
|------------------|---------------------------------------|---|-----|-----|------|---------------|
| V_{OH} | Output HIGH Voltage | $I_{OH} = -3.2$ mA, $V_{CC} = \text{Min}$ $V_{IN} = V_{IH}$ or V_{IL} | 2.4 | | | V |
| V_{OL} | Output LOW Voltage | $I_{OL} = 16$ mA, $V_{CC} = \text{Min}$ $V_{IN} = V_{IH}$ or V_{IL} | | | 0.5 | V |
| V_{IH} | Input HIGH Voltage | Guaranteed Input Logical HIGH Voltage for all Inputs (Note 1) | 2.0 | | | V |
| V_{IL} | Input LOW Voltage | Guaranteed Input Logical LOW Voltage for all Inputs (Note 1) | | | 0.8 | V |
| I_{IH} | Input HIGH Leakage Current | $V_{IN} = 5.25$ V, $V_{CC} = \text{Max}$ (Note 2) | | | 10 | μA |
| I_{IL} | Input LOW Leakage Current | $V_{IN} = 0$ V, $V_{CC} = \text{Max}$ (Note 2) | | | −100 | μA |
| I_{OZH} | Off-State Output Leakage Current HIGH | $V_{OUT} = 5.25$ V, $V_{CC} = \text{Max}$ $V_{IN} = V_{IH}$ or V_{IL} (Note 2) | | | 10 | μA |
| I_{OZL} | Off-State Output Leakage Current LOW | $V_{OUT} = 0$ V, $V_{CC} = \text{Max}$ $V_{IN} = V_{IH}$ or V_{IL} (Note 2) | | | −100 | μA |
| I_{SC} | Output Short-Circuit Current | $V_{OUT} = 0.5$ V, $V_{CC} = \text{Max}$ (Note 3) | −30 | | −160 | mA |
| I_{CC} | Supply Current (Typical) | $V_{CC} = 5$ V, $T_A = 25^\circ\text{C}$, $f = 25$ MHz (Note 4) | | 45 | | mA |

Notes:

1. These are absolute values with respect to device ground and all overshoots due to system and/or tester noise are included.
2. I/O pin leakage is the worst case of I_{IL} and I_{OZL} (or I_{IH} and I_{OZH}).
3. Not more than one output should be shorted at a time. Duration of the short-circuit should not exceed one second. $V_{OUT} = 0.5$ V has been chosen to avoid test problems caused by tester ground degradation.
4. Measured with a 16-bit up/down counter pattern. This pattern is programmed in each PAL block and is capable of being loaded, enabled, and reset.

CAPACITANCE (Note 1)

| Parameter Symbol | Parameter Description | Test Conditions | | Typ | Unit |
|------------------|-----------------------|--------------------------|--|-----|------|
| C _{IN} | Input Capacitance | V _{IN} = 2.0 V | V _{CC} = 5.0 V, T _A = 25°C, f = 1 MHz | 6 | pF |
| C _{OUT} | Output Capacitance | V _{OUT} = 2.0 V | | 8 | pF |

SWITCHING CHARACTERISTICS over INDUSTRIAL operating ranges (Note 2)

| Parameter Symbol | Parameter Description | | -18 | | -24 | | Unit | | |
|--------------------|--|--|---------------------------------------|------|--------|------|------|----|-----|
| | | | Min | Max | Min | Max | | | |
| t _{PD} | Input, I/O, or Feedback to Combinatorial Output (Note 3) | | | 18 | | 24 | ns | | |
| t _s | Setup Time from Input, I/O, or Feedback to Clock | | D-type | | 16 | 20.5 | ns | | |
| | | | T-type | | 17 | 22 | ns | | |
| t _H | Register Data Hold Time | | 0 | | 0 | | ns | | |
| t _{CO} | Clock to Output (Note 3) | | | 8.5 | | 10 | ns | | |
| t _{WL} | Clock Width | | LOW | | 7.5 | 10 | ns | | |
| t _{WH} | | | HIGH | | 7.5 | 10 | ns | | |
| f _{MAX} | Maximum Frequency (Note 1) | External Feedback | 1/(t _s + t _{CO}) | | D-type | | 40 | 32 | MHz |
| | | | T-type | | 38 | 30.5 | MHz | | |
| | | Internal Feedback (f _{CNT}) | D-type | | 47 | 36 | MHz | | |
| | | | T-type | | 44 | 34.5 | MHz | | |
| | | No Feedback | 1/(t _s + t _H) | | D-type | | 61.5 | 47 | MHz |
| | | | T-type | | 57 | 47 | MHz | | |
| t _{SL} | Setup Time from Input, I/O, or Feedback to Gate | | 16 | | 20.5 | | ns | | |
| t _{HL} | Latch Data Hold Time | | 0 | | 0 | | ns | | |
| t _{GO} | Gate to Output (Note 3) | | | 10 | | 10 | ns | | |
| t _{GWL} | Gate Width LOW | | 7.5 | | 10 | | ns | | |
| t _{PDL} | Input, I/O, or Feedback to Output Through Transparent Input or Output Latch | | | 20.5 | | 26.5 | ns | | |
| t _{SIR} | Input Register Setup Time | | 2.5 | | 2.5 | | ns | | |
| t _{HIR} | Input Register Hold Time | | 3.5 | | 4 | | ns | | |
| t _{ICO} | Input Register Clock to Combinatorial Output | | | 22 | | 28 | ns | | |
| t _{ICS} | Input Register Clock to Output Register Setup | | D-type | | 20.5 | 26.5 | ns | | |
| | | | T-type | | 22 | 28 | ns | | |
| t _{WICL} | Input Register Clock Width | | LOW | | 7.5 | 10 | ns | | |
| t _{WICH} | | | HIGH | | 7.5 | 10 | ns | | |
| f _{MAXIR} | Maximum Input Register Frequency | 1/(t _{WICL} + t _{WICH}) | 66.5 | | 50 | | MHz | | |
| t _{SIL} | Input Latch Setup Time | | 2.5 | | 2.5 | | ns | | |
| t _{HIL} | Input Latch Hold Time | | 3.5 | | 4 | | ns | | |
| t _{IGO} | Input Latch Gate to Combinatorial Output | | | 24 | | 30 | ns | | |
| t _{IGOL} | Input Latch Gate to Output Through Transparent Output Latch | | | 26.5 | | 32.5 | ns | | |
| t _{SLL} | Setup Time from Input, I/O, or Feedback Through Transparent Input Latch to Output Latch Gate | | 18 | | 23 | | ns | | |
| t _{IGS} | Input Latch Gate to Output Latch Setup | | 22 | | 28 | | ns | | |
| t _{WIGL} | Input Latch Gate Width LOW | | 7.5 | | 10 | | ns | | |
| t _{PDLL} | Input, I/O, or Feedback to Output Through Transparent Input and Output Latches | | | 23 | | 29 | ns | | |

**SWITCHING CHARACTERISTICS over INDUSTRIAL operating ranges (Note 2)
(continued)**

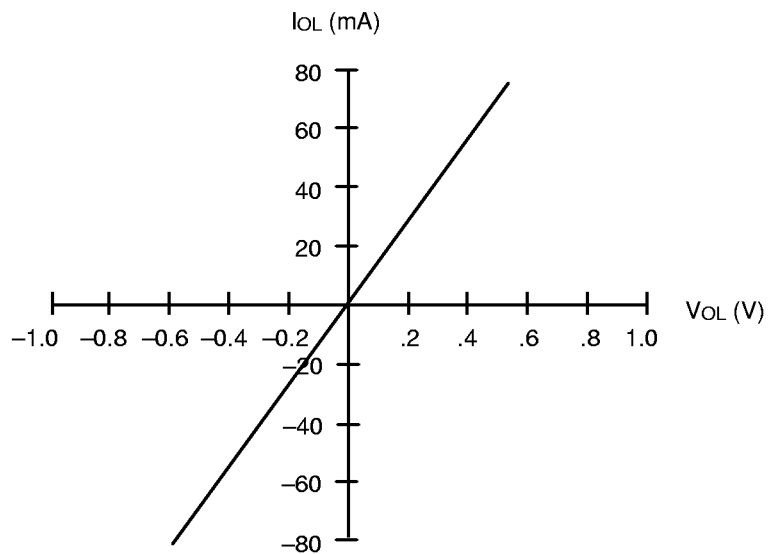
| Parameter Symbol | Parameter Description | -18 | | -24 | | Unit |
|------------------|---|-----|-----|-----|-----|------|
| | | Min | Max | Min | Max | |
| t _{AR} | Asynchronous Reset to Registered or Latched Output | | 30 | | 36 | ns |
| t _{ARW} | Asynchronous Reset Width (Note 1) | 24 | | 30 | | ns |
| t _{ARR} | Asynchronous Reset Recovery Time (Note 1) | 24 | | 30 | | ns |
| t _{AP} | Asynchronous Preset to Registered or Latched Output | | 30 | | 36 | ns |
| t _{APW} | Asynchronous Preset Width (Note 1) | 24 | | 30 | | ns |
| t _{APR} | Asynchronous Preset Recovery Time (Note 1) | 24 | | 30 | | ns |
| t _{EA} | Input, I/O, or Feedback to Output Enable (Note 3) | | 18 | | 24 | ns |
| t _{ER} | Input, I/O, or Feedback to Output Disable (Note 3) | | 18 | | 24 | ns |

Notes:

1. These parameters are not 100% tested, but are evaluated at initial characterization and at any time the design is modified where capacitance may be affected.
2. See Switching Test Circuit, for test conditions.
3. Parameters measured with 16 outputs switching.

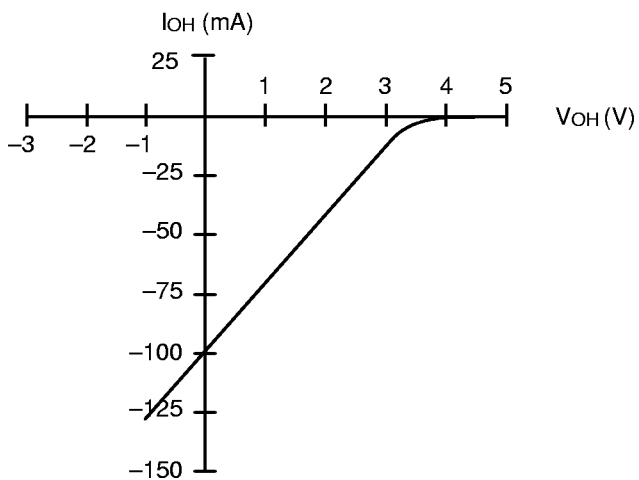
TYPICAL CURRENT VS. VOLTAGE (I-V) CHARACTERISTICS

$V_{CC} = 5.0\text{ V}$, $T_A = 25^\circ\text{C}$



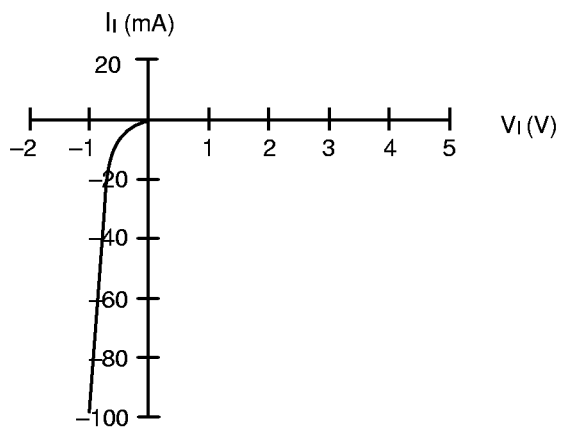
141281-5

Output, LOW



141281-6

Output, HIGH

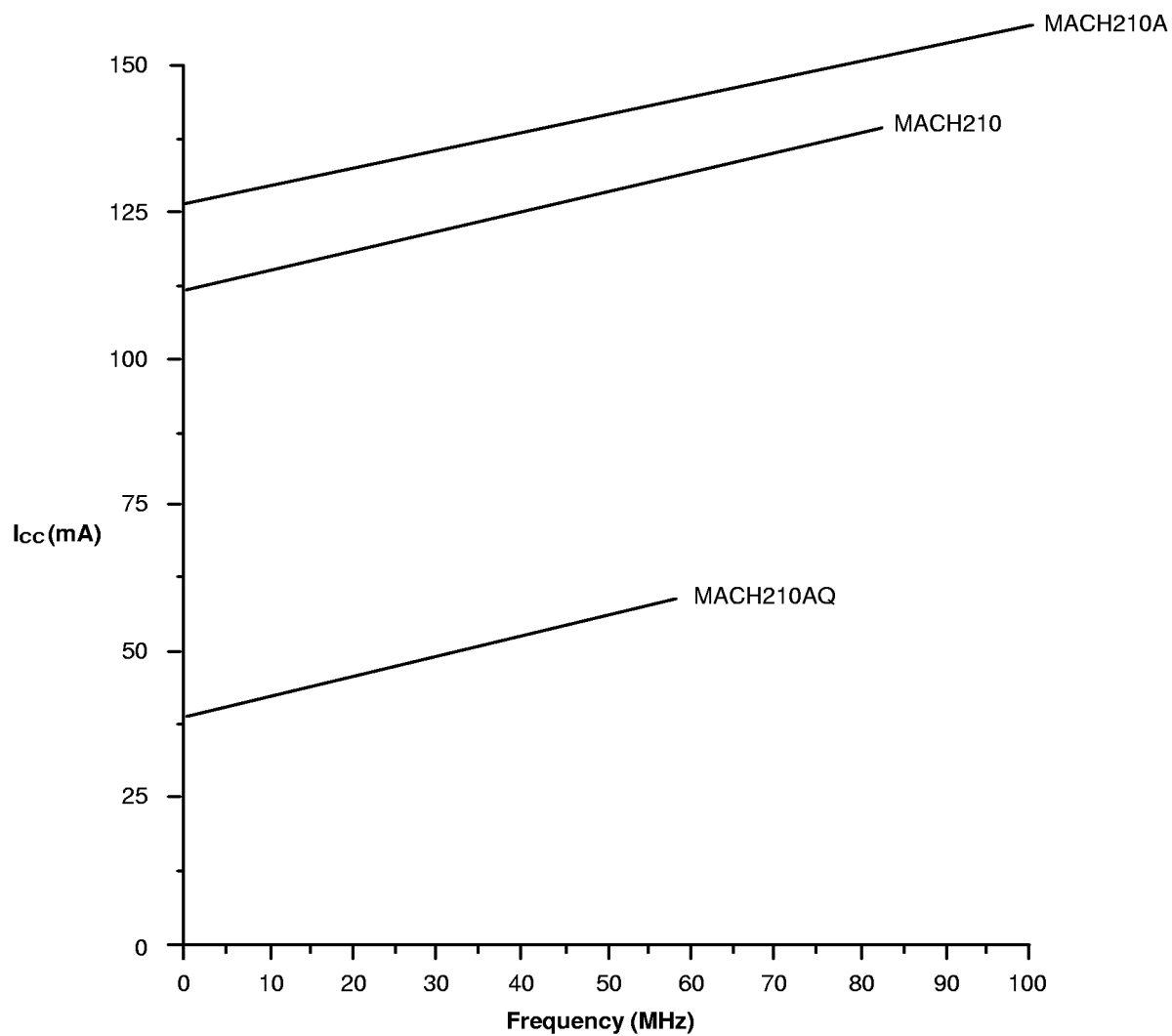


141281-7

Input

TYPICAL I_{CC} CHARACTERISTICS

$V_{CC} = 5\text{ V}$, $T_A = 25^\circ\text{C}$



141281-8

The selected "typical" pattern is a 16-bit up/down counter. This pattern is programmed in each PAL block and is capable of being loaded, enabled, and reset.

Maximum frequency shown uses internal feedback and a D-type register.

TYPICAL THERMAL CHARACTERISTICS

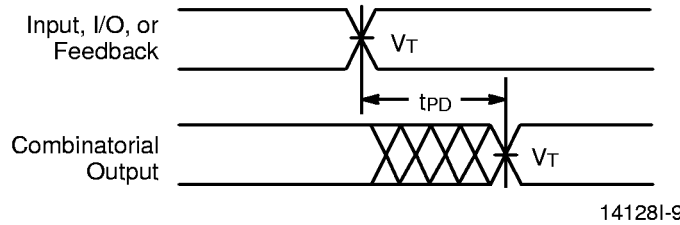
Measured at 25°C ambient. These parameters are not tested.

| Parameter Symbol | Parameter Description | Typ | | Unit | |
|------------------|--|-------------|------|------|------|
| | | TQFP | PLCC | | |
| θ_{jc} | Thermal impedance, junction to case | 11.3 | 15 | °C/W | |
| θ_{ja} | Thermal impedance, junction to ambient | 41 | 40 | °C/W | |
| θ_{jma} | Thermal impedance, junction to ambient with air flow | 200 lfm air | 35 | 36 | °C/W |
| | | 400 lfm air | 33.7 | 33 | °C/W |
| | | 600 lfm air | 32.6 | 31 | °C/W |
| | | 800 lfm air | 32 | 29 | °C/W |

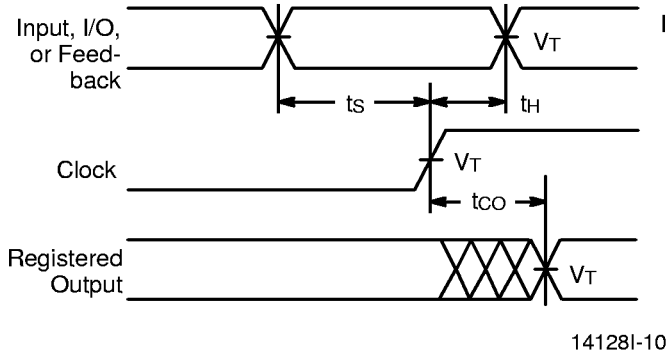
Plastic θ_{jc} Considerations

The data listed for plastic θ_{jc} are for reference only and are not recommended for use in calculating junction temperatures. The heat-flow paths in plastic-encapsulated devices are complex, making the θ_{jc} measurement relative to a specific location on the package surface. Tests indicate this measurement reference point is directly below the die-attach area on the bottom center of the package. Furthermore, θ_{jc} tests on packages are performed in a constant-temperature bath, keeping the package surface at a constant temperature. Therefore, the measurements can only be used in a similar environment.

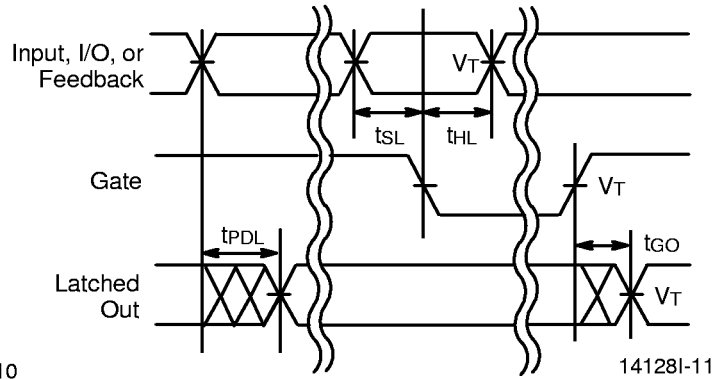
SWITCHING WAVEFORMS



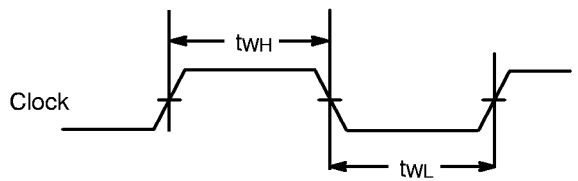
Combinatorial Output



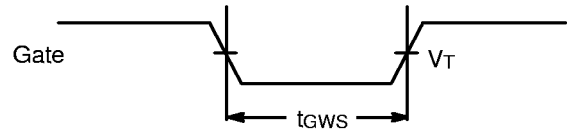
Registered Output



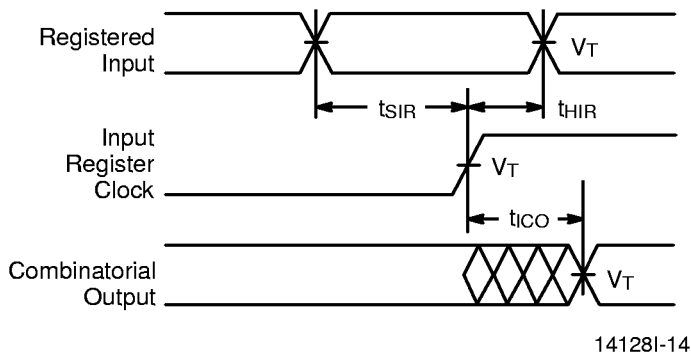
Latched Output (MACH 2, 3, and 4)



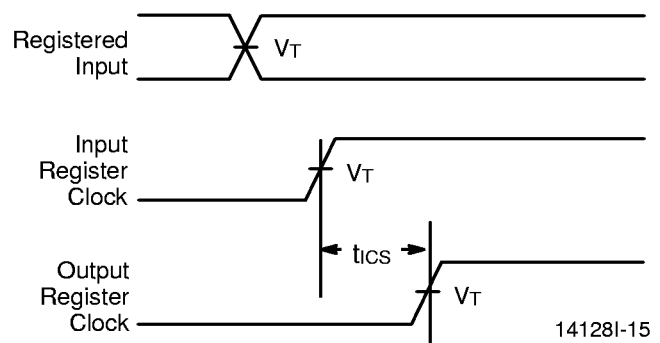
Clock Width



Gate Width (MACH 2, 3, and 4)



Registered Input (MACH 2 and 4)

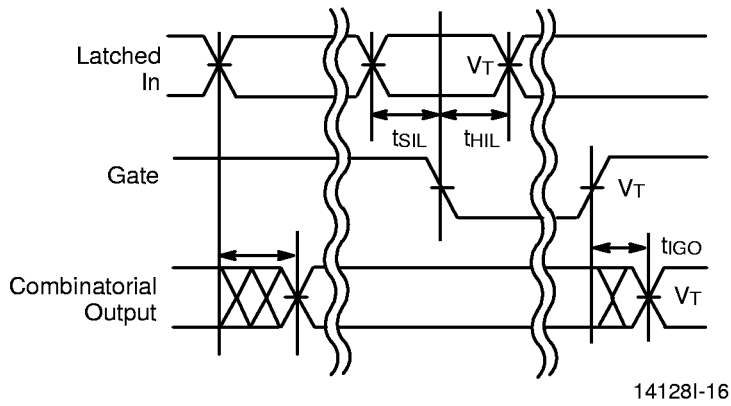


Input Register to Output Register Setup (MACH 2 and 4)

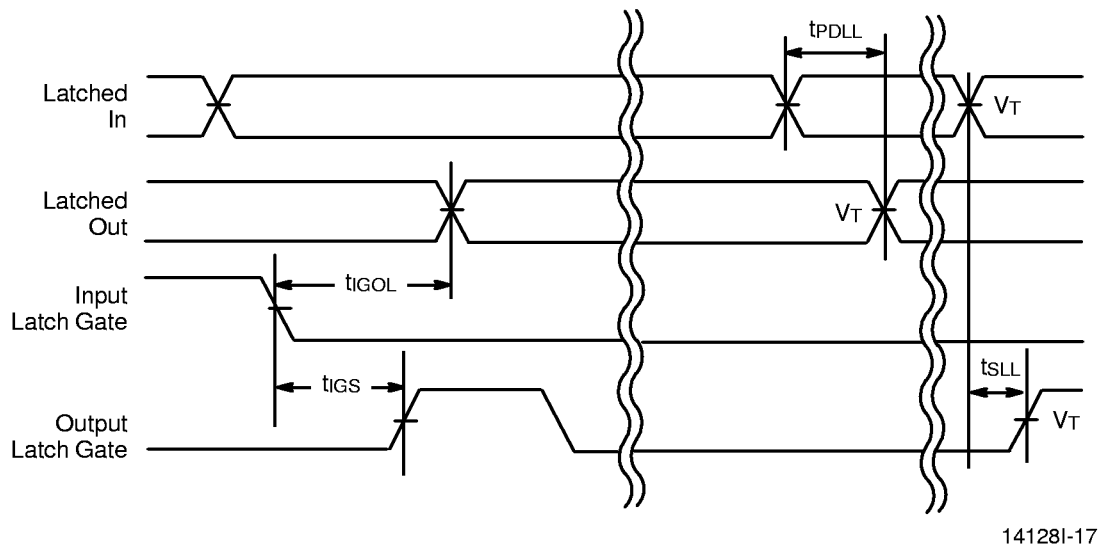
Notes:

1. $V_T = 1.5 V$.
2. Input pulse amplitude 0 V to 3.0 V.
3. Input rise and fall times 2 ns–4 ns typical.

SWITCHING WAVEFORMS



Latched Input (MACH 2 and 4)

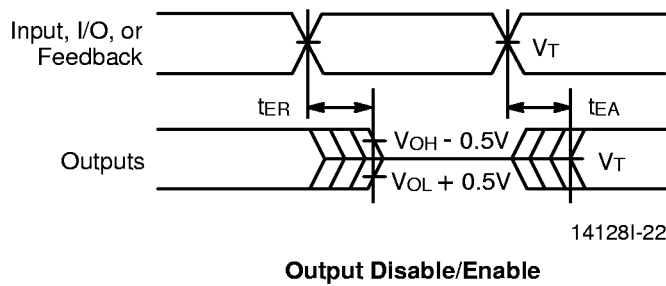
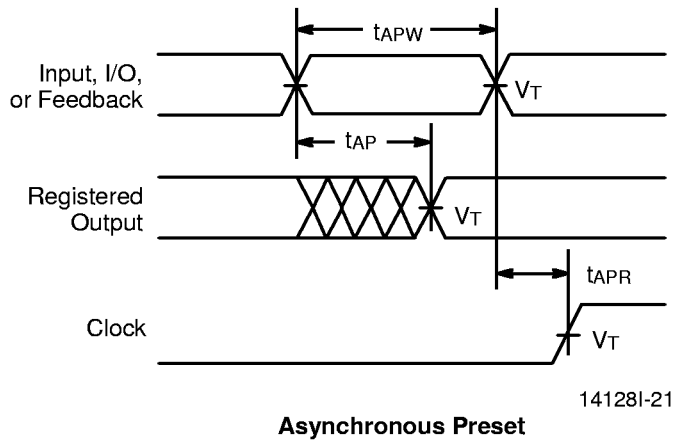
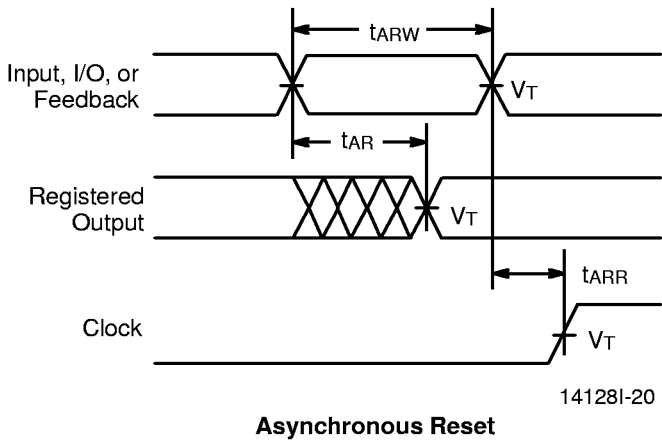
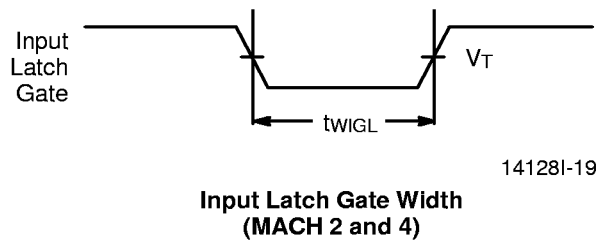
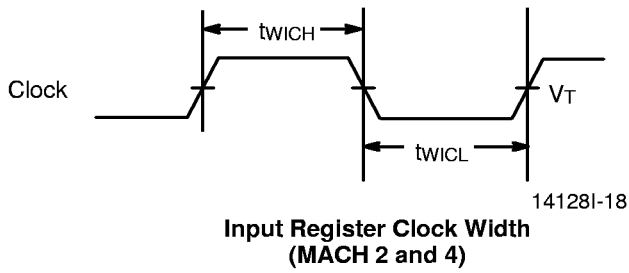


Latched Input and Output
(MACH 2, 3, and 4)

Notes:

1. $V_T = 1.5$ V.
2. Input pulse amplitude 0 V to 3.0 V.
3. Input rise and fall times 2 ns–4 ns typical.

SWITCHING WAVEFORMS



Notes:

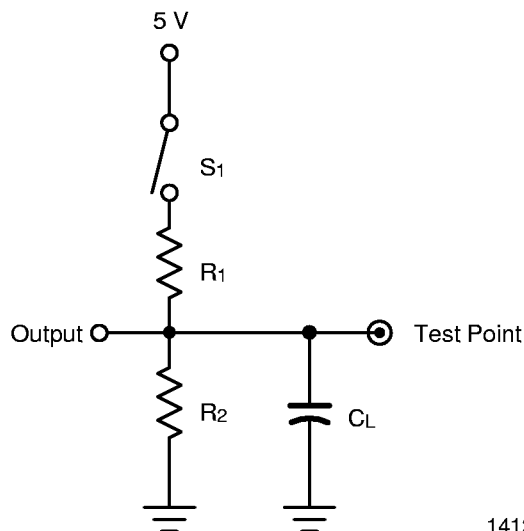
1. $V_T = 1.5 V$.
2. Input pulse amplitude 0 V to 3.0 V.
3. Input rise and fall times 2 ns–4 ns typical.

KEY TO SWITCHING WAVEFORMS

| WAVEFORM | INPUTS | OUTPUTS |
|----------|----------------------------------|---|
| | Must be Steady | Will be Steady |
| | May Change from H to L | Will be Changing from H to L |
| | May Change from L to H | Will be Changing from L to H |
| | Don't Care, Any Change Permitted | Changing, State Unknown |
| | Does Not Apply | Center Line is High-Impedance "Off" State |

KS000010-PAL

SWITCHING TEST CIRCUIT



14128I-23

| Specification | S ₁ | C _L | Commercial | | Measured Output Value |
|-----------------------------------|------------------------------|----------------|----------------|----------------|--|
| | | | R ₁ | R ₂ | |
| t _{PD} , t _{CO} | Closed | 35 pF | 300 Ω | 390 Ω | 1.5 V |
| t _{EA} | Z → H: Open Z → L: Closed | | | | 1.5 V |
| t _{ER} | H → Z: Open L → Z: Closed | 5 pF | | | H → Z: V _{OH} - 0.5 V L → Z: V _{OL} + 0.5 V |

*Switching several outputs simultaneously should be avoided for accurate measurement.

f_{MAX} PARAMETERS

The parameter f_{MAX} is the maximum clock rate at which the device is guaranteed to operate. Because the flexibility inherent in programmable logic devices offers a choice of clocked flip-flop designs, f_{MAX} is specified for three types of synchronous designs.

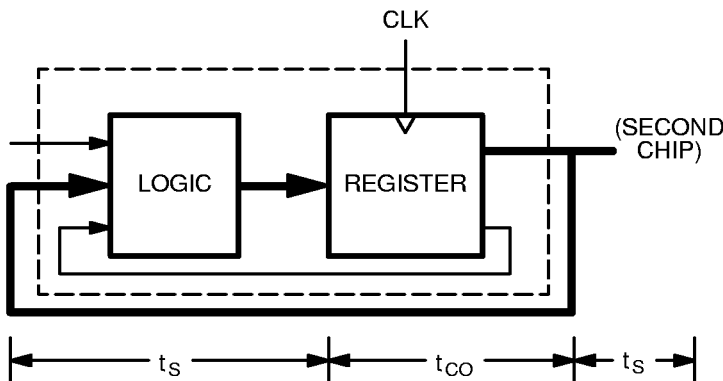
The first type of design is a state machine with feedback signals sent off-chip. This external feedback could go back to the device inputs, or to a second device in a multi-chip state machine. The slowest path defining the period is the sum of the clock-to-output time and the input setup time for the external signals ($t_s + t_{CO}$). The reciprocal, f_{MAX} , is the maximum frequency with external feedback or in conjunction with an equivalent speed device. This f_{MAX} is designated “ f_{MAX} external.”

The second type of design is a single-chip state machine with internal feedback only. In this case, flip-flop inputs are defined by the device inputs and flip-flop outputs. Under these conditions, the period is limited by the internal delay from the flip-flop outputs through the internal feedback and logic to the flip-flop inputs. This f_{MAX} is designated “ f_{MAX} internal”. A simple internal counter is a good example of this type of design; therefore, this parameter is sometimes called “ f_{CNT} .”

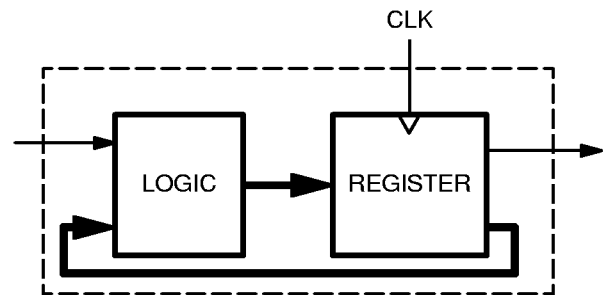
The third type of design is a simple data path application. In this case, input data is presented to the flip-flop and clocked through; no feedback is employed. Under these conditions, the period is limited by the sum of the data setup time and the data hold time ($t_s + t_H$). However, a lower limit for the period of each f_{MAX} type is the minimum clock period ($t_{WH} + t_{WL}$). Usually, this minimum clock period determines the period for the third f_{MAX} , designated “ f_{MAX} no feedback.”

For devices with input registers, one additional f_{MAX} parameter is specified: f_{MAXIR} . Because this involves no feedback, it is calculated the same way as f_{MAX} no feedback. The minimum period will be limited either by the sum of the setup and hold times ($t_{SIR} + t_{HIR}$) or the sum of the clock widths ($t_{WICL} + t_{WICH}$). The clock widths are normally the limiting parameters, so that f_{MAXIR} is specified as $1/(t_{WICL} + t_{WICH})$. Note that if both input and output registers are used in the same path, the overall frequency will be limited by t_{ICS} .

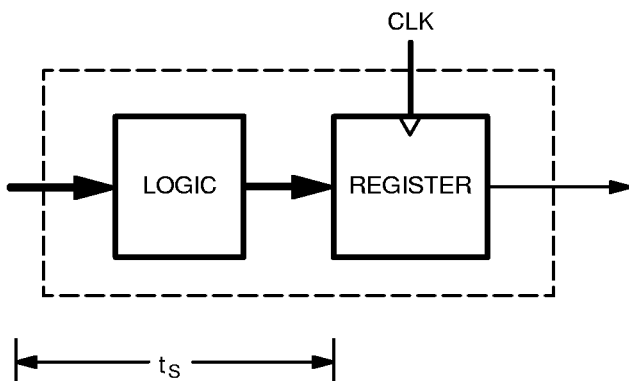
All frequencies except f_{MAX} internal are calculated from other measured AC parameters. f_{MAX} internal is measured directly.



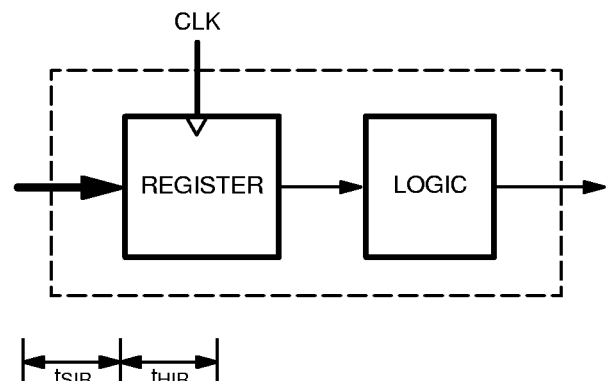
f_{MAX} External; $1/(t_s + t_{CO})$



f_{MAX} Internal (f_{CNT})



f_{MAX} No Feedback; $1/(t_s + t_H)$ or $1/(t_{WH} + t_{WL})$



f_{MAXIR} ; $1/(t_{SIR} + t_{HIR})$ or $1/(t_{WICL} + t_{WICH})$

ENDURANCE CHARACTERISTICS

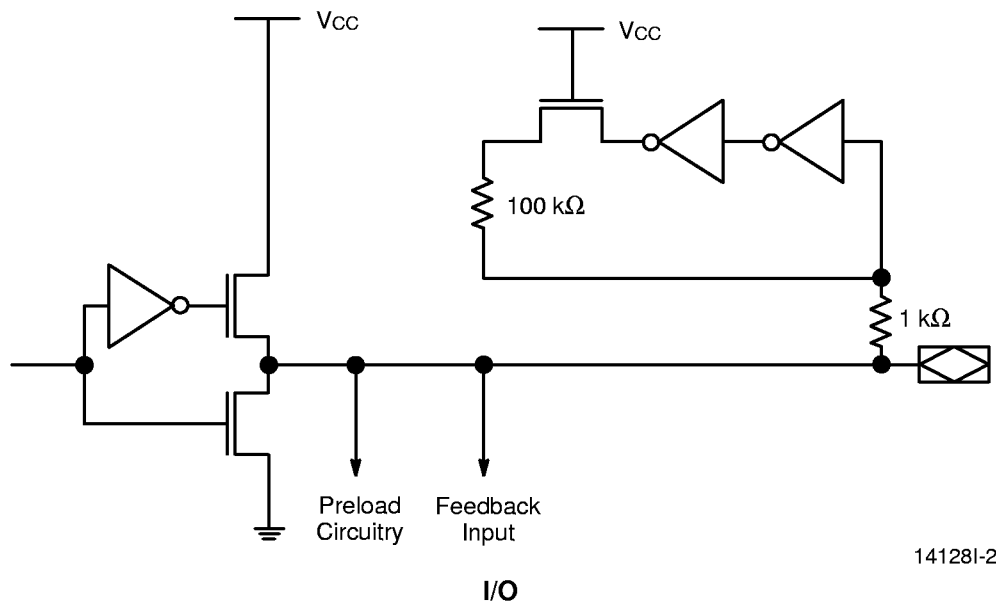
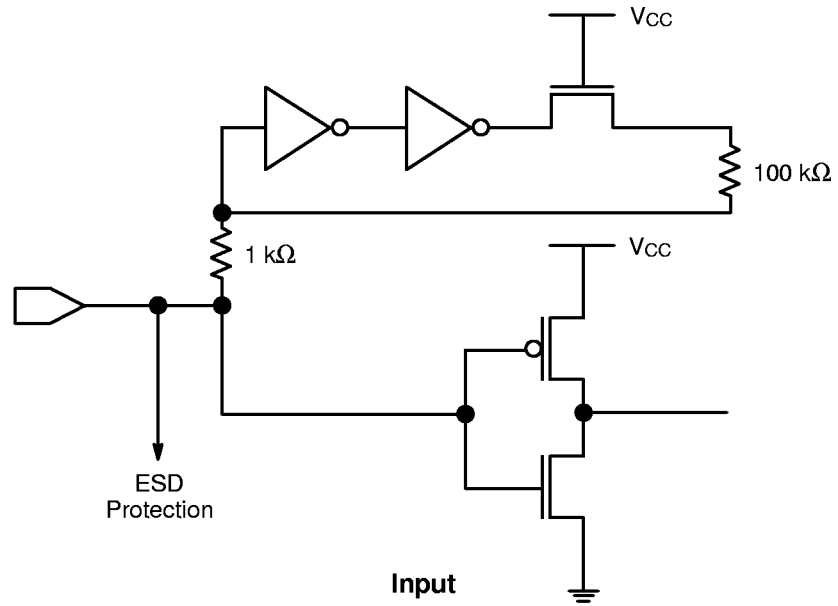
The MACH families are manufactured using our advanced Electrically Erasable process. This technology uses an EE cell to replace the fuse link used in

bipolar parts. As a result, the device can be erased and reprogrammed, a feature which allows 100% testing at the factory.

Endurance Characteristics

| Parameter Symbol | Parameter Description | Min | Units | Test Conditions |
|------------------|---------------------------------|-----|--------|-------------------------------|
| t _{DR} | Min Pattern Data Retention Time | 10 | Years | Max Storage Temperature |
| | | 20 | Years | Max Operating Temperature |
| N | Max Reprogramming Cycles | 100 | Cycles | Normal Programming Conditions |

INPUT/OUTPUT EQUIVALENT SCHEMATICS



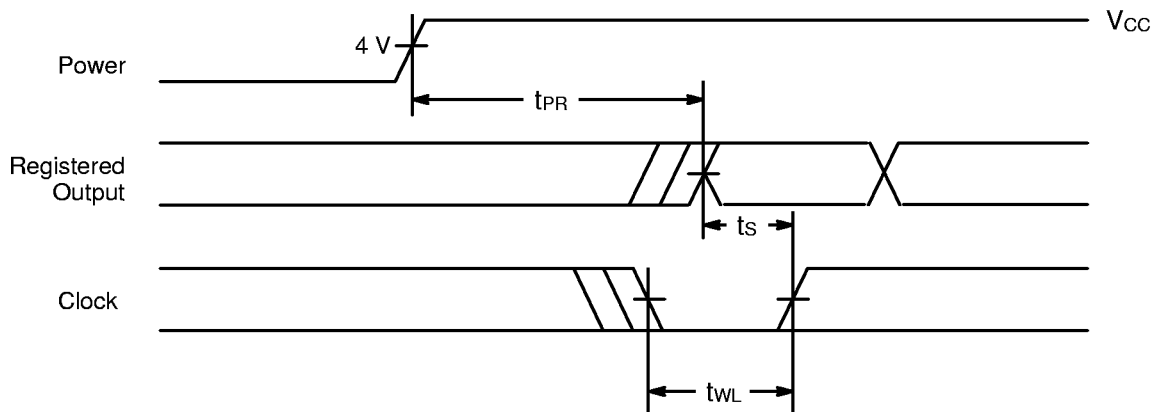
POWER-UP RESET

The MACH devices have been designed with the capability to reset during system power-up. Following power-up, all flip-flops will be reset to LOW. The output state will depend on the logic polarity. This feature provides extra flexibility to the designer and is especially valuable in simplifying state machine initialization. A timing diagram and parameter table are shown below. Due to the synchronous operation of the power-up reset and the

wide range of ways V_{CC} can rise to its steady state, two conditions are required to insure a valid power-up reset. These conditions are:

1. The V_{CC} rise must be monotonic.
2. Following reset, the clock input must not be driven from LOW to HIGH until all applicable input and feedback setup times are met.

| Parameter Symbol | Parameter Descriptions | Max | Unit |
|------------------|------------------------------|-------------------------------|---------|
| t_{PR} | Power-Up Reset Time | 10 | μs |
| t_s | Input or Feedback Setup Time | See Switching Characteristics | |
| t_{WL} | Clock Width LOW | | |



141281-26

Power-Up Reset Waveform

USING PRELOAD AND OBSERVABILITY

In order to be testable, a circuit must be both controllable and observable. To achieve this, the MACH devices incorporate register preload and observability.

In preload mode, each flip-flop in the MACH device can be loaded from the I/O pins, in order to perform functional testing of complex state machines. Register preload makes it possible to run a series of tests from a known starting state, or to load illegal states and test for proper recovery. This ability to control the MACH device's internal state can shorten test sequences, since it is easier to reach the state of interest.

The observability function makes it possible to see the internal state of the buried registers during test by overriding each register's output enable and activating the output buffer. The values stored in output and buried registers can then be observed on the I/O pins. Without this feature, a thorough functional test would be impossible for any designs with buried registers.

While the implementation of the testability features is fairly straightforward, care must be taken in certain instances to insure valid testing.

One case involves asynchronous reset and preset. If the MACH registers drive asynchronous reset or preset lines and are preloaded in such a way that reset or preset are asserted, the reset or preset may remove the preloaded data. This is illustrated in Figure 2. Care should be taken when planning functional tests, so that states that will cause unexpected resets and presets are not preloaded.

Another case to be aware of arises in testing combinatorial logic. When an output is configured as combinatorial, the observability feature forces the output into registered mode. When this happens, all product terms are forced to zero, which eliminates all combinatorial data. For a straight combinatorial output, the correct value will be restored after the preload or observe function, and there will be no problem. If the function implements a combinatorial latch, however, it relies on feedback to hold the correct value, as shown in Figure 3. As this value may change during the preload or observe operation, you cannot count on the data being correct after the operation. To insure valid testing in these cases, outputs that are combinatorial latches should not be tested immediately following a preload or observe sequence, but should first be restored to a known state.

All MACH 2 devices support both preload and observability.

Contact individual programming vendors in order to verify programmer support.

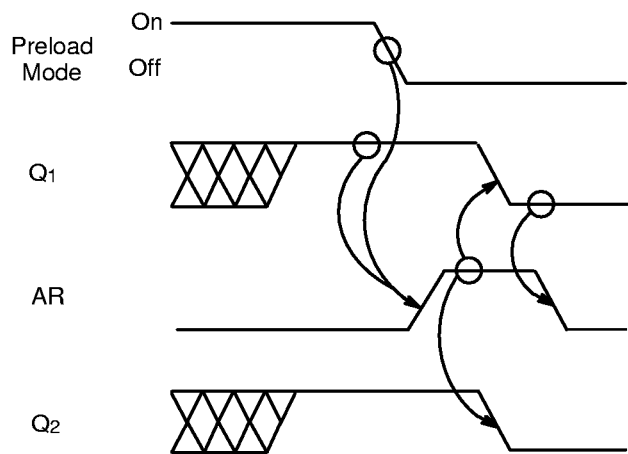
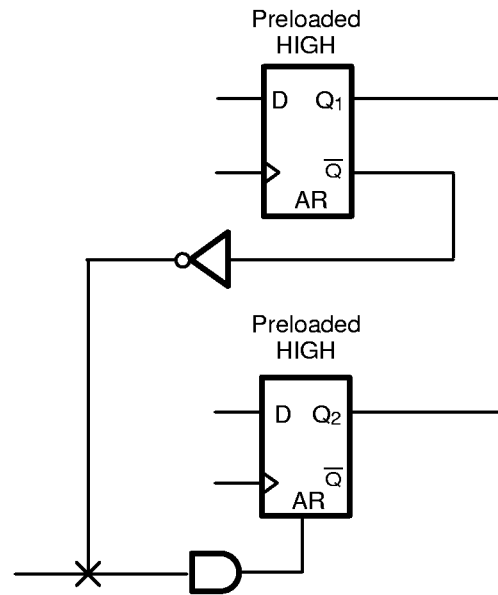


Figure 2. Preload/Reset Conflict

141281-27

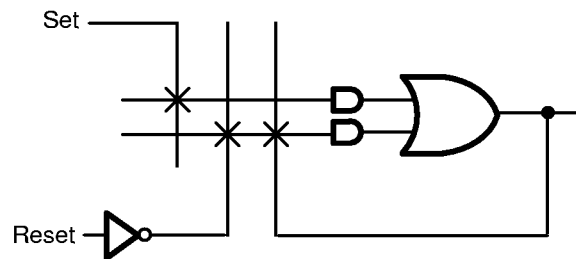


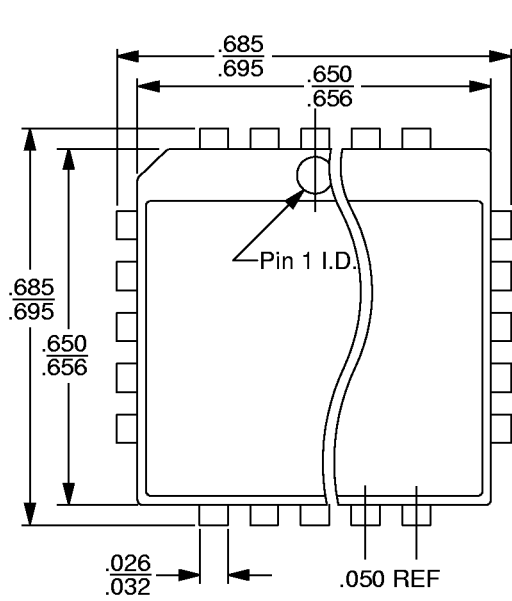
Figure 3. Combinatorial Latch

141281-28

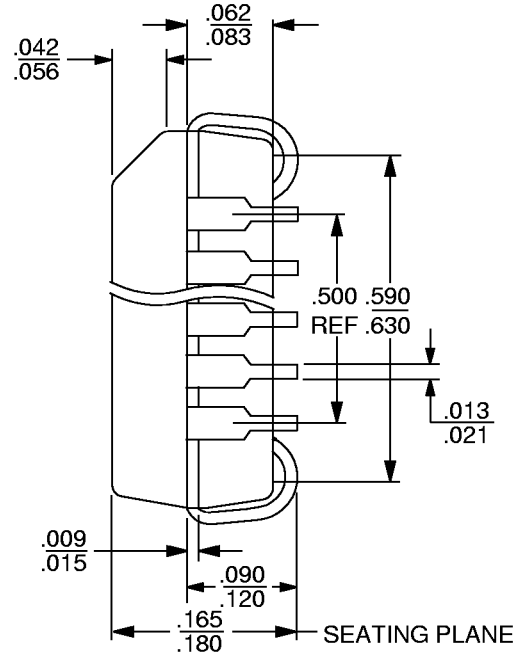
PHYSICAL DIMENSIONS*

PL 044

44-Pin Plastic Leaded Chip Carrier (measured in inches)



TOP VIEW



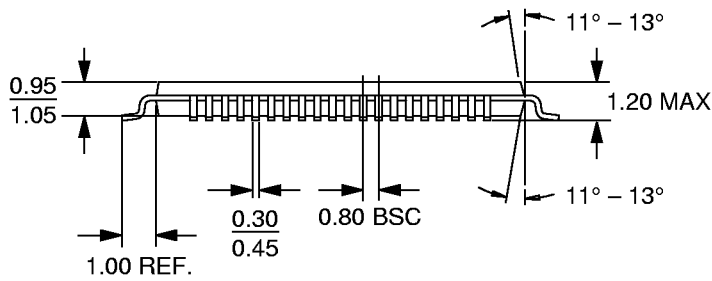
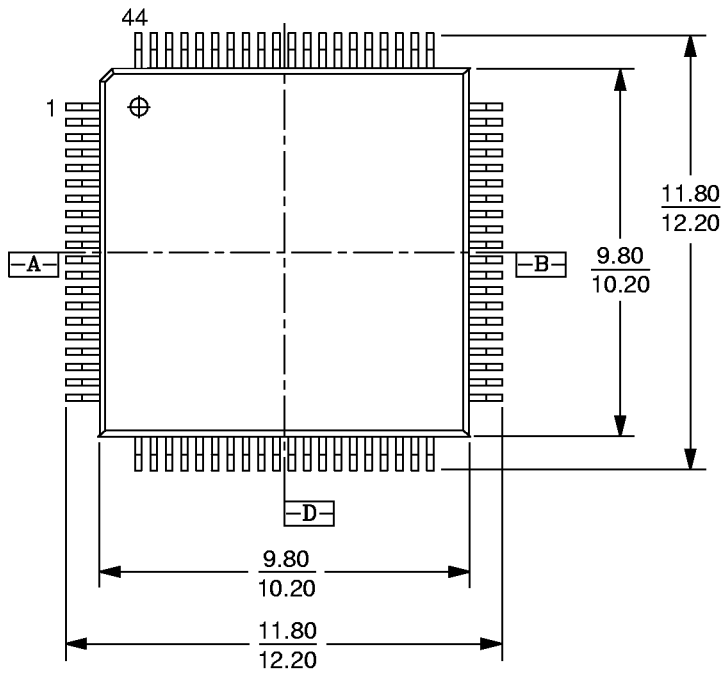
SIDE VIEW

16-038-SQ
PL 044
DA78
6-28-94 ae

PHYSICAL DIMENSIONS*

PQT044

44-Pin Thin Quad Flat Pack (measured in millimeters)



16-038-PQT-2_AH
PQT 44
5-4-95 ae

*For reference only. BSC is an ANSI standard for Basic Space Centering.