



FlashLock

# Automotive ProASIC3 Flash Family FPGAs

## Features and Benefits

### High-Temperature AEC-Q100-Qualified Devices

- Grade 2 105°C T<sub>A</sub> (115°C T<sub>J</sub>)
- Grade 1 125°C T<sub>A</sub> (135°C T<sub>J</sub>)
- PPAP Documentation

### Firm-Error Immune

- Only Automotive FPGAs to Offer Firm-Error Immunity
- Can Be Used without Configuration Upset Risk

### High Capacity

- 60 k to 1 M System Gates
- Up to 144 kbits of SRAM
- Up to 300 User I/Os

### Reprogrammable Flash Technology

- 130-nm, 7-Layer Metal (6 Copper), Flash-Based CMOS Automotive Process
- Live-at-Power-Up (LAPU) Level 0 Support
- Single-Chip Solution
- Retains Programmed Design when Powered Off

### On-Chip User Nonvolatile Memory

- 1 kbit of FlashROM with Synchronous Interface

### High Performance

- 350 MHz System Performance
- 3.3 V, 66 MHz 64-Bit PCI

### In-System Programming (ISP) and Security

- Secure ISP Using On-Chip 128-Bit Advanced Encryption Standard (AES) Decryption via JTAG (IEEE 1532-compliant)
- FlashLock® to Secure FPGA Contents (anti-tampering)

### Low Power

- 1.5 V Core Voltage
- Support for 1.5-V-Only Systems
- Low-Impedance Flash Switches

### High-Performance Routing Hierarchy

- Segmented, Hierarchical Routing and Clock Structure
- High-Performance, Low-Skew Global Network
- Architecture Supports Ultra-High Utilization

### Advanced I/O

- 700 Mbps DDR, LVDS-Capable I/Os
- 1.5 V, 1.8 V, 2.5 V, and 3.3 V Mixed-Voltage Operation
- Bank-Selectable I/O Voltages—up to 4 Banks per Chip
- Single-Ended I/O Standards: LVTTTL, LVCMOS 3.3 V / 2.5 V / 1.8 V / 1.5 V, 3.3 V PCI / 3.3 V PCI-X, and LVCMOS 2.5 V / 5.0 V Input
- Differential I/O Standards: LVPECL, LVDS, B-LVDS, and M-LVDS (A3P250 and A3P1000)
- I/O Registers on Input, Output, and Enable Paths
- Hot-Swappable and Cold-Sparing I/Os
- Programmable Output Slew Rate and Drive Strength
- Weak Pull-Up/-Down
- IEEE 1149.1 (JTAG) Boundary Scan Test
- Pin-Compatible Packages across the Automotive ProASIC®3 Family

### Clock Conditioning Circuit (CCC) and PLL

- Six CCC Blocks, One with an Integrated PLL
- Configurable Phase Shift, Multiply/Divide, Delay Capabilities, and External Feedback
- Wide Input Frequency Range (1.5 MHz up to 350 MHz)

### SRAMs

- Variable-Aspect-Ratio 4,608-Bit RAM Blocks (x1, x2, x4, x9, and x18 organizations available)

## Automotive ProASIC3 Product Family

| ProASIC3 Devices          | A3P060 | A3P125 | A3P250       | A3P1000             |
|---------------------------|--------|--------|--------------|---------------------|
| System Gates              | 60 k   | 125 k  | 250 k        | 1 M                 |
| VersaTiles (D-flip-flops) | 1,536  | 3,072  | 6,144        | 24,576              |
| RAM kbits (1,024 bits)    | 18     | 36     | 36           | 144                 |
| 4,608-Bit Blocks          | 4      | 8      | 8            | 32                  |
| FlashROM Bits             | 1 k    | 1 k    | 1 k          | 1 k                 |
| Secure (AES) ISP          | Yes    | Yes    | Yes          | Yes                 |
| Integrated PLL in CCCs    | 1      | 1      | 1            | 1                   |
| VersaNet Globals*         | 18     | 18     | 18           | 18                  |
| I/O Banks                 | 2      | 2      | 4            | 4                   |
| Maximum User I/Os         | 96     | 133    | 157          | 300                 |
| Package Pins              |        |        |              |                     |
| VQFP                      | VQ100  | VQ100  | VQ100        |                     |
| FBGA                      | FG144  | FG144  | FG144, FG256 | FG144, FG256, FG484 |

Note: \*Six chip-wide (main) globals and three additional global networks in each quadrant are available.

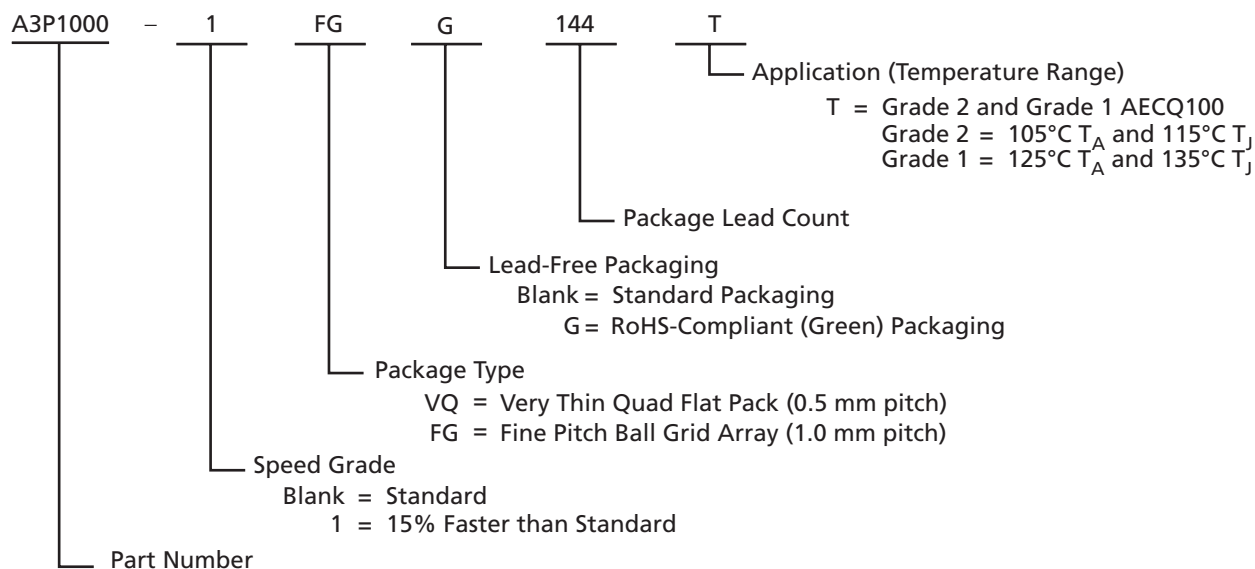
## I/Os Per Package

| ProASIC3 Devices | A3P060           | A3P125           | A3P250                        |                        | A3P1000                       |                        |
|------------------|------------------|------------------|-------------------------------|------------------------|-------------------------------|------------------------|
| Package          | I/O Type         |                  |                               |                        |                               |                        |
|                  | Single-Ended I/O | Single-Ended I/O | Single-Ended I/O <sup>2</sup> | Differential I/O Pairs | Single-Ended I/O <sup>2</sup> | Differential I/O Pairs |
| VQ100            | 71               | 71               | 68                            | 13                     | –                             | –                      |
| FG144            | 96               | 97               | 97                            | 24                     | 97                            | 25                     |
| FG256            | –                | –                | 157                           | 38                     | 177                           | 44                     |
| FG484            | –                | –                | –                             | –                      | 300                           | 74                     |

### Notes:

1. When considering migrating your design to a lower- or higher-density device, refer to the [ProASIC3 Flash Family FPGAs handbook](#) to ensure complying with design and board migration requirements.
2. Each used differential I/O pair reduces the number of available single-ended I/Os by two.
3. FG256 and FG484 are footprint-compatible packages.

## Automotive ProASIC3 Ordering Information



### Automotive ProASIC3 Devices

A3P060 = 60,000 System Gates  
 A3P125 = 125,000 System Gates  
 A3P250 = 250,000 System Gates  
 A3P1000 = 1,000,000 System Gates

**Note:** Minimum order quantities apply. Contact your local Actel sales office for details.

## Temperature Grade Offerings

| Package | A3P060  | A3P125  | A3P250  | A3P1000 |
|---------|---------|---------|---------|---------|
| VQ100   | C, I, T | C, I, T | C, I, T | –       |
| FG144   | C, I, T | C, I, T | C, I, T | C, I, T |
| FG256   | –       | –       | C, I, T | C, I, T |
| FG484   | –       | –       | –       | C, I, T |

### Notes:

1. C = Commercial temperature range: 0°C to 70°C
2. I = Industrial temperature range: –40°C to 85°C
3. T = Automotive temperature range: Grade 2 and Grade 1 AEC-Q100  
Grade 2 = 105°C  $T_A$  and 115°C  $T_J$   
Grade 1 = 125°C  $T_A$  and 135°C  $T_J$
4. Specifications for Commercial and Industrial grade devices can be found in the [ProASIC3 Flash Family FPGAs handbook](#).

## Speed Grade and Temperature Grade Matrix

| Temperature Grade                               | Std. | –1 |
|-------------------------------------------------|------|----|
| T (Grade 1 and Grade 2), Commercial, Industrial | ✓    | ✓  |

### Notes:

1. T = Automotive temperature range: Grade 2 and Grade 1 AEC-Q100  
Grade 2 = 105°C  $T_A$  and 115°C  $T_J$   
Grade 1 = 125°C  $T_A$  and 135°C  $T_J$
2. Specifications for Commercial and Industrial grade devices can be found in the [ProASIC3 Flash Family FPGAs handbook](#).

Contact your local Actel representative for device availability:

<http://www.actel.com/contact/default.aspx>.



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# 1 – Automotive ProASIC3 Device Family Overview

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## General Description

Automotive ProASIC3 nonvolatile flash technology gives automotive system designers the advantage of a secure, low-power, single-chip solution that is live at power-up (LAPU). Automotive ProASIC3 is reprogrammable and offers time-to-market benefits at an ASIC-level unit cost. These features enable designers to create high-density systems using existing ASIC or FPGA design flows and tools.

Automotive ProASIC3 devices offer 1 kbit of on-chip, reprogrammable, nonvolatile FlashROM storage as well as clock conditioning circuitry based on an integrated phase-locked loop (PLL). Automotive ProASIC3 devices have up to 1 million system gates, supported with up to 144 kbits of SRAM and up to 300 user I/Os.

Automotive ProASIC3 devices are the only firm-error-immune automotive grade FPGAs. Firm-error immunity makes them ideally suited for demanding applications in powertrain, safety, and telematics-based subsystems, where firm-error failure is not an option.

Firm errors in SRAM-based FPGAs can result in high defect levels in field-deployed systems. These unavoidable defects must be considered separately from standard defects and failure mechanisms when looking at overall system quality and reliability.

## Flash Advantages

### *Reduced Cost of Ownership*

Advantages to the designer extend beyond low unit cost, performance, and ease of use. Unlike SRAM-based FPGAs, flash-based Automotive ProASIC3 devices allow all functionality to be live at power-up; no external boot PROM is required. On-board security mechanisms prevent access to all the programming information and enable secure remote updates of the FPGA logic. Flash-based FPGAs are LAPU Class 0 devices, offering the lowest available power in a single-chip device and providing firm-error immunity. The Automotive ProASIC3 family device architecture mitigates the need for ASIC migration at high user volumes. This makes the Automotive ProASIC3 family a cost-effective ASIC replacement solution, especially for automotive applications.

### *Security*

The nonvolatile, flash-based Automotive ProASIC3 devices do not require a boot PROM, so there is no vulnerable external bitstream that can be easily copied. Automotive ProASIC3 devices incorporate FlashLock, which provides a unique combination of reprogrammability and design security without external overhead, advantages that only an FPGA with nonvolatile flash programming can offer.

Automotive ProASIC3 devices utilize a 128-bit flash-based lock and a separate AES key to secure programmed intellectual property and configuration data. In addition, all FlashROM data in Automotive ProASIC3 devices can be encrypted prior to loading, using the industry-leading AES-128 (FIPS192) bit block cipher encryption standard. The AES was adopted by the National Institute of Standards and Technology (NIST) in 2000 and replaces the 1977 DES standard. Automotive ProASIC3 devices have a built-in AES decryption engine and a flash-based AES key that make them the most comprehensive programmable logic device security solution available today. Automotive ProASIC3 devices with AES-based security allow for secure, remote field updates over public networks such as the Internet, and ensure that valuable IP remains out of the hands of system overbuilders, system cloners, and IP thieves. The contents of a programmed Automotive ProASIC3 device cannot be read back, although secure design verification is possible. Additionally, security features of Automotive ProASIC3 devices provide anti-tampering protection.

Security, built into the FPGA fabric, is an inherent component of the Automotive ProASIC3 family. The flash cells are located beneath seven metal layers, and many device design and layout

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techniques have been used to make invasive attacks extremely difficult. The Automotive ProASIC3 family, with FlashLock and AES security, is unique in being highly resistant to both invasive and noninvasive attacks. Your valuable IP is protected and secure. An Automotive ProASIC3 device provides the most impenetrable security for programmable logic designs.

### ***Single Chip***

Flash-based FPGAs store their configuration information in on-chip flash cells. Once programmed, the configuration data is an inherent part of the FPGA structure, and no external configuration data needs to be loaded at system power-up (unlike SRAM-based FPGAs). Therefore, flash-based Automotive ProASIC3 FPGAs do not require system configuration components such as EEPROMs or microcontrollers to load device configuration data. This reduces bill-of-materials costs and PCB area, and increases security and system reliability.

### ***Live at Power-Up***

The Actel flash-based Automotive ProASIC3 devices support Level 0 of the LAPU classification standard. This feature helps in system component initialization, execution of critical tasks before the processor wakes up, setup and configuration of memory blocks, clock generation, and bus activity management. The LAPU feature of flash-based Automotive ProASIC3 devices greatly simplifies total system design and reduces total system cost, often eliminating the need for CPLDs and external clock generation PLLs. In addition, glitches and brownouts in system power will not corrupt the Automotive ProASIC3 device's flash configuration, and unlike SRAM-based FPGAs, the device will not have to be reloaded when system power is restored. This enables the reduction or complete removal of the configuration PROM, expensive voltage monitor, brownout detection, and clock generator devices from the PCB design. Flash-based Automotive ProASIC3 devices simplify total system design and reduce cost and design risk while increasing system reliability and improving system initialization time.

### ***Firm-Error Immunity***

Firm errors occur most commonly when high-energy neutrons, generated in the upper atmosphere, strike a configuration cell of an SRAM FPGA. The energy of the collision can change the state of the configuration cell and thus change the logic, routing, or I/O behavior in an unpredictable way. These errors are impossible to prevent in SRAM FPGAs. The consequence of this type of error can be a complete system failure. Firm errors do not exist in the configuration memory of Automotive ProASIC3 flash-based FPGAs. Once it is programmed, the flash cell configuration element of Automotive ProASIC3 FPGAs cannot be altered by high-energy neutrons and is therefore immune to them. Recoverable (or soft) errors occur in the user data SRAM of all FPGA devices. These can easily be mitigated by using error detection and correction (EDAC) circuitry built into the FPGA fabric.

### ***Low Power***

Flash-based Automotive ProASIC3 devices exhibit very low power characteristics, similar to those of an ASIC, making them an ideal choice for power-sensitive applications. Automotive ProASIC3 devices have only a very limited power-on current surge and no high-current transition period, both of which occur on many FPGAs.

Automotive ProASIC3 devices also have low dynamic power consumption to further maximize power savings.

## Advanced Flash Technology

The Automotive ProASIC3 family offers many benefits, including nonvolatility and reprogrammability, through an advanced flash-based, 130-nm LVC MOS process with seven layers of metal. Standard CMOS design techniques are used to implement logic and control functions. The combination of fine granularity, enhanced flexible routing resources, and abundant flash switches allows for very high logic utilization without compromising device routability or performance. Logic functions within the device are interconnected through a four-level routing hierarchy.

## Advanced Architecture

The proprietary Automotive ProASIC3 architecture provides granularity comparable to standard-cell ASICs. The Automotive ProASIC3 device consists of five distinct and programmable architectural features ([Figure 1-1 on page 1-4](#) and [Figure 1-2 on page 1-4](#)):

- FPGA VersaTiles
- Dedicated FlashROM
- Dedicated SRAM memory
- Extensive CCCs and PLLs
- Advanced I/O structure

The FPGA core consists of a sea of VersaTiles. Each VersaTile can be configured as a three-input logic function, a D-flip-flop (with or without enable), or a latch by programming the appropriate flash switch interconnections. The versatility of the Automotive ProASIC3 core tile as either a three-input lookup table (LUT) equivalent or a D-flip-flop/latch with enable allows for efficient use of the FPGA fabric. The VersaTile capability is unique to the Actel ProASIC family of third-generation-architecture flash FPGAs. VersaTiles are connected with any of the four levels of routing hierarchy. Flash switches are distributed throughout the device to provide nonvolatile, reconfigurable interconnect programming. Maximum core utilization is possible for virtually any design.

In addition, extensive on-chip programming circuitry allows for rapid, single-voltage (3.3 V) programming of Automotive ProASIC3 devices via an IEEE 1532 JTAG interface.

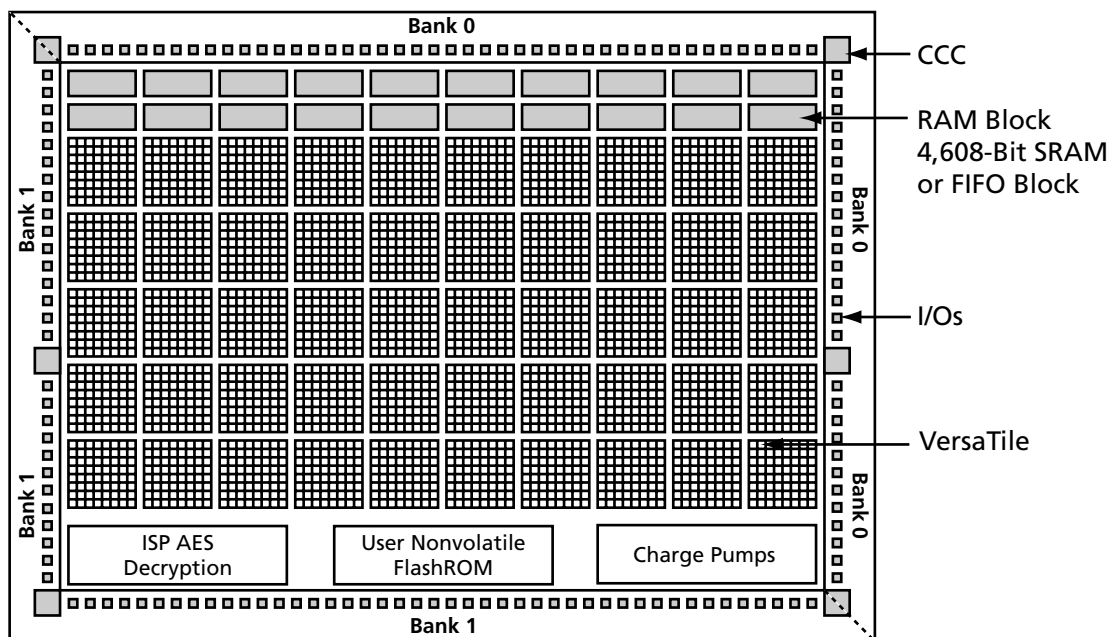


Figure 1-1 • Automotive ProASIC3 Device Architecture Overview with Two I/O Banks (A3P060 and A3P125)

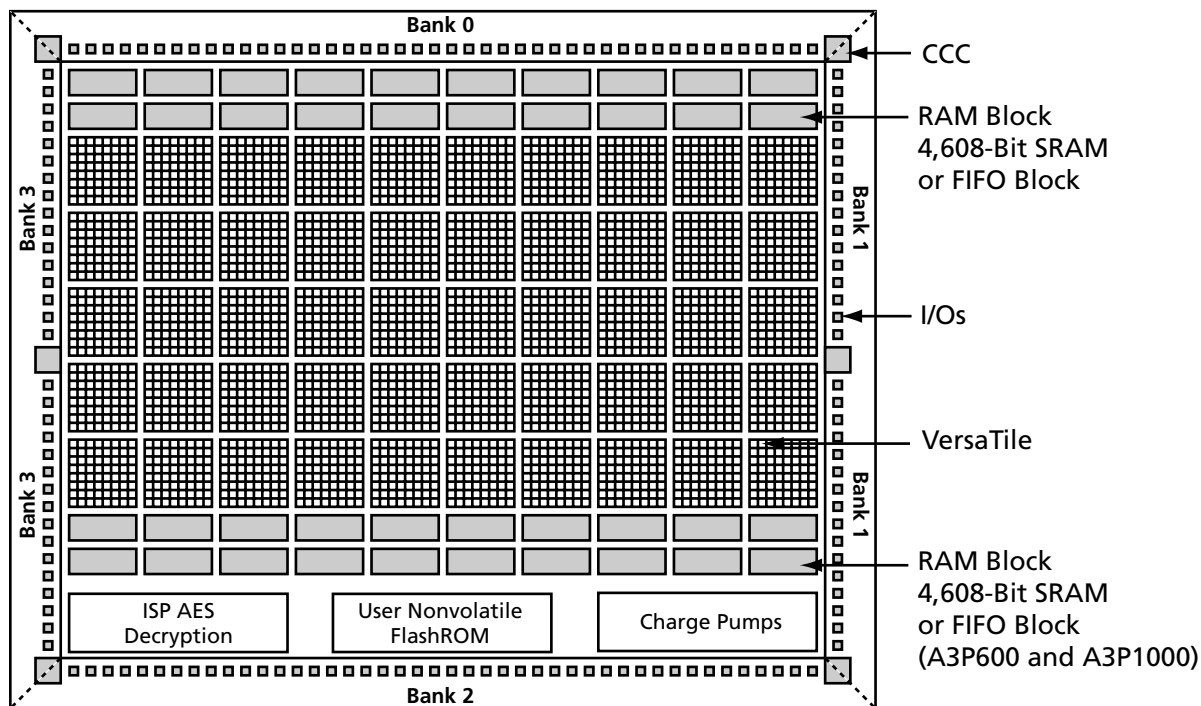


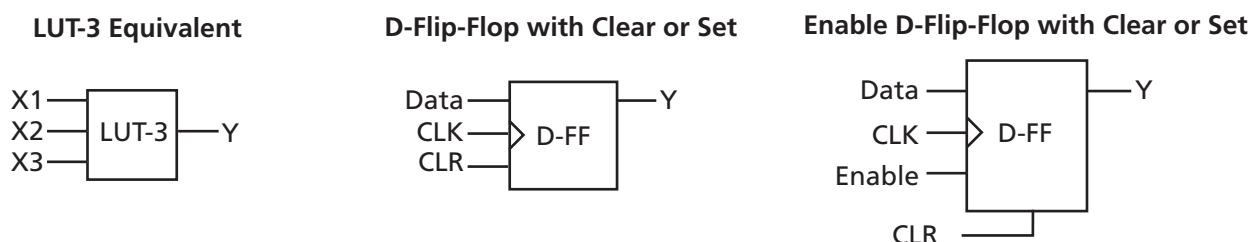
Figure 1-2 • Automotive ProASIC3 Device Architecture Overview with Four I/O Banks (A3P600 and A3P1000)

## VersaTiles

The Automotive ProASIC3 core consists of VersaTiles, which have been enhanced beyond the ProASIC<sup>PLUS</sup>® core tiles. The Automotive ProASIC3 VersaTile supports the following:

- All 3-input logic functions—LUT-3 equivalent
- Latch with clear or set
- D-flip-flop with clear or set
- Enable D-flip-flop with clear or set

Refer to [Figure 1-3](#) for VersaTile configurations.



**Figure 1-3 • VersaTile Configurations**

## User Nonvolatile FlashROM

Actel Automotive ProASIC3 devices have 1 kbit of on-chip, user-accessible, nonvolatile FlashROM. The FlashROM can be used in diverse system applications:

- Unique protocol addressing (wireless or fixed)
- System calibration settings
- Device serialization and/or inventory control
- Subscription-based business models (for example, infotainment systems)
- Secure key storage for secure communications algorithms
- Asset management/tracking
- Date stamping
- Version management

The FlashROM is written using the standard Automotive ProASIC3 IEEE 1532 JTAG programming interface.

The FlashROM can be programmed via the JTAG programming interface, and its contents can be read back either through the JTAG programming interface or via direct FPGA core addressing. Note that the FlashROM can only be programmed from the JTAG interface and cannot be programmed from the internal logic array.

The FlashROM is programmed as 8 banks of 128 bits; however, reading is performed on a byte-by-byte basis using a synchronous interface. A 7-bit address from the FPGA core defines which of the 8 banks and which of the 16 bytes within that bank are being read. The three most significant bits (MSBs) of the FlashROM address determine the bank, and the four least significant bits (LSBs) of the FlashROM address define the byte.

The Actel Automotive ProASIC3 development software solutions, Libero® Integrated Design Environment (IDE) and Designer, have extensive support for the FlashROM. One such feature is auto-generation of sequential programming files for applications requiring a unique serial number in each part. Another feature allows the inclusion of static data for system version control. Data for the FlashROM can be generated quickly and easily using Actel Libero IDE and Designer software tools. Comprehensive programming file support is also included to allow for easy programming of large numbers of parts with differing FlashROM contents.

## **SRAM**

Automotive ProASIC3 devices have embedded SRAM blocks along their north and south sides. Each variable-aspect-ratio SRAM block is 4,608 bits in size. Available memory configurations are 256×18, 512×9, 1k×4, 2k×2, and 4k×1 bits. The individual blocks have independent read and write ports that can be configured with different bit widths on each port. For example, data can be sent through a 4-bit port and read as a single bitstream. The embedded SRAM blocks can be initialized via the device JTAG port (ROM emulation mode) using the UJTAG macro.

## **PLL and CCC**

Automotive ProASIC3 devices provide designers with very flexible clock conditioning circuit (CCC) capabilities. Each member of the Automotive ProASIC3 family contains six CCCs. One CCC (center west side) has a PLL.

The six CCC blocks are located at the four corners and the centers of the east and west sides. One CCC (center west side) has a PLL.

All six CCC blocks are usable; the four corner CCCs and the east CCC allow simple clock delay operations as well as clock spine access.

The inputs of the six CCC blocks are accessible from the FPGA core or from one of several inputs located near the CCC that have dedicated connections to the CCC block.

The CCC block has these key features:

- Wide input frequency range ( $f_{IN\_CCC}$ ) = 1.5 MHz to 350 MHz
- Output frequency range ( $f_{OUT\_CCC}$ ) = 0.75 MHz to 350 MHz
- Clock delay adjustment via programmable and fixed delays from –7.56 ns to +11.12 ns
- 2 programmable delay types for clock skew minimization
- Clock frequency synthesis (for PLL only)

Additional CCC specifications:

- Internal phase shift = 0°, 90°, 180°, and 270°. Output phase shift depends on the output divider configuration (for PLL only).
- Output duty cycle = 50% ± 1.5% or better (for PLL only)
- Low output jitter: worst case < 2.5% × clock period peak-to-peak period jitter when single global network used (for PLL only)
- Maximum acquisition time is 300 μs (for PLL only)
- Low power consumption of 5 mW
- Exceptional tolerance to input period jitter— allowable input jitter is up to 1.5 ns (for PLL only)
- Four precise phases; maximum misalignment between adjacent phases of 40 ps × 350 MHz /  $f_{OUT\_CCC}$  (for PLL only)

## **Global Clocking**

Automotive ProASIC3 devices have extensive support for multiple clocking domains. In addition to the CCC and PLL support described above, there is a comprehensive global clock distribution network.

Each VersaTile input and output port has access to nine VersaNets: six chip (main) and three quadrant global networks. The VersaNets can be driven by the CCC or directly accessed from the core via multiplexers (MUXes). The VersaNets can be used to distribute low-skew clock signals or for rapid distribution of high-fanout nets.

## **I/Os with Advanced I/O Standards**

The Automotive ProASIC3 family of FPGAs features a flexible I/O structure, supporting a range of voltages (1.5 V, 1.8 V, 2.5 V, and 3.3 V). Automotive ProASIC3 FPGAs support many different I/O standards—single-ended and differential.

The I/Os are organized into banks, with two or four banks per device. The configuration of these banks determines the I/O standards supported.

Each I/O module contains several input, output, and enable registers. These registers allow the implementation of the following:

- Single-Data-Rate applications
- Double-Data-Rate applications—DDR LVDS, B-LVDS, and M-LVDS I/Os for point-to-point communications

Automotive ProASIC3 banks for the A3P250 and A3P1000 devices support LVPECL, LVDS, B-LVDS, and M-LVDS. B-LVDS and M-LVDS can support up to 20 loads.

## **Part Number and Revision Date**

Part Number 51700099-001-0

Revised January 2008

## Datasheet Categories

### ***Categories***

In order to provide the latest information to designers, some datasheets are published before data has been fully characterized. Datasheets are designated as "Product Brief," "Advance," "Preliminary," and "Production." The definition of these categories are as follows:

### ***Product Brief***

The product brief is a summarized version of a datasheet (advance or production) and contains general product information. This document gives an overview of specific device and family information.

### ***Advance***

This version contains initial estimated information based on simulation, other products, devices, or speed grades. This information can be used as estimates, but not for production. This label only applies to the DC and Switching Characteristics chapter of the datasheet and will only be used when the data has not been fully characterized.

### ***Preliminary***

The datasheet contains information based on simulation and/or initial characterization. The information is believed to be correct, but changes are possible.

### ***Unmarked (production)***

This version contains information that is considered to be final.

## **Export Administration Regulations (EAR)**

The products described in this document are subject to the Export Administration Regulations (EAR). They could require an approved export license prior to export from the United States. An export includes release of product or disclosure of technology to a foreign national inside or outside the United States.

## **Actel Safety Critical, Life Support, and High-Reliability Applications Policy**

The Actel products described in this advance status document may not have completed Actel's qualification process. Actel may amend or enhance products during the product introduction and qualification process, resulting in changes in device functionality or performance. It is the responsibility of each customer to ensure the fitness of any Actel product (but especially a new product) for a particular purpose, including appropriateness for safety-critical, life-support, and other high-reliability applications. Consult Actel's Terms and Conditions for specific liability exclusions relating to life-support applications. A reliability report covering all of Actel's products is available on the Actel website at [http://www.actel.com/documents/ORT\\_Report.pdf](http://www.actel.com/documents/ORT_Report.pdf). Actel also offers a variety of enhanced qualification and lot acceptance screening procedures. Contact your local Actel sales office for additional reliability information.



## 2 – Automotive ProASIC3 DC and Switching Characteristics

### General Specifications

#### Operating Conditions

Stresses beyond those listed in [Table 2-1](#) may cause permanent damage to the device.

Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Absolute Maximums are stress ratings only; functional operation of the device at these or any other conditions beyond those listed under the Recommended Operating Conditions specified in [Table 2-2 on page 2-2](#) is not implied.

**Table 2-1 • Absolute Maximum Ratings**

| Symbol                        | Parameter                           | Limits                                                                                                                                                                        | Units |
|-------------------------------|-------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| V <sub>CC</sub>               | DC core supply voltage              | –0.3 to 1.65                                                                                                                                                                  | V     |
| V <sub>JTAG</sub>             | JTAG DC voltage                     | –0.3 to 3.75                                                                                                                                                                  | V     |
| V <sub>PUMP</sub>             | Programming voltage                 | –0.3 to 3.75                                                                                                                                                                  | V     |
| V <sub>CCPLL</sub>            | Analog power supply (PLL)           | –0.3 to 1.65                                                                                                                                                                  | V     |
| V <sub>CCI</sub>              | DC I/O output buffer supply voltage | –0.3 to 3.75                                                                                                                                                                  | V     |
| V <sub>MV</sub>               | DC I/O input buffer supply voltage  | –0.3 to 3.75                                                                                                                                                                  | V     |
| V <sub>I</sub>                | I/O input voltage                   | –0.3 V to 3.6 V (when I/O hot insertion mode is enabled)<br>–0.3 V to (V <sub>CCI</sub> + 1 V) or 3.6 V, whichever voltage is lower (when I/O hot-insertion mode is disabled) | V     |
| T <sub>STG</sub> <sup>2</sup> | Storage temperature                 | –65 to +150                                                                                                                                                                   | °C    |
| T <sub>J</sub> <sup>2</sup>   | Junction temperature                | +150                                                                                                                                                                          | °C    |

**Notes:**

1. The device should be operated within the limits specified by the datasheet. During transitions, the input signal may undershoot or overshoot according to the limits shown in [Table 2-3 on page 2-3](#).
2. For flash programming and retention maximum limits, refer to [Figure 2-1 on page 2-2](#). For recommended operating limits, refer to [Table 2-2 on page 2-2](#).

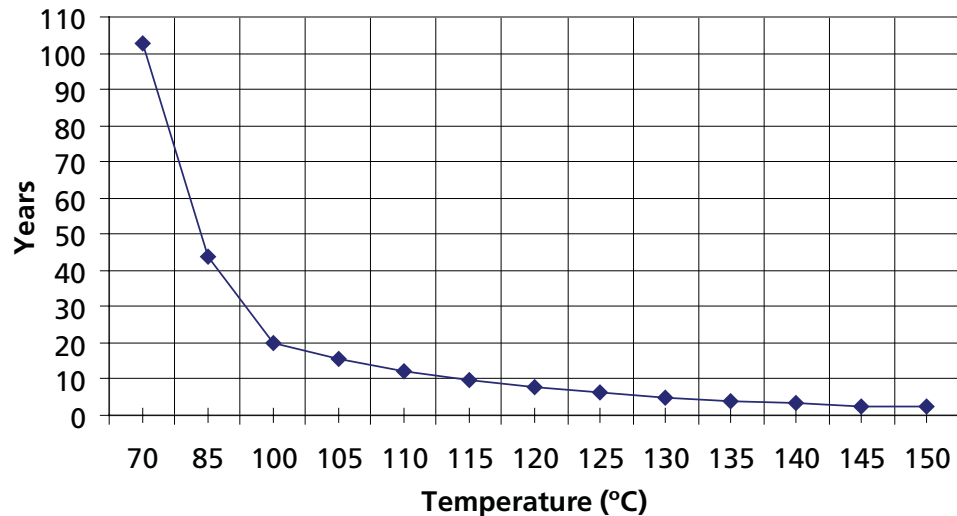
**Table 2-2 • Recommended Operating Conditions**

| Symbol              | Parameter                           |                        | Automotive Grade 1 | Automotive Grade 2 | Units |
|---------------------|-------------------------------------|------------------------|--------------------|--------------------|-------|
| $T_J$               | Junction temperature                |                        | –40 to +135        | –40 to +115        | °C    |
| $V_{CC}$            | 1.5 V DC core supply voltage        |                        | 1.425 to 1.575     | 1.425 to 1.575     | V     |
| $V_{JTAG}$          | JTAG DC voltage                     |                        | 1.4 to 3.6         | 1.4 to 3.6         | V     |
| $V_{PUMP}$          | Programming voltage                 | Programming Mode       | 3.0 to 3.6         | 3.0 to 3.6         | V     |
|                     |                                     | Operation <sup>3</sup> | 0 to 3.6           | 0 to 3.6           | V     |
| $V_{CCPLL}$         | Analog power supply (PLL)           |                        | 1.4 to 1.6         | 1.4 to 1.6         | V     |
| $V_{CCI}$ and $VMV$ | 1.5 V DC supply voltage             |                        | 1.425 to 1.575     | 1.425 to 1.575     | V     |
|                     | 1.8 V DC supply voltage             |                        | 1.7 to 1.9         | 1.7 to 1.9         | V     |
|                     | 2.5 V DC supply voltage             |                        | 2.3 to 2.7         | 2.3 to 2.7         | V     |
|                     | 3.3 V DC supply voltage             |                        | 3.0 to 3.6         | 3.0 to 3.6         | V     |
|                     | LVDS/B-LVDS/M-LVDS differential I/O |                        | 2.375 to 2.625     | 2.375 to 2.625     | V     |
|                     | LVPECL differential I/O             |                        | 3.0 to 3.6         | 3.0 to 3.6         | V     |

**Notes:**

1. The ranges given here are for power supplies only. The recommended input voltage ranges specific to each I/O standard are given in [Table 2-14 on page 2-16](#).  $VMV$  and  $V_{CCI}$  should be at the same voltage within a given I/O bank.
2. All parameters representing voltages are measured with respect to GND unless otherwise specified.
3.  $V_{PUMP}$  can be left floating during operation (not programming mode).

| $T_J$ (°C) | HTR Lifetime (yrs) |
|------------|--------------------|
| 70         | 102.7              |
| 85         | 43.8               |
| 100        | 20.0               |
| 105        | 15.6               |
| 110        | 12.3               |
| 115        | 9.7                |
| 120        | 7.7                |
| 125        | 6.2                |
| 130        | 5.0                |
| 135        | 4.0                |
| 140        | 3.3                |
| 145        | 2.7                |
| 150        | 2.2                |



**Note:** HTR time is the period during which you would not expect a verify failure due to flash cell leakage.

**Figure 2-1 • High-Temperature Data Retention (HTR)**

**Table 2-3 • Overshoot and Undershoot Limits (as measured on quiet I/Os)**

| $V_{CCI}$ and VMV | Average $V_{CCI}$ -GND Overshoot or Undershoot Duration as a Percentage of Clock Cycle | Maximum Overshoot/Undershoot (115°C) | Maximum Overshoot/Undershoot (135°C) |
|-------------------|----------------------------------------------------------------------------------------|--------------------------------------|--------------------------------------|
| 2.7 V or less     | 10%                                                                                    | 0.81 V                               | 0.72 V                               |
|                   | 5%                                                                                     | 0.90 V                               | 0.82 V                               |
| 3 V               | 10%                                                                                    | 0.80 V                               | 0.72 V                               |
|                   | 5%                                                                                     | 0.90 V                               | 0.81 V                               |
| 3.3 V             | 10%                                                                                    | 0.79 V                               | 0.69 V                               |
|                   | 5%                                                                                     | 0.88 V                               | 0.79 V                               |
| 3.6 V             | 10%                                                                                    | N/A                                  | N/A                                  |
|                   | 5%                                                                                     | N/A                                  | N/A                                  |

**Notes:**

1. The duration is allowed at one out of six clock cycles (estimated SSO density over cycles). If the overshoot/undershoot occurs at one out of two cycles, the maximum overshoot/undershoot has to be reduced by 0.15 V.
2. This table refers only to overshoot/undershoot limits for simultaneously switching I/Os and does not provide PCI overshoot/undershoot limits.

## I/O Power-Up and Supply Voltage Thresholds for Power-On Reset (Commercial and Industrial)

Sophisticated power-up management circuitry is designed into every ProASIC®3 device. These circuits ensure easy transition from the powered-off state to the powered-up state of the device. The many different supplies can power up in any sequence with minimized current spikes or surges. In addition, the I/O will be in a known state through the power-up sequence. The basic principle is shown in [Figure 2-2 on page 2-4](#).

There are five regions to consider during power-up.

ProASIC3 I/Os are activated only if ALL of the following three conditions are met:

1.  $V_{CC}$  and  $V_{CCI}$  are above the minimum specified trip points ([Figure 2-2 on page 2-4](#)).
2.  $V_{CCI} > V_{CC} - 0.75$  V (typical)
3. Chip is in the operating mode.

 **$V_{CCI}$  Trip Point:**

Ramping up:  $0.6$  V < trip\_point\_up <  $1.2$  V

Ramping down:  $0.5$  V < trip\_point\_down <  $1.1$  V

 **$V_{CC}$  Trip Point:**

Ramping up:  $0.6$  V < trip\_point\_up <  $1.1$  V

Ramping down:  $0.5$  V < trip\_point\_down <  $1$  V

$V_{CC}$  and  $V_{CCI}$  ramp-up trip points are about 100 mV higher than ramp-down trip points. This specifically built-in hysteresis prevents undesirable power-up oscillations and current surges. Note the following:

- During programming, I/Os become tristated and weakly pulled up to  $V_{CCI}$ .
- JTAG supply, PLL power supplies, and charge pump  $V_{PUMP}$  supply have no influence on I/O behavior.

### Internal Power-Up Activation Sequence

1. Core
2. Input buffers
3. Output buffers, after 200 ns delay from input buffer activation

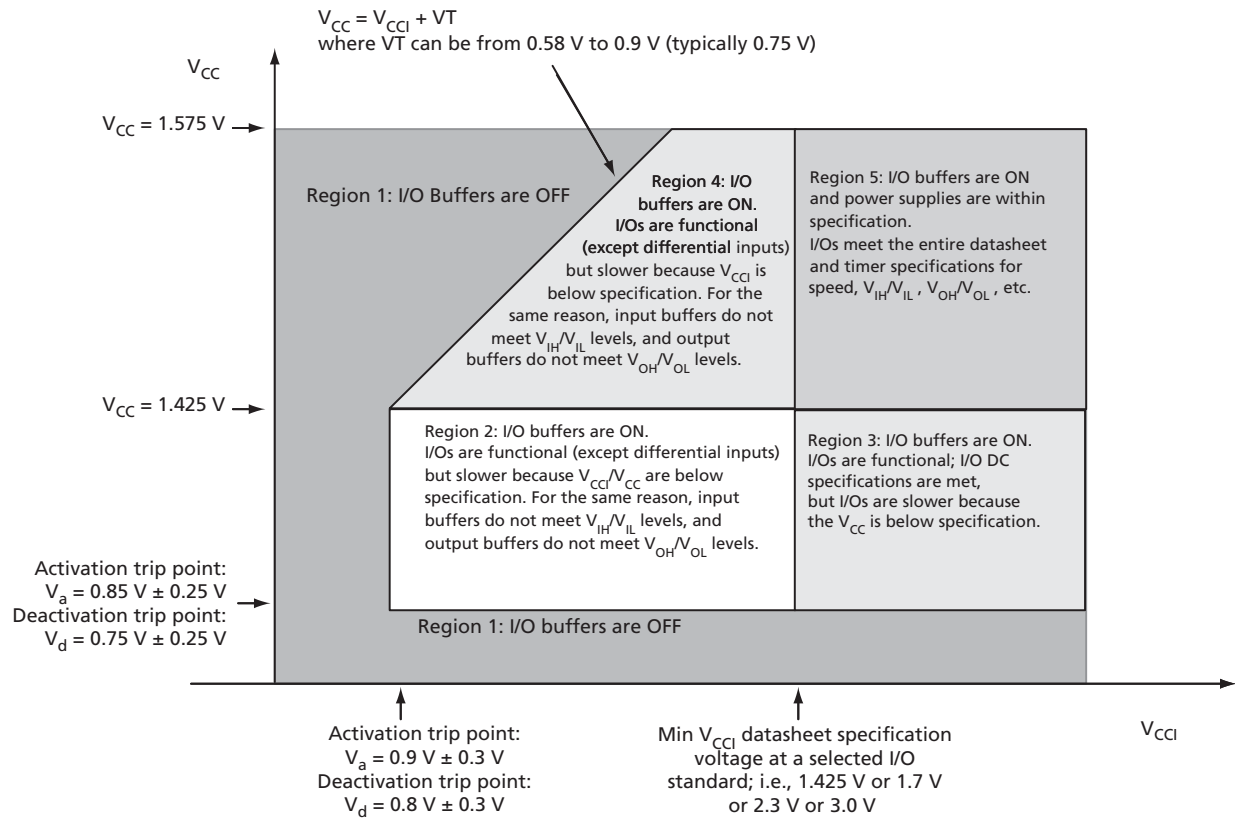


Figure 2-2 • I/O State as a Function of  $V_{CCI}$  and  $V_{CC}$  Voltage Levels

## Thermal Characteristics

### Introduction

The temperature variable in the Actel Designer software refers to the junction temperature, not the ambient temperature. This is an important distinction because dynamic and static power consumption cause the chip junction to be higher than the ambient temperature.

EQ 2-1 can be used to calculate junction temperature.

$$T_J = \text{Junction Temperature} = \Delta T + T_A$$

EQ 2-1

where:

$T_A$  = Ambient Temperature

$\Delta T$  = Temperature gradient between junction (silicon) and ambient  $\Delta T = \theta_{ja} * P$

$\theta_{ja}$  = Junction-to-ambient of the package.  $\theta_{ja}$  numbers are located in Table 2-4 on page 2-5.

P = Power dissipation

### Package Thermal Characteristics

The device junction-to-case thermal resistivity is  $\theta_{jc}$  and the junction-to-ambient air thermal resistivity is  $\theta_{ja}$ . The thermal characteristics for  $\theta_{ja}$  are shown for two air flow rates. The absolute maximum junction temperature is 110°C. EQ 2-2 shows a sample calculation of the absolute maximum power dissipation allowed for a 484-pin FBGA package at commercial temperature and in still air.

$$\text{Maximum Power Allowed} = \frac{\text{Max. junction temp. (°C)} - \text{Max. ambient temp. (°C)}}{\theta_{ja} (\text{°C/W})} = \frac{110^{\circ}\text{C} - 70^{\circ}\text{C}}{20.5^{\circ}\text{C/W}} = 1.951 \text{ W}$$

EQ 2-2

**Table 2-4 • Package Thermal Resistivities**

| Package Type                      | Device      | Pin Count | $\theta_{jc}$ | $\theta_{ja}$ |              |              | Units |
|-----------------------------------|-------------|-----------|---------------|---------------|--------------|--------------|-------|
|                                   |             |           |               | Still Air     | 200 ft./min. | 500 ft./min. |       |
| Very Thin Quad Flat Pack (VQFP)   | All devices | 100       | 10.0          | 35.3          | 29.4         | 27.1         | °C/W  |
| Fine Pitch Ball Grid Array (FBGA) | See note*   | 144       | 3.8           | 26.9          | 22.9         | 21.5         | °C/W  |
|                                   | See note*   | 256       | 3.8           | 26.6          | 22.8         | 21.5         | °C/W  |
|                                   | See note*   | 484       | 3.2           | 20.5          | 17.0         | 15.9         | °C/W  |
|                                   | A3P1000     | 144       | 6.3           | 31.6          | 26.2         | 24.2         | °C/W  |
|                                   | A3P1000     | 256       | 6.6           | 28.1          | 24.4         | 22.7         | °C/W  |
|                                   | A3P1000     | 484       | 8.0           | 23.3          | 19.0         | 16.7         | °C/W  |

\* This information applies to all ProASIC3 devices except the A3P1000. Detailed device/package thermal information will be available in future revisions of the datasheet.

### Temperature and Voltage Derating Factors

**Table 2-5 • Temperature and Voltage Derating Factors for Timing Delays**  
(normalized to  $T_J = 115^{\circ}\text{C}$ ,  $V_{CC} = 1.425 \text{ V}$ )

| Array Voltage $V_{CC}$ (V) | −40°C | 0°C  | 25°C | 70°C | 85°C | 115°C | 125°C | 135°C |
|----------------------------|-------|------|------|------|------|-------|-------|-------|
| 1.425                      | 0.83  | 0.88 | 0.90 | 0.95 | 0.97 | 1.00  | 1.01  | 1.02  |
| 1.5                        | 0.79  | 0.83 | 0.85 | 0.90 | 0.92 | 0.95  | 0.96  | 0.97  |
| 1.575                      | 0.76  | 0.80 | 0.82 | 0.87 | 0.88 | 0.91  | 0.93  | 0.94  |

## Calculating Power Dissipation

### Quiescent Supply Current

**Table 2-6 • Quiescent Supply Current Characteristics**

|                                      | A3P060 | A3P125 | A3P250 | A3P1000 |
|--------------------------------------|--------|--------|--------|---------|
| Typical (25°C)                       | 2 mA   | 2 mA   | 3 mA   | 8 mA    |
| Maximum (Automotive Grade 1) – 135°C | 53 mA  | 53 mA  | 106 mA | 265 mA  |
| Maximum (Automotive Grade 2) – 115°C | 26 mA  | 26 mA  | 53 mA  | 131 mA  |

**Note:**  $I_{DD}$  includes  $V_{CC}$ ,  $V_{PUMP}$ ,  $V_{CC1}$ , and VMV currents. Values do not include I/O static contribution, which is shown in Table 2-7 and Table 2-10 on page 2-8.

### Power per I/O Pin

**Table 2-7 • Summary of I/O Input Buffer Power (per pin) – Default I/O Software Settings<sup>1</sup>  
Applicable to Advanced I/O Banks**

|                             | VMV (V) | Static Power<br>$P_{DC2}$ (mW) <sup>1</sup> | Dynamic Power<br>$P_{AC9}$ (μW/MHz) <sup>2</sup> |
|-----------------------------|---------|---------------------------------------------|--------------------------------------------------|
| <b>Single-Ended</b>         |         |                                             |                                                  |
| 3.3 V LVTTTL / 3.3 V LVCMOS | 3.3     | –                                           | 16.69                                            |
| 2.5 V LVCMOS                | 2.5     | –                                           | 5.12                                             |
| 1.8 V LVCMOS                | 1.8     | –                                           | 2.13                                             |
| 1.5 V LVCMOS (JESD8-11)     | 1.5     | –                                           | 1.45                                             |
| 3.3 V PCI                   | 3.3     | –                                           | 18.11                                            |
| 3.3 V PCI-X                 | 3.3     | –                                           | 18.11                                            |
| <b>Differential</b>         |         |                                             |                                                  |
| LVDS                        | 2.5     | 2.26                                        | 1.20                                             |
| LVPECL                      | 3.3     | 5.72                                        | 1.87                                             |

**Notes:**

1.  $P_{DC2}$  is the static power (where applicable) measured on VMV.
2.  $P_{AC9}$  is the total dynamic power measured on  $V_{CC}$  and VMV.

**Table 2-8 • Summary of I/O Input Buffer Power (per pin) – Default I/O Software Settings<sup>1</sup>**  
Applicable to Standard Plus I/O Banks

|                             | VMV (V) | Static Power<br>$P_{DC2}$ (mW) <sup>1</sup> | Dynamic Power<br>$P_{AC9}$ (μW/MHz) <sup>2</sup> |
|-----------------------------|---------|---------------------------------------------|--------------------------------------------------|
| <b>Single-Ended</b>         |         |                                             |                                                  |
| 3.3 V LVTTTL / 3.3 V LVCMOS | 3.3     | –                                           | 16.72                                            |
| 2.5 V LVCMOS                | 2.5     | –                                           | 5.14                                             |
| 1.8 V LVCMOS                | 1.8     | –                                           | 2.13                                             |
| 1.5 V LVCMOS (JESD8-11)     | 1.5     | –                                           | 1.48                                             |
| 3.3 V PCI                   | 3.3     | –                                           | 18.13                                            |
| 3.3 V PCI-X                 | 3.3     | –                                           | 18.13                                            |

**Notes:**

1.  $P_{DC2}$  is the static power (where applicable) measured on VMV.
2.  $P_{AC9}$  is the total dynamic power measured on  $V_{CC}$  and VMV.

**Table 2-9 • Summary of I/O Output Buffer Power (per pin) – Default I/O Software Settings<sup>1</sup>**  
Applicable to Advanced I/O Banks

|                             | $C_{LOAD}$ (pF) | $V_{CCI}$ (V) | Static Power<br>$P_{DC3}$ (mW) <sup>2</sup> | Dynamic Power<br>$P_{AC10}$ (μW/MHz) <sup>3</sup> |
|-----------------------------|-----------------|---------------|---------------------------------------------|---------------------------------------------------|
| <b>Single-Ended</b>         |                 |               |                                             |                                                   |
| 3.3 V LVTTTL / 3.3 V LVCMOS | 35              | 3.3           | –                                           | 468.67                                            |
| 2.5 V LVCMOS                | 35              | 2.5           | –                                           | 267.48                                            |
| 1.8 V LVCMOS                | 35              | 1.8           | –                                           | 149.46                                            |
| 1.5 V LVCMOS (JESD8-11)     | 35              | 1.5           | –                                           | 103.12                                            |
| 3.3 V PCI                   | 10              | 3.3           | –                                           | 201.02                                            |
| 3.3 V PCI-X                 | 10              | 3.3           | –                                           | 201.02                                            |
| <b>Differential</b>         |                 |               |                                             |                                                   |
| LVDS                        | –               | 2.5           | 7.74                                        | 88.92                                             |
| LVPECL                      | –               | 3.3           | 19.54                                       | 166.52                                            |

**Notes:**

1. Dynamic power consumption is given for standard load and software default drive strength and output slew.
2.  $P_{DC3}$  is the static power (where applicable) measured on VMV.
3.  $P_{AC10}$  is the total dynamic power measured on  $V_{CCI}$  and VMV.

**Table 2-10 • Summary of I/O Output Buffer Power (per pin) – Default I/O Software Settings<sup>1</sup>  
Applicable to Standard Plus I/O Banks**

|                                | $C_{LOAD}$ (pF) | $V_{CCI}$ (V) | Static Power<br>$P_{DC3}$ (mW) <sup>2</sup> | Dynamic Power<br>$P_{AC10}$ (μW/MHz) <sup>3</sup> |
|--------------------------------|-----------------|---------------|---------------------------------------------|---------------------------------------------------|
| <b>Single-Ended</b>            |                 |               |                                             |                                                   |
| 3.3 V LVTTTL /<br>3.3 V LVCMOS | 35              | 3.3           | –                                           | 452.67                                            |
| 2.5 V LVCMOS                   | 35              | 2.5           | –                                           | 258.32                                            |
| 1.8 V LVCMOS                   | 35              | 1.8           | –                                           | 133.59                                            |
| 1.5 V LVCMOS<br>(JESD8-11)     | 35              | 1.5           | –                                           | 92.84                                             |
| 3.3 V PCI                      | 10              | 3.3           | –                                           | 184.92                                            |
| 3.3 V PCI-X                    | 10              | 3.3           | –                                           | 184.92                                            |

**Notes:**

1. Dynamic power consumption is given for standard load and software default drive strength and output slew.
2.  $P_{DC3}$  is the static power (where applicable) measured on VMV.
3.  $P_{AC10}$  is the total dynamic power measured on  $V_{CCI}$  and VMV.

## Power Consumption of Various Internal Resources

**Table 2-11 • Different Components Contributing to Dynamic Power Consumption in ProASIC3 Devices**

| Parameter         | Definition                                                     | Device Specific Dynamic Power (μW/MHz)                                     |        |        |        |
|-------------------|----------------------------------------------------------------|----------------------------------------------------------------------------|--------|--------|--------|
|                   |                                                                | A3P1000                                                                    | A3P250 | A3P125 | A3P060 |
| P <sub>AC1</sub>  | Clock contribution of a Global Rib                             | 14.50                                                                      | 11.00  | 11.00  | 9.30   |
| P <sub>AC2</sub>  | Clock contribution of a Global Spine                           | 2.48                                                                       | 1.58   | 0.81   | 0.81   |
| P <sub>AC3</sub>  | Clock contribution of a VersaTile row                          | 0.81                                                                       |        |        |        |
| P <sub>AC4</sub>  | Clock contribution of a VersaTile used as a sequential module  | 0.12                                                                       |        |        |        |
| P <sub>AC5</sub>  | First contribution of a VersaTile used as a sequential module  | 0.07                                                                       |        |        |        |
| P <sub>AC6</sub>  | Second contribution of a VersaTile used as a sequential module | 0.29                                                                       |        |        |        |
| P <sub>AC7</sub>  | Contribution of a VersaTile used as a combinatorial module     | 0.29                                                                       |        |        |        |
| P <sub>AC8</sub>  | Average contribution of a routing net                          | 0.70                                                                       |        |        |        |
| P <sub>AC9</sub>  | Contribution of an I/O input pin (standard-dependent)          | See <a href="#">Table 2-7 on page 2-6</a> .                                |        |        |        |
| P <sub>AC10</sub> | Contribution of an I/O output pin (standard-dependent)         | See <a href="#">Table 2-7</a> and <a href="#">Table 2-10 on page 2-8</a> . |        |        |        |
| P <sub>AC11</sub> | Average contribution of a RAM block during a read operation    | 25.00                                                                      |        |        |        |
| P <sub>AC12</sub> | Average contribution of a RAM block during a write operation   | 30.00                                                                      |        |        |        |
| P <sub>AC13</sub> | Static PLL contribution                                        | 2.55 mW                                                                    |        |        |        |
| P <sub>AC14</sub> | Dynamic contribution for PLL                                   | 2.60                                                                       |        |        |        |

\* For a different output load, drive strength, or slew rate, Actel recommends using the Actel power spreadsheet calculator or SmartPower tool in Actel Libero® Integrated Design Environment (IDE).

## Power Calculation Methodology

This section describes a simplified method to estimate power consumption of an application. For more accurate and detailed power estimations, use the SmartPower tool in Actel Libero IDE software.

The power calculation methodology described below uses the following variables:

- The number of PLLs as well as the number and the frequency of each output clock generated
- The number of combinatorial and sequential cells used in the design
- The internal clock frequencies
- The number and the standard of I/O pins used in the design
- The number of RAM blocks used in the design
- Toggle rates of I/O pins as well as VersaTiles—guidelines are provided in [Table 2-12 on page 2-11](#).
- Enable rates of output buffers—guidelines are provided for typical applications in [Table 2-13 on page 2-12](#).
- Read rate and write rate to the memory—guidelines are provided for typical applications in [Table 2-13 on page 2-12](#). The calculation should be repeated for each clock domain defined in the design.

## Methodology

### Total Power Consumption— $P_{TOTAL}$

$$P_{TOTAL} = P_{STAT} + P_{DYN}$$

$P_{STAT}$  is the total static power consumption.

$P_{DYN}$  is the total dynamic power consumption.

### Total Static Power Consumption— $P_{STAT}$

$$P_{STAT} = P_{DC1} + N_{INPUTS} * P_{DC2} + N_{OUTPUTS} * P_{DC3}$$

$N_{INPUTS}$  is the number of I/O input buffers used in the design.

$N_{OUTPUTS}$  is the number of I/O output buffers used in the design.

### Total Dynamic Power Consumption— $P_{DYN}$

$$P_{DYN} = P_{CLOCK} + P_{S-CELL} + P_{C-CELL} + P_{NET} + P_{INPUTS} + P_{OUTPUTS} + P_{MEMORY} + P_{PLL}$$

### Global Clock Contribution— $P_{CLOCK}$

$$P_{CLOCK} = (P_{AC1} + N_{SPINE} * P_{AC2} + N_{ROW} * P_{AC3} + N_{S-CELL} * P_{AC4}) * F_{CLK}$$

$N_{SPINE}$  is the number of global spines used in the user design—guidelines are provided in [Table 2-12 on page 2-11](#).

$N_{ROW}$  is the number of VersaTile rows used in the design—guidelines are provided in [Table 2-12 on page 2-11](#).

$F_{CLK}$  is the global clock signal frequency.

$N_{S-CELL}$  is the number of VersaTiles used as sequential modules in the design.

$P_{AC1}$ ,  $P_{AC2}$ ,  $P_{AC3}$ , and  $P_{AC4}$  are device-dependent.

### Sequential Cells Contribution— $P_{S-CELL}$

$$P_{S-CELL} = N_{S-CELL} * (P_{AC5} + \alpha_1 / 2 * P_{AC6}) * F_{CLK}$$

$N_{S-CELL}$  is the number of VersaTiles used as sequential modules in the design. When a multi-tile sequential cell is used, it should be accounted for as 1.

$\alpha_1$  is the toggle rate of VersaTile outputs—guidelines are provided in [Table 2-12 on page 2-11](#).

$F_{CLK}$  is the global clock signal frequency.

### Combinatorial Cells Contribution— $P_{C-CELL}$

$$P_{C-CELL} = N_{C-CELL} * \alpha_1 / 2 * P_{AC7} * F_{CLK}$$

$N_{C-CELL}$  is the number of VersaTiles used as combinatorial modules in the design.

$\alpha_1$  is the toggle rate of VersaTile outputs—guidelines are provided in [Table 2-12 on page 2-11](#).

$F_{CLK}$  is the global clock signal frequency.

### Routing Net Contribution— $P_{NET}$

$$P_{NET} = (N_{S-CELL} + N_{C-CELL}) * \alpha_1 / 2 * P_{AC8} * F_{CLK}$$

$N_{S-CELL}$  is the number VersaTiles used as sequential modules in the design.

$N_{C-CELL}$  is the number of VersaTiles used as combinatorial modules in the design.

$\alpha_1$  is the toggle rate of VersaTile outputs—guidelines are provided in [Table 2-12 on page 2-11](#).

$F_{CLK}$  is the global clock signal frequency.

### I/O Input Buffer Contribution— $P_{INPUTS}$

$$P_{INPUTS} = N_{INPUTS} * \alpha_2 / 2 * P_{AC9} * F_{CLK}$$

$N_{INPUTS}$  is the number of I/O input buffers used in the design.

$\alpha_2$  is the I/O buffer toggle rate—guidelines are provided in [Table 2-12 on page 2-11](#).

$F_{CLK}$  is the global clock signal frequency.

### I/O Output Buffer Contribution— $P_{\text{OUTPUTS}}$

$$P_{\text{OUTPUTS}} = N_{\text{OUTPUTS}} * \alpha_2 / 2 * \beta_1 * P_{\text{AC10}} * F_{\text{CLK}}$$

$N_{\text{OUTPUTS}}$  is the number of I/O output buffers used in the design.

$\alpha_2$  is the I/O buffer toggle rate—guidelines are provided in [Table 2-12](#).

$\beta_1$  is the I/O buffer enable rate—guidelines are provided in [Table 2-13 on page 2-12](#).

$F_{\text{CLK}}$  is the global clock signal frequency.

### RAM Contribution— $P_{\text{MEMORY}}$

$$P_{\text{MEMORY}} = P_{\text{AC11}} * N_{\text{BLOCKS}} * F_{\text{READ-CLOCK}} * \beta_2 + P_{\text{AC12}} * N_{\text{BLOCK}} * F_{\text{WRITE-CLOCK}} * \beta_3$$

$N_{\text{BLOCKS}}$  is the number of RAM blocks used in the design.

$F_{\text{READ-CLOCK}}$  is the memory read clock frequency.

$\beta_2$  is the RAM enable rate for read operations.

$F_{\text{WRITE-CLOCK}}$  is the memory write clock frequency.

$\beta_3$  is the RAM enable rate for write operations—guidelines are provided in [Table 2-13 on page 2-12](#).

### PLL Contribution— $P_{\text{PLL}}$

$$P_{\text{PLL}} = P_{\text{AC13}} + P_{\text{AC14}} * F_{\text{CLKOUT}}$$

$F_{\text{CLKIN}}$  is the input clock frequency.

$F_{\text{CLKOUT}}$  is the output clock frequency.<sup>1</sup>

## Guidelines

### Toggle Rate Definition

A toggle rate defines the frequency of a net or logic element relative to a clock. It is a percentage. If the toggle rate of a net is 100%, this means that this net switches at half the clock frequency. Below are some examples:

- The average toggle rate of a shift register is 100% because all flip-flop outputs toggle at half of the clock frequency.
- The average toggle rate of an 8-bit counter is 25%:
  - Bit 0 (LSB) = 100%
  - Bit 1 = 50%
  - Bit 2 = 25%
  - ...
  - Bit 7 (MSB) = 0.78125%
  - Average toggle rate = (100% + 50% + 25% + 12.5% + ... + 0.78125%) / 8

### Enable Rate Definition

Output enable rate is the average percentage of time during which tristate outputs are enabled. When nontristate output buffers are used, the enable rate should be 100%.

**Table 2-12 • Toggle Rate Guidelines Recommended for Power Calculation**

| Component  | Definition                       | Guideline |
|------------|----------------------------------|-----------|
| $\alpha_1$ | Toggle rate of VersaTile outputs | 10%       |
| $\alpha_2$ | I/O buffer toggle rate           | 10%       |

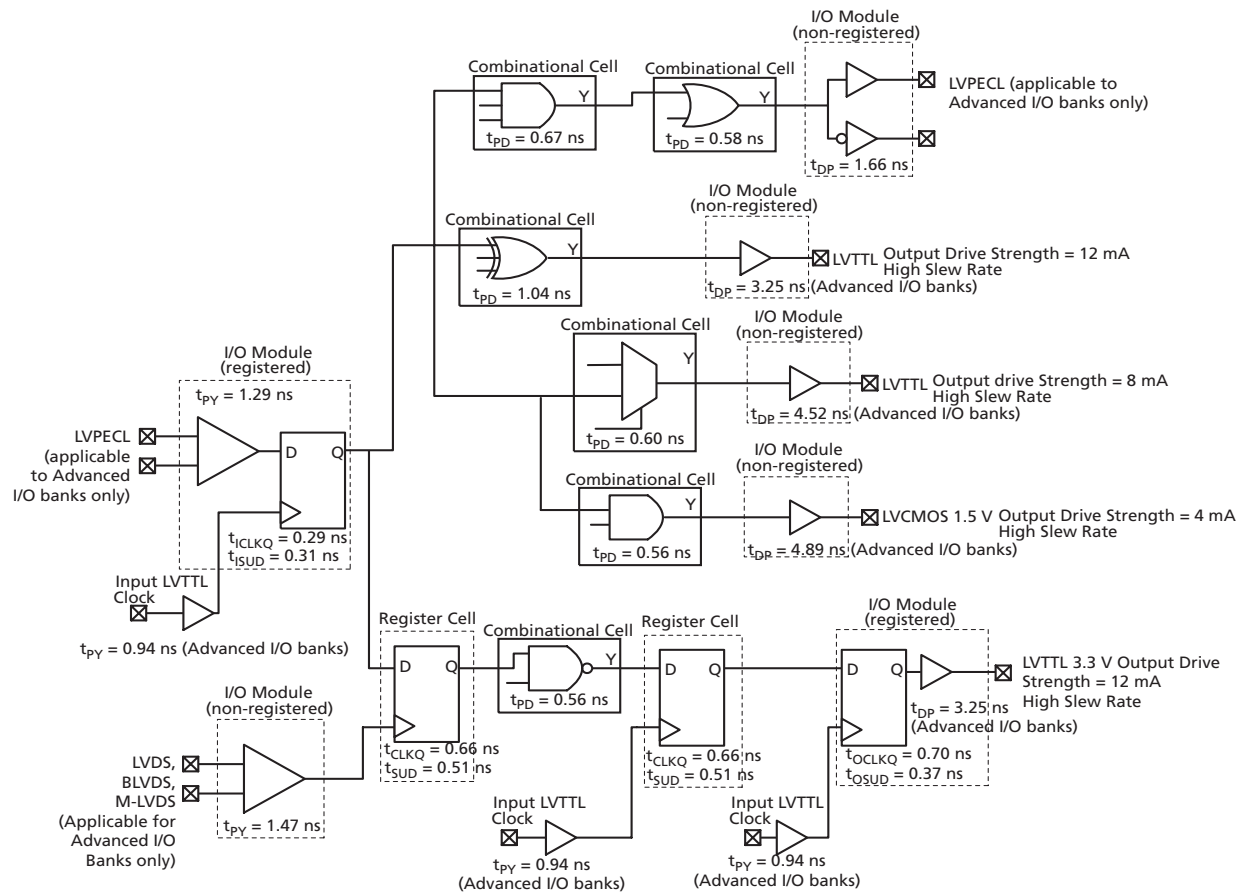
1. The PLL dynamic contribution depends on the input clock frequency, the number of output clock signals generated by the PLL, and the frequency of each output clock. If a PLL is used to generate more than one output clock, include each output clock in the formula by adding its corresponding contribution ( $P_{\text{AC14}} * F_{\text{CLKOUT}}$  product) to the total PLL contribution.

**Table 2-13 • Enable Rate Guidelines Recommended for Power Calculation**

| Component | Definition                           | Guideline |
|-----------|--------------------------------------|-----------|
| $\beta_1$ | I/O output buffer enable rate        | 100%      |
| $\beta_2$ | RAM enable rate for read operations  | 12.5%     |
| $\beta_3$ | RAM enable rate for write operations | 12.5%     |

## User I/O Characteristics

### Timing Model

**Figure 2-3 • Timing Model**

Operating Conditions: -1 Speed, Automotive Grade 2 Temp. Range ( $T_J = 115^\circ\text{C}$ ), Worst Case  
 $V_{CC} = 1.425$  V

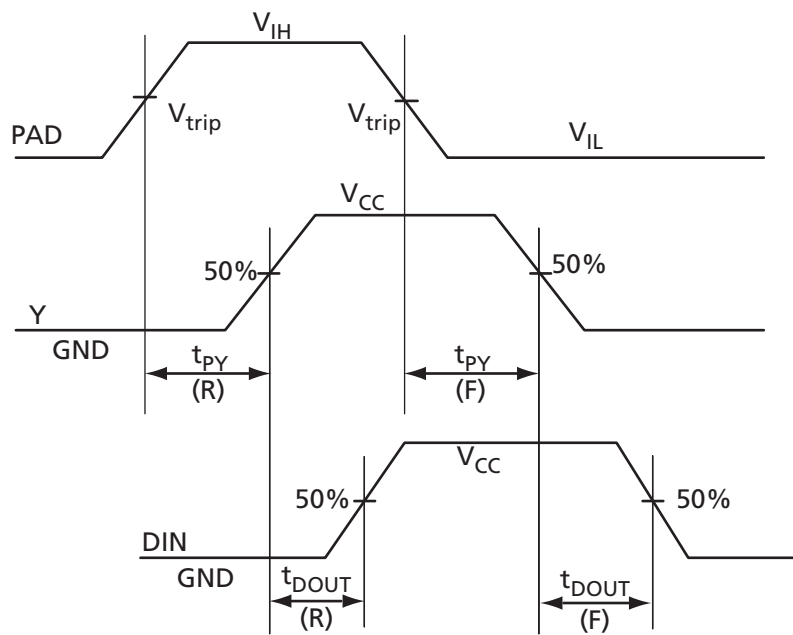
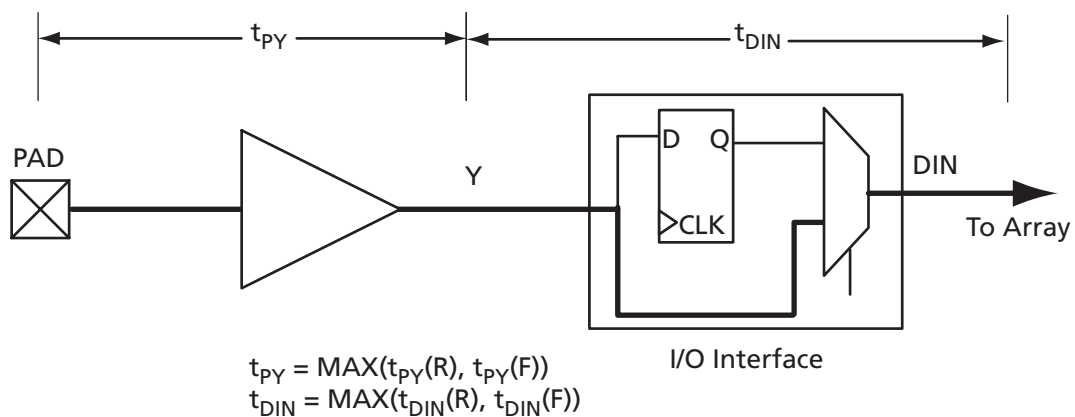


Figure 2-4 • Input Buffer Timing Model and Delays (example)

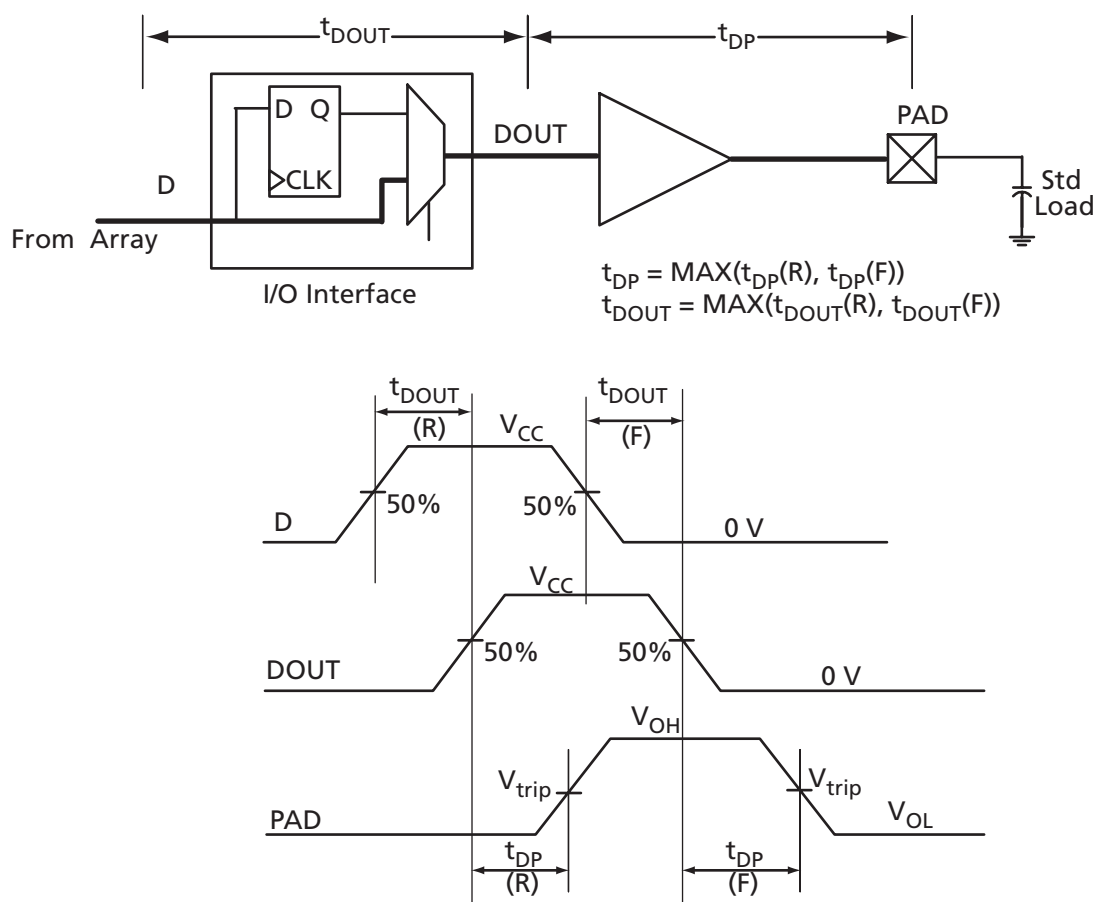


Figure 2-5 • Output Buffer Model and Delays (example)

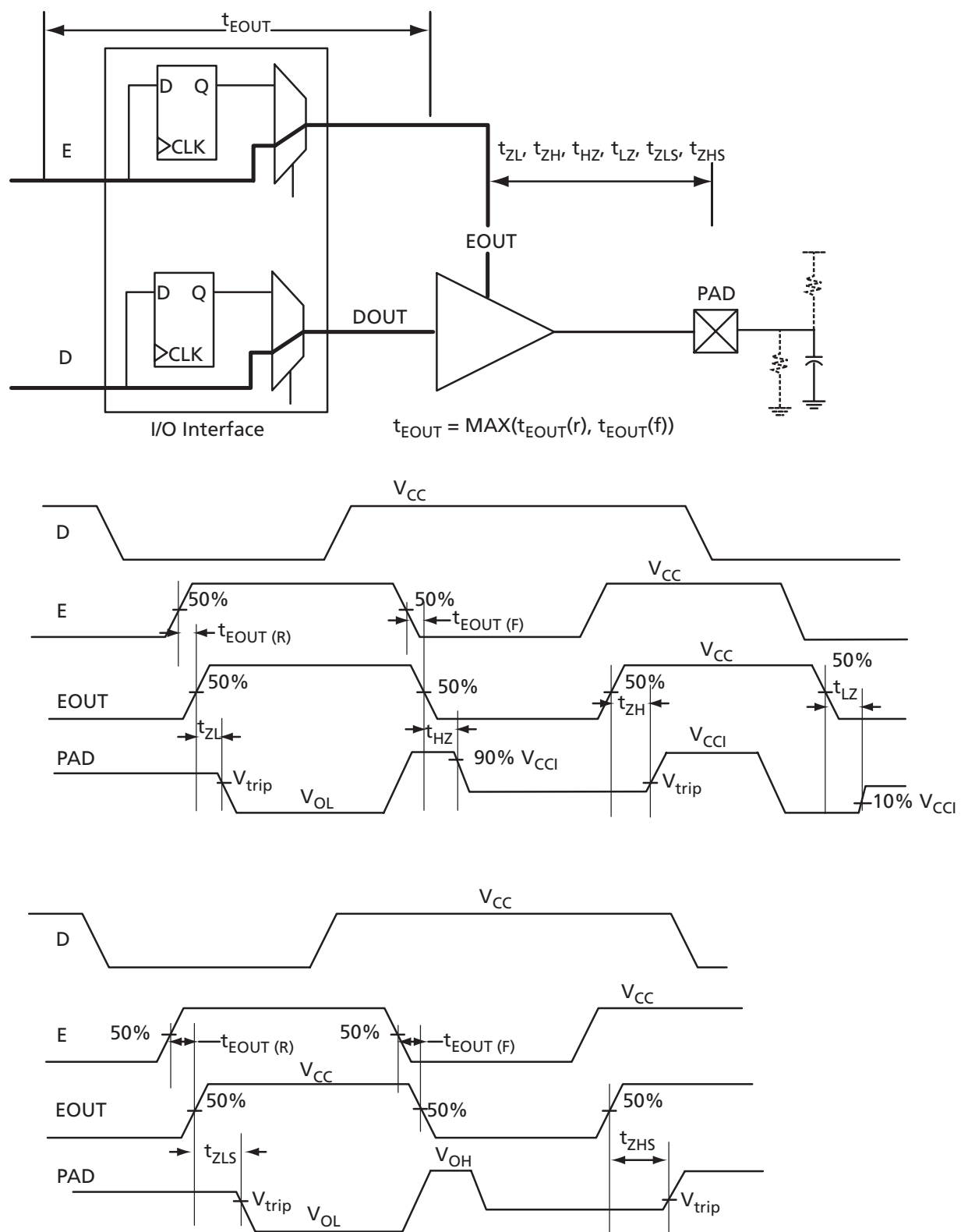


Figure 2-6 • Tristate Output Buffer Timing Model and Delays (example)

## Overview of I/O Performance

### Summary of I/O DC Input and Output Levels – Default I/O Software Settings

**Table 2-14 • Summary of Maximum and Minimum DC Input and Output Levels Applicable to Commercial and Industrial Conditions—Software Default Settings**  
Applicable to Advanced I/O Banks

| I/O Standard                | Drive Strength           | Slew Rate | V <sub>IL</sub> |                         | V <sub>IH</sub>         |        | V <sub>OL</sub>         | V <sub>OH</sub>         | I <sub>OL</sub> | I <sub>OH</sub> |
|-----------------------------|--------------------------|-----------|-----------------|-------------------------|-------------------------|--------|-------------------------|-------------------------|-----------------|-----------------|
|                             |                          |           | Min, V          | Max, V                  | Min, V                  | Max, V | Max, V                  | Min, V                  | mA              | mA              |
| 3.3 V LVTTTL / 3.3 V LVCMOS | 12 mA                    | High      | –0.3            | 0.8                     | 2                       | 3.6    | 0.4                     | 2.4                     | 12              | 12              |
| 2.5 V LVCMOS                | 12 mA                    | High      | –0.3            | 0.7                     | 1.7                     | 3.6    | 0.7                     | 1.7                     | 12              | 12              |
| 1.8 V LVCMOS                | 12 mA                    | High      | –0.3            | 0.35 * V <sub>CCl</sub> | 0.65 * V <sub>CCl</sub> | 3.6    | 0.45                    | V <sub>CCl</sub> – 0.45 | 12              | 12              |
| 1.5 V LVCMOS                | 12 mA                    | High      | –0.3            | 0.30 * V <sub>CCl</sub> | 0.7 * V <sub>CCl</sub>  | 3.6    | 0.25 * V <sub>CCl</sub> | 0.75 * V <sub>CCl</sub> | 12              | 12              |
| 3.3 V PCI                   | Per PCI specifications   |           |                 |                         |                         |        |                         |                         |                 |                 |
| 3.3 V PCI-X                 | Per PCI-X specifications |           |                 |                         |                         |        |                         |                         |                 |                 |

*Note:* Currents are measured at 125°C junction temperature.

**Table 2-15 • Summary of Maximum and Minimum DC Input and Output Levels Applicable to Commercial and Industrial Conditions—Software Default Settings**  
Applicable to Standard Plus I/O Banks

| I/O Standard                | Drive Strength           | Slew Rate | V <sub>IL</sub> |                         | V <sub>IH</sub>         |        | V <sub>OL</sub>         | V <sub>OH</sub>         | I <sub>OL</sub> | I <sub>OH</sub> |
|-----------------------------|--------------------------|-----------|-----------------|-------------------------|-------------------------|--------|-------------------------|-------------------------|-----------------|-----------------|
|                             |                          |           | Min, V          | Max, V                  | Min, V                  | Max, V | Max, V                  | Min, V                  | mA              | mA              |
| 3.3 V LVTTTL / 3.3 V LVCMOS | 12 mA                    | High      | –0.3            | 0.8                     | 2                       | 3.6    | 0.4                     | 2.4                     | 12              | 12              |
| 2.5 V LVCMOS                | 12 mA                    | High      | –0.3            | 0.7                     | 1.7                     | 3.6    | 0.7                     | 1.7                     | 12              | 12              |
| 1.8 V LVCMOS                | 8 mA                     | High      | –0.3            | 0.35 * V <sub>CCl</sub> | 0.65 * V <sub>CCl</sub> | 3.6    | 0.45                    | V <sub>CCl</sub> – 0.45 | 8               | 8               |
| 1.5 V LVCMOS                | 4 mA                     | High      | –0.3            | 0.30 * V <sub>CCl</sub> | 0.7 * V <sub>CCl</sub>  | 3.6    | 0.25 * V <sub>CCl</sub> | 0.75 * V <sub>CCl</sub> | 4               | 4               |
| 3.3 V PCI                   | Per PCI specifications   |           |                 |                         |                         |        |                         |                         |                 |                 |
| 3.3 V PCI-X                 | Per PCI-X specifications |           |                 |                         |                         |        |                         |                         |                 |                 |

*Note:* Currents are measured at 125°C junction temperature.

**Table 2-16 • Summary of Maximum and Minimum DC Input and Output Levels Applicable to Commercial and Industrial Conditions—Software Default Settings**  
Applicable to Standard I/O Banks

| I/O Standard                | Drive Strength | Slew Rate | V <sub>IL</sub> |                         | V <sub>IH</sub>         |        | V <sub>OL</sub>         | V <sub>OH</sub>         | I <sub>OL</sub> | I <sub>OH</sub> |
|-----------------------------|----------------|-----------|-----------------|-------------------------|-------------------------|--------|-------------------------|-------------------------|-----------------|-----------------|
|                             |                |           | Min, V          | Max, V                  | Min, V                  | Max, V | Max, V                  | Min, V                  | mA              | mA              |
| 3.3 V LVTTTL / 3.3 V LVCMOS | 8 mA           | High      | –0.3            | 0.8                     | 2                       | 3.6    | 0.4                     | 2.4                     | 8               | 8               |
| 2.5 V LVCMOS                | 8 mA           | High      | –0.3            | 0.7                     | 1.7                     | 3.6    | 0.7                     | 1.7                     | 8               | 8               |
| 1.8 V LVCMOS                | 4 mA           | High      | –0.3            | 0.35 * V <sub>CCl</sub> | 0.65 * V <sub>CCl</sub> | 3.6    | 0.45                    | V <sub>CCl</sub> – 0.45 | 4               | 4               |
| 1.5 V LVCMOS                | 2 mA           | High      | –0.3            | 0.30 * V <sub>CCl</sub> | 0.7 * V <sub>CCl</sub>  | 3.6    | 0.25 * V <sub>CCl</sub> | 0.75 * V <sub>CCl</sub> | 2               | 2               |

*Note:* Currents are measured at 125°C junction temperature.

**Table 2-17 • Summary of Maximum and Minimum DC Input Levels Applicable to Automotive Grade 1 and Grade 2**

| DC I/O Standards            | Automotive Grade 1 <sup>1</sup> |                 | Automotive Grade 2 <sup>2</sup> |                 |
|-----------------------------|---------------------------------|-----------------|---------------------------------|-----------------|
|                             | I <sub>IL</sub>                 | I <sub>IH</sub> | I <sub>IL</sub>                 | I <sub>IH</sub> |
|                             | μA                              | μA              | μA                              | μA              |
| 3.3 V LVTTTL / 3.3 V LVCMOS | 10                              | 10              | 15                              | 15              |
| 2.5 V LVCMOS                | 10                              | 10              | 15                              | 15              |
| 1.8 V LVCMOS                | 10                              | 10              | 15                              | 15              |
| 1.5 V LVCMOS                | 10                              | 10              | 15                              | 15              |
| 3.3 V PCI                   | 10                              | 10              | 15                              | 15              |
| 3.3 V PCI-X                 | 10                              | 10              | 15                              | 15              |

**Notes:**

1. Automotive range Grade 1 ( $-40^{\circ}\text{C} < T_J < 135^{\circ}\text{C}$ )
2. Automotive range Grade 2 ( $-40^{\circ}\text{C} < T_J < 115^{\circ}\text{C}$ )

### Summary of I/O Timing Characteristics – Default I/O Software Settings

**Table 2-18 • Summary of AC Measuring Points**

| Standard                    | Measuring Trip Point (V <sub>trip</sub> ) |
|-----------------------------|-------------------------------------------|
| 3.3 V LVTTTL / 3.3 V LVCMOS | 1.4 V                                     |
| 2.5 V LVCMOS                | 1.2 V                                     |
| 1.8 V LVCMOS                | 0.90 V                                    |
| 1.5 V LVCMOS                | 0.75 V                                    |
| 3.3 V PCI                   | 0.285 * V <sub>CCI</sub> (RR)             |
|                             | 0.615 * V <sub>CCI</sub> (FF)             |
| 3.3 V PCI-X                 | 0.285 * V <sub>CCI</sub> (RR)             |
|                             | 0.615 * V <sub>CCI</sub> (FF)             |

**Table 2-19 • I/O AC Parameter Definitions**

| Parameter         | Parameter Definition                                                        |
|-------------------|-----------------------------------------------------------------------------|
| t <sub>DP</sub>   | Data-to-Pad delay through the Output Buffer                                 |
| t <sub>PY</sub>   | Pad-to-Data delay through the Input Buffer                                  |
| t <sub>DOUT</sub> | Data-to-Output Buffer delay through the I/O interface                       |
| t <sub>EOUT</sub> | Enable-to-Output Buffer Tristate Control delay through the I/O interface    |
| t <sub>DIN</sub>  | Input Buffer-to-Data delay through the I/O interface                        |
| t <sub>HZ</sub>   | Enable-to-Pad delay through the Output Buffer—HIGH to Z                     |
| t <sub>ZH</sub>   | Enable-to-Pad delay through the Output Buffer—Z to HIGH                     |
| t <sub>LZ</sub>   | Enable-to-Pad delay through the Output Buffer—LOW to Z                      |
| t <sub>ZL</sub>   | Enable-to-Pad delay through the Output Buffer—Z to LOW                      |
| t <sub>ZHS</sub>  | Enable-to-Pad delay through the Output Buffer with delayed enable—Z to HIGH |
| t <sub>ZLS</sub>  | Enable-to-Pad delay through the Output Buffer with delayed enable—Z to LOW  |

**Table 2-20 • Summary of I/O Timing Characteristics—Software Default Settings**  
 –1 Speed Grade, Automotive-Case Conditions:  $T_J = 115^{\circ}\text{C}$ , Worst Case  $V_{CC} = 1.425\text{ V}$ , Worst Case  $V_{CCI} = 3.0\text{ V}$   
 Advanced I/O Banks

| I/O Standard                | Drive Strength (mA) | Slew Rate | Capacitive Load (pF) | External Resistor ( $\Omega$ ) | $t_{DOUT}$ (ns) | $t_{DP}$ (ns) | $t_{DIN}$ (ns) | $t_{PY}$ (ns) | $t_{EOUT}$ (ns) | $t_{ZL}$ (ns) | $t_{ZH}$ (ns) | $t_{LZ}$ (ns) | $t_{HZ}$ (ns) | $t_{ZLS}$ (ns) | $t_{ZHS}$ (ns) | Units |
|-----------------------------|---------------------|-----------|----------------------|--------------------------------|-----------------|---------------|----------------|---------------|-----------------|---------------|---------------|---------------|---------------|----------------|----------------|-------|
| 3.3 V LVTTTL / 3.3 V LVCMOS | 12 mA               | High      | 35 pF                | –                              | 0.53            | 3.25          | 0.04           | 0.94          | 0.38            | 3.31          | 1.51          | 2.96          | 1.88          | 5.37           | 2.71           | ns    |
| 2.5 V LVCMOS                | 12 mA               | High      | 35 pF                | –                              | 0.53            | 3.28          | 0.04           | 1.19          | 0.38            | 3.34          | 3.16          | 1.77          | 1.80          | 5.39           | 5.22           | ns    |
| 1.8 V LVCMOS                | 12 mA               | High      | 35 pF                | –                              | 0.53            | 3.25          | 0.04           | 1.12          | 0.38            | 1.89          | 1.63          | 3.41          | 3.75          | 3.06           | 2.82           | ns    |
| 1.5 V LVCMOS                | 12 mA               | High      | 35 pF                | –                              | 0.53            | 3.75          | 0.04           | 1.32          | 0.38            | 2.18          | 1.91          | 3.63          | 3.87          | 3.35           | 3.11           | ns    |
| 3.3 V PCI                   | Per PCI spec        | High      | 10 pF                | $25^2$                         | 0.53            | 2.12          | 0.04           | 0.78          | 0.38            | 1.23          | 0.91          | 2.57          | 2.96          | 2.41           | 2.11           | ns    |
| 3.3 V PCI-X                 | Per PCI-X spec      | High      | 10 pF                | $25^2$                         | 0.53            | 2.47          | 0.04           | 0.77          | 0.38            | 1.23          | 0.91          | 2.57          | 2.96          | 2.41           | 2.11           | ns    |
| LVDS                        | 24 mA               | High      | –                    | –                              | 0.53            | 1.68          | 0.04           | 1.47          | –               | –             | –             | –             | –             | –              | –              | ns    |
| LVPECL                      | 24 mA               | High      | –                    | –                              | 0.53            | 1.66          | 0.04           | 1.29          | –               | –             | –             | –             | –             | –              | –              | ns    |

**Notes:**

1. For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.
2. Resistance is used to measure I/O propagation delays as defined in PCI specifications. See [Figure 2-11 on page 2-47](#) for connectivity. This resistor is not required during normal operation.

**Table 2-21 • Summary of I/O Timing Characteristics—Software Default Settings**  
–1 Speed Grade, Automotive-Case Conditions:  $T_J = 115^{\circ}\text{C}$ , Worst Case  $V_{CC} = 1.425\text{ V}$ , Worst Case  $V_{CCI} = 3.0\text{ V}$   
Standard Plus I/O Banks

| I/O Standard                | Drive Strength (mA) | Slew Rate | Capacitive Load (pF) | External Resistor | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|-----------------------------|---------------------|-----------|----------------------|-------------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 3.3 V LVTTTL / 3.3 V LVCMOS | 12 mA               | High      | 35 pF                | –                 | 0.55       | 3.01     | 0.04      | 0.95     | 0.39       | 1.74     | 1.43     | 2.65     | 3.06     | 1.74      | 1.43      | ns    |
| 2.5 V LVCMOS                | 12 mA               | High      | 35 pF                | –                 | 0.55       | 3.05     | 0.04      | 1.23     | 0.39       | 3.11     | 2.99     | 1.56     | 1.69     | 5.23      | 5.11      | ns    |
| 1.8 V LVCMOS                | 8 mA                | High      | 35 pF                | –                 | 0.55       | 3.73     | 0.04      | 1.16     | 0.39       | 3.65     | 3.86     | 1.62     | 1.68     | 5.78      | 5.99      | ns    |
| 1.5 V LVCMOS                | 4 mA                | High      | 35 pF                | –                 | 0.55       | 4.60     | 0.04      | 1.35     | 0.39       | 4.61     | 5.05     | 2.07     | 1.85     | 6.74      | 7.18      | ns    |
| 3.3 V PCI                   | Per PCI spec        | High      | 10 pF                | 25 <sup>2</sup>   | 0.55       | 2.19     | 0.04      | 0.81     | 0.39       | 1.27     | 0.94     | 2.65     | 3.06     | 1.27      | 0.94      | ns    |
| 3.3 V PCI-X                 | Per PCI-X spec      | High      | 10 pF                | 25 <sup>2</sup>   | 0.55       | 2.19     | 0.04      | 0.79     | 0.39       | 1.27     | 0.94     | 2.65     | 3.06     | 1.27      | 0.94      | ns    |

**Notes:**

1. For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.
2. Resistance is used to measure I/O propagation delays as defined in PCI specifications. See [Figure 2-11 on page 2-47](#) for connectivity. This resistor is not required during normal operation.

**Table 2-22 • Summary of I/O Timing Characteristics—Software Default Settings**  
 –1 Speed Grade, Automotive-Case Conditions:  $T_J = 135^{\circ}\text{C}$ , Worst Case  $V_{CC} = 1.425\text{ V}$ , Worst Case  $V_{CCI} = 3.0\text{ V}$   
 Advanced I/O Banks

| I/O Standard                | Drive Strength (mA) | Slew Rate | Capacitive Load (pF) | External Resistor ( $\Omega$ ) | $t_{DOUT}$ (ns) | $t_{DP}$ (ns) | $t_{DIN}$ (ns) | $t_{PY}$ (ns) | $t_{EOUT}$ (ns) | $t_{ZL}$ (ns) | $t_{ZH}$ (ns) | $t_{LZ}$ (ns) | $t_{HZ}$ (ns) | $t_{ZLS}$ (ns) | $t_{ZHS}$ (ns) | Units |
|-----------------------------|---------------------|-----------|----------------------|--------------------------------|-----------------|---------------|----------------|---------------|-----------------|---------------|---------------|---------------|---------------|----------------|----------------|-------|
| 3.3 V LVTTTL / 3.3 V LVCMOS | 12 mA               | High      | 35 pF                | –                              | 0.55            | 3.36          | 0.04           | 0.97          | 0.39            | 3.42          | 1.56          | 3.05          | 1.94          | 5.55           | 2.80           | ns    |
| 2.5 V LVCMOS                | 12 mA               | High      | 35 pF                | –                              | 0.55            | 3.39          | 0.04           | 1.23          | 0.39            | 3.45          | 3.27          | 1.83          | 1.86          | 5.58           | 5.39           | ns    |
| 1.8 V LVCMOS                | 12 mA               | High      | 35 pF                | –                              | 0.55            | 3.36          | 0.04           | 1.16          | 0.39            | 1.95          | 1.68          | 3.52          | 3.88          | 3.16           | 2.92           | ns    |
| 1.5 V LVCMOS                | 12 mA               | High      | 35 pF                | –                              | 0.55            | 3.88          | 0.04           | 1.37          | 0.39            | 2.25          | 1.98          | 3.75          | 4.00          | 3.46           | 3.21           | ns    |
| 3.3 V PCI                   | Per PCI spec        | High      | 10 pF                | $25^2$                         | 0.55            | 2.19          | 0.04           | 0.81          | 0.39            | 1.27          | 0.94          | 2.65          | 3.06          | 2.49           | 2.18           | ns    |
| 3.3 V PCI-X                 | Per PCI-X spec      | High      | 10 pF                | $25^2$                         | 0.55            | 2.55          | 0.04           | 0.79          | 0.39            | 1.27          | 0.94          | 2.65          | 3.06          | 2.49           | 2.18           | ns    |
| LVDS                        | 24 mA               | High      | –                    | –                              | 0.55            | 1.74          | 0.04           | 1.52          | –               | –             | –             | –             | –             | –              | –              | ns    |
| LVPECL                      | 24 mA               | High      | –                    | –                              | 0.55            | 1.71          | 0.04           | 1.34          | –               | –             | –             | –             | –             | –              | –              | ns    |

**Notes:**

1. For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.
2. Resistance is used to measure I/O propagation delays as defined in PCI specifications. See [Figure 2-11 on page 2-47](#) for connectivity. This resistor is not required during normal operation.

**Table 2-23 • Summary of I/O Timing Characteristics—Software Default Settings**  
–1 Speed Grade, Automotive-Case Conditions:  $T_J = 115^{\circ}\text{C}$ , Worst Case  $V_{CC} = 1.425\text{ V}$ , Worst Case  $V_{CCI} = 3.0\text{ V}$   
Standard Plus I/O Banks

| I/O Standard                | Drive Strength (mA) | Slew Rate | Capacitive Load (pF) | External Resistor | $t_{DOUT}$ (ns) | $t_{DP}$ (ns) | $t_{DIN}$ (ns) | $t_{PY}$ (ns) | $t_{EOUT}$ (ns) | $t_{ZL}$ (ns) | $t_{ZH}$ (ns) | $t_{LZ}$ (ns) | $t_{HZ}$ (ns) | $t_{ZLS}$ (ns) | $t_{ZHS}$ (ns) | Units |
|-----------------------------|---------------------|-----------|----------------------|-------------------|-----------------|---------------|----------------|---------------|-----------------|---------------|---------------|---------------|---------------|----------------|----------------|-------|
| 3.3 V LVTTTL / 3.3 V LVCMOS | 12 mA               | High      | 35 pF                | –                 | 0.55            | 3.36          | 0.04           | 0.97          | 0.39            | 3.42          | 1.56          | 3.05          | 1.94          | 5.55           | 2.80           | ns    |
| 2.5 V LVCMOS                | 12 mA               | High      | 35 pF                | –                 | 0.55            | 3.05          | 0.04           | 1.23          | 0.39            | 3.11          | 2.99          | 1.56          | 1.69          | 5.23           | 5.11           | ns    |
| 1.8 V LVCMOS                | 8 mA                | High      | 35 pF                | –                 | 0.55            | 3.73          | 0.04           | 1.16          | 0.39            | 3.65          | 3.86          | 1.62          | 1.68          | 5.78           | 5.99           | ns    |
| 1.5 V LVCMOS                | 4 mA                | High      | 35 pF                | –                 | 0.55            | 4.60          | 0.04           | 1.35          | 0.39            | 4.61          | 5.05          | 2.07          | 1.85          | 6.74           | 7.18           | ns    |
| 3.3 V PCI                   | Per PCI spec        | High      | 10 pF                | $25^2$            | 0.55            | 2.55          | 0.04           | 0.82          | 0.39            | 1.27          | 0.94          | 2.65          | 3.06          | 2.49           | 2.18           | ns    |
| 3.3 V PCI-X                 | Per PCI-X spec      | High      | 10 pF                | $25^2$            | 0.55            | 2.55          | 0.04           | 0.79          | 0.39            | 1.27          | 0.94          | 2.65          | 3.06          | 2.49           | 2.18           | ns    |

**Notes:**

1. For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.
2. Resistance is used to measure I/O propagation delays as defined in PCI specifications. See [Figure 2-11 on page 2-47](#) for connectivity. This resistor is not required during normal operation.

## Detailed I/O DC Characteristics

**Table 2-24 • Input Capacitance**

| Symbol      | Definition                         | Conditions                        | Min. | Max. | Units |
|-------------|------------------------------------|-----------------------------------|------|------|-------|
| $C_{IN}$    | Input capacitance                  | $V_{IN} = 0, f = 1.0 \text{ MHz}$ |      | 8    | pF    |
| $C_{INCLK}$ | Input capacitance on the clock pin | $V_{IN} = 0, f = 1.0 \text{ MHz}$ |      | 8    | pF    |

**Table 2-25 • I/O Output Buffer Maximum Resistances<sup>1</sup>**  
Applicable to Advanced I/O Banks

| Standard                    | Drive Strength              | $R_{PULL-DOWN}$<br>( $\Omega$ ) <sup>2</sup> | $R_{PULL-UP}$<br>( $\Omega$ ) <sup>3</sup> |
|-----------------------------|-----------------------------|----------------------------------------------|--------------------------------------------|
| 3.3 V LVTTTL / 3.3 V LVCMOS | 2 mA                        | 100                                          | 300                                        |
|                             | 4 mA                        | 100                                          | 300                                        |
|                             | 6 mA                        | 50                                           | 150                                        |
|                             | 8 mA                        | 50                                           | 150                                        |
|                             | 12 mA                       | 25                                           | 75                                         |
|                             | 16 mA                       | 17                                           | 50                                         |
|                             | 24 mA                       | 11                                           | 33                                         |
| 2.5 V LVCMOS                | 2 mA                        | 100                                          | 200                                        |
|                             | 6 mA                        | 50                                           | 100                                        |
|                             | 12 mA                       | 25                                           | 50                                         |
|                             | 16 mA                       | 20                                           | 40                                         |
|                             | 24 mA                       | 11                                           | 22                                         |
| 1.8 V LVCMOS                | 2 mA                        | 200                                          | 225                                        |
|                             | 4 mA                        | 100                                          | 112                                        |
|                             | 6 mA                        | 50                                           | 56                                         |
|                             | 8 mA                        | 50                                           | 56                                         |
|                             | 12 mA                       | 20                                           | 22                                         |
|                             | 16 mA                       | 20                                           | 22                                         |
| 1.5 V LVCMOS                | 2 mA                        | 200                                          | 224                                        |
|                             | 4 mA                        | 100                                          | 112                                        |
|                             | 6 mA                        | 67                                           | 75                                         |
|                             | 8 mA                        | 33                                           | 37                                         |
|                             | 12 mA                       | 33                                           | 37                                         |
| 3.3 V PCI/PCI-X             | Per PCI/PCI-X specification | 25                                           | 75                                         |

**Notes:**

1. These maximum values are provided for informational reasons only. Minimum output buffer resistance values depend on  $V_{CCI}$ , drive strength selection, temperature, and process. For board design considerations and detailed output buffer resistances, use the corresponding IBIS models located on the Actel website at <http://www.actel.com/download/ibis/default.aspx>.
2.  $R_{(PULL-DOWN-MAX)} = (V_{OLspec}) / I_{OLspec}$
3.  $R_{(PULL-UP-MAX)} = (V_{CCImax} - V_{OHspec}) / I_{OHspec}$

**Table 2-26 • I/O Output Buffer Maximum Resistances<sup>1</sup>**  
Applicable to Standard Plus I/O Banks

| Standard                    | Drive Strength              | R <sub>PULL-DOWN</sub><br>(Ω) <sup>2</sup> | R <sub>PULL-UP</sub><br>(Ω) <sup>3</sup> |
|-----------------------------|-----------------------------|--------------------------------------------|------------------------------------------|
| 3.3 V LVTTTL / 3.3 V LVCMOS | 2 mA                        | 100                                        | 300                                      |
|                             | 4 mA                        | 100                                        | 300                                      |
|                             | 6 mA                        | 50                                         | 150                                      |
|                             | 8 mA                        | 50                                         | 150                                      |
|                             | 12 mA                       | 25                                         | 75                                       |
|                             | 16 mA                       | 25                                         | 75                                       |
| 2.5 V LVCMOS                | 2 mA                        | 100                                        | 200                                      |
|                             | 6 mA                        | 50                                         | 100                                      |
|                             | 12 mA                       | 25                                         | 50                                       |
| 1.8 V LVCMOS                | 2 mA                        | 200                                        | 225                                      |
|                             | 4 mA                        | 100                                        | 112                                      |
|                             | 6 mA                        | 50                                         | 56                                       |
|                             | 8 mA                        | 50                                         | 56                                       |
| 1.5 V LVCMOS                | 2 mA                        | 200                                        | 224                                      |
|                             | 4 mA                        | 100                                        | 112                                      |
| 3.3 V PCI/PCI-X             | Per PCI/PCI-X specification | 0                                          | 0                                        |

**Notes:**

1. These maximum values are provided for informational reasons only. Minimum output buffer resistance values depend on  $V_{CC}$ , drive strength selection, temperature, and process. For board design considerations and detailed output buffer resistances, use the corresponding IBIS models located on the Actel website at <http://www.actel.com/download/libis/default.aspx>.
2.  $R_{(PULL-DOWN-MAX)} = (V_{OLspec}) / I_{OLspec}$
3.  $R_{(PULL-UP-MAX)} = (V_{CCImax} - V_{OHspec}) / I_{OHspec}$

**Table 2-27 • I/O Weak Pull-Up/Pull-Down Resistances**  
Minimum and Maximum Weak Pull-Up/Pull-Down Resistance Values

| V <sub>CC</sub> | R <sub>(WEAK PULL-UP)</sub> <sup>1</sup><br>(Ω) |      | R <sub>(WEAK PULL-DOWN)</sub> <sup>2</sup><br>(Ω) |       |
|-----------------|-------------------------------------------------|------|---------------------------------------------------|-------|
|                 | Min.                                            | Max. | Min.                                              | Max.  |
| 3.3 V           | 10 k                                            | 45 k | 10 k                                              | 45 k  |
| 2.5 V           | 11 k                                            | 55 k | 12 k                                              | 74 k  |
| 1.8 V           | 18 k                                            | 70 k | 17 k                                              | 110 k |
| 1.5 V           | 19 k                                            | 90 k | 19 k                                              | 140 k |

**Notes:**

1.  $R_{(WEAK PULL-UP-MAX)} = (V_{OLspec}) / I_{(WEAK PULL-UP-MIN)}$
2.  $R_{(WEAK PULL-UP-MAX)} = (V_{CCImax} - V_{OHspec}) / I_{(WEAK PULL-UP-MIN)}$

**Table 2-28 • I/O Short Currents  $I_{OSH}/I_{OSL}$   
Applicable to Advanced I/O Banks**

|                             | Drive Strength              | $I_{OSL}$ (mA)* | $I_{OSH}$ (mA)* |
|-----------------------------|-----------------------------|-----------------|-----------------|
| 3.3 V LVTTTL / 3.3 V LVCMOS | 2 mA                        | 27              | 25              |
|                             | 4 mA                        | 27              | 25              |
|                             | 6 mA                        | 54              | 51              |
|                             | 8 mA                        | 54              | 51              |
|                             | 12 mA                       | 109             | 103             |
|                             | 16 mA                       | 127             | 132             |
|                             | 24 mA                       | 181             | 268             |
| 3.3 V LVCMOS                | 2 mA                        | 27              | 25              |
|                             | 4 mA                        | 27              | 25              |
|                             | 6 mA                        | 54              | 51              |
|                             | 8 mA                        | 54              | 51              |
|                             | 12 mA                       | 109             | 103             |
|                             | 16 mA                       | 127             | 132             |
|                             | 24 mA                       | 181             | 268             |
| 2.5 V LVCMOS                | 2 mA                        | 18              | 16              |
|                             | 6 mA                        | 37              | 32              |
|                             | 12 mA                       | 74              | 65              |
|                             | 16 mA                       | 87              | 83              |
|                             | 24 mA                       | 124             | 169             |
| 1.8 V LVCMOS                | 2 mA                        | 11              | 9               |
|                             | 4 mA                        | 22              | 17              |
|                             | 6 mA                        | 44              | 35              |
|                             | 8 mA                        | 51              | 45              |
|                             | 12 mA                       | 74              | 91              |
|                             | 16 mA                       | 74              | 91              |
| 1.5 V LVCMOS                | 2 mA                        | 16              | 13              |
|                             | 4 mA                        | 33              | 25              |
|                             | 6 mA                        | 39              | 32              |
|                             | 8 mA                        | 55              | 66              |
|                             | 12 mA                       | 55              | 66              |
| 3.3 V PCI/PCI-X             | Per PCI/PCI-X specification | 109             | 103             |

\*  $T_J = 100^{\circ}\text{C}$

**Table 2-29 • I/O Short Currents  $I_{OSH}/I_{OSL}$**   
Applicable to Standard Plus I/O Banks

|                             | Drive Strength              | $I_{OSL}$ (mA)* | $I_{OSH}$ (mA)* |
|-----------------------------|-----------------------------|-----------------|-----------------|
| 3.3 V LVTTTL / 3.3 V LVCMOS | 2 mA                        | 27              | 25              |
|                             | 4 mA                        | 27              | 25              |
|                             | 6 mA                        | 54              | 51              |
|                             | 8 mA                        | 54              | 51              |
|                             | 12 mA                       | 109             | 103             |
|                             | 16 mA                       | 109             | 103             |
| 2.5 V LVCMOS                | 2 mA                        | 18              | 16              |
|                             | 6 mA                        | 37              | 32              |
|                             | 12 mA                       | 74              | 65              |
| 1.8 V LVCMOS                | 2 mA                        | 11              | 9               |
|                             | 4 mA                        | 22              | 17              |
|                             | 6 mA                        | 44              | 35              |
|                             | 8 mA                        | 44              | 35              |
| 1.5 V LVCMOS                | 2 mA                        | 16              | 13              |
|                             | 4 mA                        | 33              | 25              |
| 3.3 V PCI/PCI-X             | Per PCI/PCI-X specification | 109             | 103             |

\*  $T_J = 100^\circ\text{C}$

The length of time an I/O can withstand  $I_{OSH}/I_{OSL}$  events depends on the junction temperature. The reliability data below is based on a 3.3 V, 12 mA I/O setting, which is the worst case for this type of analysis.

For example, at  $110^\circ\text{C}$ , the short current condition would have to be sustained for more than three months to cause a reliability concern. The I/O design does not contain any short circuit protection, but such protection would only be needed in extremely prolonged stress conditions.

**Table 2-30 • Duration of Short Circuit Event before Failure**

| Temperature         | Time before Failure |
|---------------------|---------------------|
| $-40^\circ\text{C}$ | > 20 years          |
| $0^\circ\text{C}$   | > 20 years          |
| $25^\circ\text{C}$  | > 20 years          |
| $70^\circ\text{C}$  | 5 years             |
| $85^\circ\text{C}$  | 2 years             |
| $100^\circ\text{C}$ | 6 months            |
| $110^\circ\text{C}$ | 3 months            |
| $125^\circ\text{C}$ | 25 days             |
| $135^\circ$         | 12 days             |

**Table 2-31 • I/O Input Rise Time, Fall Time, and Related I/O Reliability**

| Input Buffer              | Input Rise/Fall Time (min.) | Input Rise/Fall Time (max.) | Reliability      |
|---------------------------|-----------------------------|-----------------------------|------------------|
| LVTTTL/LVCMOS             | No requirement              | 10 ns *                     | 20 years (110°C) |
| LVDS/B-LVDS/M-LVDS/LVPECL | No requirement              | 10 ns *                     | 10 years (100°C) |

\* The maximum input rise/fall time is related to the noise induced into the input buffer trace. If the noise is low, the rise time and fall time of input buffers can be increased beyond the maximum value. The longer the rise/fall times, the more susceptible the input signal is to the board noise. Actel recommends signal integrity evaluation/characterization of the system to ensure there is no excessive noise coupling into input signals.

## Single-Ended I/O Characteristics

### 3.3 V LVTTTL / 3.3 V LVCMOS

Low-Voltage Transistor–Transistor Logic (LVTTTL) is a general-purpose standard (EIA/JESD) for 3.3 V applications. It uses an LVTTTL input buffer and push-pull output buffer.

**Table 2-32 • Minimum and Maximum DC Input and Output Levels**  
Applicable to Advanced I/O Banks

| 3.3 V LVTTTL /<br>3.3 V LVCMOS | V <sub>IL</sub> |         | V <sub>IH</sub> |         | V <sub>OL</sub> | V <sub>OH</sub> | I <sub>OL</sub> | I <sub>OH</sub> | I <sub>OSL</sub>      | I <sub>OSH</sub>      | I <sub>IL</sub> | I <sub>IH</sub> |
|--------------------------------|-----------------|---------|-----------------|---------|-----------------|-----------------|-----------------|-----------------|-----------------------|-----------------------|-----------------|-----------------|
| Drive Strength                 | Min., V         | Max., V | Min., V         | Max., V | Max., V         | Min., V         | mA              | mA              | Max., mA <sup>1</sup> | Max., mA <sup>1</sup> | μA <sup>2</sup> | μA <sup>2</sup> |
| 2 mA                           | –0.3            | 0.8     | 2               | 3.6     | 0.4             | 2.4             | 2               | 2               | 27                    | 25                    | 10              | 10              |
| 4 mA                           | –0.3            | 0.8     | 2               | 3.6     | 0.4             | 2.4             | 4               | 4               | 27                    | 25                    | 10              | 10              |
| 6 mA                           | –0.3            | 0.8     | 2               | 3.6     | 0.4             | 2.4             | 6               | 6               | 54                    | 51                    | 10              | 10              |
| 8 mA                           | –0.3            | 0.8     | 2               | 3.6     | 0.4             | 2.4             | 8               | 8               | 54                    | 51                    | 10              | 10              |
| 12 mA                          | –0.3            | 0.8     | 2               | 3.6     | 0.4             | 2.4             | 12              | 12              | 109                   | 103                   | 10              | 10              |
| 16 mA                          | –0.3            | 0.8     | 2               | 3.6     | 0.4             | 2.4             | 16              | 16              | 127                   | 132                   | 10              | 10              |
| 24 mA                          | –0.3            | 0.8     | 2               | 3.6     | 0.4             | 2.4             | 24              | 24              | 181                   | 268                   | 10              | 10              |

#### Notes:

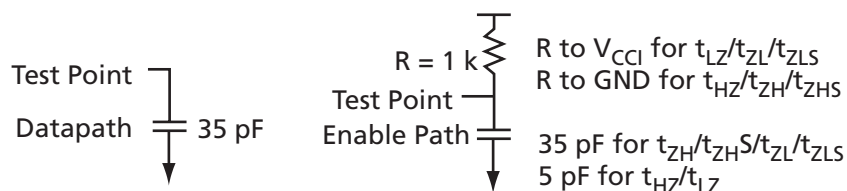
1. Currents are measured at high temperature (100°C junction temperature) and maximum voltage.
2. Currents are measured at 125°C junction temperature.
3. Software default selection highlighted in gray.

**Table 2-33 • Minimum and Maximum DC Input and Output Levels**  
Applicable to Standard Plus I/O Banks

| 3.3 V LVTTTL /<br>3.3 V LVCMOS | $V_{IL}$ |         | $V_{IH}$ |         | $V_{OL}$ | $V_{OH}$ | $I_{OL}$ | $I_{OH}$ | $I_{OSL}$             | $I_{OSH}$             | $I_{IL}$  | $I_{IH}$  |
|--------------------------------|----------|---------|----------|---------|----------|----------|----------|----------|-----------------------|-----------------------|-----------|-----------|
| Drive<br>Strength              | Min., V  | Max., V | Min., V  | Max., V | Max., V  | Min., V  | mA       | mA       | Max., mA <sup>1</sup> | Max., mA <sup>1</sup> | $\mu A^2$ | $\mu A^2$ |
| 2 mA                           | -0.3     | 0.8     | 2        | 3.6     | 0.4      | 2.4      | 2        | 2        | 27                    | 25                    | 10        | 10        |
| 4 mA                           | -0.3     | 0.8     | 2        | 3.6     | 0.4      | 2.4      | 4        | 4        | 27                    | 25                    | 10        | 10        |
| 6 mA                           | -0.3     | 0.8     | 2        | 3.6     | 0.4      | 2.4      | 6        | 6        | 54                    | 51                    | 10        | 10        |
| 8 mA                           | -0.3     | 0.8     | 2        | 3.6     | 0.4      | 2.4      | 8        | 8        | 54                    | 51                    | 10        | 10        |
| 12 mA                          | -0.3     | 0.8     | 2        | 3.6     | 0.4      | 2.4      | 12       | 12       | 109                   | 103                   | 10        | 10        |
| 16 mA                          | -0.3     | 0.8     | 2        | 3.6     | 0.4      | 2.4      | 16       | 16       | 109                   | 103                   | 10        | 10        |

**Notes:**

1. Currents are measured at high temperature (100°C junction temperature) and maximum voltage.
2. Currents are measured at 125°C junction temperature.
3. Software default selection highlighted in gray.



**Figure 2-7 • AC Loading**

**Table 2-34 • AC Waveforms, Measuring Points, and Capacitive Loads**

| Input LOW (V) | Input HIGH (V) | Measuring Point* (V) | $C_{LOAD}$ (pF) |
|---------------|----------------|----------------------|-----------------|
| 0             | 3.3            | 1.4                  | 35              |

\* Measuring point =  $V_{trip}$ . See Table 2-18 on page 2-17 for a complete table of trip points.

## Timing Characteristics

**Table 2-35 • 3.3 V LVTTTL / 3.3 V LVCMOS High Slew**

Automotive-Case Conditions:  $T_J = 135^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 3.0\text{ V}$   
 Applicable to Advanced I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 4 mA           | STD         | 0.64       | 8.56     | 0.05      | 1.14     | 0.46       | 8.72     | 7.37     | 1.46     | 1.42     | 11.22     | 9.866     | ns    |
|                | -1          | 0.55       | 7.28     | 0.04      | 0.97     | 0.39       | 7.42     | 6.27     | 1.46     | 1.42     | 9.54      | 8.393     | ns    |
| 6 mA           | STD         | 0.64       | 5.49     | 0.05      | 1.14     | 0.46       | 5.59     | 4.55     | 1.65     | 1.74     | 8.09      | 7.05      | ns    |
|                | -1          | 0.55       | 4.67     | 0.04      | 0.97     | 0.39       | 4.75     | 3.87     | 1.65     | 1.74     | 6.88      | 5.997     | ns    |
| 8 mA           | STD         | 0.64       | 5.49     | 0.05      | 1.14     | 0.46       | 5.59     | 4.55     | 1.65     | 1.74     | 8.09      | 7.05      | ns    |
|                | -1          | 0.55       | 4.67     | 0.04      | 0.97     | 0.39       | 4.75     | 3.87     | 1.65     | 1.74     | 6.88      | 5.997     | ns    |
| 12 mA          | STD         | 0.64       | 3.95     | 0.05      | 1.14     | 0.46       | 4.02     | 1.56     | 3.59     | 1.94     | 6.52      | 2.795     | ns    |
|                | -1          | 0.55       | 3.36     | 0.04      | 0.97     | 0.39       | 3.42     | 1.56     | 3.05     | 1.94     | 5.55      | 2.797     | ns    |
| 16 mA          | STD         | 0.64       | 3.73     | 0.05      | 1.14     | 0.46       | 1.84     | 1.42     | 3.65     | 4.11     | 3.05      | 2.651     | ns    |
|                | -1          | 0.55       | 3.17     | 0.04      | 0.97     | 0.39       | 1.84     | 1.42     | 3.10     | 3.50     | 3.05      | 2.653     | ns    |
| 24 mA          | STD         | 0.64       | 3.44     | 0.05      | 1.14     | 0.46       | 1.70     | 1.17     | 3.72     | 4.54     | 2.91      | 2.405     | ns    |
|                | -1          | 0.55       | 2.92     | 0.04      | 0.97     | 0.39       | 1.70     | 1.17     | 3.16     | 3.86     | 2.91      | 2.407     | ns    |

**Notes:**

1. Software default selection highlighted in gray.
2. For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-36 • 3.3 V LVTTTL / 3.3 V LVCMOS Low Slew**

Automotive-Case Conditions:  $T_J = 135^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 3.0\text{ V}$   
 Applicable to Advanced I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 4 mA           | STD         | 0.64       | 11.47    | 0.05      | 1.14     | 0.46       | 11.68    | 9.95     | 1.46     | 1.33     | 14.18     | 12.449    | ns    |
|                | -1          | 0.55       | 9.75     | 0.04      | 0.97     | 0.39       | 9.94     | 8.46     | 1.46     | 1.33     | 12.06     | 10.59     | ns    |
| 6 mA           | STD         | 0.64       | 8.13     | 0.05      | 1.14     | 0.46       | 8.28     | 7.03     | 1.65     | 1.65     | 10.79     | 9.526     | ns    |
|                | -1          | 0.55       | 6.92     | 0.04      | 0.97     | 0.39       | 7.05     | 5.98     | 1.65     | 1.65     | 9.17      | 8.103     | ns    |
| 8 mA           | STD         | 0.64       | 8.13     | 0.05      | 1.14     | 0.46       | 8.28     | 7.03     | 1.65     | 1.65     | 10.79     | 9.526     | ns    |
|                | -1          | 0.55       | 6.92     | 0.04      | 0.97     | 0.39       | 7.05     | 5.98     | 1.65     | 1.65     | 9.17      | 8.103     | ns    |
| 12 mA          | STD         | 0.64       | 6.24     | 0.05      | 1.14     | 0.46       | 6.36     | 5.45     | 1.77     | 1.85     | 8.86      | 7.946     | ns    |
|                | -1          | 0.55       | 5.31     | 0.04      | 0.97     | 0.39       | 5.41     | 4.63     | 1.77     | 1.85     | 7.53      | 6.76      | ns    |
| 16 mA          | STD         | 0.64       | 5.82     | 0.05      | 1.14     | 0.46       | 5.93     | 5.10     | 1.80     | 1.90     | 8.43      | 7.604     | ns    |
|                | -1          | 0.55       | 4.95     | 0.04      | 0.97     | 0.39       | 5.04     | 4.34     | 1.80     | 1.90     | 7.17      | 6.468     | ns    |
| 24 mA          | STD         | 0.64       | 5.42     | 0.05      | 1.14     | 0.46       | 5.52     | 5.08     | 1.83     | 2.10     | 8.02      | 7.581     | ns    |
|                | -1          | 0.55       | 4.61     | 0.04      | 0.97     | 0.39       | 4.70     | 4.32     | 1.83     | 2.11     | 6.82      | 6.449     | ns    |

**Note:** For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-37 • 3.3 V LVTTTL / 3.3 V LVCMOS High Slew**

Automotive-Case Conditions:  $T_J = 135^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 3.0\text{ V}$   
Applicable to Standard Plus I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 4 mA           | STD         | 0.64       | 8.06     | 0.05      | 1.12     | 0.46       | 8.20     | 7.03     | 1.26     | 1.27     | 8.20      | 7.027     | ns    |
|                | -1          | 0.55       | 6.85     | 0.04      | .095     | 0.39       | 6.98     | 5.98     | 1.26     | 1.27     | 6.98      | 5.978     | ns    |
| 6 mA           | STD         | 0.64       | 5.03     | 0.05      | 1.12     | 0.46       | 5.13     | 4.27     | 1.42     | 1.56     | 5.13      | 4.267     | ns    |
|                | -1          | 0.55       | 4.28     | 0.04      | 0.95     | 0.39       | 4.36     | 3.63     | 1.42     | 1.56     | 4.36      | 3.63      | ns    |
| 8 mA           | STD         | 0.64       | 5.03     | 0.05      | 1.12     | 0.46       | 5.13     | 4.27     | 1.42     | 1.56     | 5.13      | 4.267     | ns    |
|                | -1          | 0.55       | 4.28     | 0.04      | 0.95     | 0.39       | 4.36     | 3.63     | 1.42     | 1.56     | 4.36      | 3.63      | ns    |
| 12 mA          | STD         | 0.64       | 3.53     | 0.05      | 1.12     | 0.46       | 1.74     | 1.43     | 3.12     | 3.60     | 1.74      | 1.427     | ns    |
|                | -1          | 0.55       | 3.01     | 0.04      | 0.95     | 0.39       | 1.74     | 1.43     | 2.65     | 3.06     | 1.74      | 1.428     | ns    |
| 16 mA          | STD         | 0.64       | 3.53     | 0.05      | 1.12     | 0.46       | 1.74     | 1.43     | 3.12     | 3.60     | 1.74      | 1.427     | ns    |
|                | -1          | 0.55       | 3.01     | 0.04      | 0.95     | 0.39       | 1.74     | 1.43     | 2.65     | 3.06     | 1.74      | 1.428     | ns    |

**Notes:**

1. Software default selection highlighted in gray.
2. For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-38 • 3.3 V LVTTTL / 3.3 V LVCMOS Low Slew**

Automotive-Case Conditions:  $T_J = 135^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 3.0\text{ V}$   
Applicable to Standard Plus I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 4 mA           | STD         | 0.64       | 10.82    | 0.05      | 1.12     | 0.46       | 11.02    | 9.42     | 1.26     | 1.20     | 11.02     | 9.419     | ns    |
|                | -1          | 0.55       | 9.21     | 0.04      | 0.95     | 0.39       | 9.38     | 8.01     | 1.26     | 1.20     | 9.38      | 8.012     | ns    |
| 6 mA           | STD         | 0.64       | 7.49     | 0.05      | 1.12     | 0.46       | 7.63     | 6.58     | 1.43     | 1.48     | 7.63      | 6.58      | ns    |
|                | -1          | 0.55       | 6.37     | 0.04      | 0.95     | 0.39       | 6.49     | 5.60     | 1.43     | 1.49     | 6.49      | 5.598     | ns    |
| 8 mA           | STD         | 0.64       | 7.49     | 0.05      | 1.12     | 0.46       | 7.63     | 6.58     | 1.43     | 1.48     | 7.63      | 6.58      | ns    |
|                | -1          | 0.55       | 6.37     | 0.04      | 0.95     | 0.39       | 6.49     | 5.60     | 1.43     | 1.49     | 6.49      | 5.598     | ns    |
| 12 mA          | STD         | 0.64       | 5.64     | 0.05      | 1.12     | 0.46       | 5.75     | 5.04     | 1.54     | 1.67     | 5.75      | 5.042     | ns    |
|                | -1          | 0.55       | 4.80     | 0.04      | 0.95     | 0.39       | 4.89     | 4.29     | 1.54     | 1.67     | 4.89      | 4.289     | ns    |
| 16 mA          | STD         | 0.64       | 5.64     | 0.05      | 1.12     | 0.46       | 5.75     | 5.04     | 1.54     | 1.67     | 5.75      | 5.042     | ns    |
|                | -1          | 0.55       | 4.80     | 0.04      | 0.95     | 0.39       | 4.89     | 4.29     | 1.54     | 1.67     | 4.89      | 4.289     | ns    |

**Note:** For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-39 • 3.3 V LVTTTL / 3.3 V LVCMOS High Slew**

Automotive-Case Conditions:  $T_J = 115^\circ\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 3.0\text{ V}$   
 Applicable to Advanced I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 4 mA           | STD         | 0.63       | 8.28     | 0.05      | 1.10     | 0.45       | 8.44     | 7.13     | 1.42     | 1.37     | 10.85     | 9.55      | ns    |
|                | -1          | 0.53       | 7.05     | 0.04      | 0.94     | 0.38       | 7.18     | 6.06     | 1.42     | 1.37     | 9.23      | 8.12      | ns    |
| 6 mA           | STD         | 0.63       | 5.31     | 0.05      | 1.10     | 0.45       | 5.41     | 4.40     | 1.60     | 1.68     | 7.83      | 6.82      | ns    |
|                | -1          | 0.53       | 4.52     | 0.04      | 0.94     | 0.38       | 4.60     | 3.74     | 1.60     | 1.68     | 6.66      | 5.80      | ns    |
| 8 mA           | STD         | 0.63       | 5.31     | 0.05      | 1.10     | 0.45       | 5.41     | 4.40     | 1.60     | 1.68     | 7.83      | 6.82      | ns    |
|                | -1          | 0.53       | 4.52     | 0.04      | 0.94     | 0.38       | 4.60     | 3.74     | 1.60     | 1.68     | 6.66      | 5.80      | ns    |
| 12 mA          | STD         | 0.63       | 3.82     | 0.05      | 1.10     | 0.45       | 3.89     | 1.51     | 3.47     | 1.88     | 6.31      | 2.70      | ns    |
|                | -1          | 0.53       | 3.25     | 0.04      | 0.94     | 0.38       | 3.31     | 1.51     | 2.96     | 1.88     | 5.37      | 2.71      | ns    |
| 16 mA          | STD         | 0.63       | 3.60     | 0.05      | 1.10     | 0.45       | 1.78     | 1.37     | 3.53     | 3.98     | 2.95      | 2.57      | ns    |
|                | -1          | 0.53       | 3.07     | 0.04      | 0.94     | 0.38       | 1.78     | 1.37     | 3.00     | 3.38     | 2.95      | 2.57      | ns    |
| 24 mA          | STD         | 0.63       | 3.33     | 0.05      | 1.10     | 0.45       | 1.64     | 1.13     | 3.60     | 4.39     | 2.81      | 2.33      | ns    |
|                | -1          | 0.53       | 2.83     | 0.04      | 0.94     | 0.38       | 1.64     | 1.13     | 3.06     | 3.74     | 2.82      | 2.33      | ns    |

**Notes:**

1. Software default selection highlighted in gray.
2. For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-40 • 3.3 V LVTTTL / 3.3 V LVCMOS Low Slew**

Automotive-Case Conditions:  $T_J = 115^\circ\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 3.0\text{ V}$   
 Applicable to Advanced I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 4 mA           | STD         | 0.63       | 11.09    | 0.05      | 1.10     | 0.45       | 11.30    | 9.63     | 1.41     | 1.29     | 13.72     | 12.04     | ns    |
|                | -1          | 0.53       | 9.44     | 0.04      | 0.94     | 0.38       | 9.61     | 8.19     | 1.41     | 1.29     | 11.67     | 10.25     | ns    |
| 6 mA           | STD         | 0.63       | 7.87     | 0.05      | 1.10     | 0.45       | 8.02     | 6.80     | 1.59     | 1.59     | 10.43     | 9.22      | ns    |
|                | -1          | 0.53       | 6.69     | 0.04      | 0.94     | 0.38       | 6.82     | 5.78     | 1.59     | 1.60     | 8.88      | 7.84      | ns    |
| 8 mA           | STD         | 0.63       | 7.87     | 0.05      | 1.10     | 0.45       | 8.02     | 6.80     | 1.59     | 1.59     | 10.43     | 9.22      | ns    |
|                | -1          | 0.53       | 6.69     | 0.04      | 0.94     | 0.38       | 6.82     | 5.78     | 1.59     | 1.60     | 8.88      | 7.84      | ns    |
| 12 mA          | STD         | 0.63       | 6.04     | 0.05      | 1.10     | 0.45       | 6.15     | 5.27     | 1.71     | 1.79     | 8.57      | 7.69      | ns    |
|                | -1          | 0.53       | 5.14     | 0.04      | 0.94     | 0.38       | 5.23     | 4.48     | 1.71     | 1.79     | 7.29      | 6.54      | ns    |
| 16 mA          | STD         | 0.63       | 5.63     | 0.05      | 1.10     | 0.45       | 5.74     | 4.94     | 1.74     | 1.84     | 8.16      | 7.36      | ns    |
|                | -1          | 0.53       | 4.79     | 0.04      | 0.94     | 0.38       | 4.88     | 4.20     | 1.74     | 1.84     | 6.94      | 6.26      | ns    |
| 24 mA          | STD         | 0.63       | 5.25     | 0.05      | 1.10     | 0.45       | 5.34     | 4.92     | 1.77     | 2.04     | 7.76      | 7.34      | ns    |
|                | -1          | 0.53       | 4.46     | 0.04      | 0.94     | 0.38       | 4.55     | 4.18     | 1.77     | 2.04     | 6.60      | 6.24      | ns    |

**Note:** For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-41 • 3.3 V LVTTTL / 3.3 V LVCMOS High Slew**

Automotive-Case Conditions:  $T_J = 115^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 3.0\text{ V}$   
Applicable to Standard Plus I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 4 mA           | STD         | 0.63       | 7.79     | 0.05      | 1.08     | 0.45       | 7.94     | 6.80     | 1.22     | 1.23     | 7.94      | 6.80      | ns    |
|                | -1          | 0.55       | 6.85     | 0.04      | 0.95     | 0.39       | 6.98     | 5.98     | 1.26     | 1.27     | 6.98      | 5.98      | ns    |
| 6 mA           | STD         | 0.63       | 4.87     | 0.05      | 1.08     | 0.45       | 4.96     | 4.13     | 1.38     | 1.51     | 4.96      | 4.13      | ns    |
|                | -1          | 0.55       | 4.28     | 0.04      | 0.95     | 0.39       | 4.36     | 3.63     | 1.42     | 1.56     | 4.36      | 3.63      | ns    |
| 8 mA           | STD         | 0.63       | 4.87     | 0.05      | 1.08     | 0.45       | 4.96     | 4.13     | 1.38     | 1.51     | 4.96      | 4.13      | ns    |
|                | -1          | 0.55       | 4.28     | 0.04      | 0.95     | 0.39       | 4.36     | 3.63     | 1.42     | 1.56     | 4.36      | 3.63      | ns    |
| 12 mA          | STD         | 0.63       | 3.42     | 0.05      | 1.08     | 0.45       | 1.69     | 1.38     | 3.02     | 3.48     | 1.69      | 1.38      | ns    |
|                | -1          | 0.55       | 3.01     | 0.04      | 0.95     | 0.39       | 1.74     | 1.43     | 2.65     | 3.06     | 1.74      | 1.43      | ns    |
| 16 mA          | STD         | 0.63       | 3.42     | 0.05      | 1.08     | 0.45       | 1.69     | 1.38     | 3.02     | 3.48     | 1.69      | 1.38      | ns    |
|                | -1          | 0.55       | 3.01     | 0.04      | 0.95     | 0.39       | 1.74     | 1.43     | 2.65     | 3.06     | 1.74      | 1.43      | ns    |

**Notes:**

1. Software default selection highlighted in gray.
2. For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-42 • 3.3 V LVTTTL / 3.3 V LVCMOS Low Slew**

Automotive-Case Conditions:  $T_J = 115^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 3.0\text{ V}$   
Applicable to Standard Plus I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 4 mA           | STD         | 0.63       | 10.47    | 0.05      | 1.08     | 0.45       | 10.66    | 9.11     | 1.22     | 1.16     | 10.66     | 9.11      | ns    |
|                | -1          | 0.55       | 9.21     | 0.04      | 0.95     | 0.39       | 9.38     | 8.01     | 1.26     | 1.20     | 9.38      | 8.01      | ns    |
| 6 mA           | STD         | 0.63       | 7.25     | 0.05      | 1.08     | 0.45       | 7.38     | 6.37     | 1.38     | 1.44     | 7.38      | 6.37      | ns    |
|                | -1          | 0.55       | 6.37     | 0.04      | 0.95     | 0.39       | 6.49     | 5.60     | 1.43     | 1.49     | 6.49      | 5.60      | ns    |
| 8 mA           | STD         | 0.63       | 7.25     | 0.05      | 1.08     | 0.45       | 7.38     | 6.37     | 1.38     | 1.44     | 7.38      | 6.37      | ns    |
|                | -1          | 0.55       | 6.37     | 0.04      | 0.95     | 0.39       | 6.49     | 5.60     | 1.43     | 1.49     | 6.49      | 5.60      | ns    |
| 12 mA          | STD         | 0.63       | 5.46     | 0.05      | 1.08     | 0.45       | 5.56     | 4.88     | 1.49     | 1.61     | 5.56      | 4.88      | ns    |
|                | -1          | 0.55       | 4.80     | 0.04      | 0.95     | 0.39       | 4.89     | 4.29     | 1.54     | 1.67     | 4.89      | 4.29      | ns    |
| 16 mA          | STD         | 0.63       | 5.46     | 0.05      | 1.08     | 0.45       | 5.56     | 4.88     | 1.49     | 1.61     | 5.56      | 4.88      | ns    |
|                | -1          | 0.55       | 4.80     | 0.04      | 0.95     | 0.39       | 4.89     | 4.29     | 1.54     | 1.67     | 4.89      | 4.29      | ns    |

**Note:** For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

## 2.5 V LVCMOS

Low-Voltage CMOS for 2.5 V is an extension of the LVCMOS standard (JESD8-5) used for general-purpose 2.5 V applications. It uses a 5 V-tolerant input buffer and push-pull output buffer.

**Table 2-43 • Minimum and Maximum DC Input and Output Levels**  
Applicable to Advanced I/O Banks

| 2.5 V LVCMOS   | $V_{IL}$ |         | $V_{IH}$ |         | $V_{OL}$ | $V_{OH}$ | $I_{OL}$ | $I_{OH}$ | $I_{OSL}$             | $I_{OSH}$             | $I_{IL}$  | $I_{IH}$  |
|----------------|----------|---------|----------|---------|----------|----------|----------|----------|-----------------------|-----------------------|-----------|-----------|
| Drive Strength | Min., V  | Max., V | Min., V  | Max., V | Max., V  | Min., V  | mA       | mA       | Max., mA <sup>1</sup> | Max., mA <sup>1</sup> | $\mu A^2$ | $\mu A^2$ |
| 2 mA           | -0.3     | 0.7     | 1.7      | 3.6     | 0.7      | 1.7      | 2        | 2        | 18                    | 16                    | 10        | 10        |
| 6 mA           | -0.3     | 0.7     | 1.7      | 3.6     | 0.7      | 1.7      | 6        | 6        | 37                    | 32                    | 10        | 10        |
| 12 mA          | -0.3     | 0.7     | 1.7      | 3.6     | 0.7      | 1.7      | 12       | 12       | 74                    | 65                    | 10        | 10        |
| 16 mA          | -0.3     | 0.7     | 1.7      | 3.6     | 0.7      | 1.7      | 16       | 16       | 87                    | 83                    | 10        | 10        |
| 24 mA          | -0.3     | 0.7     | 1.7      | 3.6     | 0.7      | 1.7      | 24       | 24       | 124                   | 169                   | 10        | 10        |

**Notes:**

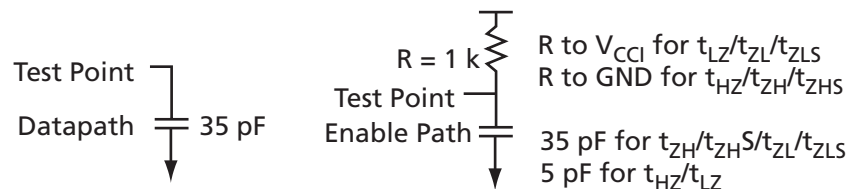
1. Currents are measured at high temperature (100°C junction temperature) and maximum voltage.
2. Currents are measured at 125°C junction temperature.
3. Software default selection highlighted in gray.

**Table 2-44 • Minimum and Maximum DC Input and Output Levels**  
Applicable to Standard Plus I/O Banks

| 2.5 V LVCMOS   | $V_{IL}$ |         | $V_{IH}$ |         | $V_{OL}$ | $V_{OH}$ | $I_{OL}$ | $I_{OH}$ | $I_{OSL}$             | $I_{OSH}$             | $I_{IL}$  | $I_{IH}$  |
|----------------|----------|---------|----------|---------|----------|----------|----------|----------|-----------------------|-----------------------|-----------|-----------|
| Drive Strength | Min., V  | Max., V | Min., V  | Max., V | Max., V  | Min., V  | mA       | mA       | Max., mA <sup>1</sup> | Max., mA <sup>1</sup> | $\mu A^2$ | $\mu A^2$ |
| 2 mA           | -0.3     | 0.7     | 1.7      | 3.6     | 0.7      | 1.7      | 2        | 2        | 18                    | 16                    | 10        | 10        |
| 6 mA           | -0.3     | 0.7     | 1.7      | 3.6     | 0.7      | 1.7      | 6        | 6        | 37                    | 32                    | 10        | 10        |
| 12 mA          | -0.3     | 0.7     | 1.7      | 3.6     | 0.7      | 1.7      | 12       | 12       | 74                    | 65                    | 10        | 10        |

**Notes:**

1. Currents are measured at high temperature (100°C junction temperature) and maximum voltage.
2. Currents are measured at 125°C junction temperature.
3. Software default selection highlighted in gray.



**Figure 2-8 • AC Loading**

**Table 2-45 • AC Waveforms, Measuring Points, and Capacitive Loads**

| Input LOW (V) | Input HIGH (V) | Measuring Point* (V) | $C_{LOAD}$ (pF) |
|---------------|----------------|----------------------|-----------------|
| 0             | 2.5            | 1.2                  | 35              |

\* Measuring point =  $V_{trip}$ . See Table 2-18 on page 2-17 for a complete table of trip points.

## Timing Characteristics

**Table 2-46 • 2.5 V LVC MOS High Slew**

Automotive-Case Conditions:  $T_J = 135^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 2.3\text{ V}$   
Applicable to Advanced I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 2 mA           | STD         | 0.64       | 9.69     | 0.05      | 1.45     | 0.46       | 8.76     | 9.69     | 1.48     | 1.25     | 11.26     | 12.187    | ns    |
|                | -1          | 0.55       | 8.24     | 0.04      | 1.23     | 0.39       | 7.45     | 8.24     | 1.48     | 1.25     | 9.58      | 10.367    | ns    |
| 6 mA           | STD         | 0.64       | 5.78     | 0.05      | 1.45     | 0.46       | 5.63     | 5.78     | 1.68     | 1.62     | 8.13      | 8.277     | ns    |
|                | -1          | 0.55       | 4.91     | 0.04      | 1.23     | 0.39       | 4.79     | 4.91     | 1.69     | 1.63     | 6.92      | 7.04      | ns    |
| 12 mA          | STD         | 0.64       | 3.98     | 0.05      | 1.45     | 0.46       | 4.05     | 3.84     | 1.82     | 1.86     | 6.55      | 6.338     | ns    |
|                | -1          | 0.55       | 3.39     | 0.04      | 1.23     | 0.39       | 3.45     | 3.27     | 1.83     | 1.86     | 5.58      | 5.392     | ns    |
| 16 mA          | STD         | 0.64       | 3.75     | 0.05      | 1.45     | 0.46       | 1.85     | 1.69     | 3.76     | 3.97     | 3.06      | 2.926     | ns    |
|                | -1          | 0.55       | 3.19     | 0.04      | 1.23     | 0.39       | 1.85     | 1.69     | 3.20     | 3.38     | 3.06      | 2.929     | ns    |
| 24 mA          | STD         | 0.64       | 3.45     | 0.05      | 1.45     | 0.46       | 1.70     | 1.35     | 3.84     | 4.47     | 2.92      | 2.585     | ns    |
|                | -1          | 0.55       | 2.94     | 0.04      | 1.23     | 0.39       | 1.71     | 1.35     | 3.27     | 3.80     | 2.92      | 2.586     | ns    |

### Notes:

1. Software default selection highlighted in gray.
2. For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-47 • 2.5 V LVC MOS Low Slew**

Automotive-Case Conditions:  $T_J = 135^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 2.3\text{ V}$   
Applicable to Advanced I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 2 mA           | STD         | 0.64       | 12.12    | 0.05      | 1.45     | 0.46       | 12.54    | 12.74    | 1.48     | 1.19     | 15.04     | 15.243    | ns    |
|                | -1          | 0.55       | 10.31    | 0.04      | 1.23     | 0.39       | 10.67    | 10.84    | 1.48     | 1.20     | 12.80     | 12.966    | ns    |
| 6 mA           | STD         | 0.64       | 8.24     | 0.05      | 1.45     | 0.46       | 9.07     | 8.74     | 1.68     | 1.57     | 11.57     | 11.237    | ns    |
|                | -1          | 0.55       | 7.01     | 0.04      | 1.23     | 0.39       | 7.71     | 7.43     | 1.69     | 1.57     | 9.84      | 9.559     | ns    |
| 12 mA          | STD         | 0.64       | 6.91     | 0.05      | 1.45     | 0.46       | 7.04     | 6.62     | 1.82     | 1.80     | 9.54      | 9.117     | ns    |
|                | -1          | 0.55       | 5.88     | 0.04      | 1.23     | 0.39       | 5.99     | 5.63     | 1.83     | 1.80     | 8.11      | 7.756     | ns    |
| 16 mA          | STD         | 0.64       | 6.44     | 0.05      | 1.45     | 0.46       | 6.56     | 6.18     | 1.86     | 1.86     | 9.06      | 8.678     | ns    |
|                | -1          | 0.55       | 5.48     | 0.04      | 1.23     | 0.39       | 5.58     | 5.26     | 1.86     | 1.86     | 7.71      | 7.382     | ns    |
| 24 mA          | STD         | 0.64       | 6.16     | 0.05      | 1.45     | 0.46       | 6.15     | 6.16     | 1.90     | 2.10     | 8.65      | 8.657     | ns    |
|                | -1          | 0.55       | 5.24     | 0.04      | 1.23     | 0.39       | 5.23     | 5.24     | 1.90     | 2.10     | 7.36      | 7.364     | ns    |

**Note:** For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-48 • 2.5 V LVC MOS High Slew**

Automotive-Case Conditions:  $T_J = 135^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 2.3\text{ V}$   
 Applicable to Standard Plus I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 2 mA           | STD         | 0.64       | 9.26     | 0.05      | 1.45     | 0.46       | 8.28     | 9.26     | 1.24     | 1.12     | 10.78     | 11.756    | ns    |
|                | -1          | 0.55       | 7.87     | 0.04      | 1.23     | 0.39       | 7.05     | 7.87     | 1.24     | 1.13     | 9.17      | 10        | ns    |
| 6 mA           | STD         | 0.64       | 5.43     | 0.05      | 1.45     | 0.46       | 5.19     | 5.43     | 1.43     | 1.47     | 7.69      | 7.926     | ns    |
|                | -1          | 0.55       | 4.62     | 0.04      | 1.23     | 0.39       | 4.42     | 4.62     | 1.43     | 1.47     | 6.55      | 6.743     | ns    |
| 12 mA          | STD         | 0.64       | 3.59     | 0.05      | 1.45     | 0.46       | 3.65     | 3.51     | 1.56     | 1.69     | 6.15      | 6.012     | ns    |
|                | -1          | 0.55       | 3.05     | 0.04      | 1.23     | 0.39       | 3.11     | 2.99     | 1.56     | 1.69     | 5.23      | 5.114     | ns    |

**Notes:**

1. Software default selection highlighted in gray.
2. For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-49 • 2.5 V LVC MOS Low Slew**

Automotive-Case Conditions:  $T_J = 135^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 2.3\text{ V}$   
 Applicable to Standard Plus I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 2 mA           | STD         | 0.64       | 12.12    | 0.05      | 1.45     | 0.46       | 11.89    | 12.12    | 1.25     | 1.08     | 14.39     | 14.622    | ns    |
|                | -1          | 0.55       | 10.31    | 0.04      | 1.23     | 0.39       | 10.12    | 10.31    | 1.25     | 1.08     | 12.24     | 12.438    | ns    |
| 6 mA           | STD         | 0.64       | 8.24     | 0.05      | 1.45     | 0.46       | 8.39     | 8.23     | 1.43     | 1.42     | 10.89     | 10.73     | ns    |
|                | -1          | 0.55       | 7.01     | 0.04      | 1.23     | 0.39       | 7.14     | 7.00     | 1.43     | 1.42     | 9.26      | 9.128     | ns    |
| 12 mA          | STD         | 0.64       | 6.30     | 0.05      | 1.45     | 0.46       | 6.41     | 6.16     | 1.56     | 1.63     | 8.91      | 8.656     | ns    |
|                | -1          | 0.55       | 5.35     | 0.04      | 1.23     | 0.39       | 5.45     | 5.24     | 1.56     | 1.63     | 7.58      | 7.364     | ns    |

**Note:** For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-50 • 2.5 V LVC MOS High Slew**

Automotive-Case Conditions:  $T_J = 115^\circ\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 2.3\text{ V}$   
Applicable to Advanced I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 2 mA           | STD         | 0.63       | 9.37     | 0.05      | 1.40     | 0.45       | 8.47     | 9.37     | 1.43     | 1.21     | 10.89     | 11.79     | ns    |
|                | -1          | 0.53       | 7.97     | 0.04      | 1.19     | 0.38       | 7.21     | 7.97     | 1.43     | 1.21     | 9.27      | 10.03     | ns    |
| 6 mA           | STD         | 0.63       | 5.59     | 0.05      | 1.40     | 0.45       | 5.45     | 5.59     | 1.63     | 1.57     | 7.87      | 8.01      | ns    |
|                | -1          | 0.53       | 4.75     | 0.04      | 1.19     | 0.38       | 4.63     | 4.75     | 1.63     | 1.57     | 6.69      | 6.81      | ns    |
| 12 mA          | STD         | 0.63       | 3.85     | 0.05      | 1.40     | 0.45       | 3.92     | 3.71     | 1.77     | 1.80     | 6.34      | 6.13      | ns    |
|                | -1          | 0.53       | 3.28     | 0.04      | 1.19     | 0.38       | 3.34     | 3.16     | 1.77     | 1.80     | 5.39      | 5.22      | ns    |
| 16 mA          | STD         | 0.63       | 3.63     | 0.05      | 1.40     | 0.45       | 1.79     | 1.64     | 3.64     | 3.84     | 2.96      | 2.83      | ns    |
|                | -1          | 0.53       | 3.08     | 0.04      | 1.19     | 0.38       | 1.79     | 1.64     | 3.09     | 3.27     | 2.96      | 2.83      | ns    |
| 24 mA          | STD         | 0.63       | 3.34     | 0.05      | 1.40     | 0.45       | 1.65     | 1.31     | 3.72     | 4.32     | 2.82      | 2.50      | ns    |
|                | -1          | 0.53       | 2.84     | 0.04      | 1.19     | 0.38       | 1.65     | 1.31     | 3.16     | 3.68     | 2.82      | 2.50      | ns    |

**Notes:**

1. Software default selection highlighted in gray.
2. For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-51 • 2.5 V LVC MOS Low Slew**

Automotive-Case Conditions:  $T_J = 115^\circ\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 2.3\text{ V}$   
Applicable to Advanced I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 2 mA           | STD         | 0.63       | 11.73    | 0.05      | 1.40     | 0.45       | 12.14    | 12.33    | 1.43     | 1.16     | 14.55     | 14.75     | ns    |
|                | -1          | 0.53       | 9.98     | 0.04      | 1.19     | 0.38       | 10.32    | 10.49    | 1.43     | 1.16     | 12.38     | 12.55     | ns    |
| 6 mA           | STD         | 0.63       | 7.97     | 0.05      | 1.40     | 0.45       | 8.77     | 8.45     | 1.63     | 1.51     | 11.19     | 10.87     | ns    |
|                | -1          | 0.53       | 6.78     | 0.04      | 1.19     | 0.38       | 7.46     | 7.19     | 1.63     | 1.52     | 9.52      | 9.25      | ns    |
| 12 mA          | STD         | 0.63       | 6.68     | 0.05      | 1.40     | 0.45       | 6.81     | 6.40     | 1.77     | 1.74     | 9.23      | 8.82      | ns    |
|                | -1          | 0.53       | 5.69     | 0.04      | 1.19     | 0.38       | 5.79     | 5.45     | 1.77     | 1.74     | 7.85      | 7.50      | ns    |
| 16 mA          | STD         | 0.63       | 6.24     | 0.05      | 1.40     | 0.45       | 6.35     | 5.98     | 1.80     | 1.80     | 8.77      | 8.40      | ns    |
|                | -1          | 0.53       | 5.30     | 0.04      | 1.19     | 0.38       | 5.40     | 5.08     | 1.80     | 1.80     | 7.46      | 7.14      | ns    |
| 24 mA          | STD         | 0.63       | 5.96     | 0.05      | 1.40     | 0.45       | 5.95     | 5.96     | 1.84     | 2.03     | 8.37      | 8.38      | ns    |
|                | -1          | 0.53       | 5.07     | 0.04      | 1.19     | 0.38       | 5.06     | 5.07     | 1.84     | 2.03     | 7.12      | 7.12      | ns    |

**Note:** For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-52 • 2.5 V LVCMOS High Slew**

Automotive-Case Conditions:  $T_J = 115^\circ\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 2.3\text{ V}$   
 Applicable to Standard Plus I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 2 mA           | STD         | 0.63       | 8.95     | 0.05      | 1.40     | 0.45       | 8.01     | 8.95     | 1.20     | 1.09     | 10.43     | 11.37     | ns    |
|                | -1          | 0.53       | 7.62     | 0.04      | 1.19     | 0.38       | 6.82     | 7.62     | 1.20     | 1.09     | 8.87      | 9.68      | ns    |
| 6 mA           | STD         | 0.63       | 5.25     | 0.05      | 1.40     | 0.45       | 5.03     | 5.25     | 1.38     | 1.42     | 7.44      | 7.67      | ns    |
|                | -1          | 0.53       | 4.47     | 0.04      | 1.19     | 0.38       | 4.27     | 4.47     | 1.38     | 1.42     | 6.33      | 6.52      | ns    |
| 12 mA          | STD         | 0.63       | 3.47     | 0.05      | 1.40     | 0.45       | 3.53     | 3.40     | 1.51     | 1.63     | 5.95      | 5.82      | ns    |
|                | -1          | 0.53       | 2.95     | 0.04      | 1.19     | 0.38       | 3.01     | 2.89     | 1.51     | 1.63     | 5.06      | 4.95      | ns    |

Notes:

1. Software default selection highlighted in gray.
2. For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-53 • 2.5 V LVCMOS Low Slew**

Automotive-Case Conditions:  $T_J = 115^\circ\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 2.3\text{ V}$   
 Applicable to Standard Plus I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 2 mA           | STD         | 0.63       | 11.73    | 0.05      | 1.40     | 0.45       | 11.51    | 11.73    | 1.21     | 1.04     | 13.93     | 14.15     | ns    |
|                | -1          | 0.53       | 9.98     | 0.04      | 1.19     | 0.38       | 9.79     | 9.98     | 1.21     | 1.04     | 11.85     | 12.03     | ns    |
| 6 mA           | STD         | 0.63       | 7.97     | 0.05      | 1.40     | 0.45       | 8.12     | 7.96     | 1.38     | 1.37     | 10.54     | 10.38     | ns    |
|                | -1          | 0.53       | 6.78     | 0.04      | 1.19     | 0.38       | 6.91     | 6.77     | 1.39     | 1.37     | 8.96      | 8.83      | ns    |
| 12 mA          | STD         | 0.63       | 6.09     | 0.05      | 1.40     | 0.45       | 6.20     | 5.96     | 1.51     | 1.58     | 8.62      | 8.38      | ns    |
|                | -1          | 0.53       | 5.18     | 0.04      | 1.19     | 0.38       | 5.28     | 5.07     | 1.51     | 1.58     | 7.33      | 7.12      | ns    |

Note: For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

## 1.8 V LVCMOS

Low-voltage CMOS for 1.8 V is an extension of the LVCMOS standard (JESD8-5) used for general-purpose 1.8 V applications. It uses a 1.8 V input buffer and a push-pull output buffer.

**Table 2-54 • Minimum and Maximum DC Input and Output Levels**  
Applicable to Advanced I/O Banks

| 1.8 V LVCMOS   | $V_{IL}$ |                  | $V_{IH}$         |         | $V_{OL}$ | $V_{OH}$         | $I_{OL}$ | $I_{OH}$ | $I_{OSL}$             | $I_{OSH}$             | $I_{IL}$  | $I_{IH}$  |
|----------------|----------|------------------|------------------|---------|----------|------------------|----------|----------|-----------------------|-----------------------|-----------|-----------|
| Drive Strength | Min., V  | Max., V          | Min., V          | Max., V | Max., V  | Min., V          | mA       | mA       | Max., mA <sup>1</sup> | Max., mA <sup>1</sup> | $\mu A^2$ | $\mu A^2$ |
| 2 mA           | -0.3     | $0.35 * V_{CCI}$ | $0.65 * V_{CCI}$ | 3.6     | 0.45     | $V_{CCI} - 0.45$ | 2        | 2        | 11                    | 9                     | 10        | 10        |
| 4 mA           | -0.3     | $0.35 * V_{CCI}$ | $0.65 * V_{CCI}$ | 3.6     | 0.45     | $V_{CCI} - 0.45$ | 4        | 4        | 22                    | 17                    | 10        | 10        |
| 6 mA           | -0.3     | $0.35 * V_{CCI}$ | $0.65 * V_{CCI}$ | 3.6     | 0.45     | $V_{CCI} - 0.45$ | 6        | 6        | 44                    | 35                    | 10        | 10        |
| 8 mA           | -0.3     | $0.35 * V_{CCI}$ | $0.65 * V_{CCI}$ | 3.6     | 0.45     | $V_{CCI} - 0.45$ | 8        | 8        | 51                    | 45                    | 10        | 10        |
| 12 mA          | -0.3     | $0.35 * V_{CCI}$ | $0.65 * V_{CCI}$ | 3.6     | 0.45     | $V_{CCI} - 0.45$ | 12       | 12       | 74                    | 91                    | 10        | 10        |
| 16 mA          | -0.3     | $0.35 * V_{CCI}$ | $0.65 * V_{CCI}$ | 3.6     | 0.45     | $V_{CCI} - 0.45$ | 16       | 16       | 74                    | 91                    | 10        | 10        |

Notes:

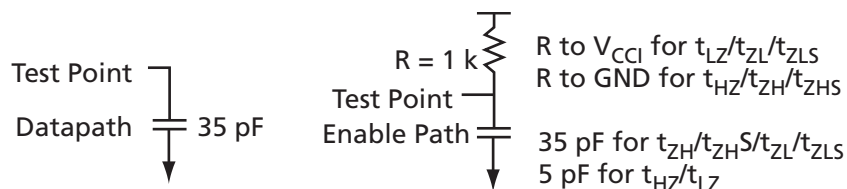
1. Currents are measured at high temperature (100°C junction temperature) and maximum voltage.
2. Currents are measured at 125°C junction temperature.
3. Software default selection highlighted in gray.

**Table 2-55 • Minimum and Maximum DC Input and Output Levels**  
Applicable to Standard Plus I/O I/O Banks

| 1.8 V LVCMOS   | $V_{IL}$ |                  | $V_{IH}$         |         | $V_{OL}$ | $V_{OH}$         | $I_{OL}$ | $I_{OH}$ | $I_{OSL}$             | $I_{OSH}$             | $I_{IL}$  | $I_{IH}$  |
|----------------|----------|------------------|------------------|---------|----------|------------------|----------|----------|-----------------------|-----------------------|-----------|-----------|
| Drive Strength | Min., V  | Max., V          | Min., V          | Max., V | Max., V  | Min., V          | mA       | mA       | Max., mA <sup>1</sup> | Max., mA <sup>1</sup> | $\mu A^2$ | $\mu A^2$ |
| 2 mA           | -0.3     | $0.35 * V_{CCI}$ | $0.65 * V_{CCI}$ | 3.6     | 0.45     | $V_{CCI} - 0.45$ | 2        | 2        | 11                    | 9                     | 10        | 10        |
| 4 mA           | -0.3     | $0.35 * V_{CCI}$ | $0.65 * V_{CCI}$ | 3.6     | 0.45     | $V_{CCI} - 0.45$ | 4        | 4        | 22                    | 17                    | 10        | 10        |
| 6 mA           | -0.3     | $0.35 * V_{CCI}$ | $0.65 * V_{CCI}$ | 3.6     | 0.45     | $V_{CCI} - 0.45$ | 6        | 6        | 44                    | 35                    | 10        | 10        |
| 8 mA           | -0.3     | $0.35 * V_{CCI}$ | $0.65 * V_{CCI}$ | 3.6     | 0.45     | $V_{CCI} - 0.45$ | 8        | 8        | 44                    | 35                    | 10        | 10        |

Notes:

1. Currents are measured at high temperature (100°C junction temperature) and maximum voltage.
2. Currents are measured at 125°C junction temperature.
3. Software default selection highlighted in gray.



**Figure 2-9 • AC Loading**

**Table 2-56 • AC Waveforms, Measuring Points, and Capacitive Loads**

| Input LOW (V) | Input HIGH (V) | Measuring Point* (V) | C <sub>LOAD</sub> (pF) |
|---------------|----------------|----------------------|------------------------|
| 0             | 1.8            | 0.9                  | 35                     |

\* Measuring point =  $V_{trip}$ . See [Table 2-18 on page 2-17](#) for a complete table of trip points.

### Timing Characteristics

**Table 2-57 • 1.8 V LVCMOS High Slew**

Automotive-Case Conditions:  $T_J = 135^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 2.3\text{ V}$   
Applicable to Advanced I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 2 mA           | STD         | 0.64       | 13.26    | 0.05      | 1.36     | 0.46       | 10.22    | 13.26    | 1.53     | 0.90     | 12.72     | 15.764    | ns    |
|                | -1          | 0.55       | 11.28    | 0.04      | 1.16     | 0.39       | 8.69     | 11.28    | 1.53     | 0.90     | 10.82     | 13.41     | ns    |
| 4 mA           | STD         | 0.64       | 7.73     | 0.05      | 1.36     | 0.46       | 6.55     | 7.73     | 1.78     | 1.54     | 9.05      | 10.232    | ns    |
|                | -1          | 0.55       | 6.58     | 0.04      | 1.16     | 0.39       | 5.58     | 6.58     | 1.78     | 1.54     | 7.70      | 8.704     | ns    |
| 6 mA           | STD         | 0.64       | 4.97     | 0.05      | 1.36     | 0.46       | 4.67     | 4.97     | 1.95     | 1.83     | 7.17      | 7.472     | ns    |
|                | -1          | 0.55       | 4.23     | 0.04      | 1.16     | 0.39       | 3.98     | 4.23     | 1.95     | 1.83     | 6.10      | 6.356     | ns    |
| 8 mA           | STD         | 0.64       | 4.39     | 0.05      | 1.36     | 0.46       | 4.39     | 4.39     | 1.99     | 1.91     | 6.89      | 6.888     | ns    |
|                | -1          | 0.55       | 3.73     | 0.04      | 1.16     | 0.39       | 3.74     | 3.73     | 1.99     | 1.91     | 5.86      | 5.859     | ns    |
| 12 mA          | STD         | 0.64       | 3.95     | 0.05      | 1.36     | 0.46       | 1.95     | 1.68     | 4.14     | 4.56     | 3.16      | 2.915     | ns    |
|                | -1          | 0.55       | 3.36     | 0.04      | 1.16     | 0.39       | 1.95     | 1.68     | 3.52     | 3.88     | 3.16      | 2.918     | ns    |
| 16 mA          | STD         | 0.64       | 3.95     | 0.05      | 1.36     | 0.46       | 1.95     | 1.68     | 4.14     | 4.56     | 3.16      | 2.915     | ns    |
|                | -1          | 0.55       | 3.36     | 0.04      | 1.16     | 0.39       | 1.95     | 1.68     | 3.52     | 3.88     | 3.16      | 2.918     | ns    |

#### Notes:

1. Software default selection highlighted in gray.
2. For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-58 • 1.8 V LVC MOS Low Slew**

Automotive-Case Conditions:  $T_J = 135^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 2.3\text{ V}$   
Applicable to Advanced I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 2 mA           | STD         | 0.64       | 17.36    | 0.05      | 1.45     | 0.46       | 15.78    | 17.36    | 1.53     | 0.87     | 18.28     | 19.864    | ns    |
|                | -1          | 0.55       | 14.77    | 0.04      | 1.23     | 0.39       | 13.42    | 14.77    | 1.54     | 0.87     | 15.55     | 16.897    | ns    |
| 4 mA           | STD         | 0.64       | 11.71    | 0.05      | 1.45     | 0.46       | 11.64    | 11.71    | 1.78     | 1.48     | 14.14     | 14.214    | ns    |
|                | -1          | 0.55       | 9.96     | 0.04      | 1.23     | 0.39       | 9.90     | 9.96     | 1.78     | 1.48     | 12.03     | 12.091    | ns    |
| 6 mA           | STD         | 0.64       | 9.00     | 0.05      | 1.45     | 0.46       | 9.17     | 8.77     | 1.95     | 1.77     | 11.67     | 11.267    | ns    |
|                | -1          | 0.55       | 7.66     | 0.04      | 1.23     | 0.39       | 7.80     | 7.46     | 1.95     | 1.77     | 9.92      | 9.585     | ns    |
| 8 mA           | STD         | 0.64       | 8.39     | 0.05      | 1.45     | 0.46       | 8.54     | 8.16     | 1.99     | 1.85     | 11.04     | 10.66     | ns    |
|                | -1          | 0.55       | 7.14     | 0.04      | 1.23     | 0.39       | 7.27     | 6.94     | 1.99     | 1.85     | 9.40      | 9.068     | ns    |
| 12 mA          | STD         | 0.64       | 8.15     | 0.05      | 1.45     | 0.46       | 8.09     | 8.15     | 2.05     | 2.14     | 10.59     | 10.654    | ns    |
|                | -1          | 0.55       | 6.94     | 0.04      | 1.23     | 0.39       | 6.88     | 6.94     | 2.05     | 2.14     | 9.01      | 9.063     | ns    |
| 16 mA          | STD         | 0.64       | 8.15     | 0.05      | 1.45     | 0.46       | 8.09     | 8.15     | 2.05     | 2.14     | 10.59     | 10.654    | ns    |
|                | -1          | 0.55       | 6.94     | 0.04      | 1.23     | 0.39       | 6.88     | 6.94     | 2.05     | 2.14     | 9.01      | 9.063     | ns    |

*Note:* For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-59 • 1.8 V LVC MOS High Slew**

Automotive-Case Conditions:  $T_J = 135^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 2.3\text{ V}$   
Applicable to Standard Plus I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 2 mA           | STD         | 0.64       | 13.26    | 0.05      | 1.36     | 0.46       | 9.75     | 12.67    | 1.24     | 0.82     | 12.26     | 15.17     | ns    |
|                | -1          | 0.55       | 11.28    | 0.04      | 1.16     | 0.39       | 8.30     | 10.78    | 1.24     | 0.83     | 10.43     | 12.905    | ns    |
| 4 mA           | STD         | 0.64       | 7.73     | 0.05      | 1.36     | 0.46       | 6.13     | 7.25     | 1.46     | 1.41     | 8.63      | 9.749     | ns    |
|                | -1          | 0.55       | 6.58     | 0.04      | 1.16     | 0.39       | 5.21     | 6.17     | 1.46     | 1.41     | 7.34      | 8.293     | ns    |
| 6 mA           | STD         | 0.64       | 4.97     | 0.05      | 1.36     | 0.46       | 4.29     | 4.54     | 1.62     | 1.68     | 6.79      | 7.039     | ns    |
|                | -1          | 0.55       | 4.23     | 0.04      | 1.16     | 0.39       | 3.65     | 3.86     | 1.62     | 1.68     | 5.78      | 5.987     | ns    |
| 8 mA           | STD         | 0.64       | 4.39     | 0.05      | 1.36     | 0.46       | 4.29     | 4.54     | 1.62     | 1.68     | 6.79      | 7.039     | ns    |
|                | -1          | 0.55       | 3.73     | 0.04      | 1.16     | 0.39       | 3.65     | 3.86     | 1.62     | 1.68     | 5.78      | 5.987     | ns    |

*Notes:*

1. Software default selection highlighted in gray.
2. For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-60 • 1.8 V LVC MOS Low Slew**

Automotive-Case Conditions:  $T_J = 135^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 2.3\text{ V}$   
 Applicable to Standard Plus I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 2 mA           | STD         | 0.64       | 17.36    | 0.05      | 1.45     | 0.46       | 15.09    | 16.55    | 1.24     | 0.79     | 17.59     | 19.052    | ns    |
|                | -1          | 0.55       | 14.77    | 0.04      | 1.23     | 0.39       | 12.84    | 14.08    | 1.24     | 0.79     | 14.96     | 16.207    | ns    |
| 4 mA           | STD         | 0.64       | 11.71    | 0.05      | 1.45     | 0.46       | 10.88    | 11.07    | 1.47     | 1.35     | 13.38     | 13.567    | ns    |
|                | -1          | 0.55       | 9.96     | 0.04      | 1.23     | 0.39       | 9.26     | 9.41     | 1.47     | 1.35     | 11.38     | 11.541    | ns    |
| 6 mA           | STD         | 0.64       | 9.00     | 0.05      | 1.45     | 0.46       | 8.47     | 8.18     | 1.62     | 1.62     | 10.97     | 10.685    | ns    |
|                | -1          | 0.55       | 7.66     | 0.04      | 1.23     | 0.39       | 7.21     | 6.96     | 1.62     | 1.62     | 9.33      | 9.089     | ns    |
| 8 mA           | STD         | 0.64       | 8.39     | 0.05      | 1.45     | 0.46       | 8.47     | 8.18     | 1.62     | 1.62     | 10.97     | 10.685    | ns    |
|                | -1          | 0.55       | 7.14     | 0.04      | 1.23     | 0.39       | 7.21     | 6.96     | 1.62     | 1.62     | 9.33      | 9.089     | ns    |

**Note:** For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-61 • 1.8 V LVC MOS High Slew**

Automotive-Case Conditions:  $T_J = 115^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 2.3\text{ V}$   
 Applicable to Advanced I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 2 mA           | STD         | 0.63       | 12.83    | 0.05      | 1.32     | 0.45       | 9.88     | 12.83    | 1.48     | 0.87     | 12.30     | 15.25     | ns    |
|                | -1          | 0.53       | 10.92    | 0.04      | 1.12     | 0.38       | 8.41     | 10.92    | 1.48     | 0.87     | 10.46     | 12.97     | ns    |
| 4 mA           | STD         | 0.63       | 7.48     | 0.05      | 1.32     | 0.45       | 6.34     | 7.48     | 1.72     | 1.49     | 8.76      | 9.90      | ns    |
|                | -1          | 0.53       | 6.36     | 0.04      | 1.12     | 0.38       | 5.39     | 6.36     | 1.72     | 1.49     | 7.45      | 8.42      | ns    |
| 6 mA           | STD         | 0.63       | 4.81     | 0.05      | 1.32     | 0.45       | 4.52     | 4.81     | 1.89     | 1.77     | 6.94      | 7.23      | ns    |
|                | -1          | 0.53       | 4.09     | 0.04      | 1.12     | 0.38       | 3.85     | 4.09     | 1.89     | 1.77     | 5.90      | 6.15      | ns    |
| 8 mA           | STD         | 0.63       | 4.25     | 0.05      | 1.32     | 0.45       | 4.25     | 4.25     | 1.92     | 1.85     | 6.67      | 6.66      | ns    |
|                | -1          | 0.53       | 3.61     | 0.04      | 1.12     | 0.38       | 3.61     | 3.61     | 1.93     | 1.85     | 5.67      | 5.67      | ns    |
| 12 mA          | STD         | 0.63       | 3.82     | 0.05      | 1.32     | 0.45       | 1.89     | 1.63     | 4.00     | 4.41     | 3.06      | 2.82      | ns    |
|                | -1          | 0.53       | 3.25     | 0.04      | 1.12     | 0.38       | 1.89     | 1.63     | 3.41     | 3.75     | 3.06      | 2.82      | ns    |
| 16 mA          | STD         | 0.63       | 3.82     | 0.05      | 1.32     | 0.45       | 1.89     | 1.63     | 4.00     | 4.41     | 3.06      | 2.82      | ns    |
|                | -1          | 0.53       | 3.25     | 0.04      | 1.12     | 0.38       | 1.89     | 1.63     | 3.41     | 3.75     | 3.06      | 2.82      | ns    |

**Notes:**

1. Software default selection highlighted in gray.
2. For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-62 • 1.8 V LVC MOS Low Slew**

Automotive-Case Conditions:  $T_J = 115^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 2.3\text{ V}$   
Applicable to Advanced I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 2 mA           | STD         | 0.63       | 16.80    | 0.05      | 1.40     | 0.45       | 15.27    | 16.80    | 1.48     | 0.84     | 17.69     | 19.22     | ns    |
|                | -1          | 0.53       | 14.29    | 0.04      | 1.19     | 0.38       | 12.99    | 14.29    | 1.49     | 0.84     | 15.05     | 16.35     | ns    |
| 4 mA           | STD         | 0.63       | 11.33    | 0.05      | 1.40     | 0.45       | 11.26    | 11.33    | 1.73     | 1.43     | 13.68     | 13.75     | ns    |
|                | -1          | 0.53       | 9.64     | 0.04      | 1.19     | 0.38       | 9.58     | 9.64     | 1.73     | 1.43     | 11.64     | 11.70     | ns    |
| 6 mA           | STD         | 0.63       | 8.71     | 0.05      | 1.40     | 0.45       | 8.87     | 8.48     | 1.89     | 1.72     | 11.29     | 10.90     | ns    |
|                | -1          | 0.53       | 7.41     | 0.04      | 1.19     | 0.38       | 7.54     | 7.22     | 1.89     | 1.72     | 9.60      | 9.27      | ns    |
| 8 mA           | STD         | 0.63       | 8.12     | 0.05      | 1.40     | 0.45       | 8.27     | 7.89     | 1.93     | 1.79     | 10.69     | 10.31     | ns    |
|                | -1          | 0.53       | 6.90     | 0.04      | 1.19     | 0.38       | 7.03     | 6.72     | 1.93     | 1.79     | 9.09      | 8.77      | ns    |
| 12 mA          | STD         | 0.63       | 7.89     | 0.05      | 1.40     | 0.45       | 7.83     | 7.89     | 1.98     | 2.07     | 10.25     | 10.31     | ns    |
|                | -1          | 0.53       | 6.71     | 0.04      | 1.19     | 0.38       | 6.66     | 6.71     | 1.98     | 2.07     | 8.72      | 8.77      | ns    |
| 16 mA          | STD         | 0.63       | 7.89     | 0.05      | 1.40     | 0.45       | 7.83     | 7.89     | 1.98     | 2.07     | 10.25     | 10.31     | ns    |
|                | -1          | 0.53       | 6.71     | 0.04      | 1.19     | 0.38       | 6.66     | 6.71     | 1.98     | 2.07     | 8.72      | 8.77      | ns    |

*Note:* For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-63 • 1.8 V LVC MOS High Slew**

Automotive-Case Conditions:  $T_J = 115^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 2.3\text{ V}$   
Applicable to Standard Plus I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 2 mA           | STD         | 0.63       | 12.83    | 0.05      | 1.32     | 0.45       | 9.44     | 12.26    | 1.20     | 0.80     | 11.86     | 14.68     | ns    |
|                | -1          | 0.53       | 10.92    | 0.04      | 1.12     | 0.38       | 8.03     | 10.43    | 1.20     | 0.80     | 10.09     | 12.49     | ns    |
| 4 mA           | STD         | 0.63       | 7.48     | 0.05      | 1.32     | 0.45       | 5.93     | 7.01     | 1.41     | 1.36     | 8.35      | 9.43      | ns    |
|                | -1          | 0.53       | 6.36     | 0.04      | 1.12     | 0.38       | 5.04     | 5.97     | 1.42     | 1.37     | 7.10      | 8.02      | ns    |
| 6 mA           | STD         | 0.63       | 4.81     | 0.05      | 1.32     | 0.45       | 4.15     | 4.39     | 1.57     | 1.63     | 6.57      | 6.81      | ns    |
|                | -1          | 0.53       | 4.09     | 0.04      | 1.12     | 0.38       | 3.53     | 3.74     | 1.57     | 1.63     | 5.59      | 5.79      | ns    |
| 8 mA           | STD         | 0.63       | 4.25     | 0.05      | 1.32     | 0.45       | 4.15     | 4.39     | 1.57     | 1.63     | 6.57      | 6.81      | ns    |
|                | -1          | 0.53       | 3.61     | 0.04      | 1.12     | 0.38       | 3.53     | 3.74     | 1.57     | 1.63     | 5.59      | 5.79      | ns    |

*Notes:*

1. Software default selection highlighted in gray.
2. For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-64 • 1.8 V LVCMOS Low Slew**

Automotive-Case Conditions:  $T_J = 115^\circ\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 2.3\text{ V}$   
 Applicable to Standard Plus I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 2 mA           | STD         | 0.63       | 16.80    | 0.05      | 1.40     | 0.45       | 14.60    | 16.01    | 1.20     | 0.77     | 17.02     | 18.43     | ns    |
|                | -1          | 0.53       | 14.29    | 0.04      | 1.19     | 0.38       | 12.42    | 13.62    | 1.20     | 0.77     | 14.48     | 15.68     | ns    |
| 4 mA           | STD         | 0.63       | 11.33    | 0.05      | 1.40     | 0.45       | 10.53    | 10.71    | 1.42     | 1.31     | 12.95     | 13.13     | ns    |
|                | -1          | 0.53       | 9.64     | 0.04      | 1.19     | 0.38       | 8.96     | 9.11     | 1.42     | 1.31     | 11.01     | 11.17     | ns    |
| 6 mA           | STD         | 0.63       | 8.71     | 0.05      | 1.40     | 0.45       | 8.19     | 7.92     | 1.57     | 1.57     | 10.61     | 10.34     | ns    |
|                | -1          | 0.53       | 7.41     | 0.04      | 1.19     | 0.38       | 6.97     | 6.74     | 1.57     | 1.57     | 9.03      | 8.79      | ns    |
| 8 mA           | STD         | 0.63       | 8.12     | 0.05      | 1.40     | 0.45       | 8.19     | 7.92     | 1.57     | 1.57     | 10.61     | 10.34     | ns    |
|                | -1          | 0.53       | 6.90     | 0.04      | 1.19     | 0.38       | 6.97     | 6.74     | 1.57     | 1.57     | 9.03      | 8.79      | ns    |

**Note:** For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

### 1.5 V LVCMOS (JESD8-11)

Low-Voltage CMOS for 1.5 V is an extension of the LVCMOS standard (JESD8-5) used for general-purpose 1.5 V applications. It uses a 1.5 V input buffer and a push-pull output buffer.

**Table 2-65 • Minimum and Maximum DC Input and Output Levels**  
 Applicable to Advanced I/O Banks

| 1.5 V LVCMOS   | $V_{IL}$ |                  | $V_{IH}$        |         | $V_{OL}$         | $V_{OH}$         | $I_{OL}$ | $I_{OH}$ | $I_{OSL}$             | $I_{OSH}$             | $I_{IL}$        | $I_{IH}$        |
|----------------|----------|------------------|-----------------|---------|------------------|------------------|----------|----------|-----------------------|-----------------------|-----------------|-----------------|
| Drive Strength | Min., V  | Max., V          | Min., V         | Max., V | Max., V          | Min., V          | mA       | mA       | Max., mA <sup>1</sup> | Max., mA <sup>1</sup> | $\mu\text{A}^2$ | $\mu\text{A}^2$ |
| 2 mA           | -0.3     | $0.30 * V_{CCI}$ | $0.7 * V_{CCI}$ | 3.6     | $0.25 * V_{CCI}$ | $0.75 * V_{CCI}$ | 2        | 2        | 16                    | 13                    | 10              | 10              |
| 4 mA           | -0.3     | $0.30 * V_{CCI}$ | $0.7 * V_{CCI}$ | 3.6     | $0.25 * V_{CCI}$ | $0.75 * V_{CCI}$ | 4        | 4        | 33                    | 25                    | 10              | 10              |
| 6 mA           | -0.3     | $0.30 * V_{CCI}$ | $0.7 * V_{CCI}$ | 3.6     | $0.25 * V_{CCI}$ | $0.75 * V_{CCI}$ | 6        | 6        | 39                    | 32                    | 10              | 10              |
| 8 mA           | -0.3     | $0.30 * V_{CCI}$ | $0.7 * V_{CCI}$ | 3.6     | $0.25 * V_{CCI}$ | $0.75 * V_{CCI}$ | 8        | 8        | 55                    | 66                    | 10              | 10              |
| 12 mA          | -0.3     | $0.30 * V_{CCI}$ | $0.7 * V_{CCI}$ | 3.6     | $0.25 * V_{CCI}$ | $0.75 * V_{CCI}$ | 12       | 12       | 55                    | 66                    | 10              | 10              |

**Notes:**

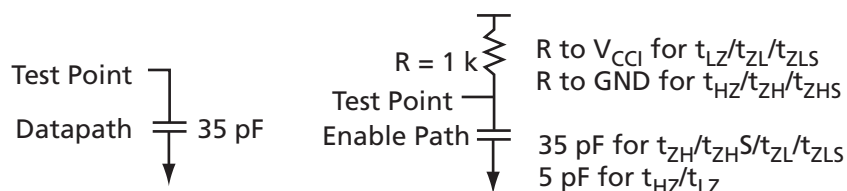
1. Currents are measured at high temperature (100°C junction temperature) and maximum voltage.
2. Currents are measured at 125°C junction temperature.
3. Software default selection highlighted in gray.

**Table 2-66 • Minimum and Maximum DC Input and Output Levels**  
Applicable to Standard Plus I/O Banks

| 1.5 V<br>LVCMOS   | $V_{IL}$ |                  | $V_{IH}$        |         | $V_{OL}$         | $V_{OH}$         | $I_{OL}$ | $I_{OH}$ | $I_{OSL}$             | $I_{OSH}$             | $I_{IL}$  | $I_{IH}$  |
|-------------------|----------|------------------|-----------------|---------|------------------|------------------|----------|----------|-----------------------|-----------------------|-----------|-----------|
| Drive<br>Strength | Min., V  | Max., V          | Min., V         | Max., V | Max., V          | Min., V          | mA       | mA       | Max., mA <sup>1</sup> | Max., mA <sup>1</sup> | $\mu A^2$ | $\mu A^2$ |
| 2 mA              | -0.3     | $0.30 * V_{CCI}$ | $0.7 * V_{CCI}$ | 3.6     | $0.25 * V_{CCI}$ | $0.75 * V_{CCI}$ | 2        | 2        | 0                     | 0                     | 10        | 10        |
| 4 mA              | -0.3     | $0.30 * V_{CCI}$ | $0.7 * V_{CCI}$ | 3.6     | $0.25 * V_{CCI}$ | $0.75 * V_{CCI}$ | 4        | 4        | 0                     | 0                     | 10        | 10        |

**Notes:**

1. Currents are measured at high temperature (100°C junction temperature) and maximum voltage.
2. Currents are measured at 125°C junction temperature.
3. Software default selection highlighted in gray.



**Figure 2-10 • AC Loading**

**Table 2-67 • AC Waveforms, Measuring Points, and Capacitive Loads**

| Input LOW (V) | Input HIGH (V) | Measuring Point* (V) | $C_{LOAD}$ (pF) |
|---------------|----------------|----------------------|-----------------|
| 0             | 1.5            | 0.75                 | 35              |

\* Measuring point =  $V_{trip}$ . See Table 2-18 on page 2-17 for a complete table of trip points.

## Timing Characteristics

Table 2-68 • 1.5 V LVCMOS High Slew

Automotive-Case Conditions:  $T_J = 135^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 2.3\text{ V}$   
 Applicable to Advanced I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 2 mA           | STD         | 0.64       | 9.35     | 0.05      | 1.61     | 0.46       | 7.63     | 9.35     | 1.87     | 1.50     | 10.13     | 11.851    | ns    |
|                | -1          | 0.55       | 7.95     | 0.04      | 1.37     | 0.39       | 6.49     | 7.95     | 1.87     | 1.50     | 8.62      | 10.081    | ns    |
| 4 mA           | STD         | 0.64       | 5.94     | 0.05      | 1.61     | 0.46       | 5.42     | 5.94     | 2.07     | 1.84     | 7.92      | 8.442     | ns    |
|                | -1          | 0.55       | 5.05     | 0.04      | 1.37     | 0.39       | 4.61     | 5.05     | 2.07     | 1.85     | 6.74      | 7.181     | ns    |
| 6 mA           | STD         | 0.64       | 5.22     | 0.05      | 1.61     | 0.46       | 5.09     | 5.22     | 2.11     | 1.93     | 7.59      | 7.718     | ns    |
|                | -1          | 0.55       | 4.44     | 0.04      | 1.37     | 0.39       | 4.33     | 4.44     | 2.11     | 1.93     | 6.45      | 6.566     | ns    |
| 8 mA           | STD         | 0.64       | 4.56     | 0.05      | 1.61     | 0.46       | 2.25     | 1.98     | 4.41     | 4.70     | 3.46      | 3.211     | ns    |
|                | -1          | 0.55       | 3.88     | 0.04      | 1.37     | 0.39       | 2.25     | 1.98     | 3.75     | 4.00     | 3.46      | 3.213     | ns    |
| 12 mA          | STD         | 0.64       | 4.56     | 0.05      | 1.61     | 0.46       | 2.25     | 1.98     | 4.41     | 4.70     | 3.46      | 3.211     | ns    |
|                | -1          | 0.55       | 3.88     | 0.04      | 1.37     | 0.39       | 2.25     | 1.98     | 3.75     | 4.00     | 3.46      | 3.213     | ns    |

## Notes:

1. Software default selection highlighted in gray.
2. For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

Table 2-69 • 1.5 V LVCMOS Low Slew

Automotive-Case Conditions:  $T_J = 135^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 2.3\text{ V}$   
 Applicable to Advanced I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 2 mA           | STD         | 0.64       | 14.29    | 0.05      | 1.45     | 0.46       | 14.32    | 14.29    | 1.88     | 1.43     | 16.82     | 16.794    | ns    |
|                | -1          | 0.55       | 12.16    | 0.04      | 1.23     | 0.39       | 12.18    | 12.16    | 1.88     | 1.43     | 14.31     | 14.286    | ns    |
| 4 mA           | STD         | 0.64       | 11.19    | 0.05      | 1.45     | 0.46       | 11.40    | 10.67    | 2.07     | 1.77     | 13.90     | 13.175    | ns    |
|                | -1          | 0.55       | 9.52     | 0.04      | 1.23     | 0.39       | 9.70     | 9.08     | 2.07     | 1.77     | 11.82     | 11.207    | ns    |
| 6 mA           | STD         | 0.64       | 10.44    | 0.05      | 1.45     | 0.46       | 10.63    | 9.94     | 2.12     | 1.86     | 13.13     | 12.442    | ns    |
|                | -1          | 0.55       | 8.88     | 0.04      | 1.23     | 0.39       | 9.04     | 8.46     | 2.12     | 1.86     | 11.17     | 10.584    | ns    |
| 8 mA           | STD         | 0.64       | 9.96     | 0.05      | 1.45     | 0.46       | 10.15    | 9.94     | 2.18     | 2.19     | 12.65     | 12.445    | ns    |
|                | -1          | 0.55       | 8.47     | 0.04      | 1.23     | 0.39       | 8.63     | 8.46     | 2.19     | 2.20     | 10.76     | 10.586    | ns    |
| 12 mA          | STD         | 0.64       | 9.96     | 0.05      | 1.45     | 0.46       | 10.15    | 9.94     | 2.18     | 2.19     | 12.65     | 12.445    | ns    |
|                | -1          | 0.55       | 8.47     | 0.04      | 1.23     | 0.39       | 8.63     | 8.46     | 2.19     | 2.20     | 10.76     | 10.586    | ns    |

Note: For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-70 • 1.5 V LVC MOS High Slew**

Automotive-Case Conditions:  $T_J = 135^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 2.3\text{ V}$   
Applicable to Standard Plus I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 2 mA           | STD         | 0.64       | 8.76     | 0.05      | 1.59     | 0.46       | 7.63     | 9.35     | 1.87     | 1.50     | 10.13     | 11.851    | ns    |
|                | -1          | 0.55       | 7.45     | 0.04      | 1.35     | 0.39       | 6.49     | 7.95     | 1.87     | 1.50     | 8.62      | 10.081    | ns    |
| 4 mA           | STD         | 0.64       | 5.41     | 0.05      | 1.59     | 0.46       | 5.42     | 5.94     | 2.07     | 1.84     | 7.92      | 8.442     | ns    |
|                | -1          | 0.55       | 4.60     | 0.04      | 1.35     | 0.39       | 4.61     | 5.05     | 2.07     | 1.85     | 6.74      | 7.181     | ns    |

**Notes:**

1. Software default selection highlighted in gray.
2. For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-71 • 1.5 V LVC MOS Low Slew**

Automotive-Case Conditions:  $T_J = 135^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 2.3\text{ V}$   
Applicable to Standard Plus I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 2 mA           | STD         | 0.64       | 13.51    | 0.05      | 1.45     | 0.46       | 14.32    | 14.29    | 1.88     | 1.43     | 16.82     | 16.794    | ns    |
|                | -1          | 0.55       | 11.49    | 0.04      | 1.23     | 0.39       | 12.18    | 12.16    | 1.88     | 1.43     | 14.31     | 14.286    | ns    |
| 4 mA           | STD         | 0.64       | 10.38    | 0.05      | 1.45     | 0.46       | 11.40    | 10.67    | 2.07     | 1.77     | 13.90     | 13.175    | ns    |
|                | -1          | 0.55       | 8.83     | 0.04      | 1.23     | 0.39       | 9.70     | 9.08     | 2.07     | 1.77     | 11.82     | 11.207    | ns    |

**Note:** For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-72 • 1.5 V LVC MOS High Slew**

Automotive-Case Conditions:  $T_J = 115^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 2.3\text{ V}$   
Applicable to Advanced I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 2 mA           | STD         | 0.63       | 9.05     | 0.05      | 1.56     | 0.45       | 7.38     | 9.05     | 1.81     | 1.45     | 9.80      | 11.47     | ns    |
|                | -1          | 0.53       | 7.70     | 0.04      | 1.32     | 0.38       | 6.28     | 7.70     | 1.81     | 1.45     | 8.34      | 9.75      | ns    |
| 4 mA           | STD         | 0.63       | 5.75     | 0.05      | 1.56     | 0.45       | 5.25     | 5.75     | 2.00     | 1.78     | 7.67      | 8.17      | ns    |
|                | -1          | 0.53       | 4.89     | 0.04      | 1.32     | 0.38       | 4.46     | 4.89     | 2.00     | 1.78     | 6.52      | 6.95      | ns    |
| 6 mA           | STD         | 0.63       | 5.05     | 0.05      | 1.56     | 0.45       | 4.92     | 5.05     | 2.04     | 1.87     | 7.34      | 7.47      | ns    |
|                | -1          | 0.53       | 4.29     | 0.04      | 1.32     | 0.38       | 4.19     | 4.29     | 2.04     | 1.87     | 6.24      | 6.35      | ns    |
| 8 mA           | STD         | 0.63       | 4.41     | 0.05      | 1.56     | 0.45       | 2.18     | 1.91     | 4.27     | 4.55     | 3.35      | 3.11      | ns    |
|                | -1          | 0.53       | 3.75     | 0.04      | 1.32     | 0.38       | 2.18     | 1.91     | 3.63     | 3.87     | 3.35      | 3.11      | ns    |
| 12 mA          | STD         | 0.63       | 4.41     | 0.05      | 1.56     | 0.45       | 2.18     | 1.91     | 4.27     | 4.55     | 3.35      | 3.11      | ns    |
|                | -1          | 0.53       | 3.75     | 0.04      | 1.32     | 0.38       | 2.18     | 1.91     | 3.63     | 3.87     | 3.35      | 3.11      | ns    |

**Notes:**

1. Software default selection highlighted in gray.
2. For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-73 • 1.5 V LVC MOS Low Slew**

Automotive-Case Conditions:  $T_J = 115^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 2.3\text{ V}$   
Applicable to Advanced I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 2 mA           | STD         | 0.63       | 13.83    | 0.05      | 1.40     | 0.45       | 13.86    | 13.83    | 1.82     | 1.39     | 16.28     | 16.25     | ns    |
|                | -1          | 0.53       | 11.76    | 0.04      | 1.19     | 0.38       | 11.79    | 11.76    | 1.82     | 1.39     | 13.85     | 13.82     | ns    |
| 4 mA           | STD         | 0.63       | 10.83    | 0.05      | 1.40     | 0.45       | 11.03    | 10.33    | 2.00     | 1.71     | 13.45     | 12.75     | ns    |
|                | -1          | 0.53       | 9.21     | 0.04      | 1.19     | 0.38       | 9.38     | 8.79     | 2.01     | 1.72     | 11.44     | 10.84     | ns    |
| 6 mA           | STD         | 0.63       | 10.10    | 0.05      | 1.40     | 0.45       | 10.28    | 9.62     | 2.05     | 1.80     | 12.70     | 12.04     | ns    |
|                | -1          | 0.53       | 8.59     | 0.04      | 1.19     | 0.38       | 8.75     | 8.18     | 2.05     | 1.80     | 10.81     | 10.24     | ns    |
| 8 mA           | STD         | 0.63       | 9.64     | 0.05      | 1.40     | 0.45       | 9.82     | 9.62     | 2.11     | 2.12     | 12.23     | 12.04     | ns    |
|                | -1          | 0.53       | 8.20     | 0.04      | 1.19     | 0.38       | 8.35     | 8.18     | 2.11     | 2.12     | 10.41     | 10.24     | ns    |
| 12 mA          | STD         | 0.63       | 9.64     | 0.05      | 1.40     | 0.45       | 9.82     | 9.62     | 2.11     | 2.12     | 12.23     | 12.04     | ns    |
|                | -1          | 0.53       | 8.20     | 0.04      | 1.19     | 0.38       | 8.35     | 8.18     | 2.11     | 2.12     | 10.41     | 10.24     | ns    |

**Note:** For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-74 • 1.5 V LVC MOS High Slew**

Automotive-Case Conditions:  $T_J = 115^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 2.3\text{ V}$   
Applicable to Standard Plus I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 2 mA           | STD         | 0.63       | 8.47     | 0.05      | 1.54     | 0.45       | 7.38     | 9.05     | 1.81     | 1.45     | 9.80      | 11.47     | ns    |
|                | -1          | 0.53       | 7.21     | 0.04      | 1.31     | 0.38       | 6.28     | 7.70     | 1.81     | 1.45     | 8.34      | 9.75      | ns    |
| 4 mA           | STD         | 0.63       | 5.24     | 0.05      | 1.54     | 0.45       | 5.25     | 5.75     | 2.00     | 1.78     | 7.67      | 8.17      | ns    |
|                | -1          | 0.53       | 4.45     | 0.04      | 1.31     | 0.38       | 4.46     | 4.89     | 2.00     | 1.78     | 6.52      | 6.95      | ns    |

**Notes:**

1. Software default selection highlighted in gray.
2. For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-75 • 1.5 V LVC MOS Low Slew**

Automotive-Case Conditions:  $T_J = 115^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 2.3\text{ V}$   
Applicable to Standard Plus I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| 2 mA           | STD         | 0.63       | 13.07    | 0.05      | 1.40     | 0.45       | 13.86    | 13.83    | 1.82     | 1.39     | 16.28     | 16.25     | ns    |
|                | -1          | 0.53       | 11.12    | 0.04      | 1.19     | 0.38       | 11.79    | 11.76    | 1.82     | 1.39     | 13.85     | 13.82     | ns    |
| 4 mA           | STD         | 0.63       | 10.04    | 0.05      | 1.40     | 0.45       | 11.03    | 10.33    | 2.00     | 1.71     | 13.45     | 12.75     | ns    |
|                | -1          | 0.53       | 8.54     | 0.04      | 1.19     | 0.38       | 9.38     | 8.79     | 2.01     | 1.72     | 11.44     | 10.84     | ns    |

**Note:** For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

### 3.3 V PCI, 3.3 V PCI-X

The Peripheral Component Interface for 3.3 V standard specifies support for 33 MHz and 66 MHz PCI Bus applications.

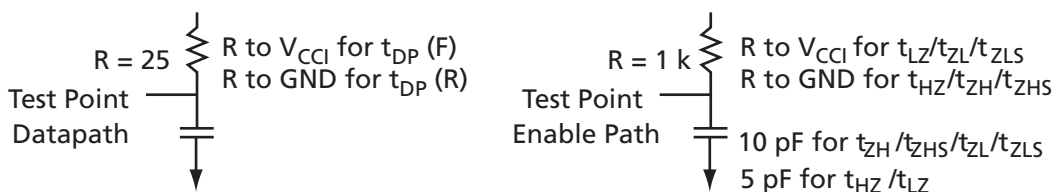
**Table 2-76 • Minimum and Maximum DC Input and Output Levels**

| 3.3 V PCI/PCI-X       | V <sub>IL</sub> |        | V <sub>IH</sub> |        | V <sub>OL</sub> | V <sub>OH</sub> | I <sub>OL</sub> | I <sub>OH</sub> | I <sub>OSL</sub>     | I <sub>OSH</sub>     | I <sub>IL</sub> | I <sub>IH</sub> |
|-----------------------|-----------------|--------|-----------------|--------|-----------------|-----------------|-----------------|-----------------|----------------------|----------------------|-----------------|-----------------|
| Drive Strength        | Min, V          | Max, V | Min, V          | Max, V | Max, V          | Min, V          | mA              | mA              | Max, mA <sup>1</sup> | Max, mA <sup>1</sup> | μA <sup>2</sup> | μA <sup>2</sup> |
| Per PCI specification | Per PCI curves  |        |                 |        |                 |                 |                 |                 |                      |                      | 10              | 10              |

**Notes:**

1. Currents are measured at high temperature (100°C junction temperature) and maximum voltage.
2. Currents are measured at 125°C junction temperature.

AC loadings are defined per the PCI/PCI-X specifications for the datapath; Actel loadings for enable path characterization are described in [Figure 2-11](#).



**Figure 2-11 • AC Loading**

AC loadings are defined per PCI/PCI-X specifications for the datapath; Actel loading for tristate is described in [Table 2-77](#).

**Table 2-77 • AC Waveforms, Measuring Points, and Capacitive Loads**

| Input LOW (V) | Input HIGH (V) | Measuring Point* (V)                                                                               | C <sub>LOAD</sub> (pF) |
|---------------|----------------|----------------------------------------------------------------------------------------------------|------------------------|
| 0             | 3.3            | 0.285 * V <sub>CCI</sub> for t <sub>DP(R)</sub><br>0.615 * V <sub>CCI</sub> for t <sub>DP(F)</sub> | 10                     |

\* Measuring point = V<sub>trip</sub>. See [Table 2-18 on page 2-17](#) for a complete table of trip points.

### Timing Characteristics

**Table 2-78 • 3.3 V PCI/PCI-X**

Automotive-Case Conditions: T<sub>J</sub> = 135°C, Worst-Case V<sub>CC</sub> = 1.425 V, Worst-Case V<sub>CCI</sub> = 3.0 V  
Applicable to Advanced I/O Banks

| Speed Grade | t <sub>DOUT</sub> | t <sub>DP</sub> | t <sub>DIN</sub> | t <sub>PY</sub> | t <sub>EOUT</sub> | t <sub>ZL</sub> | t <sub>ZH</sub> | t <sub>LZ</sub> | t <sub>HZ</sub> | t <sub>ZLS</sub> | t <sub>ZHS</sub> | Units |
|-------------|-------------------|-----------------|------------------|-----------------|-------------------|-----------------|-----------------|-----------------|-----------------|------------------|------------------|-------|
| Std.        | 0.64              | 2.58            | 0.05             | 0.95            | 0.46              | 1.27            | 0.94            | 3.12            | 3.60            | 2.49             | 2.18             | ns    |
| -1          | 0.55              | 2.19            | 0.04             | 0.81            | 0.39              | 1.27            | 0.94            | 2.65            | 3.06            | 2.49             | 2.18             | ns    |

**Note:** For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-79 • 3.3 V PCI/PCI-X**

Automotive-Case Conditions:  $T_J = 135^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 3.0\text{ V}$   
Applicable to Standard Plus I/O Banks

| Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| Std.        | 0.64       | 3.00     | 0.05      | 0.93     | 0.46       | 1.27     | 0.94     | 3.12     | 3.60     | 2.49      | 2.18      | ns    |
| -1          | 0.55       | 2.55     | 0.04      | 0.79     | 0.39       | 1.27     | 0.94     | 2.65     | 3.06     | 2.49      | 2.18      | ns    |

*Note:* For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-80 • 3.3 V PCI/PCI-X**

Automotive-Case Conditions:  $T_J = 115^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 3.0\text{ V}$   
Applicable to Advanced I/O Banks

| Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| Std.        | 0.628      | 2.50     | 0.05      | 0.92     | 0.45       | 1.23     | 0.91     | 3.02     | 3.48     | 2.40      | 2.11      | ns    |
| -1          | 0.53       | 2.12     | 0.04      | 0.78     | 0.38       | 1.23     | 0.91     | 2.57     | 2.96     | 2.41      | 2.11      | ns    |

*Note:* For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-81 • 3.3 V PCI/PCI-X**

Automotive-Case Conditions:  $T_J = 115^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 3.0\text{ V}$   
Applicable to Standard Plus I/O Banks

| Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | $t_{ZLS}$ | $t_{ZHS}$ | Units |
|-------------|------------|----------|-----------|----------|------------|----------|----------|----------|----------|-----------|-----------|-------|
| Std.        | 0.628      | 2.90     | 0.05      | 0.90     | 0.45       | 1.23     | 0.91     | 3.02     | 3.48     | 2.40      | 2.11      | ns    |
| -1          | 0.53       | 2.47     | 0.04      | 0.77     | 0.38       | 1.23     | 0.91     | 2.57     | 2.96     | 2.41      | 2.11      | ns    |

*Note:* For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

## Differential I/O Characteristics

### Physical Implementation

Configuration of the I/O modules as a differential pair is handled by Actel Designer software when the user instantiates a differential I/O macro in the design.

Differential I/Os can also be used in conjunction with the embedded Input Register (InReg), Output Register (OutReg), Enable Register (EnReg), and Double Data Rate (DDR). However, there is no support for bidirectional I/Os or tristates with the LVPECL standards.

### LVDS

Low-Voltage Differential Signaling (ANSI/TIA/EIA-644) is a high-speed, differential I/O standard. It requires that one data bit be carried through two signal lines, so two pins are needed. It also requires external resistor termination.

The full implementation of the LVDS transmitter and receiver is shown in an example in [Figure 2-12 on page 2-49](#). The building blocks of the LVDS transmitter-receiver are one transmitter macro, one receiver macro, three board resistors at the transmitter end, and one resistor at the receiver end. The values for the three driver resistors are different from those used in the LVPECL implementation because the output standard specifications are different.

Along with LVDS I/O, ProASIC3 also supports Bus LVDS structure and Multipoint LVDS (M-LVDS) configuration (up to 40 nodes).

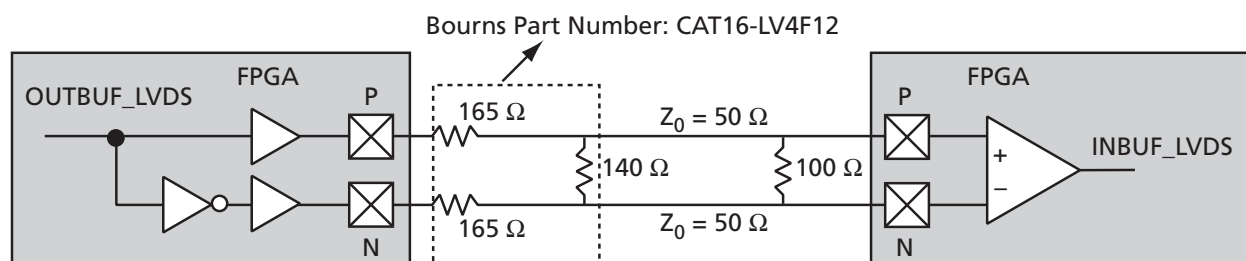


Figure 2-12 • LVDS Circuit Diagram and Board-Level Implementation

Table 2-82 • Minimum and Maximum DC Input and Output Levels

| DC Parameter | Description                 | Min.  | Typ.  | Max.  | Units |
|--------------|-----------------------------|-------|-------|-------|-------|
| $V_{CCI}$    | Supply Voltage              | 2.375 | 2.5   | 2.625 | V     |
| $V_{OL}$     | Output LOW Voltage          | 0.9   | 1.075 | 1.25  | V     |
| $V_{OH}$     | Output HIGH Voltage         | 1.25  | 1.425 | 1.6   | V     |
| $V_I$        | Input Voltage               | 0     | –     | 2.925 | V     |
| $V_{ODIFF}$  | Differential Output Voltage | 250   | 350   | 450   | mV    |
| $V_{OCM}$    | Output Common-Mode Voltage  | 1.125 | 1.25  | 1.375 | V     |
| $V_{ICM}$    | Input Common-Mode Voltage   | 0.05  | 1.25  | 2.35  | V     |
| $V_{IDIFF}$  | Input Differential Voltage  | 100   | 350   | –     | mV    |

#### Notes:

1.  $\pm 5\%$
2. Differential input voltage =  $\pm 350$  mV

Table 2-83 • AC Waveforms, Measuring Points, and Capacitive Loads

| Input LOW (V) | Input HIGH (V) | Measuring Point* (V) |
|---------------|----------------|----------------------|
| 1.075         | 1.325          | Cross point          |

\* Measuring point =  $V_{trip}$ . See Table 2-18 on page 2-17 for a complete table of trip points.

### Timing Characteristics

Table 2-84 • LVDS

Automotive-Case Conditions:  $T_J = 135^\circ\text{C}$ , Worst-Case  $V_{CC} = 1.425$  V, Worst-Case  $V_{CCI} = 2.3$  V

| Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | Units |
|-------------|------------|----------|-----------|----------|-------|
| Std.        | 0.64       | 2.05     | 0.05      | 1.79     | ns    |
| –1          | 0.55       | 1.74     | 0.04      | 1.52     | ns    |

Note: For specific junction temperature and voltage supply levels, refer to Table 2-5 on page 2-5 for derating values.

**Table 2-85 • LVDS**  
**Automotive-Case Conditions:  $T_J = 115^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 2.3\text{ V}$**

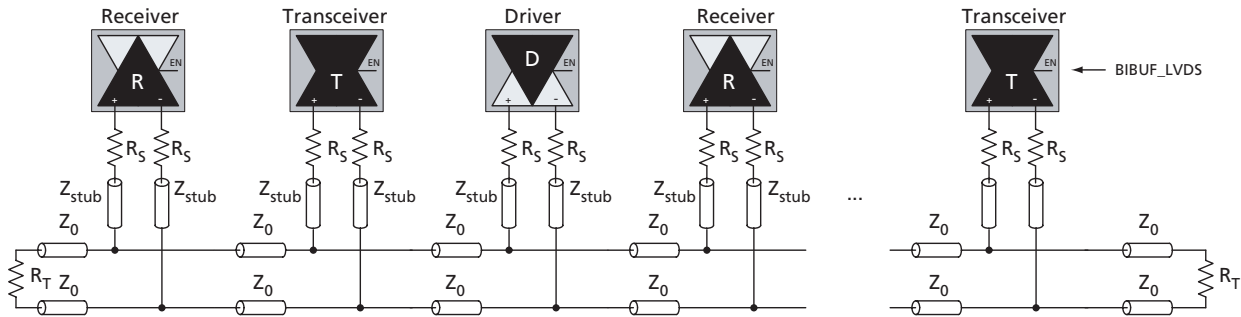
| Speed Grade | $t_{\text{DOUT}}$ | $t_{\text{DP}}$ | $t_{\text{DIN}}$ | $t_{\text{PY}}$ | Units |
|-------------|-------------------|-----------------|------------------|-----------------|-------|
| Std.        | 0.63              | 1.98            | 0.05             | 1.73            | ns    |
| -1          | 0.53              | 1.68            | 0.04             | 1.47            | ns    |

*Note:* For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

### B-LVDS/M-LVDS

Bus LVDS (B-LVDS) and Multipoint LVDS (M-LVDS) specifications extend the existing LVDS standard to high-performance multipoint bus applications. Multidrop and multipoint bus configurations may contain any combination of drivers, receivers, and transceivers. Actel LVDS drivers provide the higher drive current required by B-LVDS and M-LVDS to accommodate the loading. The drivers require series terminations for better signal quality and to control voltage swing. Termination is also required at both ends of the bus since the driver can be located anywhere on the bus. These configurations can be implemented using the TRIBUF\_LVDS and BIBUF\_LVDS macros along with appropriate terminations. Multipoint designs using Actel LVDS macros can achieve up to 200 MHz with a maximum of 20 loads. A sample application is given in [Figure 2-13](#). The input and output buffer delays are available in the LVDS section in [Table 2-84 on page 2-49](#).

Example: For a bus consisting of 20 equidistant loads, the following terminations provide the required differential voltage, in worst-case Industrial operating conditions, at the farthest receiver:  $R_S = 60\ \Omega$  and  $R_T = 70\ \Omega$ , given  $Z_0 = 50\ \Omega$  (2") and  $Z_{\text{stub}} = 50\ \Omega$  (~1.5").



**Figure 2-13 • B-LVDS/M-LVDS Multipoint Application Using LVDS I/O Buffers**

### LVPECL

Low-Voltage Positive Emitter-Coupled Logic (LVPECL) is another differential I/O standard. It requires that one data bit be carried through two signal lines. Like LVDS, two pins are needed. It also requires external resistor termination.

The full implementation of the LVDS transmitter and receiver is shown in an example in [Figure 2-14 on page 2-51](#). The building blocks of the LVPECL transmitter-receiver are one transmitter macro, one receiver macro, three board resistors at the transmitter end, and one resistor at the receiver end. The values for the three driver resistors are different from those used in the LVDS implementation because the output standard specifications are different.

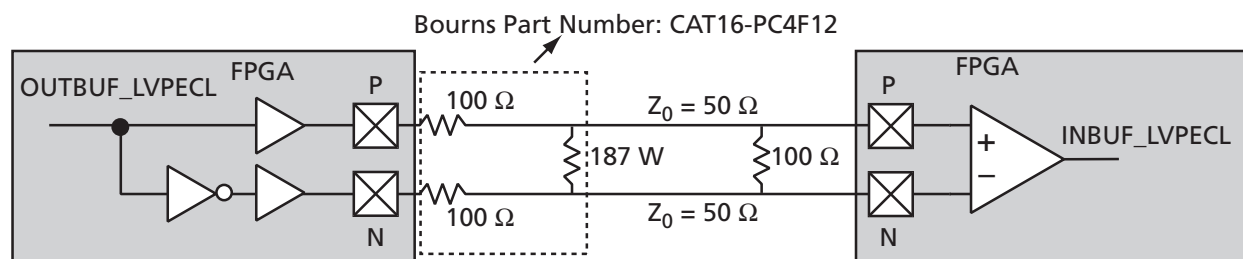


Figure 2-14 • LVPECL Circuit Diagram and Board-Level Implementation

Table 2-86 • Minimum and Maximum DC Input and Output Levels

| DC Parameter     | Description                    | Min.  | Max. | Min.  | Max. | Min.  | Max. | Units |
|------------------|--------------------------------|-------|------|-------|------|-------|------|-------|
| $V_{CCI}$        | Supply Voltage                 | 3.0   |      | 3.3   |      | 3.6   |      | V     |
| $V_{OL}$         | Output LOW Voltage             | 0.96  | 1.27 | 1.06  | 1.43 | 1.30  | 1.57 | V     |
| $V_{OH}$         | Output HIGH Voltage            | 1.8   | 2.11 | 1.92  | 2.28 | 2.13  | 2.41 | V     |
| $V_{IL}, V_{IH}$ | Input LOW, Input HIGH Voltages | 0     | 3.3  | 0     | 3.6  | 0     | 3.9  | V     |
| $V_{ODIFF}$      | Differential Output Voltage    | 0.625 | 0.97 | 0.625 | 0.97 | 0.625 | 0.97 | V     |
| $V_{OCM}$        | Output Common-Mode Voltage     | 1.762 | 1.98 | 1.762 | 1.98 | 1.762 | 1.98 | V     |
| $V_{ICM}$        | Input Common-Mode Voltage      | 1.01  | 2.57 | 1.01  | 2.57 | 1.01  | 2.57 | V     |
| $V_{IDIFF}$      | Input Differential Voltage     | 300   |      | 300   |      | 300   |      | mV    |

Table 2-87 • AC Waveforms, Measuring Points, and Capacitive Loads

| Input LOW (V) | Input HIGH (V) | Measuring Point* (V) |
|---------------|----------------|----------------------|
| 1.64          | 1.94           | Cross point          |

\* Measuring point =  $V_{trip}$ . See Table 2-18 on page 2-17 for a complete table of trip points.

### Timing Characteristics

Table 2-88 • LVPECL

Automotive-Case Conditions:  $T_J = 135^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 3.0\text{ V}$

| Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | Units |
|-------------|------------|----------|-----------|----------|-------|
| Std.        | 0.64       | 2.01     | 0.05      | 1.57     | ns    |
| -1          | 0.55       | 1.71     | 0.04      | 1.34     | ns    |

Note: For specific junction temperature and voltage supply levels, refer to Table 2-5 on page 2-5 for derating values.

Table 2-89 • LVPECL

Automotive-Case Conditions:  $T_J = 115^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ , Worst-Case  $V_{CCI} = 3.0\text{ V}$

| Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | Units |
|-------------|------------|----------|-----------|----------|-------|
| Std.        | 0.63       | 1.95     | 0.05      | 1.52     | ns    |
| -1          | 0.53       | 1.66     | 0.04      | 1.29     | ns    |

Note: For specific junction temperature and voltage supply levels, refer to Table 2-5 on page 2-5 for derating values.

## I/O Register Specifications

### Fully Registered I/O Buffers with Synchronous Enable and Asynchronous Preset

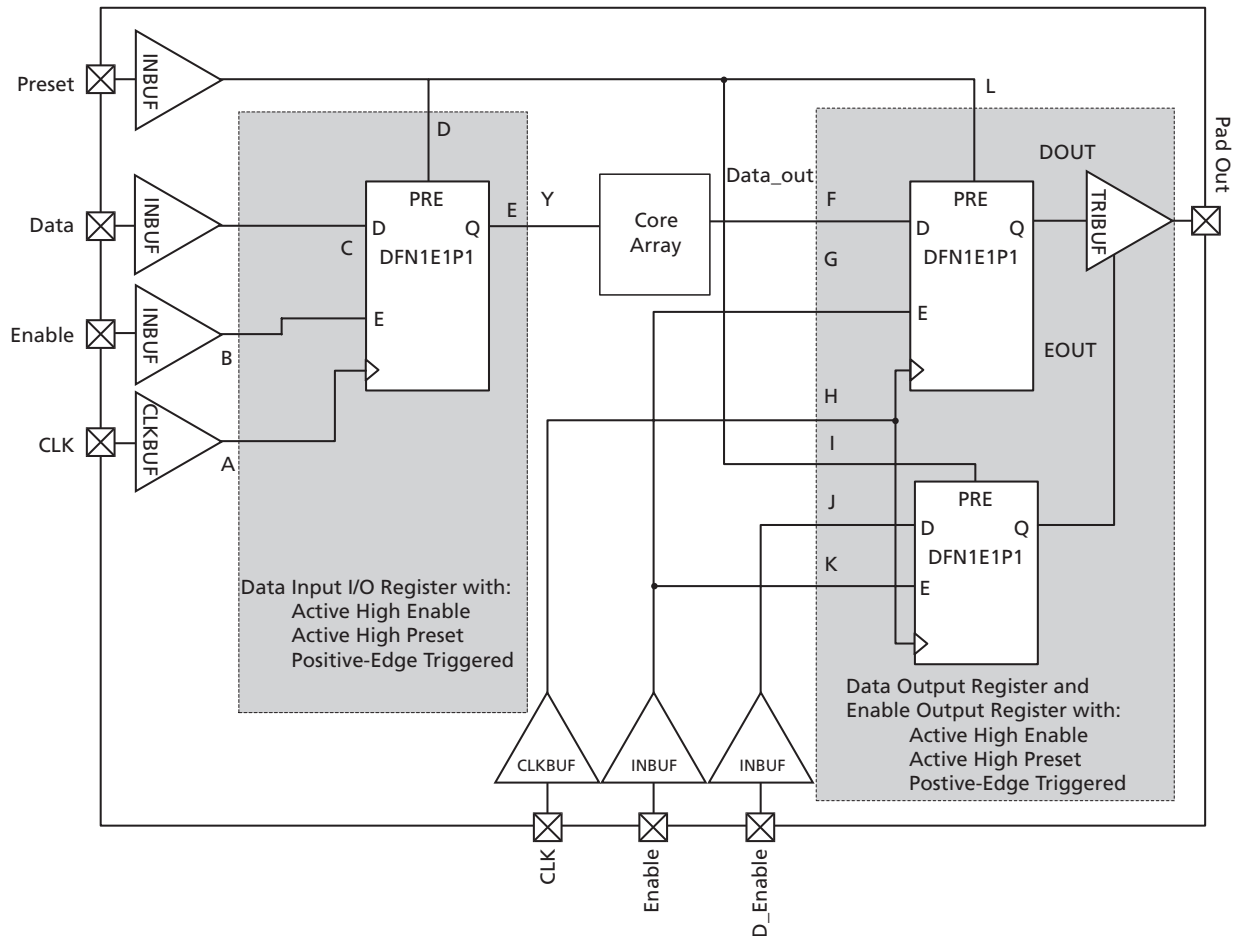


Figure 2-15 • Timing Model of Registered I/O Buffers with Synchronous Enable and Asynchronous Preset

**Table 2-90 • Parameter Definition and Measuring Nodes**

| Parameter Name        | Parameter Definition                                             | Measuring Nodes (from, to)* |
|-----------------------|------------------------------------------------------------------|-----------------------------|
| t <sub>OCLKQ</sub>    | Clock-to-Q of the Output Data Register                           | H, DOUT                     |
| t <sub>OSUD</sub>     | Data Setup Time for the Output Data Register                     | F, H                        |
| t <sub>OHD</sub>      | Data Hold Time for the Output Data Register                      | F, H                        |
| t <sub>OSUE</sub>     | Enable Setup Time for the Output Data Register                   | G, H                        |
| t <sub>OHE</sub>      | Enable Hold Time for the Output Data Register                    | G, H                        |
| t <sub>OPRE2Q</sub>   | Asynchronous Preset-to-Q of the Output Data Register             | L, DOUT                     |
| t <sub>OREMPRE</sub>  | Asynchronous Preset Removal Time for the Output Data Register    | L, H                        |
| t <sub>ORECPRE</sub>  | Asynchronous Preset Recovery Time for the Output Data Register   | L, H                        |
| t <sub>OCLKQ</sub>    | Clock-to-Q of the Output Enable Register                         | H, EOUT                     |
| t <sub>OESUD</sub>    | Data Setup Time for the Output Enable Register                   | J, H                        |
| t <sub>OEHd</sub>     | Data Hold Time for the Output Enable Register                    | J, H                        |
| t <sub>OESUE</sub>    | Enable Setup Time for the Output Enable Register                 | K, H                        |
| t <sub>OEHd</sub>     | Enable Hold Time for the Output Enable Register                  | K, H                        |
| t <sub>OEPRE2Q</sub>  | Asynchronous Preset-to-Q of the Output Enable Register           | I, EOUT                     |
| t <sub>OEREMPRE</sub> | Asynchronous Preset Removal Time for the Output Enable Register  | I, H                        |
| t <sub>OERECPRE</sub> | Asynchronous Preset Recovery Time for the Output Enable Register | I, H                        |
| t <sub>ICLKQ</sub>    | Clock-to-Q of the Input Data Register                            | A, E                        |
| t <sub>ISUD</sub>     | Data Setup Time for the Input Data Register                      | C, A                        |
| t <sub>IHD</sub>      | Data Hold Time for the Input Data Register                       | C, A                        |
| t <sub>ISUE</sub>     | Enable Setup Time for the Input Data Register                    | B, A                        |
| t <sub>IHE</sub>      | Enable Hold Time for the Input Data Register                     | B, A                        |
| t <sub>IPRE2Q</sub>   | Asynchronous Preset-to-Q of the Input Data Register              | D, E                        |
| t <sub>IEMPRE</sub>   | Asynchronous Preset Removal Time for the Input Data Register     | D, A                        |
| t <sub>IIECPRE</sub>  | Asynchronous Preset Recovery Time for the Input Data Register    | D, A                        |

\* See Figure 2-15 on page 2-52 for more information.

## Fully Registered I/O Buffers with Synchronous Enable and Asynchronous Clear

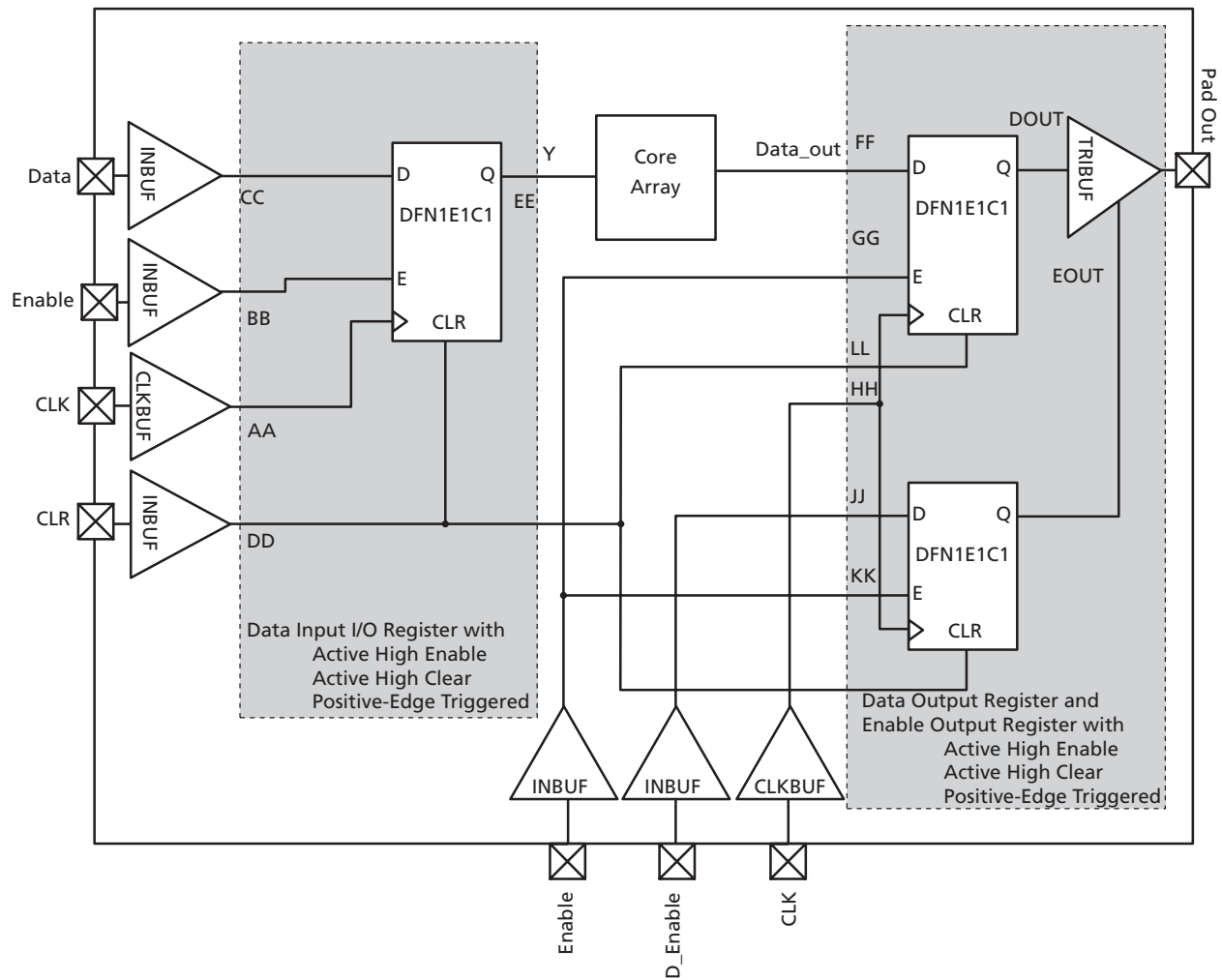


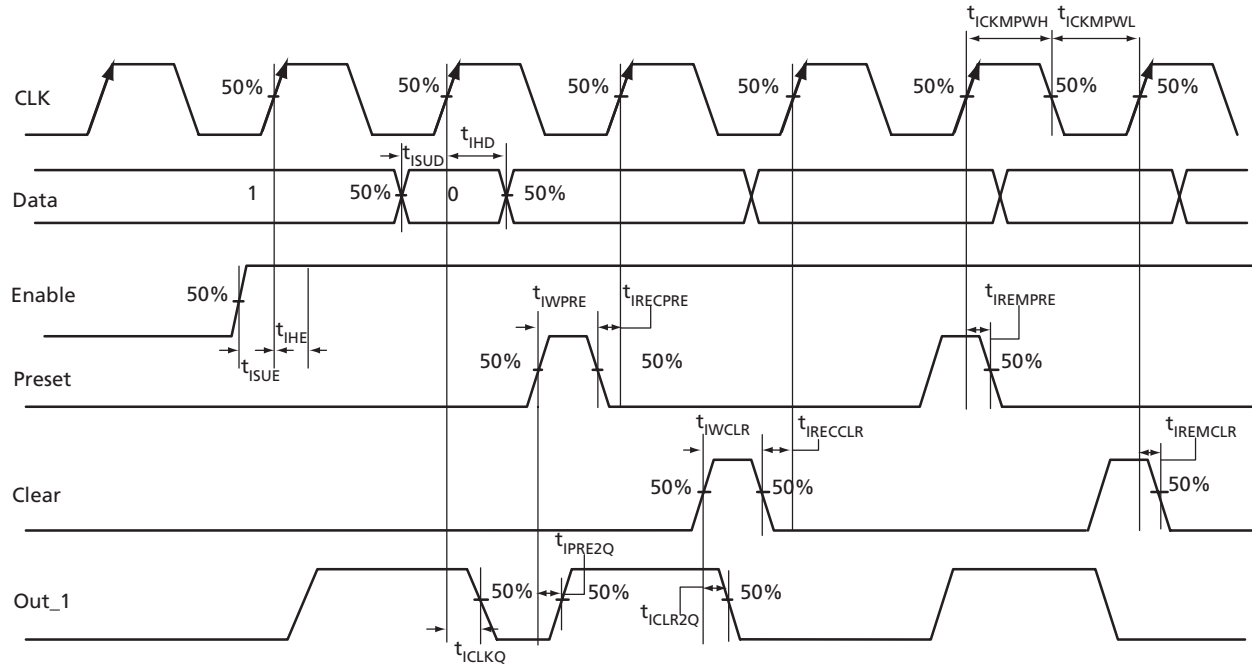
Figure 2-16 • Timing Model of the Registered I/O Buffers with Synchronous Enable and Asynchronous Clear

**Table 2-91 • Parameter Definitions and Measuring Nodes**

| Parameter Name       | Parameter Definition                                            | Measuring Nodes (from, to)* |
|----------------------|-----------------------------------------------------------------|-----------------------------|
| t <sub>CLKQ</sub>    | Clock-to-Q of the Output Data Register                          | HH, DOUT                    |
| t <sub>OSUD</sub>    | Data Setup Time for the Output Data Register                    | FF, HH                      |
| t <sub>OHD</sub>     | Data Hold Time for the Output Data Register                     | FF, HH                      |
| t <sub>OSUE</sub>    | Enable Setup Time for the Output Data Register                  | GG, HH                      |
| t <sub>OHE</sub>     | Enable Hold Time for the Output Data Register                   | GG, HH                      |
| t <sub>OCLR2Q</sub>  | Asynchronous Clear-to-Q of the Output Data Register             | LL, DOUT                    |
| t <sub>OREMCLR</sub> | Asynchronous Clear Removal Time for the Output Data Register    | LL, HH                      |
| t <sub>ORECCLR</sub> | Asynchronous Clear Recovery Time for the Output Data Register   | LL, HH                      |
| t <sub>OCLKQ</sub>   | Clock-to-Q of the Output Enable Register                        | HH, EOUT                    |
| t <sub>OESUD</sub>   | Data Setup Time for the Output Enable Register                  | JJ, HH                      |
| t <sub>OEHd</sub>    | Data Hold Time for the Output Enable Register                   | JJ, HH                      |
| t <sub>OESUE</sub>   | Enable Setup Time for the Output Enable Register                | KK, HH                      |
| t <sub>OEHd</sub>    | Enable Hold Time for the Output Enable Register                 | KK, HH                      |
| t <sub>OCLR2Q</sub>  | Asynchronous Clear-to-Q of the Output Enable Register           | II, EOUT                    |
| t <sub>OREMCLR</sub> | Asynchronous Clear Removal Time for the Output Enable Register  | II, HH                      |
| t <sub>ORECCLR</sub> | Asynchronous Clear Recovery Time for the Output Enable Register | II, HH                      |
| t <sub>CLKQ</sub>    | Clock-to-Q of the Input Data Register                           | AA, EE                      |
| t <sub>ISUD</sub>    | Data Setup Time for the Input Data Register                     | CC, AA                      |
| t <sub>IHD</sub>     | Data Hold Time for the Input Data Register                      | CC, AA                      |
| t <sub>ISUE</sub>    | Enable Setup Time for the Input Data Register                   | BB, AA                      |
| t <sub>IHE</sub>     | Enable Hold Time for the Input Data Register                    | BB, AA                      |
| t <sub>ICLR2Q</sub>  | Asynchronous Clear-to-Q of the Input Data Register              | DD, EE                      |
| t <sub>IREMCLR</sub> | Asynchronous Clear Removal Time for the Input Data Register     | DD, AA                      |
| t <sub>IRECCLR</sub> | Asynchronous Clear Recovery Time for the Input Data Register    | DD, AA                      |

\* See Figure 2-16 on page 2-54 for more information.

## Input Register



**Figure 2-17 • Input Register Timing Diagram**

### Timing Characteristics

**Table 2-92 • Input Data Register Propagation Delays**  
Automotive-Case Conditions:  $T_J = 135^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$

| Parameter            | Description                                                         | -1   | Std. | Units |
|----------------------|---------------------------------------------------------------------|------|------|-------|
| $t_{\text{ICLKQ}}$   | Clock-to-Q of the Input Data Register                               | 0.29 | 0.34 | ns    |
| $t_{\text{ISUD}}$    | Data Setup Time for the Input Data Register                         | 0.32 | 0.38 | ns    |
| $t_{\text{IHD}}$     | Data Hold Time for the Input Data Register                          | 0.00 | 0.00 | ns    |
| $t_{\text{ISUE}}$    | Enable Setup Time for the Input Data Register                       | 0.45 | 0.53 | ns    |
| $t_{\text{IHE}}$     | Enable Hold Time for the Input Data Register                        | 0.00 | 0.00 | ns    |
| $t_{\text{ICLR2Q}}$  | Asynchronous Clear-to-Q of the Input Data Register                  | 0.55 | 0.65 | ns    |
| $t_{\text{IPRE2Q}}$  | Asynchronous Preset-to-Q of the Input Data Register                 | 0.55 | 0.65 | ns    |
| $t_{\text{IEMCLR}}$  | Asynchronous Clear Removal Time for the Input Data Register         | 0.00 | 0.00 | ns    |
| $t_{\text{IRECCLR}}$ | Asynchronous Clear Recovery Time for the Input Data Register        | 0.27 | 0.32 | ns    |
| $t_{\text{IEMPRE}}$  | Asynchronous Preset Removal Time for the Input Data Register        | 0.00 | 0.00 | ns    |
| $t_{\text{IRECPRE}}$ | Asynchronous Preset Recovery Time for the Input Data Register       | 0.27 | 0.32 | ns    |
| $t_{\text{IWCLR}}$   | Asynchronous Clear Minimum Pulse Width for the Input Data Register  | 0.25 | 0.30 | ns    |
| $t_{\text{IWPRE}}$   | Asynchronous Preset Minimum Pulse Width for the Input Data Register | 0.25 | 0.30 | ns    |
| $t_{\text{ICKMPWH}}$ | Clock Minimum Pulse Width HIGH for the Input Data Register          | 0.41 | 0.48 | ns    |
| $t_{\text{ICKMPWL}}$ | Clock Minimum Pulse Width LOW for the Input Data Register           | 0.37 | 0.43 | ns    |

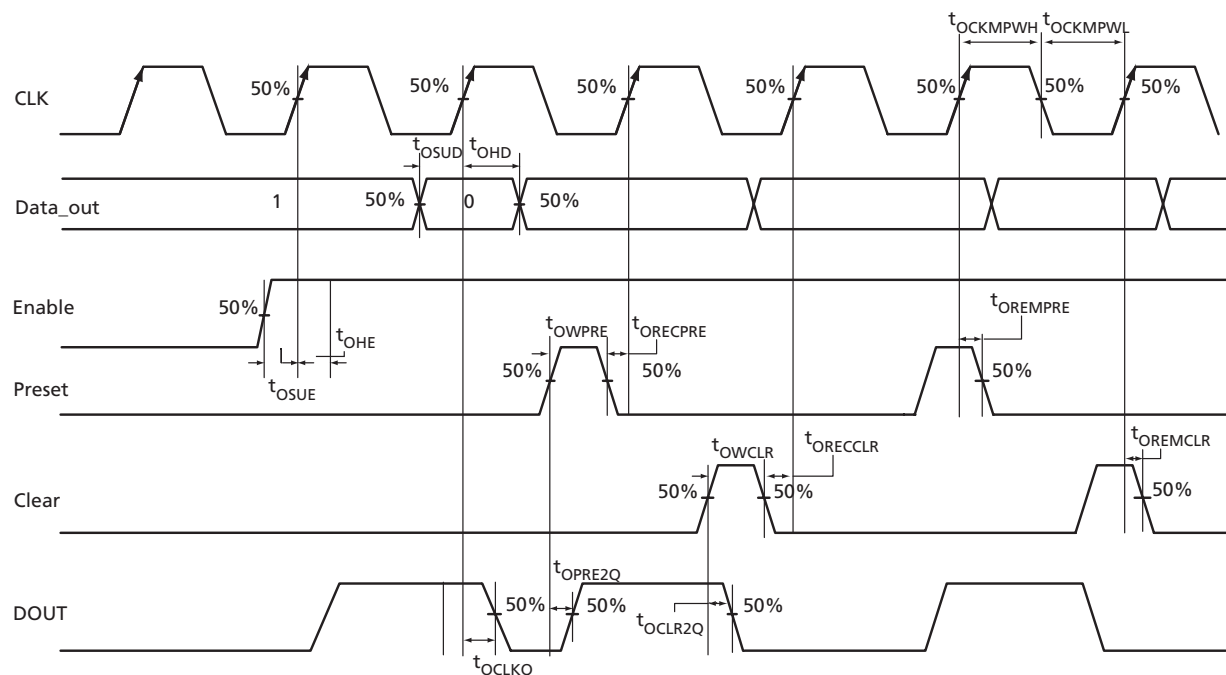
**Note:** For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-93 • Input Data Register Propagation Delays**  
Automotive-Case Conditions:  $T_J = 115^\circ\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$

| Parameter            | Description                                                         | -1   | Std. | Units |
|----------------------|---------------------------------------------------------------------|------|------|-------|
| $t_{\text{CLKQ}}$    | Clock-to-Q of the Input Data Register                               | 0.29 | 0.34 | ns    |
| $t_{\text{ISUD}}$    | Data Setup Time for the Input Data Register                         | 0.31 | 0.37 | ns    |
| $t_{\text{IHD}}$     | Data Hold Time for the Input Data Register                          | 0.00 | 0.00 | ns    |
| $t_{\text{ISUE}}$    | Enable Setup Time for the Input Data Register                       | 0.44 | 0.52 | ns    |
| $t_{\text{IHE}}$     | Enable Hold Time for the Input Data Register                        | 0.00 | 0.00 | ns    |
| $t_{\text{ICLR2Q}}$  | Asynchronous Clear-to-Q of the Input Data Register                  | 0.54 | 0.64 | ns    |
| $t_{\text{IPRE2Q}}$  | Asynchronous Preset-to-Q of the Input Data Register                 | 0.54 | 0.64 | ns    |
| $t_{\text{IREMCLR}}$ | Asynchronous Clear Removal Time for the Input Data Register         | 0.00 | 0.00 | ns    |
| $t_{\text{IRECCLR}}$ | Asynchronous Clear Recovery Time for the Input Data Register        | 0.27 | 0.31 | ns    |
| $t_{\text{IREMPRE}}$ | Asynchronous Preset Removal Time for the Input Data Register        | 0.00 | 0.00 | ns    |
| $t_{\text{IRECPRE}}$ | Asynchronous Preset Recovery Time for the Input Data Register       | 0.27 | 0.31 | ns    |
| $t_{\text{IWCLR}}$   | Asynchronous Clear Minimum Pulse Width for the Input Data Register  | 0.25 | 0.30 | ns    |
| $t_{\text{IWPRE}}$   | Asynchronous Preset Minimum Pulse Width for the Input Data Register | 0.25 | 0.30 | ns    |
| $t_{\text{ICKMPWH}}$ | Clock Minimum Pulse Width HIGH for the Input Data Register          | 0.41 | 0.48 | ns    |
| $t_{\text{ICKMPWL}}$ | Clock Minimum Pulse Width LOW for the Input Data Register           | 0.37 | 0.43 | ns    |

**Note:** For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

## Output Register



**Figure 2-18 • Output Register Timing Diagram**

## Timing Characteristics

**Table 2-94 • Output Data Register Propagation Delays**  
**Automotive-Case Conditions:  $T_J = 135^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$**

| Parameter            | Description                                                          | -1   | Std. | Units |
|----------------------|----------------------------------------------------------------------|------|------|-------|
| $t_{\text{OCLKQ}}$   | Clock-to-Q of the Output Data Register                               | 0.72 | 0.84 | ns    |
| $t_{\text{OSUD}}$    | Data Setup Time for the Output Data Register                         | 0.38 | 0.45 | ns    |
| $t_{\text{OHD}}$     | Data Hold Time for the Output Data Register                          | 0.00 | 0.00 | ns    |
| $t_{\text{OSUE}}$    | Enable Setup Time for the Output Data Register                       | 0.53 | 0.63 | ns    |
| $t_{\text{OHE}}$     | Enable Hold Time for the Output Data Register                        | 0.00 | 0.00 | ns    |
| $t_{\text{OCLR2Q}}$  | Asynchronous Clear-to-Q of the Output Data Register                  | 0.98 | 1.15 | ns    |
| $t_{\text{OPRE2Q}}$  | Asynchronous Preset-to-Q of the Output Data Register                 | 0.98 | 1.15 | ns    |
| $t_{\text{OREMCLR}}$ | Asynchronous Clear Removal Time for the Output Data Register         | 0.00 | 0.00 | ns    |
| $t_{\text{ORECCLR}}$ | Asynchronous Clear Recovery Time for the Output Data Register        | 0.27 | 0.32 | ns    |
| $t_{\text{OREMPRE}}$ | Asynchronous Preset Removal Time for the Output Data Register        | 0.00 | 0.00 | ns    |
| $t_{\text{ORECPRE}}$ | Asynchronous Preset Recovery Time for the Output Data Register       | 0.27 | 0.32 | ns    |
| $t_{\text{OWCLR}}$   | Asynchronous Clear Minimum Pulse Width for the Output Data Register  | 0.25 | 0.30 | ns    |
| $t_{\text{OWPRE}}$   | Asynchronous Preset Minimum Pulse Width for the Output Data Register | 0.25 | 0.30 | ns    |
| $t_{\text{OCKMPWH}}$ | Clock Minimum Pulse Width HIGH for the Output Data Register          | 0.41 | 0.48 | ns    |
| $t_{\text{OCKMPWL}}$ | Clock Minimum Pulse Width LOW for the Output Data Register           | 0.37 | 0.43 | ns    |

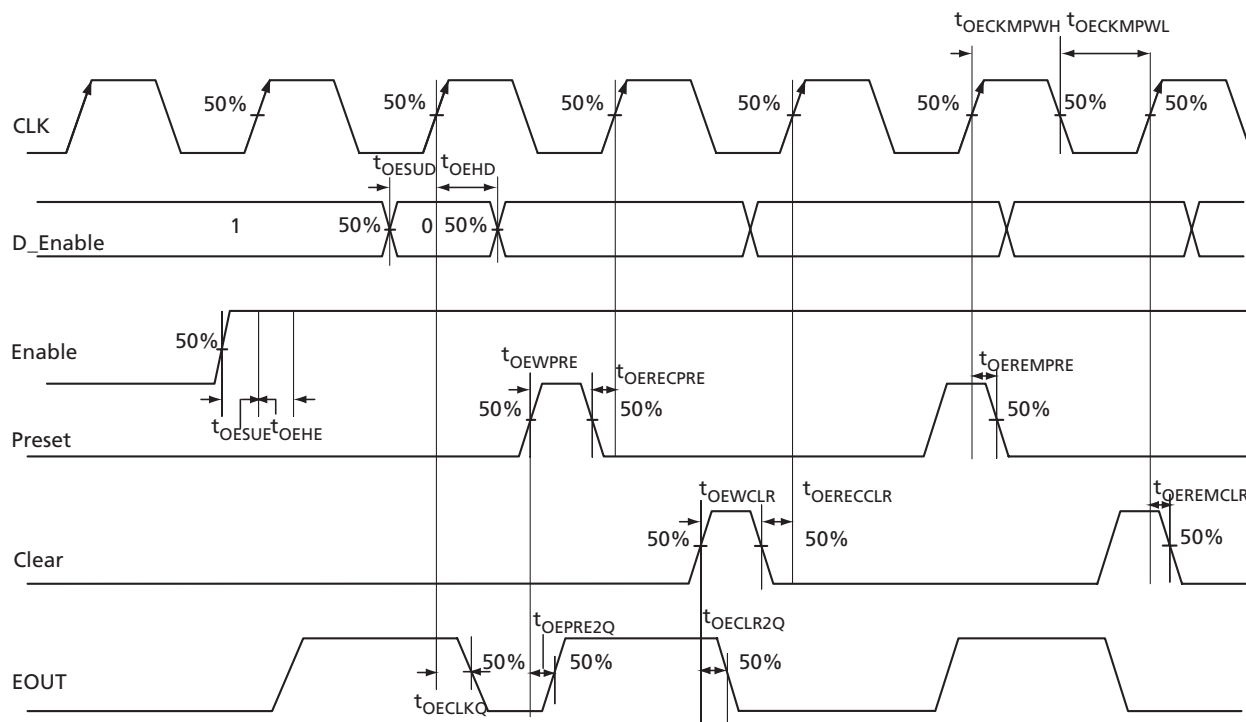
*Note:* For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-95 • Output Data Register Propagation Delays**  
**Automotive-Case Conditions:  $T_J = 115^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$**

| Parameter            | Description                                                          | -1   | Std. | Units |
|----------------------|----------------------------------------------------------------------|------|------|-------|
| $t_{\text{OCLKQ}}$   | Clock-to-Q of the Output Data Register                               | 0.70 | 0.82 | ns    |
| $t_{\text{OSUD}}$    | Data Setup Time for the Output Data Register                         | 0.37 | 0.44 | ns    |
| $t_{\text{OHD}}$     | Data Hold Time for the Output Data Register                          | 0.00 | 0.00 | ns    |
| $t_{\text{OSUE}}$    | Enable Setup Time for the Output Data Register                       | 0.52 | 0.61 | ns    |
| $t_{\text{OHE}}$     | Enable Hold Time for the Output Data Register                        | 0.00 | 0.00 | ns    |
| $t_{\text{OCLR2Q}}$  | Asynchronous Clear-to-Q of the Output Data Register                  | 0.96 | 1.12 | ns    |
| $t_{\text{OPRE2Q}}$  | Asynchronous Preset-to-Q of the Output Data Register                 | 0.96 | 1.12 | ns    |
| $t_{\text{OREMCLR}}$ | Asynchronous Clear Removal Time for the Output Data Register         | 0.00 | 0.00 | ns    |
| $t_{\text{ORECCLR}}$ | Asynchronous Clear Recovery Time for the Output Data Register        | 0.27 | 0.31 | ns    |
| $t_{\text{OREMPRE}}$ | Asynchronous Preset Removal Time for the Output Data Register        | 0.00 | 0.00 | ns    |
| $t_{\text{ORECPRE}}$ | Asynchronous Preset Recovery Time for the Output Data Register       | 0.27 | 0.31 | ns    |
| $t_{\text{OWCLR}}$   | Asynchronous Clear Minimum Pulse Width for the Output Data Register  | 0.25 | 0.30 | ns    |
| $t_{\text{OWPRE}}$   | Asynchronous Preset Minimum Pulse Width for the Output Data Register | 0.25 | 0.30 | ns    |
| $t_{\text{OCKMPWH}}$ | Clock Minimum Pulse Width HIGH for the Output Data Register          | 0.41 | 0.48 | ns    |
| $t_{\text{OCKMPWL}}$ | Clock Minimum Pulse Width LOW for the Output Data Register           | 0.37 | 0.43 | ns    |

*Note:* For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

## Output Enable Register



**Figure 2-19 • Output Enable Register Timing Diagram**

### Timing Characteristics

**Table 2-96 • Output Enable Register Propagation Delays**  
Automotive-Case Conditions:  $T_J = 135^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$

| Parameter      | Description                                                            | -1   | Std. | Units |
|----------------|------------------------------------------------------------------------|------|------|-------|
| $t_{OECLKQ}$   | Clock-to-Q of the Output Enable Register                               | 0.54 | 0.64 | ns    |
| $t_{OESUD}$    | Data Setup Time for the Output Enable Register                         | 0.38 | 0.45 | ns    |
| $t_{OEHD}$     | Data Hold Time for the Output Enable Register                          | 0.00 | 0.00 | ns    |
| $t_{OESUE}$    | Enable Setup Time for the Output Enable Register                       | 0.53 | 0.62 | ns    |
| $t_{OEHE}$     | Enable Hold Time for the Output Enable Register                        | 0.00 | 0.00 | ns    |
| $t_{OECLR2Q}$  | Asynchronous Clear-to-Q of the Output Enable Register                  | 0.81 | 0.95 | ns    |
| $t_{OEPRE2Q}$  | Asynchronous Preset-to-Q of the Output Enable Register                 | 0.81 | 0.95 | ns    |
| $t_{OEREMCLR}$ | Asynchronous Clear Removal Time for the Output Enable Register         | 0.00 | 0.00 | ns    |
| $t_{OERECCLR}$ | Asynchronous Clear Recovery Time for the Output Enable Register        | 0.27 | 0.32 | ns    |
| $t_{OEREMPRE}$ | Asynchronous Preset Removal Time for the Output Enable Register        | 0.00 | 0.00 | ns    |
| $t_{OERECPRE}$ | Asynchronous Preset Recovery Time for the Output Enable Register       | 0.27 | 0.32 | ns    |
| $t_{OEWCCLR}$  | Asynchronous Clear Minimum Pulse Width for the Output Enable Register  | 0.25 | 0.30 | ns    |
| $t_{OEWPPE}$   | Asynchronous Preset Minimum Pulse Width for the Output Enable Register | 0.25 | 0.30 | ns    |
| $t_{OECKMPWH}$ | Clock Minimum Pulse Width HIGH for the Output Enable Register          | 0.41 | 0.48 | ns    |
| $t_{OECKMPWL}$ | Clock Minimum Pulse Width LOW for the Output Enable Register           | 0.37 | 0.43 | ns    |

**Note:** For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

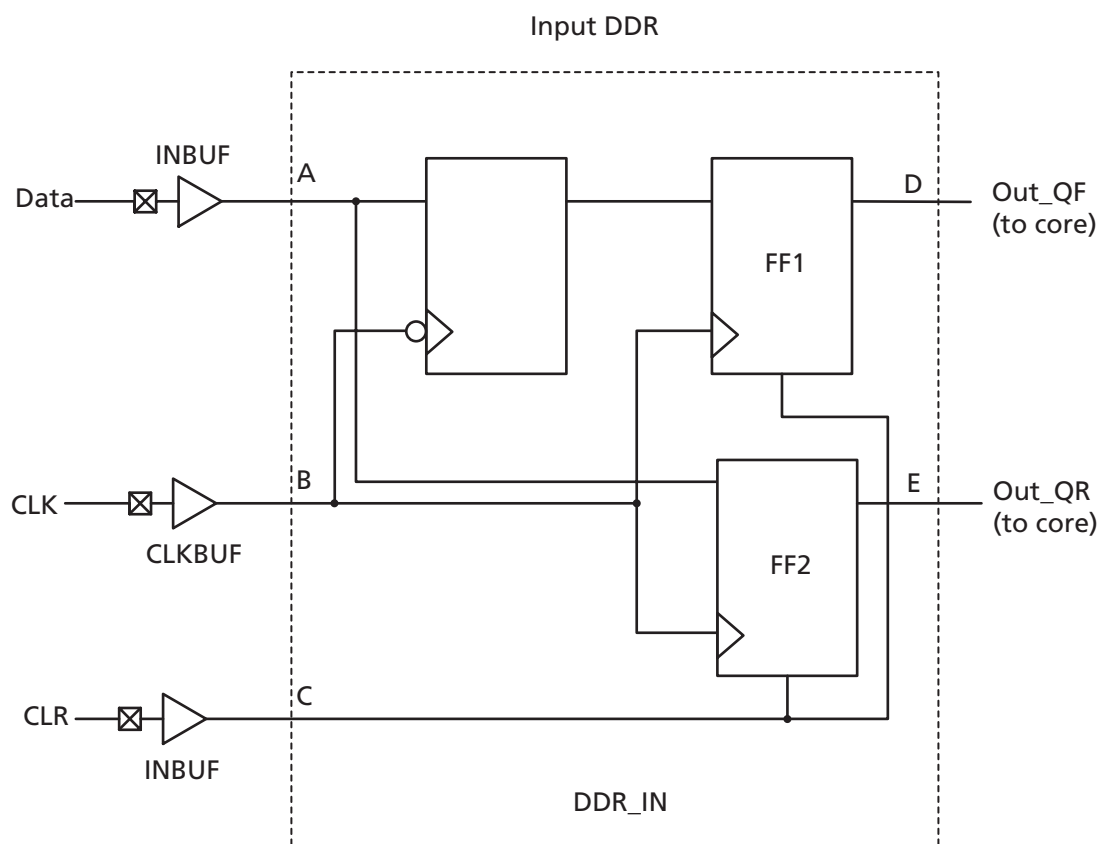
**Table 2-97 • Output Enable Register Propagation Delays**  
Automotive-Case Conditions:  $T_J = 115^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$

| Parameter      | Description                                                            | –1   | Std. | Units |
|----------------|------------------------------------------------------------------------|------|------|-------|
| $t_{OECLKQ}$   | Clock-to-Q of the Output Enable Register                               | 0.53 | 0.62 | ns    |
| $t_{OESUD}$    | Data Setup Time for the Output Enable Register                         | 0.37 | 0.44 | ns    |
| $t_{OEHD}$     | Data Hold Time for the Output Enable Register                          | 0.00 | 0.00 | ns    |
| $t_{OESUE}$    | Enable Setup Time for the Output Enable Register                       | 0.52 | 0.61 | ns    |
| $t_{OEHE}$     | Enable Hold Time for the Output Enable Register                        | 0.00 | 0.00 | ns    |
| $t_{OECLR2Q}$  | Asynchronous Clear-to-Q of the Output Enable Register                  | 0.79 | 0.93 | ns    |
| $t_{OEPRE2Q}$  | Asynchronous Preset-to-Q of the Output Enable Register                 | 0.79 | 0.93 | ns    |
| $t_{OEREMCLR}$ | Asynchronous Clear Removal Time for the Output Enable Register         | 0.00 | 0.00 | ns    |
| $t_{OERECCLR}$ | Asynchronous Clear Recovery Time for the Output Enable Register        | 0.27 | 0.31 | ns    |
| $t_{OEREMPRE}$ | Asynchronous Preset Removal Time for the Output Enable Register        | 0.00 | 0.00 | ns    |
| $t_{OERECPRE}$ | Asynchronous Preset Recovery Time for the Output Enable Register       | 0.27 | 0.31 | ns    |
| $t_{OEWCCLR}$  | Asynchronous Clear Minimum Pulse Width for the Output Enable Register  | 0.25 | 0.30 | ns    |
| $t_{OEWPPE}$   | Asynchronous Preset Minimum Pulse Width for the Output Enable Register | 0.25 | 0.30 | ns    |
| $t_{OECKMPWH}$ | Clock Minimum Pulse Width HIGH for the Output Enable Register          | 0.41 | 0.48 | ns    |
| $t_{OECKMPWL}$ | Clock Minimum Pulse Width LOW for the Output Enable Register           | 0.37 | 0.43 | ns    |

**Note:** For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

## DDR Module Specifications

### Input DDR Module



**Figure 2-20 • Input DDR Timing Model**

**Table 2-98 • Parameter Definitions**

| Parameter Name   | Parameter Definition         | Measuring Nodes (from, to) |
|------------------|------------------------------|----------------------------|
| $t_{DDRICKQ1}$   | Clock-to-Out Out_QR          | B, D                       |
| $t_{DDRICKQ2}$   | Clock-to-Out Out_QF          | B, E                       |
| $t_{DDRISUD}$    | Data Setup Time of DDR Input | A, B                       |
| $t_{DDRIHD}$     | Data Hold Time of DDR Input  | A, B                       |
| $t_{DDRICLR2Q1}$ | Clear-to-Out Out_QR          | C, D                       |
| $t_{DDRICLR2Q2}$ | Clear-to-Out Out_QF          | C, E                       |
| $t_{DDRIREMCLR}$ | Clear Removal                | C, B                       |
| $t_{DDRIRECCLR}$ | Clear Recovery               | C, B                       |

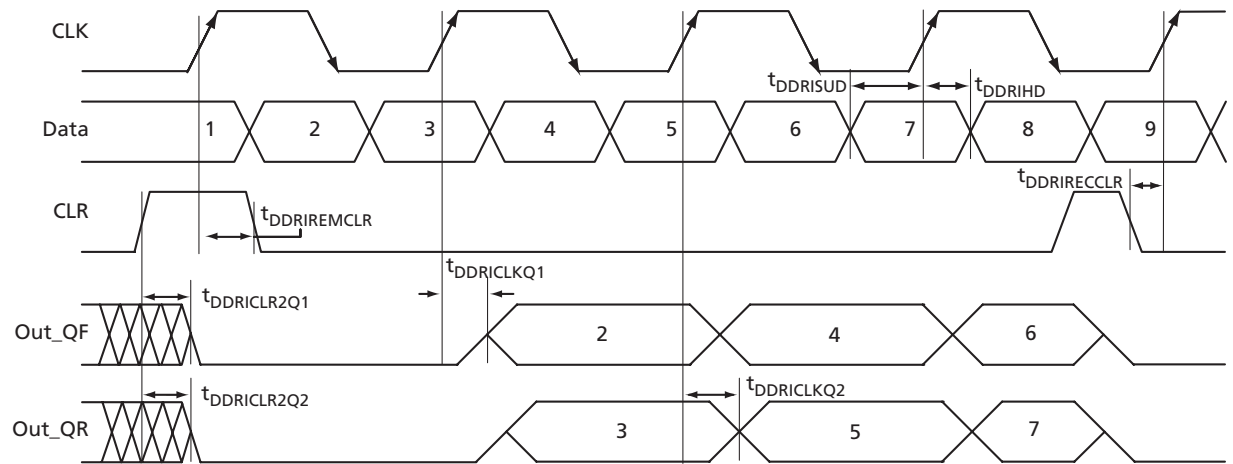


Figure 2-21 • Input DDR Timing Diagram

### Timing Characteristics

Table 2-99 • Input DDR Propagation Delays

Automotive-Case Conditions:  $T_J = 135^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$

| Parameter        | Description                                          | -1   | Std. | Units |
|------------------|------------------------------------------------------|------|------|-------|
| $t_{DDRICKQ1}$   | Clock-to-Out Out_QR for Input DDR                    | 0.33 | 0.39 | ns    |
| $t_{DDRICKQ2}$   | Clock-to-Out Out_QF for Input DDR                    | 0.47 | 0.56 | ns    |
| $t_{DDRISUD}$    | Data Setup for Input DDR                             | 0.34 | 0.40 | ns    |
| $t_{DDRIHD}$     | Data Hold for Input DDR                              | 0.00 | 0.00 | ns    |
| $t_{DDRIR2Q1}$   | Asynchronous Clear-to-Out Out_QR for Input DDR       | 0.56 | 0.66 | ns    |
| $t_{DDRIR2Q2}$   | Asynchronous Clear-to-Out Out_QF for Input DDR       | 0.69 | 0.82 | ns    |
| $t_{DDRIREMCLR}$ | Asynchronous Clear Removal Time for Input DDR        | 0.00 | 0.00 | ns    |
| $t_{DDRIRECCLR}$ | Asynchronous Clear Recovery Time for Input DDR       | 0.27 | 0.32 | ns    |
| $t_{DDRIRWCLR}$  | Asynchronous Clear Minimum Pulse Width for Input DDR | 0.25 | 0.30 | ns    |
| $t_{DDRICKMPWH}$ | Clock Minimum Pulse Width HIGH for Input DDR         | 0.41 | 0.48 | ns    |
| $t_{DDRICKMPWL}$ | Clock Minimum Pulse Width LOW for Input DDR          | 0.37 | 0.43 | ns    |
| $F_{DDRIMAX}$    | Maximum Frequency for Input DDR                      | TBD  | TBD  | MHz   |

**Note:** For specific junction temperature and voltage supply levels, refer to Table 2-5 on page 2-5 for derating values.

**Table 2-100 • Input DDR Propagation Delays**

Automotive-Case Conditions:  $T_J = 115^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ 

| Parameter               | Description                                          | -1   | Std. | Units |
|-------------------------|------------------------------------------------------|------|------|-------|
| $t_{\text{DDRCLKQ1}}$   | Clock-to-Out Out_QR for Input DDR                    | 0.33 | 0.38 | ns    |
| $t_{\text{DDRCLKQ2}}$   | Clock-to-Out Out_QF for Input DDR                    | 0.46 | 0.54 | ns    |
| $t_{\text{DDRISUD}}$    | Data Setup for Input DDR                             | 0.34 | 0.40 | ns    |
| $t_{\text{DDRHD}}$      | Data Hold for Input DDR                              | 0.00 | 0.00 | ns    |
| $t_{\text{DDRCLR2Q1}}$  | Asynchronous Clear-to-Out Out_QR for Input DDR       | 0.55 | 0.65 | ns    |
| $t_{\text{DDRCLR2Q2}}$  | Asynchronous Clear-to-Out Out_QF for Input DDR       | 0.68 | 0.80 | ns    |
| $t_{\text{DDRREMLCLR}}$ | Asynchronous Clear Removal Time for Input DDR        | 0.00 | 0.00 | ns    |
| $t_{\text{DDRRECCCLR}}$ | Asynchronous Clear Recovery Time for Input DDR       | 0.27 | 0.31 | ns    |
| $t_{\text{DDRWCCLR}}$   | Asynchronous Clear Minimum Pulse Width for Input DDR | 0.25 | 0.30 | ns    |
| $t_{\text{DDRCKMPWH}}$  | Clock Minimum Pulse Width HIGH for Input DDR         | 0.41 | 0.48 | ns    |
| $t_{\text{DDRCKMPWL}}$  | Clock Minimum Pulse Width LOW for Input DDR          | 0.37 | 0.43 | ns    |
| $F_{\text{DDRIMAX}}$    | Maximum Frequency for Input DDR                      | TBD  | TBD  | MHz   |

**Note:** For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

## Output DDR Module

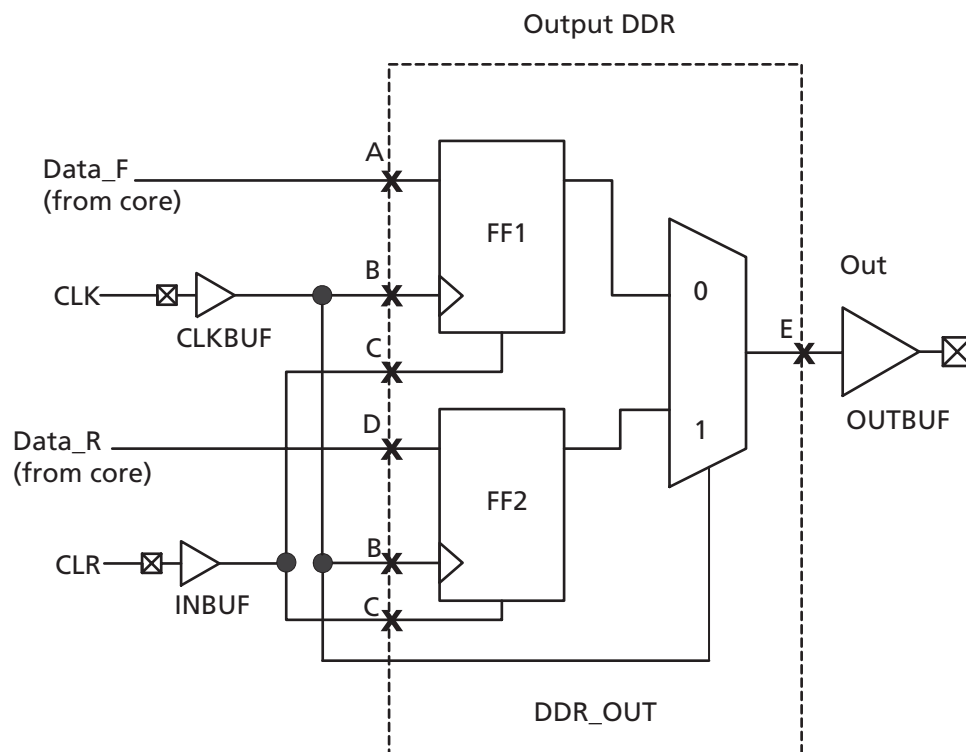

**Figure 2-22 • Output DDR Timing Model**

Table 2-101 • Parameter Definitions

| Parameter Name          | Parameter Definition      | Measuring Nodes (from, to) |
|-------------------------|---------------------------|----------------------------|
| $t_{\text{DDROCLKQ}}$   | Clock-to-Out              | B, E                       |
| $t_{\text{DDROCLR2Q}}$  | Asynchronous Clear-to-Out | C, E                       |
| $t_{\text{DDROREMCLR}}$ | Clear Removal             | C, B                       |
| $t_{\text{DDROECCLR}}$  | Clear Recovery            | C, B                       |
| $t_{\text{DDROSUD1}}$   | Data Setup Data_F         | A, B                       |
| $t_{\text{DDROSUD2}}$   | Data Setup Data_R         | D, B                       |
| $t_{\text{DDROHD1}}$    | Data Hold Data_F          | A, B                       |
| $t_{\text{DDROHD2}}$    | Data Hold Data_R          | D, B                       |

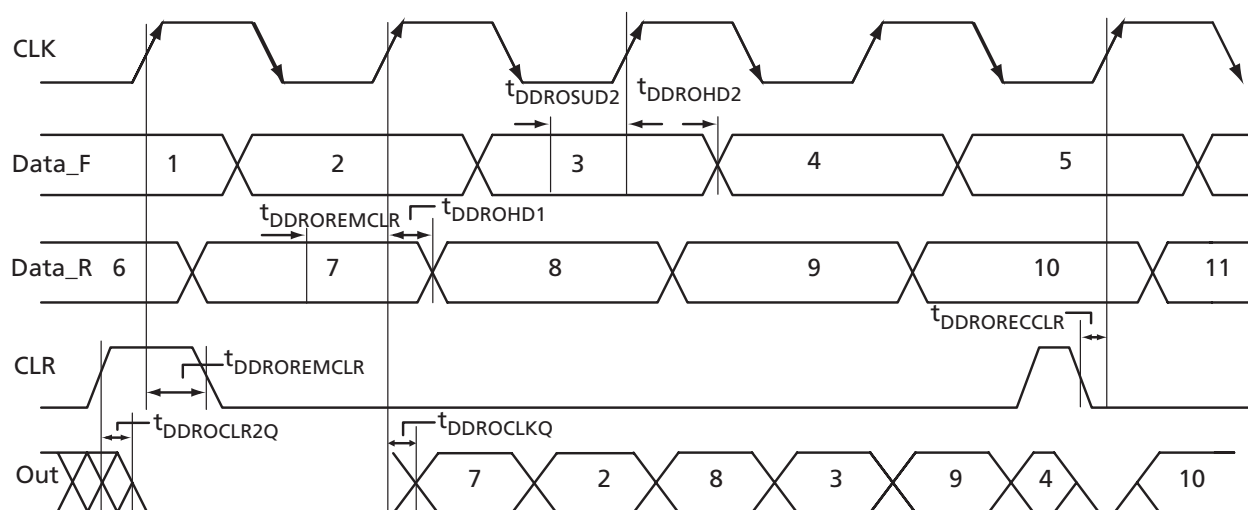


Figure 2-23 • Output DDR Timing Diagram

## Timing Characteristics

**Table 2-102 • Output DDR Propagation Delays**

Commercial-Case Conditions:  $T_J = 135^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ 

| Parameter        | Description                                           | -1   | Std. | Units |
|------------------|-------------------------------------------------------|------|------|-------|
| $t_{DDROCLKQ}$   | Clock-to-Out of DDR for Output DDR                    | 0.85 | 1.00 | ns    |
| $t_{DDROSUD1}$   | Data_F Data Setup for Output DDR                      | 0.46 | 0.54 | ns    |
| $t_{DDROSUD2}$   | Data_R Data Setup for Output DDR                      | 0.46 | 0.54 | ns    |
| $t_{DDROHD1}$    | Data_F Data Hold for Output DDR                       | 0.00 | 0.00 | ns    |
| $t_{DDROHD2}$    | Data_R Data Hold for Output DDR                       | 0.00 | 0.00 | ns    |
| $t_{DDROCLR2Q}$  | Asynchronous Clear-to-Out for Output DDR              | 0.97 | 1.15 | ns    |
| $t_{DDROREMCLR}$ | Asynchronous Clear Removal Time for Output DDR        | 0.00 | 0.00 | ns    |
| $t_{DDROECCLR}$  | Asynchronous Clear Recovery Time for Output DDR       | 0.27 | 0.32 | ns    |
| $t_{DDROWCLR1}$  | Asynchronous Clear Minimum Pulse Width for Output DDR | 0.25 | 0.30 | ns    |
| $t_{DDROCKMPWH}$ | Clock Minimum Pulse Width HIGH for the Output DDR     | 0.41 | 0.48 | ns    |
| $t_{DDROCKMPWL}$ | Clock Minimum Pulse Width LOW for the Output DDR      | 0.37 | 0.43 | ns    |
| $F_{DDOMAX}$     | Maximum Frequency for the Output DDR                  | TBD  | TBD  | MHz   |

**Note:** For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-103 • Output DDR Propagation Delays**

Commercial-Case Conditions:  $T_J = 115^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ 

| Parameter        | Description                                           | -1   | Std. | Units |
|------------------|-------------------------------------------------------|------|------|-------|
| $t_{DDROCLKQ}$   | Clock-to-Out of DDR for Output DDR                    | 0.84 | 0.98 | ns    |
| $t_{DDROSUD1}$   | Data_F Data Setup for Output DDR                      | 0.45 | 0.53 | ns    |
| $t_{DDROSUD2}$   | Data_R Data Setup for Output DDR                      | 0.45 | 0.53 | ns    |
| $t_{DDROHD1}$    | Data_F Data Hold for Output DDR                       | 0.00 | 0.00 | ns    |
| $t_{DDROHD2}$    | Data_R Data Hold for Output DDR                       | 0.00 | 0.00 | ns    |
| $t_{DDROCLR2Q}$  | Asynchronous Clear-to-Out for Output DDR              | 0.96 | 1.12 | ns    |
| $t_{DDROREMCLR}$ | Asynchronous Clear Removal Time for Output DDR        | 0.00 | 0.00 | ns    |
| $t_{DDROECCLR}$  | Asynchronous Clear Recovery Time for Output DDR       | 0.27 | 0.31 | ns    |
| $t_{DDROWCLR1}$  | Asynchronous Clear Minimum Pulse Width for Output DDR | 0.25 | 0.30 | ns    |
| $t_{DDROCKMPWH}$ | Clock Minimum Pulse Width HIGH for the Output DDR     | 0.41 | 0.48 | ns    |
| $t_{DDROCKMPWL}$ | Clock Minimum Pulse Width LOW for the Output DDR      | 0.37 | 0.43 | ns    |
| $F_{DDOMAX}$     | Maximum Frequency for the Output DDR                  | TBD  | TBD  | MHz   |

**Note:** For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

## VersaTile Characteristics

### VersaTile Specifications as a Combinatorial Module

The ProASIC3 library offers all combinations of LUT-3 combinatorial functions. In this section, timing characteristics are presented for a sample of the library. For more details, refer to the *Fusion*, *IGLOOle*, and *ProASIC3/E Macro Library Guide*.

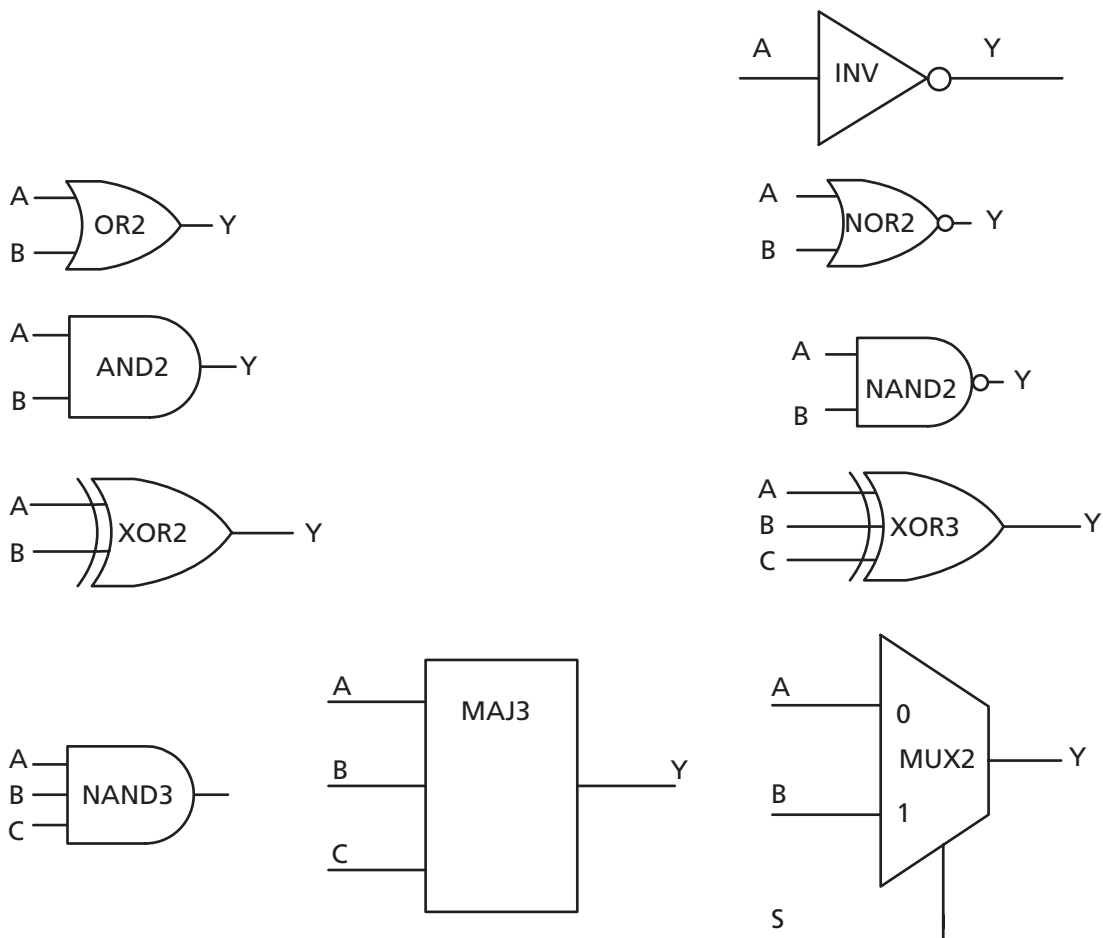


Figure 2-24 • Sample of Combinatorial Cells

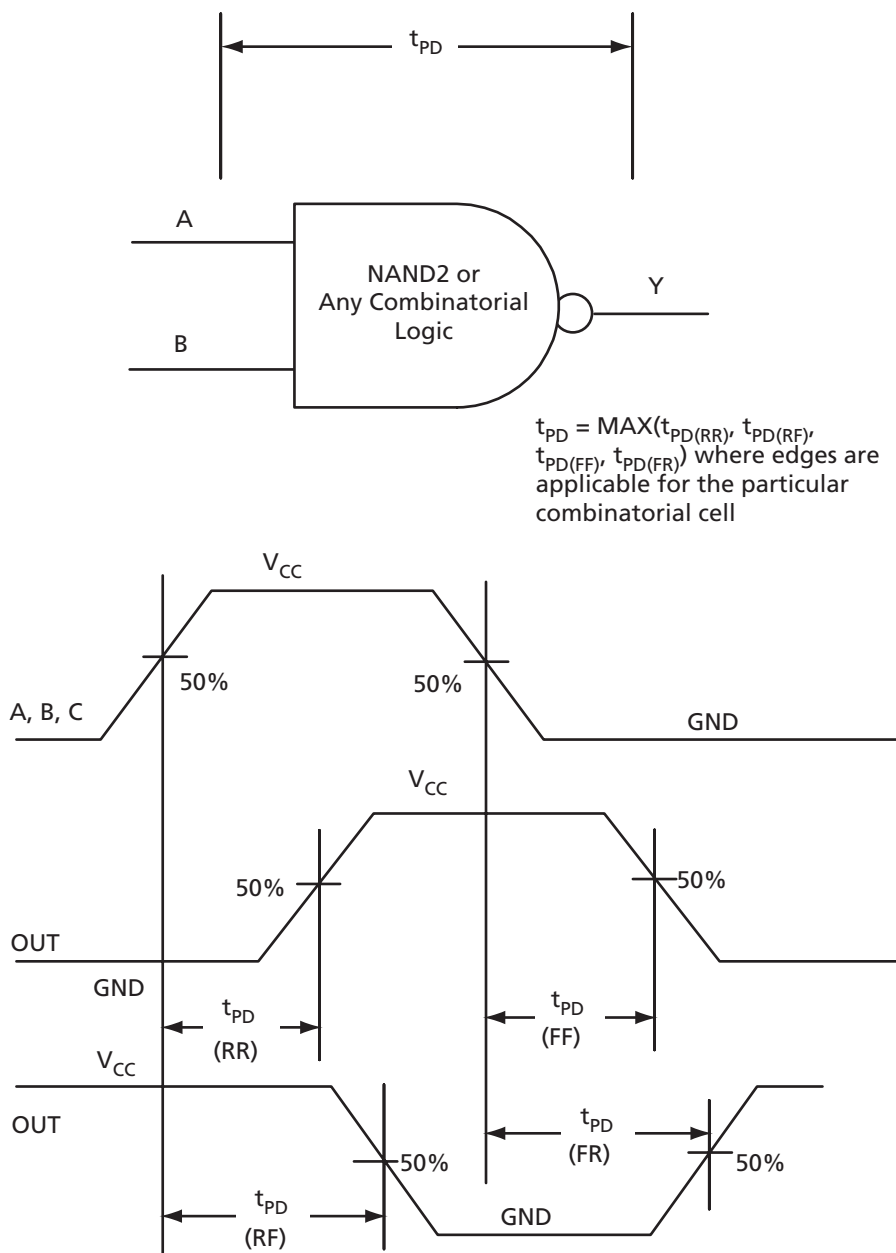


Figure 2-25 • Timing Model and Waveforms

## Timing Characteristics

**Table 2-104 • Combinatorial Cell Propagation Delays**

Automotive-Case Conditions:  $T_J = 135^\circ\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$

| Combinatorial Cell | Equation                         | Parameter | –1   | Std. | Units |
|--------------------|----------------------------------|-----------|------|------|-------|
| INV                | $Y = !A$                         | $t_{PD}$  | 0.49 | 0.57 | ns    |
| AND2               | $Y = A \cdot B$                  | $t_{PD}$  | 0.57 | 0.67 | ns    |
| NAND2              | $Y = !(A \cdot B)$               | $t_{PD}$  | 0.57 | 0.67 | ns    |
| OR2                | $Y = A + B$                      | $t_{PD}$  | 0.59 | 0.69 | ns    |
| NOR2               | $Y = !(A + B)$                   | $t_{PD}$  | 0.59 | 0.69 | ns    |
| XOR2               | $Y = A \oplus B$                 | $t_{PD}$  | 0.90 | 1.05 | ns    |
| MAJ3               | $Y = \text{MAJ}(A, B, C)$        | $t_{PD}$  | 0.85 | 1.00 | ns    |
| XOR3               | $Y = A \oplus B \oplus C$        | $t_{PD}$  | 1.06 | 1.25 | ns    |
| MUX2               | $Y = A \text{ !S} + B \text{ S}$ | $t_{PD}$  | 0.62 | 0.72 | ns    |
| AND3               | $Y = A \cdot B \cdot C$          | $t_{PD}$  | 0.68 | 0.80 | ns    |

*Note:* For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-105 • Combinatorial Cell Propagation Delays**

Automotive-Case Conditions:  $T_J = 115^\circ\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$

| Combinatorial Cell | Equation                         | Parameter | –1   | Std. | Units |
|--------------------|----------------------------------|-----------|------|------|-------|
| INV                | $Y = !A$                         | $t_{PD}$  | 0.48 | 0.56 | ns    |
| AND2               | $Y = A \cdot B$                  | $t_{PD}$  | 0.56 | 0.66 | ns    |
| NAND2              | $Y = !(A \cdot B)$               | $t_{PD}$  | 0.56 | 0.66 | ns    |
| OR2                | $Y = A + B$                      | $t_{PD}$  | 0.58 | 0.68 | ns    |
| NOR2               | $Y = !(A + B)$                   | $t_{PD}$  | 0.58 | 0.68 | ns    |
| XOR2               | $Y = A \oplus B$                 | $t_{PD}$  | 0.88 | 1.03 | ns    |
| MAJ3               | $Y = \text{MAJ}(A, B, C)$        | $t_{PD}$  | 0.83 | 0.98 | ns    |
| XOR3               | $Y = A \oplus B \oplus C$        | $t_{PD}$  | 1.04 | 1.23 | ns    |
| MUX2               | $Y = A \text{ !S} + B \text{ S}$ | $t_{PD}$  | 0.60 | 0.71 | ns    |
| AND3               | $Y = A \cdot B \cdot C$          | $t_{PD}$  | 0.67 | 0.79 | ns    |

*Note:* For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

## VersaTile Specifications as a Sequential Module

The ProASIC3 library offers a wide variety of sequential cells, including flip-flops and latches. Each has a data input and optional enable, clear, or preset. In this section, timing characteristics are presented for a representative sample from the library. For more details, refer to the [Fusion, IGLOOle and ProASIC3IE Macro Library Guide](#).

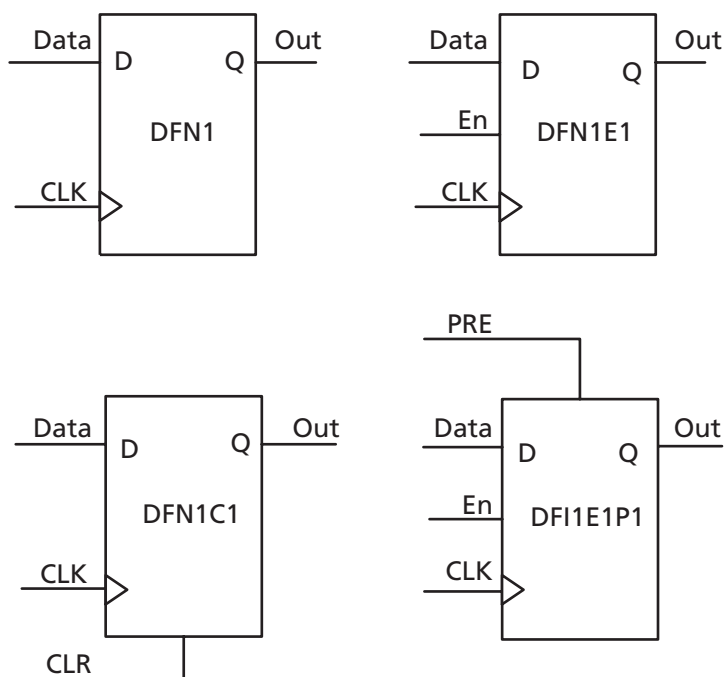


Figure 2-26 • Sample of Sequential Cells

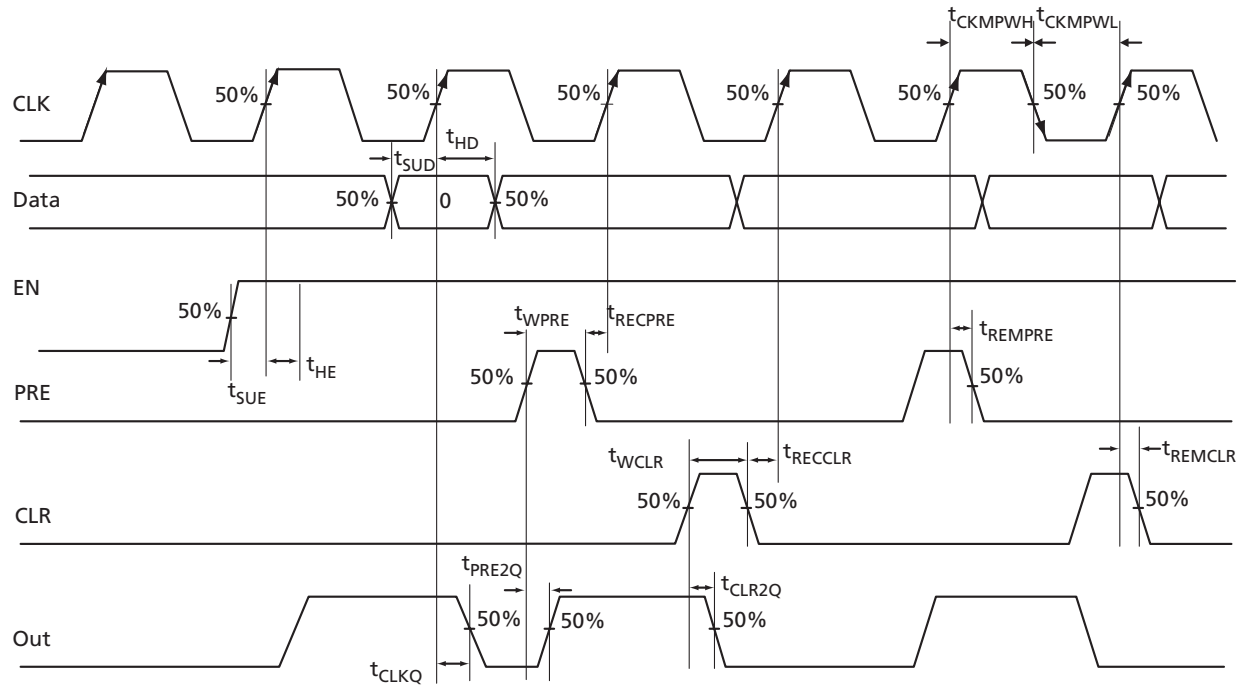


Figure 2-27 • Timing Model and Waveforms

### Timing Characteristics

Table 2-106 • Register Delays

Automotive-Case Conditions:  $T_J = 135^\circ\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$

| Parameter    | Description                                                   | -1   | Std. | Units |
|--------------|---------------------------------------------------------------|------|------|-------|
| $t_{CLKQ}$   | Clock-to-Q of the Core Register                               | 0.67 | 0.79 | ns    |
| $t_{SUD}$    | Data Setup Time for the Core Register                         | 0.52 | 0.61 | ns    |
| $t_{HD}$     | Data Hold Time for the Core Register                          | 0.00 | 0.00 | ns    |
| $t_{SUE}$    | Enable Setup Time for the Core Register                       | 0.55 | 0.65 | ns    |
| $t_{HE}$     | Enable Hold Time for the Core Register                        | 0.00 | 0.00 | ns    |
| $t_{CLR2Q}$  | Asynchronous Clear-to-Q of the Core Register                  | 0.49 | 0.57 | ns    |
| $t_{PRE2Q}$  | Asynchronous Preset-to-Q of the Core Register                 | 0.49 | 0.57 | ns    |
| $t_{REMCLR}$ | Asynchronous Clear Removal Time for the Core Register         | 0.00 | 0.00 | ns    |
| $t_{RECCLR}$ | Asynchronous Clear Recovery Time for the Core Register        | 0.27 | 0.32 | ns    |
| $t_{REMPRE}$ | Asynchronous Preset Removal Time for the Core Register        | 0.00 | 0.00 | ns    |
| $t_{RECPRE}$ | Asynchronous Preset Recovery Time for the Core Register       | 0.27 | 0.32 | ns    |
| $t_{WCLR}$   | Asynchronous Clear Minimum Pulse Width for the Core Register  | 0.25 | 0.30 | ns    |
| $t_{WPRE}$   | Asynchronous Preset Minimum Pulse Width for the Core Register | 0.25 | 0.30 | ns    |
| $t_{CKMPWH}$ | Clock Minimum Pulse Width HIGH for the Core Register          | 0.41 | 0.48 | ns    |
| $t_{CKMPWL}$ | Clock Minimum Pulse Width LOW for the Core Register           | 0.37 | 0.43 | ns    |

**Note:** For specific junction temperature and voltage supply levels, refer to Table 2-5 on page 2-5 for derating values.

**Table 2-107 • Register Delays**

Automotive-Case Conditions:  $T_J = 115^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ 

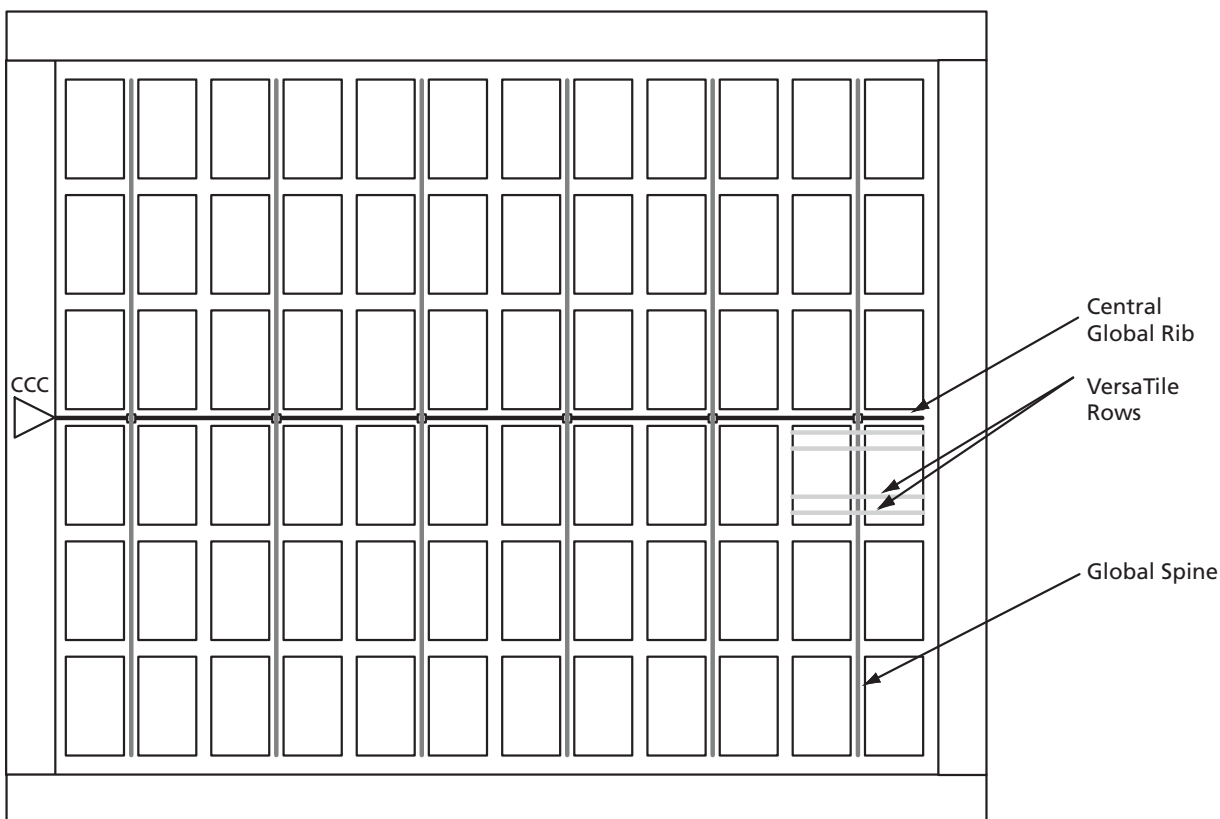
| Parameter    | Description                                                   | –1   | Std. | Units |
|--------------|---------------------------------------------------------------|------|------|-------|
| $t_{CLKQ}$   | Clock-to-Q of the Core Register                               | 0.66 | 0.77 | ns    |
| $t_{SUD}$    | Data Setup Time for the Core Register                         | 0.51 | 0.60 | ns    |
| $t_{HD}$     | Data Hold Time for the Core Register                          | 0.00 | 0.00 | ns    |
| $t_{SUE}$    | Enable Setup Time for the Core Register                       | 0.54 | 0.64 | ns    |
| $t_{HE}$     | Enable Hold Time for the Core Register                        | 0.00 | 0.00 | ns    |
| $t_{CLR2Q}$  | Asynchronous Clear-to-Q of the Core Register                  | 0.48 | 0.56 | ns    |
| $t_{PRE2Q}$  | Asynchronous Preset-to-Q of the Core Register                 | 0.48 | 0.56 | ns    |
| $t_{REMCLR}$ | Asynchronous Clear Removal Time for the Core Register         | 0.00 | 0.00 | ns    |
| $t_{RECCLR}$ | Asynchronous Clear Recovery Time for the Core Register        | 0.27 | 0.31 | ns    |
| $t_{REMPRE}$ | Asynchronous Preset Removal Time for the Core Register        | 0.00 | 0.00 | ns    |
| $t_{RECPRE}$ | Asynchronous Preset Recovery Time for the Core Register       | 0.27 | 0.31 | ns    |
| $t_{WCLR}$   | Asynchronous Clear Minimum Pulse Width for the Core Register  | 0.25 | 0.30 | ns    |
| $t_{WPRE}$   | Asynchronous Preset Minimum Pulse Width for the Core Register | 0.25 | 0.30 | ns    |
| $t_{CKMPWH}$ | Clock Minimum Pulse Width HIGH for the Core Register          | 0.41 | 0.48 | ns    |
| $t_{CKMPWL}$ | Clock Minimum Pulse Width LOW for the Core Register           | 0.37 | 0.43 | ns    |

**Note:** For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

## Global Resource Characteristics

### A3P250 Clock Tree Topology

Clock delays are device-specific. [Figure 2-28](#) is an example of a global tree used for clock routing. The global tree presented in [Figure 2-28](#) is driven by a CCC located on the west side of the A3P250 device. It is used to drive all D-flip-flops in the device.



**Figure 2-28 • Example of Global Tree Use in an A3P250 Device for Clock Routing**

## Global Tree Timing Characteristics

Global clock delays include the central rib delay, the spine delay, and the row delay. Delays do not include I/O input buffer clock delays, as these are I/O standard-dependent, and the clock may be driven and conditioned internally by the CCC module. For more details on clock conditioning capabilities, refer to the ["Clock Conditioning Circuits" section on page 2-77](#). [Table 2-114 on page 2-76](#) to [Table 2-125 on page 2-95](#) present minimum and maximum global clock delays within each device. Minimum and maximum delays are measured with minimum and maximum loading.

### Timing Characteristics

**Table 2-108 • A3P060 Global Resource**

Commercial-Case Conditions:  $T_J = 135^{\circ}\text{C}$ ,  $V_{CC} = 1.425\text{ V}$

| Parameter     | Description                               | –1                |                   | Std.              |                   | Units |
|---------------|-------------------------------------------|-------------------|-------------------|-------------------|-------------------|-------|
|               |                                           | Min. <sup>1</sup> | Max. <sup>2</sup> | Min. <sup>1</sup> | Max. <sup>2</sup> |       |
| $t_{RCKL}$    | Input LOW Delay for Global Clock          | 0.87              | 1.16              | 1.02              | 1.37              | ns    |
| $t_{RCKH}$    | Input HIGH Delay for Global Clock         | 0.86              | 1.20              | 1.01              | 1.42              | ns    |
| $t_{RCKMPWH}$ | Minimum Pulse Width HIGH for Global Clock |                   |                   |                   |                   | ns    |
| $t_{RCKMPWL}$ | Minimum Pulse Width LOW for Global Clock  |                   |                   |                   |                   | ns    |
| $t_{RCKSW}$   | Maximum Skew for Global Clock             |                   | 0.35              |                   | 0.41              | ns    |
| $F_{RMAX}$    | Maximum Frequency for Global Clock        |                   |                   |                   |                   | MHz   |

#### Notes:

1. Value reflects minimum load. The delay is measured from the CCC output to the clock pin of a sequential element, located in a lightly loaded row (single element is connected to the global net).
2. Value reflects maximum load. The delay is measured on the clock pin of the farthest sequential element, located in a fully loaded row (all available flip-flops are connected to the global net in the row).
3. For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-109 • A3P060 Global Resource**

Commercial-Case Conditions:  $T_J = 115^{\circ}\text{C}$ ,  $V_{CC} = 1.425\text{ V}$

| Parameter     | Description                               | –1                |                   | Std.              |                   | Units |
|---------------|-------------------------------------------|-------------------|-------------------|-------------------|-------------------|-------|
|               |                                           | Min. <sup>1</sup> | Max. <sup>2</sup> | Min. <sup>1</sup> | Max. <sup>2</sup> |       |
| $t_{RCKL}$    | Input LOW Delay for Global Clock          | 0.85              | 1.13              | 1.00              | 1.33              | ns    |
| $t_{RCKH}$    | Input HIGH Delay for Global Clock         | 0.84              | 1.18              | 0.99              | 1.38              | ns    |
| $t_{RCKMPWH}$ | Minimum Pulse Width HIGH for Global Clock |                   |                   |                   |                   | ns    |
| $t_{RCKMPWL}$ | Minimum Pulse Width LOW for Global Clock  |                   |                   |                   |                   | ns    |
| $t_{RCKSW}$   | Maximum Skew for Global Clock             |                   | 0.34              |                   | 0.40              | ns    |
| $F_{RMAX}$    | Maximum Frequency for Global Clock        |                   |                   |                   |                   | MHz   |

#### Notes:

1. Value reflects minimum load. The delay is measured from the CCC output to the clock pin of a sequential element, located in a lightly loaded row (single element is connected to the global net).
2. Value reflects maximum load. The delay is measured on the clock pin of the farthest sequential element, located in a fully loaded row (all available flip-flops are connected to the global net in the row).
3. For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-110 • A3P125 Global Resource**Commercial-Case Conditions:  $T_J = 135^{\circ}\text{C}$ ,  $V_{CC} = 1.425\text{ V}$ 

| Parameter            | Description                               | –1                |                   | Std.              |                   | Units |
|----------------------|-------------------------------------------|-------------------|-------------------|-------------------|-------------------|-------|
|                      |                                           | Min. <sup>1</sup> | Max. <sup>2</sup> | Min. <sup>1</sup> | Max. <sup>2</sup> |       |
| $t_{\text{RCKL}}$    | Input LOW Delay for Global Clock          | 0.93              | 1.22              | 1.09              | 1.43              | ns    |
| $t_{\text{RCKH}}$    | Input HIGH Delay for Global Clock         | 0.92              | 1.26              | 1.08              | 1.49              | ns    |
| $t_{\text{RCKMPWH}}$ | Minimum Pulse Width HIGH for Global Clock |                   |                   |                   |                   | ns    |
| $t_{\text{RCKMPWL}}$ | Minimum Pulse Width LOW for Global Clock  |                   |                   |                   |                   | ns    |
| $t_{\text{RCKSW}}$   | Maximum Skew for Global Clock             |                   | 0.35              |                   | 0.41              | ns    |
| $F_{\text{RMAX}}$    | Maximum Frequency for Global Clock        |                   |                   |                   |                   | MHz   |

**Notes:**

1. Value reflects minimum load. The delay is measured from the CCC output to the clock pin of a sequential element, located in a lightly loaded row (single element is connected to the global net).
2. Value reflects maximum load. The delay is measured on the clock pin of the farthest sequential element, located in a fully loaded row (all available flip-flops are connected to the global net in the row).
3. For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-111 • A3P125 Global Resource**Commercial-Case Conditions:  $T_J = 115^{\circ}\text{C}$ ,  $V_{CC} = 1.425\text{ V}$ 

| Parameter            | Description                               | –1                |                   | Std.              |                   | Units |
|----------------------|-------------------------------------------|-------------------|-------------------|-------------------|-------------------|-------|
|                      |                                           | Min. <sup>1</sup> | Max. <sup>2</sup> | Min. <sup>1</sup> | Max. <sup>2</sup> |       |
| $t_{\text{RCKL}}$    | Input LOW Delay for Global Clock          | 0.90              | 1.19              | 1.06              | 1.40              | ns    |
| $t_{\text{RCKH}}$    | Input HIGH Delay for Global Clock         | 0.90              | 1.23              | 1.05              | 1.45              | ns    |
| $t_{\text{RCKMPWH}}$ | Minimum Pulse Width HIGH for Global Clock |                   |                   |                   |                   | ns    |
| $t_{\text{RCKMPWL}}$ | Minimum Pulse Width LOW for Global Clock  |                   |                   |                   |                   | ns    |
| $t_{\text{RCKSW}}$   | Maximum Skew for Global Clock             |                   | 0.34              |                   | 0.40              | ns    |
| $F_{\text{RMAX}}$    | Maximum Frequency for Global Clock        |                   |                   |                   |                   | MHz   |

**Notes:**

1. Value reflects minimum load. The delay is measured from the CCC output to the clock pin of a sequential element, located in a lightly loaded row (single element is connected to the global net).
2. Value reflects maximum load. The delay is measured on the clock pin of the farthest sequential element, located in a fully loaded row (all available flip-flops are connected to the global net in the row).
3. For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-112 • A3P250 Global Resource**

Commercial-Case Conditions:  $T_J = 135^{\circ}\text{C}$ ,  $V_{CC} = 1.425\text{ V}$ 

| Parameter            | Description                               | –1                |                   | Std.              |                   | Units |
|----------------------|-------------------------------------------|-------------------|-------------------|-------------------|-------------------|-------|
|                      |                                           | Min. <sup>1</sup> | Max. <sup>2</sup> | Min. <sup>1</sup> | Max. <sup>2</sup> |       |
| $t_{\text{RCKL}}$    | Input LOW Delay for Global Clock          | 0.96              | 1.25              | 1.13              | 1.47              | ns    |
| $t_{\text{RCKH}}$    | Input HIGH Delay for Global Clock         | 0.94              | 1.28              | 1.10              | 1.51              | ns    |
| $t_{\text{RCKMPWH}}$ | Minimum Pulse Width HIGH for Global Clock |                   |                   |                   |                   | ns    |
| $t_{\text{RCKMPWL}}$ | Minimum Pulse Width LOW for Global Clock  |                   |                   |                   |                   | ns    |
| $t_{\text{RCKSW}}$   | Maximum Skew for Global Clock             |                   | 0.35              |                   | 0.41              | ns    |
| $F_{\text{RMAX}}$    | Maximum Frequency for Global Clock        |                   |                   |                   |                   | MHz   |

**Notes:**

1. Value reflects minimum load. The delay is measured from the CCC output to the clock pin of a sequential element, located in a lightly loaded row (single element is connected to the global net).
2. Value reflects maximum load. The delay is measured on the clock pin of the farthest sequential element, located in a fully loaded row (all available flip-flops are connected to the global net in the row).
3. For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-113 • A3P250 Global Resource**

Commercial-Case Conditions:  $T_J = 115^{\circ}\text{C}$ ,  $V_{CC} = 1.425\text{ V}$ 

| Parameter            | Description                               | –1                |                   | Std.              |                   | Units |
|----------------------|-------------------------------------------|-------------------|-------------------|-------------------|-------------------|-------|
|                      |                                           | Min. <sup>1</sup> | Max. <sup>2</sup> | Min. <sup>1</sup> | Max. <sup>2</sup> |       |
| $t_{\text{RCKL}}$    | Input LOW Delay for Global Clock          | 0.94              | 1.22              | 1.10              | 1.44              | ns    |
| $t_{\text{RCKH}}$    | Input HIGH Delay for Global Clock         | 0.92              | 1.25              | 1.08              | 1.47              | ns    |
| $t_{\text{RCKMPWH}}$ | Minimum Pulse Width HIGH for Global Clock |                   |                   |                   |                   | ns    |
| $t_{\text{RCKMPWL}}$ | Minimum Pulse Width LOW for Global Clock  |                   |                   |                   |                   | ns    |
| $t_{\text{RCKSW}}$   | Maximum Skew for Global Clock             |                   | 0.34              |                   | 0.40              | ns    |
| $F_{\text{RMAX}}$    | Maximum Frequency for Global Clock        |                   |                   |                   |                   | MHz   |

**Notes:**

1. Value reflects minimum load. The delay is measured from the CCC output to the clock pin of a sequential element, located in a lightly loaded row (single element is connected to the global net).
2. Value reflects maximum load. The delay is measured on the clock pin of the farthest sequential element, located in a fully loaded row (all available flip-flops are connected to the global net in the row).
3. For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-114 • A3P1000 Global Resource**Automotive-Case Conditions:  $T_J = 135^{\circ}\text{C}$ ,  $V_{CC} = 1.425\text{ V}$ 

| Parameter     | Description                               | –1                |                   | Std.              |                   | Units |
|---------------|-------------------------------------------|-------------------|-------------------|-------------------|-------------------|-------|
|               |                                           | Min. <sup>1</sup> | Max. <sup>2</sup> | Min. <sup>1</sup> | Max. <sup>2</sup> |       |
| $t_{RCKL}$    | Input LOW Delay for Global Clock          | 1.17              | 1.46              | 1.37              | 1.72              | ns    |
| $t_{RCKH}$    | Input HIGH Delay for Global Clock         | 1.15              | 1.50              | 1.36              | 1.76              | ns    |
| $t_{RCKMPWH}$ | Minimum Pulse Width HIGH for Global Clock |                   |                   |                   |                   | ns    |
| $t_{RCKMPWL}$ | Minimum Pulse Width LOW for Global Clock  |                   |                   |                   |                   | ns    |
| $t_{RCKSW}$   | Maximum Skew for Global Clock             |                   | 0.35              |                   | 0.41              | ns    |
| $F_{RMAX}$    | Maximum Frequency for Global Clock        |                   |                   |                   |                   | MHz   |

**Notes:**

1. Value reflects minimum load. The delay is measured from the CCC output to the clock pin of a sequential element, located in a lightly loaded row (single element is connected to the global net).
2. Value reflects maximum load. The delay is measured on the clock pin of the farthest sequential element, located in a fully loaded row (all available flip-flops are connected to the global net in the row).
3. For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-115 • A3P1000 Global Resource**Automotive-Case Conditions:  $T_J = 115^{\circ}\text{C}$ ,  $V_{CC} = 1.425\text{ V}$ 

| Parameter     | Description                               | –1                |                   | Std.              |                   | Units |
|---------------|-------------------------------------------|-------------------|-------------------|-------------------|-------------------|-------|
|               |                                           | Min. <sup>1</sup> | Max. <sup>2</sup> | Min. <sup>1</sup> | Max. <sup>2</sup> |       |
| $t_{RCKL}$    | Input LOW Delay for Global Clock          | 1.14              | 1.43              | 1.34              | 1.68              | ns    |
| $t_{RCKH}$    | Input HIGH Delay for Global Clock         | 1.13              | 1.46              | 1.32              | 1.72              | ns    |
| $t_{RCKMPWH}$ | Minimum Pulse Width HIGH for Global Clock |                   |                   |                   |                   | ns    |
| $t_{RCKMPWL}$ | Minimum Pulse Width LOW for Global Clock  |                   |                   |                   |                   | ns    |
| $t_{RCKSW}$   | Maximum Skew for Global Clock             |                   | 0.34              |                   | 0.40              | ns    |
| $F_{RMAX}$    | Maximum Frequency for Global Clock        |                   |                   |                   |                   | MHz   |

**Notes:**

1. Value reflects minimum load. The delay is measured from the CCC output to the clock pin of a sequential element, located in a lightly loaded row (single element is connected to the global net).
2. Value reflects maximum load. The delay is measured on the clock pin of the farthest sequential element, located in a fully loaded row (all available flip-flops are connected to the global net in the row).
3. For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

## Clock Conditioning Circuits

### CCC Electrical Specifications

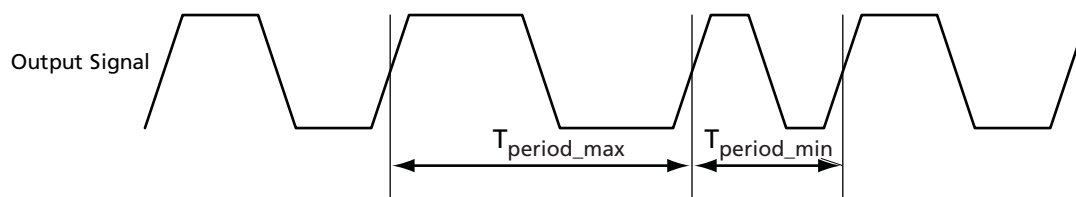
#### Timing Characteristics

**Table 2-116 • Automotive ProASIC3 CCC/PLL Specification**

| Parameter                                                      | Minimum                        | Typical | Maximum                | Units |
|----------------------------------------------------------------|--------------------------------|---------|------------------------|-------|
| Clock Conditioning Circuitry Input Frequency $f_{IN\_CCC}$     | 1.5                            |         | 350                    | MHz   |
| Clock Conditioning Circuitry Output Frequency $f_{OUT\_CCC}$   | 0.75                           |         | 350                    | MHz   |
| Delay Increments in Programmable Delay Blocks <sup>1, 2</sup>  |                                | 160     |                        | ps    |
| Number of Programmable Values in Each Programmable Delay Block |                                |         | 32                     |       |
| Input Period Jitter                                            |                                |         | 1.5                    | ns    |
| CCC Output Peak-to-Peak Period Jitter $F_{CCC\_OUT}$           | Max Peak-to-Peak Period Jitter |         |                        |       |
|                                                                | 1 Global Network Used          |         | 3 Global Networks Used |       |
| 0.75 MHz to 24 MHz                                             | 0.50%                          |         | 0.70%                  |       |
| 24 MHz to 100 MHz                                              | 1.00%                          |         | 1.20%                  |       |
| 100 MHz to 250 MHz                                             | 1.75%                          |         | 2.00%                  |       |
| 250 MHz to 350 MHz                                             | 2.50%                          |         | 5.60%                  |       |
| Acquisition Time                                               |                                |         |                        |       |
| (A3P250 and A3P1000 only) LockControl = 0                      |                                |         | 300                    | μs    |
| LockControl = 1                                                |                                |         | 300                    | μs    |
| (all other dies) LockControl = 0                               |                                |         | 300                    | μs    |
| LockControl = 1                                                |                                |         | 6.0                    | ms    |
| Tracking Jitter <sup>4</sup>                                   |                                |         |                        |       |
| (A3P250 and A3P1000 only) LockControl = 0                      |                                |         | 1.6                    | ns    |
| LockControl = 1                                                |                                |         | 1.6                    | ns    |
| (all other dies) LockControl = 0                               |                                |         | 1.6                    | ns    |
| LockControl = 1                                                |                                |         | 0.8                    | ns    |
| Output Duty Cycle                                              | 48.5                           |         | 51.5                   | %     |
| Delay Range in Block: Programmable Delay 1 <sup>1, 2</sup>     | 0.6                            |         | 5.56                   | ns    |
| Delay Range in Block: Programmable Delay 2 <sup>1, 2</sup>     | 0.025                          |         | 5.56                   | ns    |
| Delay Range in Block: Fixed Delay <sup>1, 2</sup>              |                                | 2.2     |                        | ns    |

**Notes:**

1. This delay is a function of voltage and temperature. See [Table 2-5 on page 2-5](#) for deratings.
2.  $T_J = 25^\circ\text{C}$ ,  $V_{CC} = 1.5\text{ V}$
3. Tracking jitter is defined as the variation in clock edge position of PLL outputs with reference to the PLL input clock edge. Tracking jitter does not measure the variation in PLL output period, which is covered by the period jitter parameter.



*Note:* Peak-to-peak jitter measurements are defined by  $T_{\text{peak-to-peak}} = T_{\text{period\_max}} - T_{\text{period\_min}}$ .

**Figure 2-29 • Peak-to-Peak Jitter Definition**

## Embedded SRAM and FIFO Characteristics

### SRAM

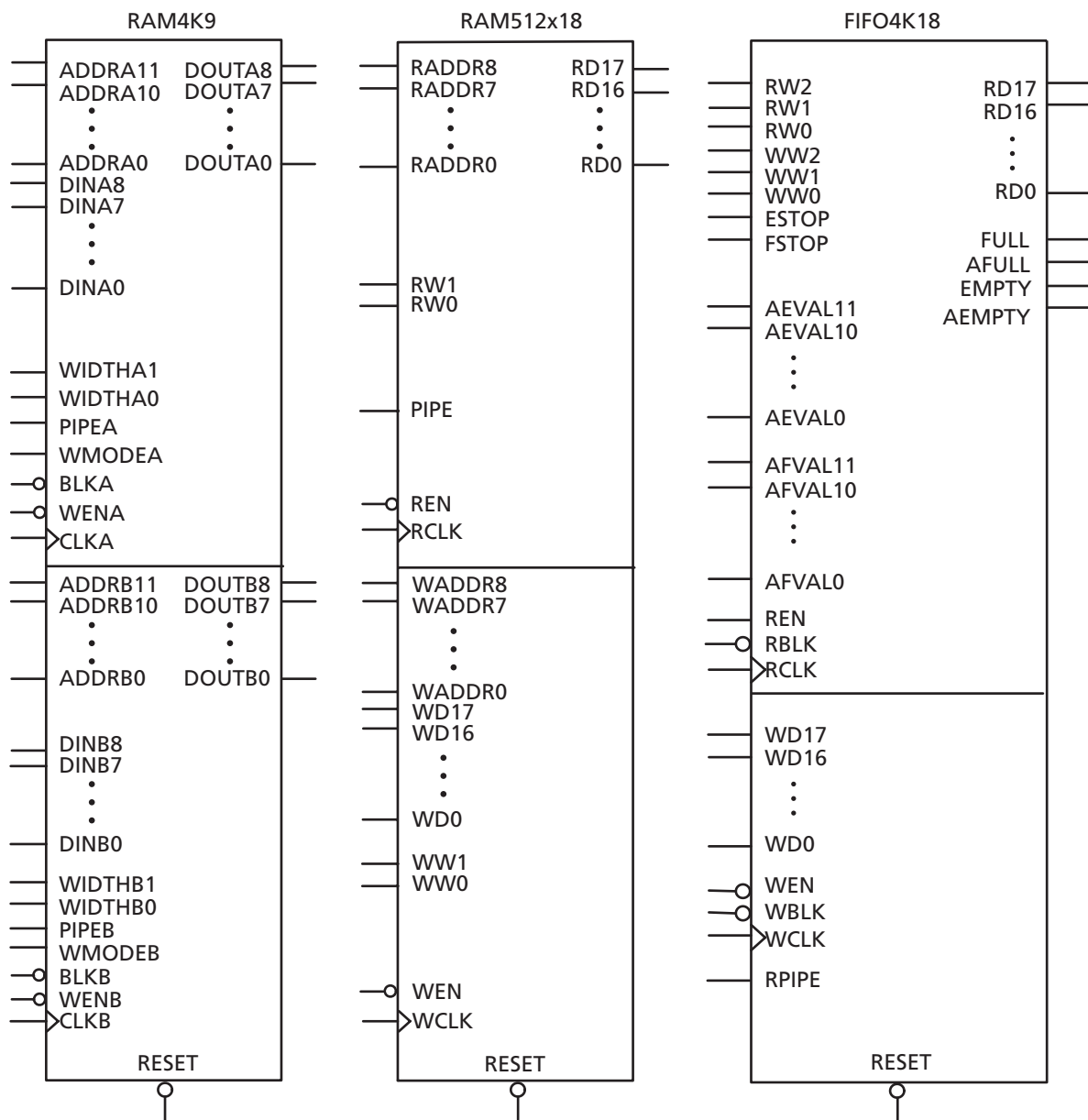


Figure 2-30 • RAM Models

## Timing Waveforms

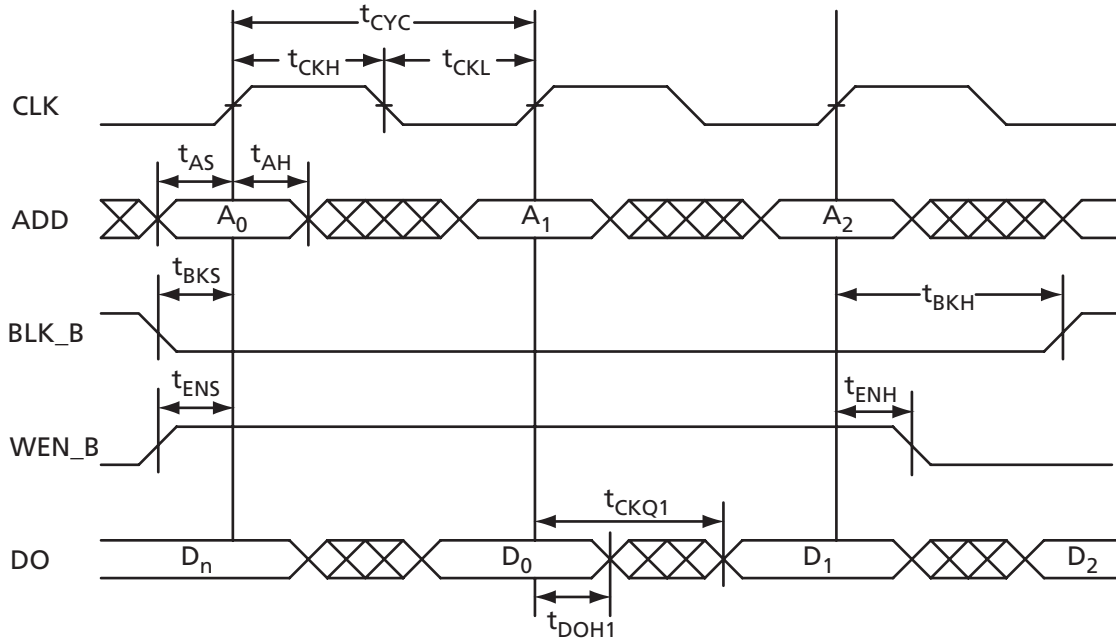


Figure 2-31 • RAM Read for Pass-Through Output

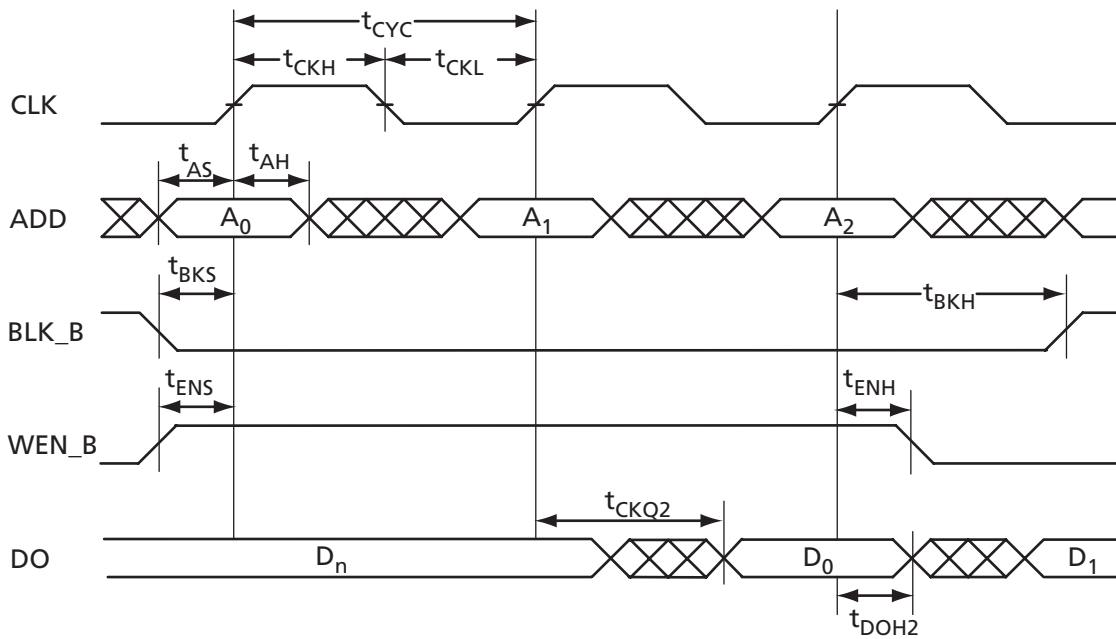
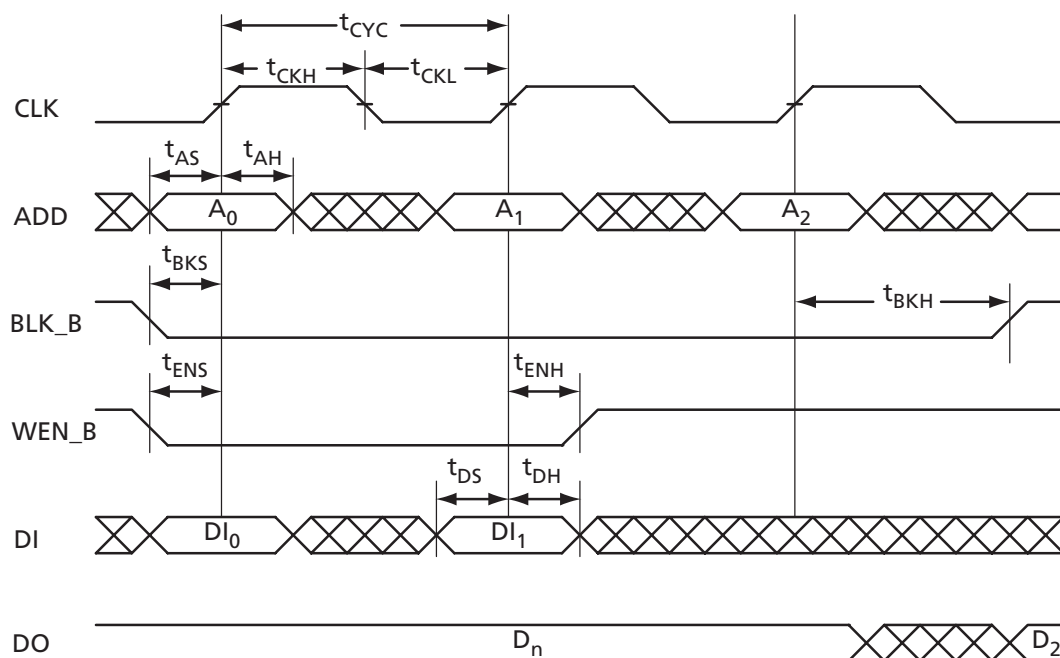
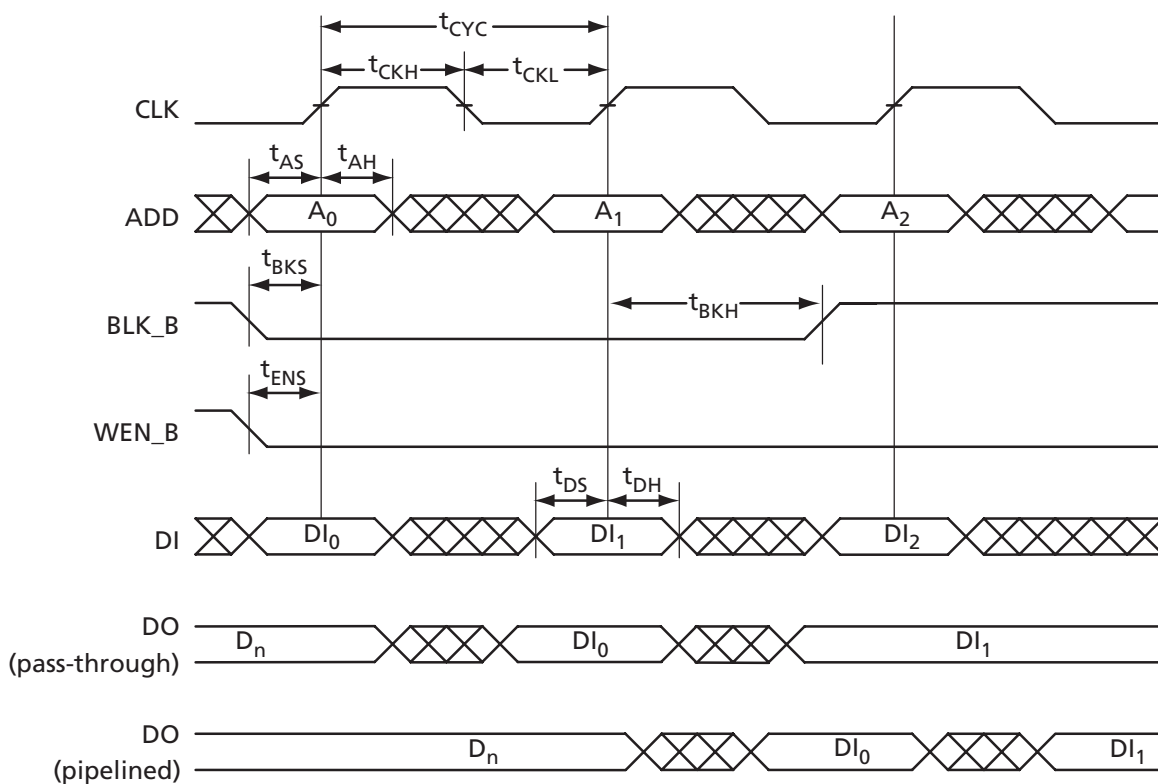


Figure 2-32 • RAM Read for Pipelined Output


**Figure 2-33 • RAM Write, Output Retained (WMODE = 0)**

**Figure 2-34 • RAM Write, Output as Write Data (WMODE = 1)**

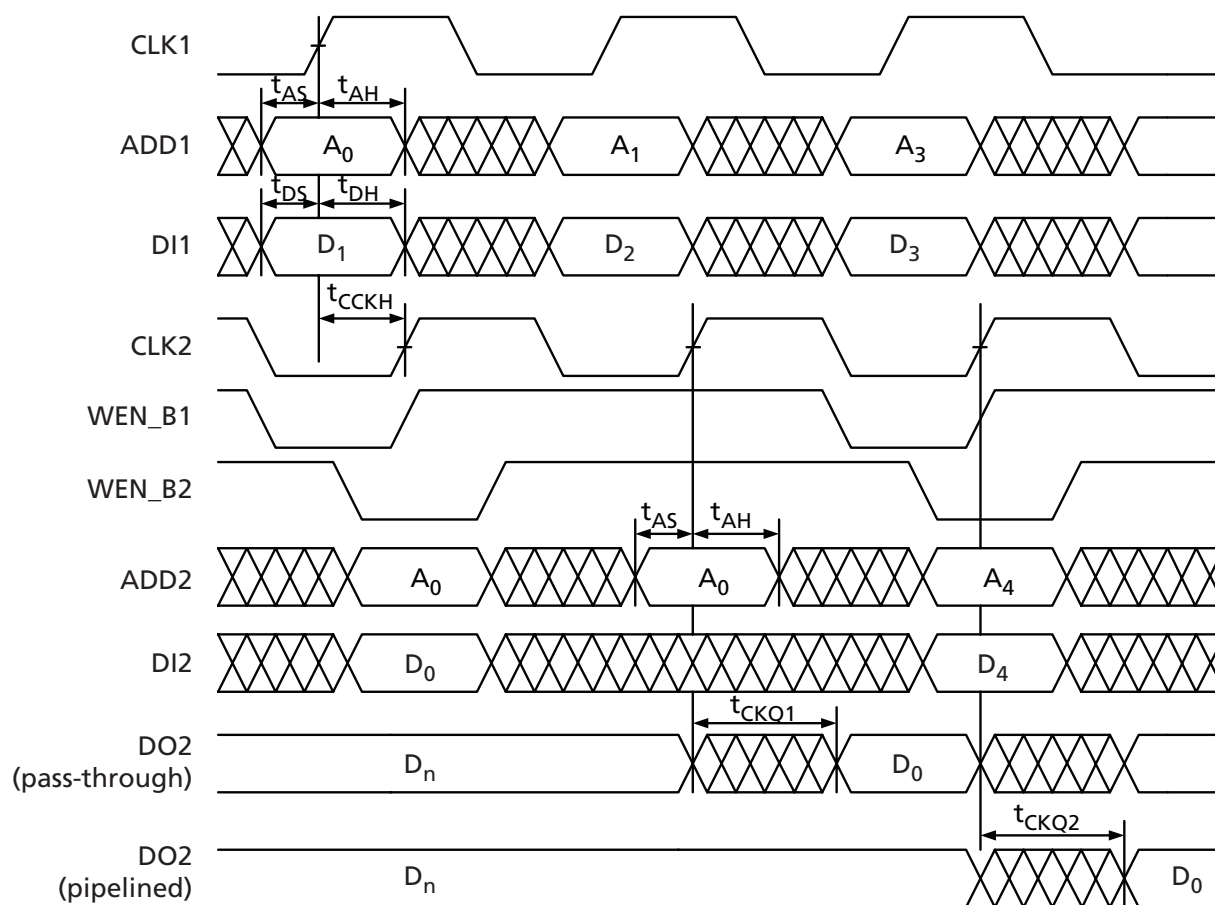


Figure 2-35 • Write Access after Write to Same Address

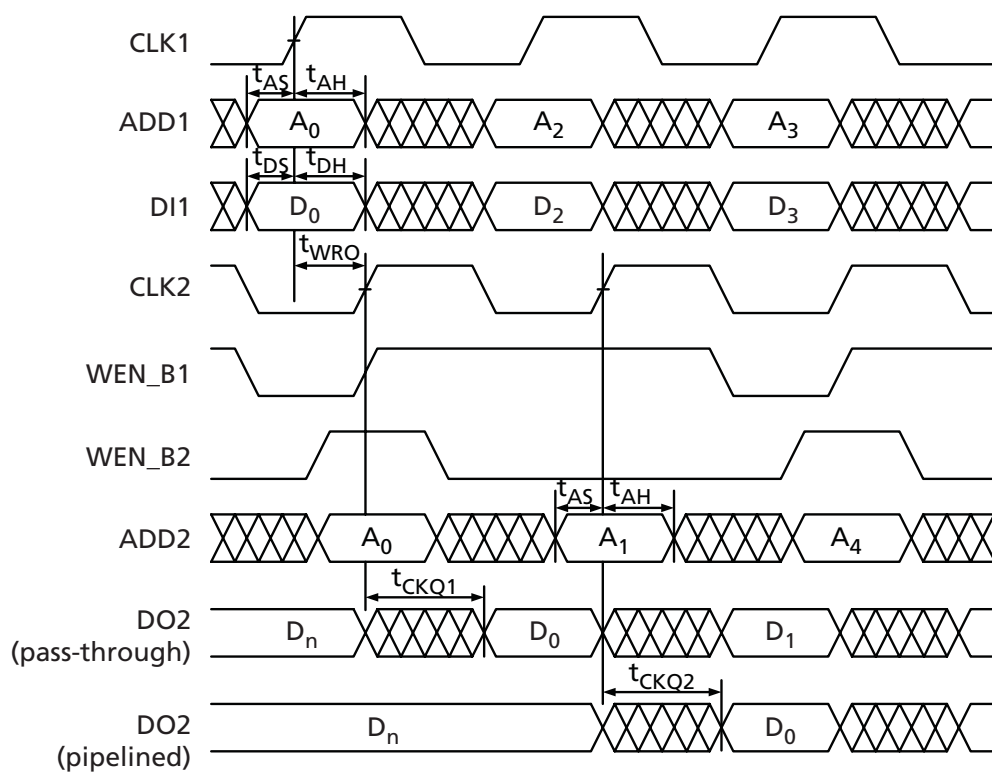


Figure 2-36 • Read Access after Write to Same Address

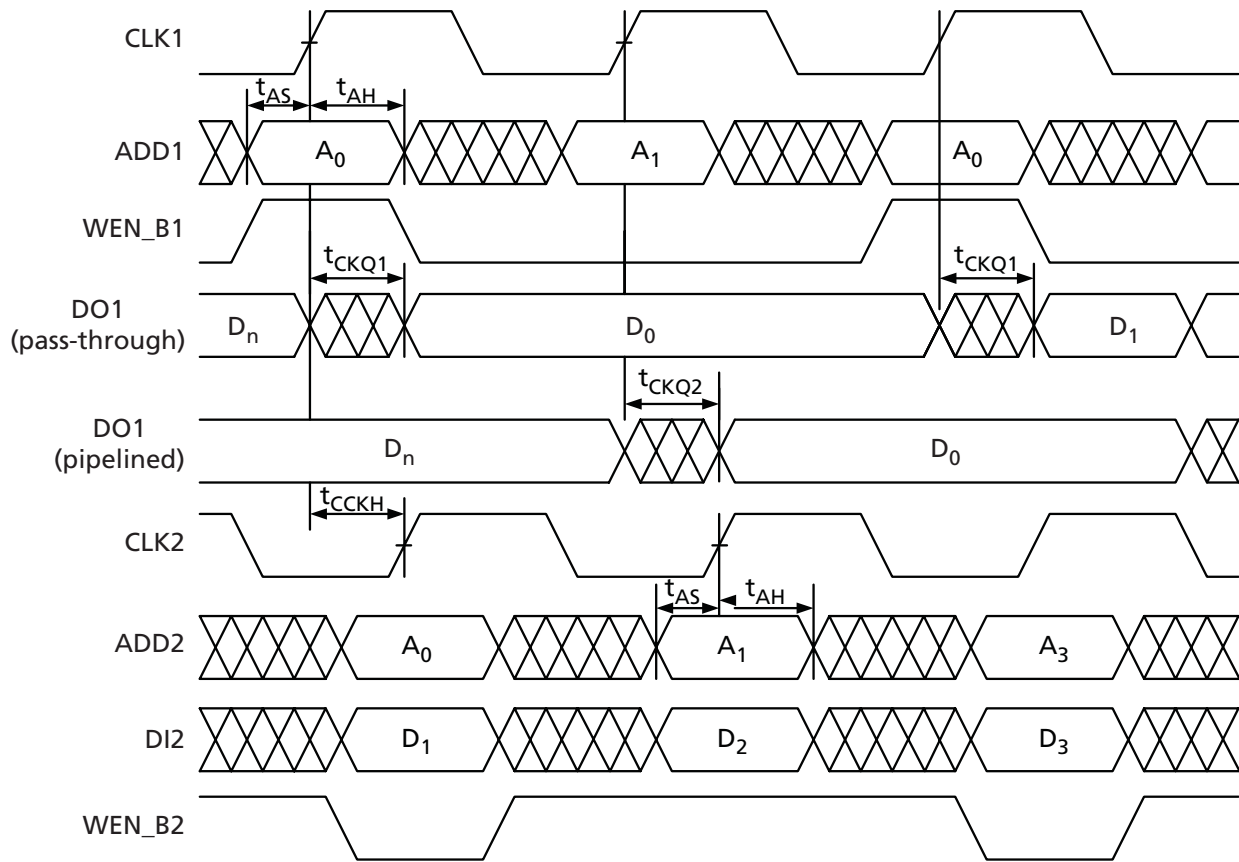


Figure 2-37 • Write Access after Read to Same Address

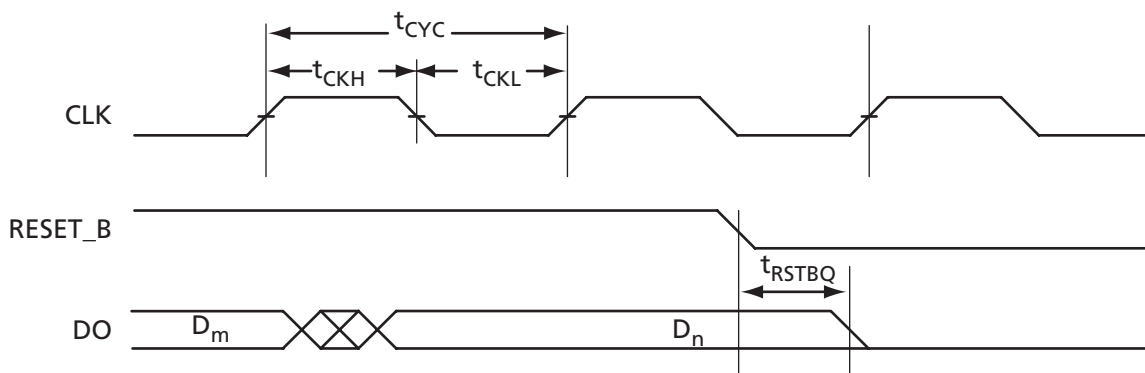


Figure 2-38 • RAM Reset

## Timing Characteristics

**Table 2-117 • RAM4K9**

Automotive-Case Conditions:  $T_J = 135^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ 

| Parameter     | Description                                                                                   | –1   | Std. | Units |
|---------------|-----------------------------------------------------------------------------------------------|------|------|-------|
| $t_{AS}$      | Address Setup Time                                                                            | 0.30 | 0.36 | ns    |
| $t_{AH}$      | Address Hold Time                                                                             | 0.00 | 0.00 | ns    |
| $t_{ENS}$     | REN_B, WEN_B Setup Time                                                                       | 0.17 | 0.20 | ns    |
| $t_{ENH}$     | REN_B, WEN_B Hold Time                                                                        | 0.12 | 0.14 | ns    |
| $t_{BKS}$     | BLK_B Setup Time                                                                              | 0.28 | 0.33 | ns    |
| $t_{BKH}$     | BLK_B Hold Time                                                                               | 0.02 | 0.03 | ns    |
| $t_{DS}$      | Input Data (DI) Setup Time                                                                    | 0.22 | 0.26 | ns    |
| $t_{DH}$      | Input Data (DI) Hold Time                                                                     | 0.00 | 0.00 | ns    |
| $t_{CKQ1}$    | Clock HIGH to New Data Valid on DO (output retained, WMODE = 0)                               | 2.17 | 2.55 | ns    |
|               | Clock HIGH to New Data Valid on DO (flow-through, WMODE = 1)                                  | 2.86 | 3.37 | ns    |
| $t_{CKQ2}$    | Clock HIGH to New Data Valid on DO (pipelined)                                                | 1.09 | 1.28 | ns    |
| $t_{WRO}$     | Address collision clk-to-clk delay for reliable read access after write on same address       | TBD  | TBD  | ns    |
| $t_{CCKH}$    | Address collision clk-to-clk delay for reliable write access after write/read on same address | TBD  | TBD  | ns    |
| $t_{RSTBQ}$   | RESET_B LOW to Data Out LOW on DO (flow-through)                                              | 1.12 | 1.32 | ns    |
|               | RESET_B LOW to Data Out LOW on DO (pipelined)                                                 | 1.12 | 1.32 | ns    |
| $t_{REMRSTB}$ | RESET_B Removal                                                                               | 0.35 | 0.41 | ns    |
| $t_{RECRSTB}$ | RESET_B Recovery                                                                              | 1.82 | 2.14 | ns    |
| $t_{MPWRSTB}$ | RESET_B Minimum Pulse Width                                                                   | 0.26 | 0.30 | ns    |
| $t_{CYC}$     | Clock Cycle Time                                                                              | 3.93 | 4.62 | ns    |
| $F_{MAX}$     | Maximum Frequency                                                                             | 255  | 217  | MHz   |

**Note:** For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-118 • RAM512X18****Automotive-Case Conditions:  $T_J = 135^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$** 

| Parameter     | Description                                                                                   | –1   | Std. | Units |
|---------------|-----------------------------------------------------------------------------------------------|------|------|-------|
| $t_{AS}$      | Address Setup Time                                                                            | 0.30 | 0.35 | ns    |
| $t_{AH}$      | Address Hold Time                                                                             | 0.00 | 0.00 | ns    |
| $t_{ENS}$     | REN_B, WEN_B Setup Time                                                                       | 0.11 | 0.13 | ns    |
| $t_{ENH}$     | REN_B, WEN_B Hold Time                                                                        | 0.07 | 0.08 | ns    |
| $t_{DS}$      | Input data (DI) Setup Time                                                                    | 0.22 | 0.26 | ns    |
| $t_{DH}$      | Input data (DI) Hold Time                                                                     | 0.00 | 0.00 | ns    |
| $t_{CKQ1}$    | Clock HIGH to New Data Valid on DO (output retained, WMODE = 0)                               | 2.58 | 3.03 | ns    |
| $t_{CKQ2}$    | Clock HIGH to New Data Valid on DO (pipelined)                                                | 1.07 | 1.26 | ns    |
| $t_{WRO}$     | Address collision clk-to-clk delay for reliable read access after write on same address       | TBD  | TBD  | ns    |
| $t_{CCKH}$    | Address collision clk-to-clk delay for reliable write access after write/read on same address | TBD  | TBD  | ns    |
| $t_{RSTBQ}$   | RESET_B LOW to Data Out LOW on DO (flow-through)                                              | 1.10 | 1.29 | ns    |
|               | RESET_B LOW to Data Out LOW on DO (pipelined)                                                 | 1.10 | 1.29 | ns    |
| $t_{REMRSTB}$ | RESET_B Removal                                                                               | 0.34 | 0.40 | ns    |
| $t_{RECRSTB}$ | RESET_B Recovery                                                                              | 1.79 | 2.10 | ns    |
| $t_{MPWRSTB}$ | RESET_B Minimum Pulse Width                                                                   | 0.25 | 0.30 | ns    |
| $t_{CYC}$     | Clock Cycle Time                                                                              | 3.85 | 4.53 | ns    |
| $F_{MAX}$     | Maximum Frequency                                                                             | 260  | 221  | MHz   |

**Note:** For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-119 • RAM4K9**

Automotive-Case Conditions:  $T_J = 115^{\circ}\text{C}$ , Worst Case  $V_{CC} = 1.425\text{ V}$ 

| Parameter     | Description                                                                                   | –1   | Std. | Units |
|---------------|-----------------------------------------------------------------------------------------------|------|------|-------|
| $t_{AS}$      | Address Setup Time                                                                            | 0.30 | 0.35 | ns    |
| $t_{AH}$      | Address Hold Time                                                                             | 0.00 | 0.00 | ns    |
| $t_{ENS}$     | REN_B, WEN_B Setup Time                                                                       | 0.17 | 0.20 | ns    |
| $t_{ENH}$     | REN_B, WEN_B Hold Time                                                                        | 0.12 | 0.14 | ns    |
| $t_{BKS}$     | BLK_B Setup Time                                                                              | 0.28 | 0.33 | ns    |
| $t_{BKH}$     | BLK_B Hold Time                                                                               | 0.02 | 0.03 | ns    |
| $t_{DS}$      | Input data (DI) Setup Time                                                                    | 0.22 | 0.26 | ns    |
| $t_{DH}$      | Input data (DI) Hold Time                                                                     | 0.00 | 0.00 | ns    |
| $t_{CKQ1}$    | Clock HIGH to New Data Valid on DO (output retained, WMODE = 0)                               | 2.13 | 2.50 | ns    |
|               | Clock HIGH to New Data Valid on DO (flow-through, WMODE = 1)                                  | 2.81 | 3.30 | ns    |
| $t_{CKQ2}$    | Clock HIGH to New Data Valid on DO (pipelined)                                                | 1.07 | 1.25 | ns    |
| $t_{WRO}$     | Address collision clk-to-clk delay for reliable read access after write on same address       | TBD  | TBD  | ns    |
| $t_{CCKH}$    | Address collision clk-to-clk delay for reliable write access after write/read on same address | TBD  | TBD  | ns    |
| $t_{RSTBQ}$   | RESET_B LOW to Data Out LOW on DO (flow-through)                                              | 1.10 | 1.29 | ns    |
|               | RESET_B LOW to Data Out LOW on DO (pipelined)                                                 | 1.10 | 1.29 | ns    |
| $t_{REMRSTB}$ | RESET_B Removal                                                                               | 0.34 | 0.40 | ns    |
| $t_{RECRSTB}$ | RESET_B Recovery                                                                              | 1.79 | 2.10 | ns    |
| $t_{MPWRSTB}$ | RESET_B Minimum Pulse Width                                                                   | 0.25 | 0.30 | ns    |
| $t_{CYC}$     | Clock Cycle Time                                                                              | 3.85 | 4.53 | ns    |
| $F_{MAX}$     | Maximum Frequency                                                                             | 260  | 221  | MHz   |

**Note:** For specific junction temperature and voltage-supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-120 • RAM512X18****Automotive-Case Conditions:  $T_J = 115^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$** 

| Parameter     | Description                                                                                   | –1   | Std. | Units |
|---------------|-----------------------------------------------------------------------------------------------|------|------|-------|
| $t_{AS}$      | Address Setup Time                                                                            | 0.30 | 0.35 | ns    |
| $t_{AH}$      | Address Hold Time                                                                             | 0.00 | 0.00 | ns    |
| $t_{ENS}$     | REN_B, WEN_B Setup Time                                                                       | 0.11 | 0.13 | ns    |
| $t_{ENH}$     | REN_B, WEN_B Hold Time                                                                        | 0.07 | 0.08 | ns    |
| $t_{DS}$      | Input data (DI) Setup Time                                                                    | 0.22 | 0.26 | ns    |
| $t_{DH}$      | Input data (DI) Hold Time                                                                     | 0.00 | 0.00 | ns    |
| $t_{CKQ1}$    | Clock HIGH to New Data Valid on DO (output retained, WMODE = 0)                               | 2.58 | 3.03 | ns    |
| $t_{CKQ2}$    | Clock HIGH to New Data Valid on DO (pipelined)                                                | 1.07 | 1.26 | ns    |
| $t_{WRO}$     | Address collision clk-to-clk delay for reliable read access after write on same address       | TBD  | TBD  | ns    |
| $t_{CCKH}$    | Address collision clk-to-clk delay for reliable write access after write/read on same address | TBD  | TBD  | ns    |
| $t_{RSTBQ}$   | RESET_B LOW to Data Out LOW on DO (flow-through)                                              | 1.10 | 1.29 | ns    |
|               | RESET_B LOW to Data Out LOW on DO (pipelined)                                                 | 1.10 | 1.29 | ns    |
| $t_{REMRSTB}$ | RESET_B Removal                                                                               | 0.34 | 0.40 | ns    |
| $t_{RECRSTB}$ | RESET_B Recovery                                                                              | 1.79 | 2.10 | ns    |
| $t_{MPWRSTB}$ | RESET_B Minimum Pulse Width                                                                   | 0.25 | 0.30 | ns    |
| $t_{CYC}$     | Clock Cycle Time                                                                              | 3.85 | 4.53 | ns    |
| $F_{MAX}$     | Maximum Frequency                                                                             | 260  | 221  | MHz   |

**Note:** For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

## FIFO

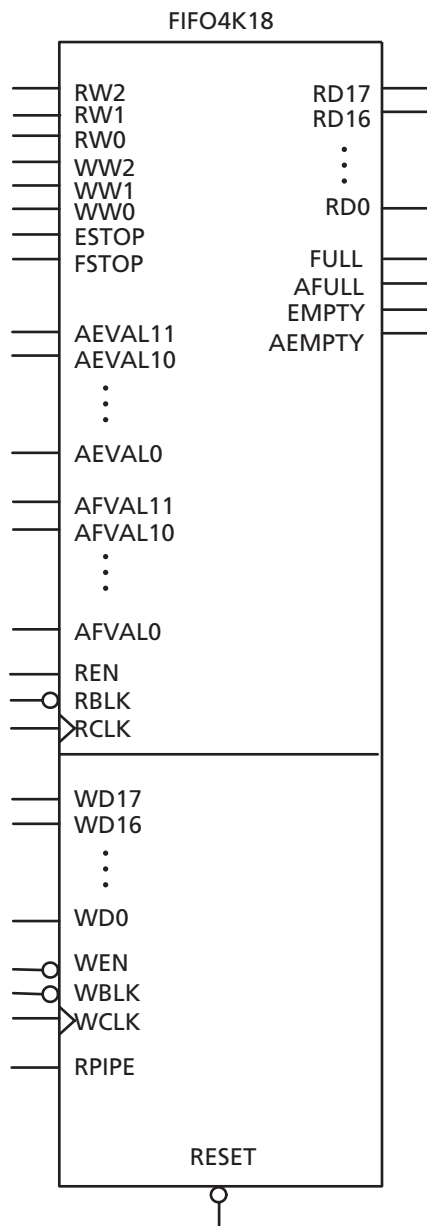


Figure 2-39 • FIFO Model

## Timing Waveforms

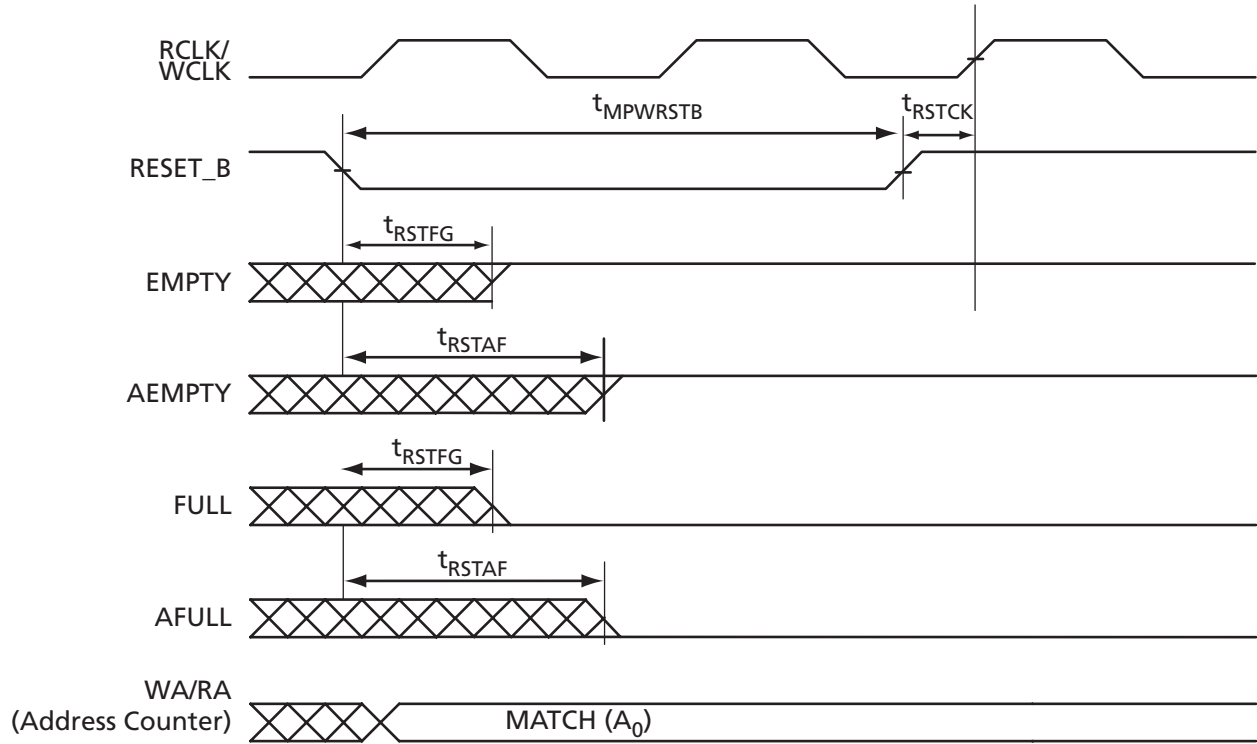


Figure 2-40 • FIFO Reset

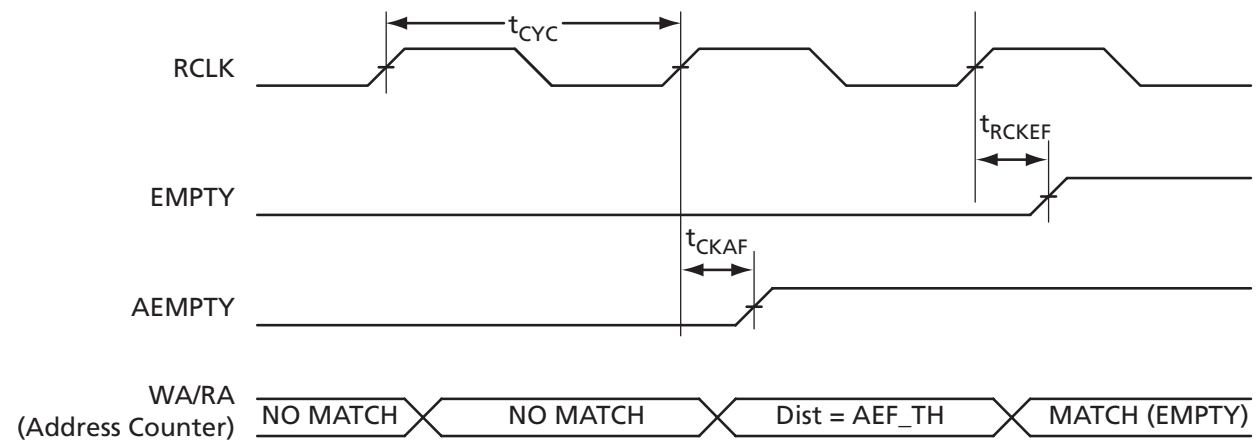


Figure 2-41 • FIFO EMPTY Flag and AEMPTY Flag Assertion

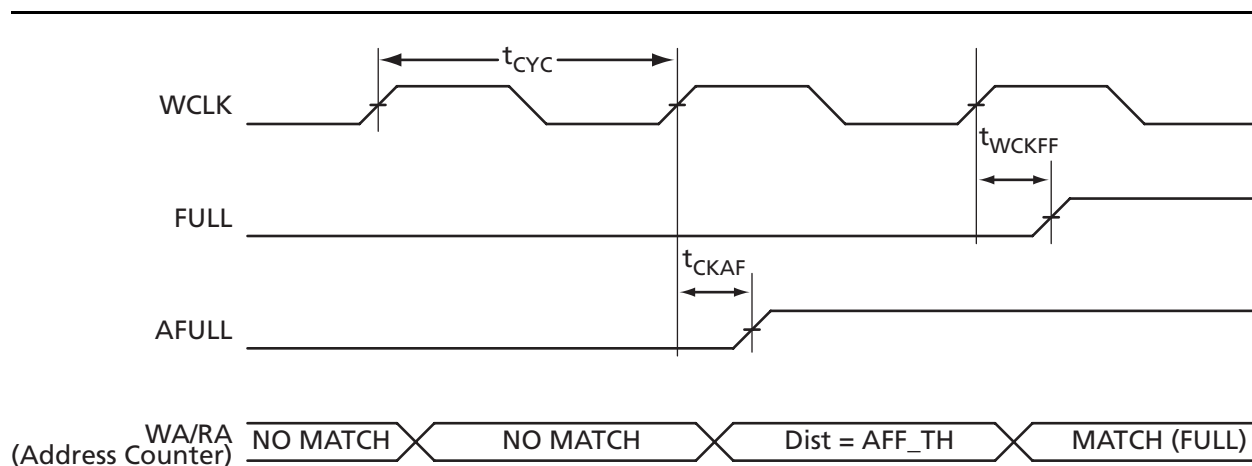


Figure 2-42 • FIFO FULL Flag and AFULL Flag Assertion

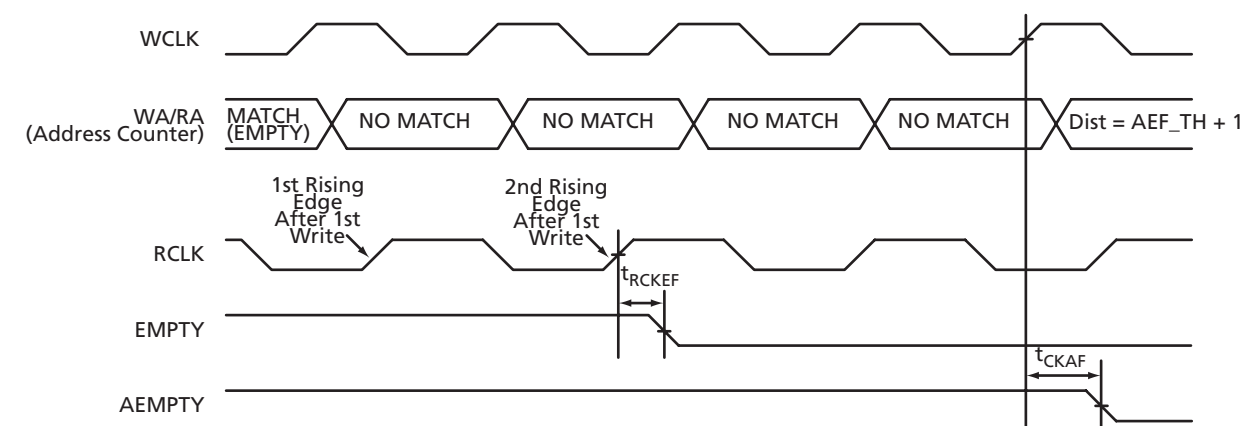


Figure 2-43 • FIFO EMPTY Flag and AEMPTY Flag Deassertion

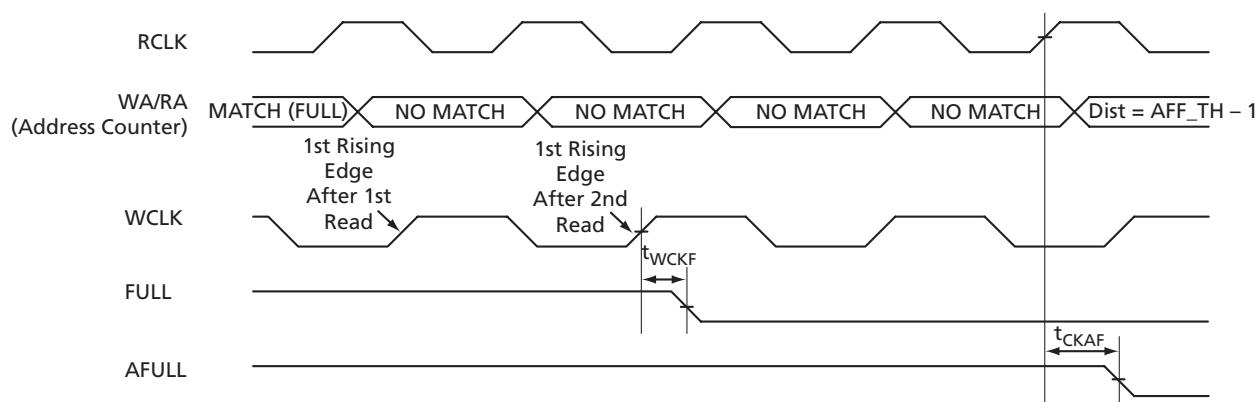


Figure 2-44 • FIFO FULL Flag and AFULL Flag Deassertion

## Timing Characteristics

**Table 2-121 • FIFO**

**Worst-Case Automotive Conditions:  $T_J = 135^{\circ}\text{C}$ ,  $V_{CC} = 1.425\text{ V}$**

| Parameter     | Description                                       | –1   | Std. | Units |
|---------------|---------------------------------------------------|------|------|-------|
| $t_{ENS}$     | REN_B, WEN_B Setup Time                           | 1.97 | 1.67 | ns    |
| $t_{ENH}$     | REN_B, WEN_B Hold Time                            | 0.03 | 0.02 | ns    |
| $t_{BKS}$     | BLK_B Setup Time                                  | 0.28 | 0.32 | ns    |
| $t_{BKH}$     | BLK_B Hold Time                                   | 0.00 | 0.00 | ns    |
| $t_{DS}$      | Input Data (DI) Setup Time                        | 0.26 | 0.22 | ns    |
| $t_{DH}$      | Input Data (DI) Hold Time                         | 0.00 | 0.00 | ns    |
| $t_{CKQ1}$    | Clock HIGH to New Data Valid on DO (flow-through) | 3.37 | 2.86 | ns    |
| $t_{CKQ2}$    | Clock HIGH to New Data Valid on DO (pipelined)    | 1.28 | 1.09 | ns    |
| $t_{RCKEF}$   | RCLK HIGH to Empty Flag Valid                     | 2.45 | 2.09 | ns    |
| $t_{WCKFF}$   | WCLK HIGH to Full Flag Valid                      | 2.33 | 1.98 | ns    |
| $t_{CKAF}$    | Clock HIGH to Almost Empty/Full Flag Valid        | 8.85 | 7.53 | ns    |
| $t_{RSTFG}$   | RESET_B LOW to Empty/Full Flag Valid              | 2.42 | 2.06 | ns    |
| $t_{RSTAF}$   | RESET_B LOW to Almost Empty/Full Flag Valid       | 8.76 | 7.45 | ns    |
| $t_{RSTBQ}$   | RESET_B LOW to Data Out LOW on DO (flow-through)  | 1.32 | 1.12 | ns    |
|               | RESET_B LOW to Data Out LOW on DO (pipelined)     | 1.32 | 1.12 | ns    |
| $t_{REMRSTB}$ | RESET_B Removal                                   | 0.41 | 0.35 | ns    |
| $t_{RECRSTB}$ | RESET_B Recovery                                  | 2.14 | 1.82 | ns    |
| $t_{MPWRSTB}$ | RESET_B Minimum Pulse Width                       | 0.30 | 0.26 | ns    |
| $t_{CYC}$     | Clock Cycle Time                                  | 4.62 | 3.93 | ns    |
| $F_{MAX}$     | Maximum Frequency for FIFO                        | 217  | 255  | MHz   |

**Note:** For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

**Table 2-122 • FIFO**
**Worst-Case Automotive Conditions:  $T_J = 115^{\circ}\text{C}$ ,  $V_{CC} = 1.425\text{ V}$** 

| Parameter     | Description                                       | -1   | Std. | Units |
|---------------|---------------------------------------------------|------|------|-------|
| $t_{ENS}$     | REN_B, WEN_B Setup Time                           | 1.93 | 1.64 | ns    |
| $t_{ENH}$     | REN_B, WEN_B Hold Time                            | 0.03 | 0.02 | ns    |
| $t_{BKS}$     | BLK_B Setup Time                                  | 0.27 | 0.32 | ns    |
| $t_{BKH}$     | BLK_B Hold Time                                   | 0.00 | 0.00 | ns    |
| $t_{DS}$      | Input Data (DI) Setup Time                        | 0.26 | 0.22 | ns    |
| $t_{DH}$      | Input Data (DI) Hold Time                         | 0.00 | 0.00 | ns    |
| $t_{CKQ1}$    | Clock HIGH to New Data Valid on DO (flow-through) | 3.30 | 2.81 | ns    |
| $t_{CKQ2}$    | Clock HIGH to New Data Valid on DO (pipelined)    | 1.25 | 1.07 | ns    |
| $t_{RCKEF}$   | RCLK HIGH to Empty Flag Valid                     | 2.41 | 2.05 | ns    |
| $t_{WCKFF}$   | WCLK HIGH to Full Flag Valid                      | 2.29 | 1.95 | ns    |
| $t_{CKAF}$    | Clock HIGH to Almost Empty/Full Flag Valid        | 8.68 | 7.38 | ns    |
| $t_{RSTFG}$   | RESET_B LOW to Empty/Full Flag Valid              | 2.37 | 2.02 | ns    |
| $t_{RSTAF}$   | RESET_B LOW to Almost Empty/Full Flag Valid       | 8.59 | 7.30 | ns    |
| $t_{RSTBQ}$   | RESET_B LOW to Data Out LOW on DO (flow-through)  | 1.29 | 1.10 | ns    |
|               | RESET_B LOW to Data Out LOW on DO (pipelined)     | 1.29 | 1.10 | ns    |
| $t_{REMRSTB}$ | RESET_B Removal                                   | 0.40 | 0.34 | ns    |
| $t_{RECRSTB}$ | RESET_B Recovery                                  | 2.10 | 1.79 | ns    |
| $t_{MPWRSTB}$ | RESET_B Minimum Pulse Width                       | 0.30 | 0.25 | ns    |
| $t_{CYC}$     | Clock Cycle Time                                  | 4.53 | 3.85 | ns    |
| $f_{MAX}$     | Maximum Frequency for FIFO                        | 221  | 260  | MHz   |

**Note:** For specific junction temperature and voltage supply levels, refer to [Table 2-5 on page 2-5](#) for derating values.

## Embedded FlashROM Characteristics

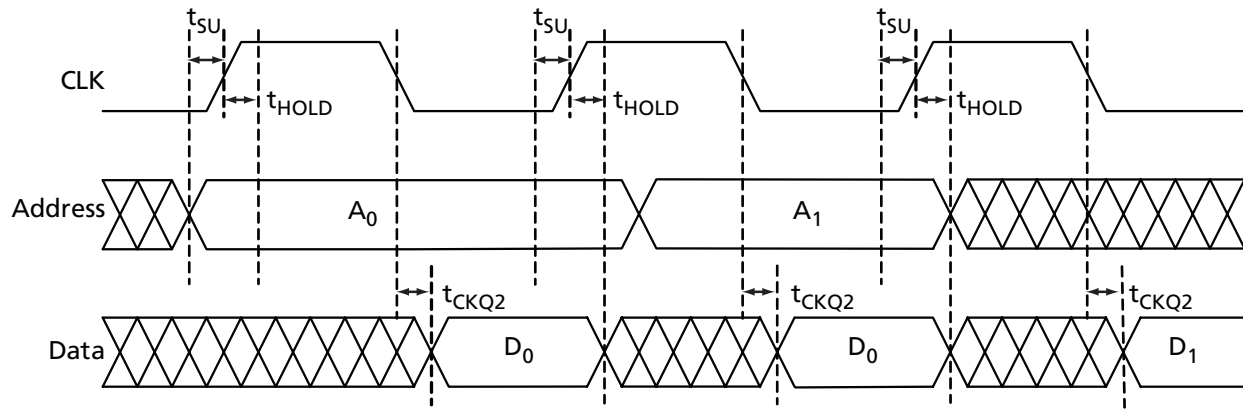


Figure 2-45 • Timing Diagram

### Timing Characteristics

Table 2-123 • Embedded FlashROM Access Time

Automotive-Case Conditions:  $T_J = 135^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$

| Parameter  | Description             | –1    | Std.  | Units |
|------------|-------------------------|-------|-------|-------|
| $t_{SU}$   | Address Setup Time      | 0.65  | 0.76  | ns    |
| $t_{HOLD}$ | Address Hold Time       | 0.00  | 0.00  | ns    |
| $t_{CK2Q}$ | Clock to Out            | 19.73 | 23.20 | ns    |
| $F_{MAX}$  | Maximum Clock Frequency | 15    | 15    | MHz   |

Table 2-124 • Embedded FlashROM Access Time

Automotive-Case Conditions:  $T_J = 115^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$

| Parameter  | Description             | –1    | Std.  | Units |
|------------|-------------------------|-------|-------|-------|
| $t_{SU}$   | Address Setup Time      | 0.64  | 0.75  | ns    |
| $t_{HOLD}$ | Address Hold Time       | 0.00  | 0.00  | ns    |
| $t_{CK2Q}$ | Clock to Out            | 19.35 | 22.74 | ns    |
| $F_{MAX}$  | Maximum Clock Frequency | 15    | 15    | MHz   |

## JTAG 1532 Characteristics

JTAG timing delays do not include JTAG I/Os. To obtain complete JTAG timing, add I/O buffer delays to the corresponding standard selected; refer to the I/O timing characteristics in the "User I/O Characteristics" section on page 2-12 for more details.

### Timing Characteristics

Table 2-125 • JTAG 1532

Commercial-Case Conditions:  $T_J = 70^\circ\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$

| Parameter     | Description                 | -2 | -1 | Std. | Units |
|---------------|-----------------------------|----|----|------|-------|
| $t_{DISU}$    | Test Data Input Setup Time  |    |    |      | ns    |
| $t_{DIHD}$    | Test Data Input Hold Time   |    |    |      | ns    |
| $t_{TMSSU}$   | Test Mode Select Setup Time |    |    |      | ns    |
| $t_{TMDHD}$   | Test Mode Select Hold Time  |    |    |      | ns    |
| $t_{TCK2Q}$   | Clock to Q (data out)       |    |    |      | ns    |
| $t_{RSTB2Q}$  | Reset to Q (data out)       |    |    |      | ns    |
| $F_{TCKMAX}$  | TCK Maximum Frequency       | 20 | 20 | 20   | MHz   |
| $t_{TRSTREM}$ | ResetB Removal Time         |    |    |      | ns    |
| $t_{TRSTREC}$ | ResetB Recovery Time        |    |    |      | ns    |
| $t_{TRSTMPW}$ | ResetB Minimum Pulse        |    |    |      | ns    |

*Note:* For specific junction temperature and voltage supply levels, refer to Table 2-5 on page 2-5 for derating values.

## Part Number and Revision Date

Part Number 51700099-002-0

Revised January 2008

## Actel Safety Critical, Life Support, and High-Reliability Applications Policy

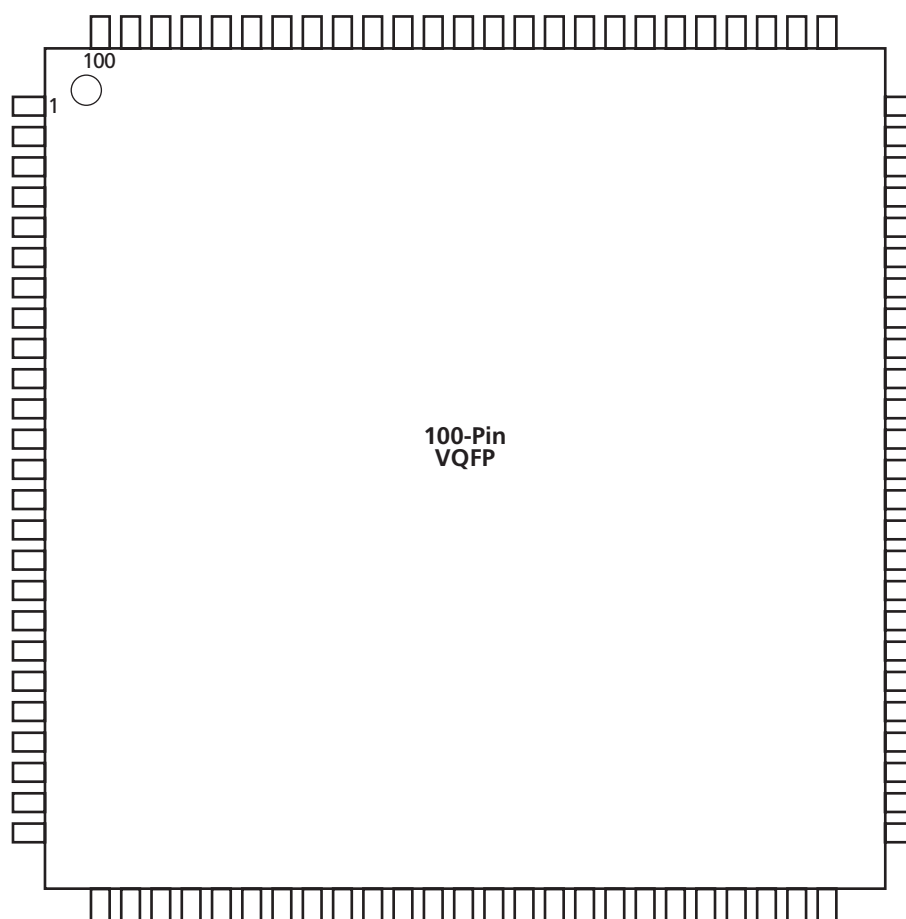
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## 3 – Package Pin Assignments

### 100-Pin VQFP



*Note: This is the top view of the package.*

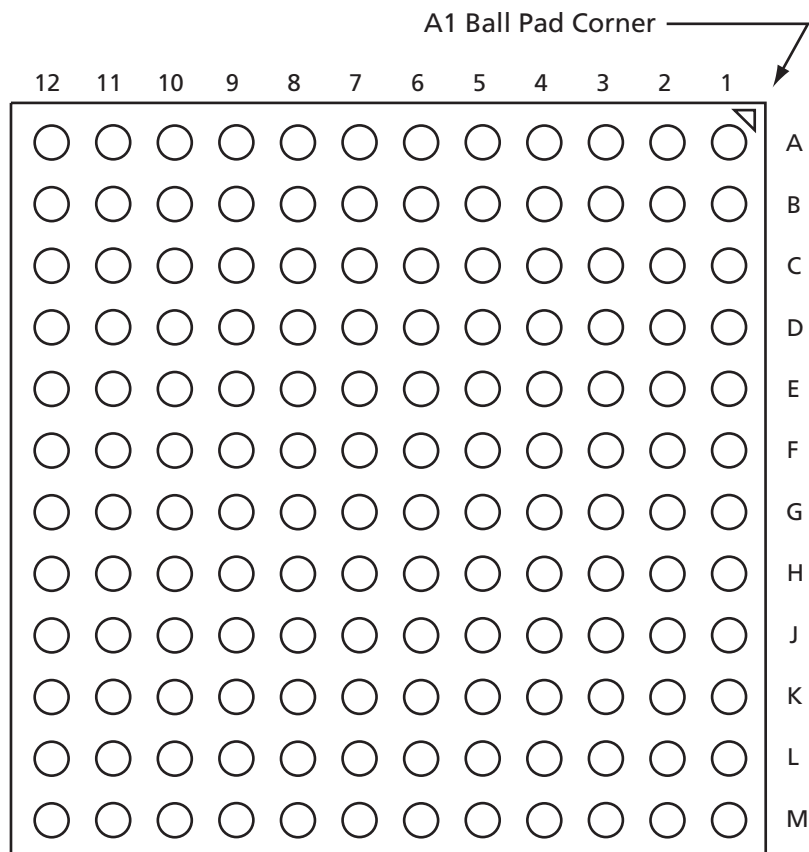
#### Note

For Package Manufacturing and Environmental information, visit the Resource Center at <http://www.actel.com/products/solutions/package/docs.aspx>.

| 100-Pin VQFP |                     | 100-Pin VQFP |                     | 100-Pin VQFP |                     |
|--------------|---------------------|--------------|---------------------|--------------|---------------------|
| Pin Number   | A3P060 Function     | Pin Number   | A3P060 Function     | Pin Number   | A3P060 Function     |
| 1            | GND                 | 35           | IO62RSB1            | 69           | IO31RSB0            |
| 2            | GAA2/IO51RSB1       | 36           | IO61RSB1            | 70           | GBC2/IO29RSB0       |
| 3            | IO52RSB1            | 37           | V <sub>CC</sub>     | 71           | GBB2/IO27RSB0       |
| 4            | GAB2/IO53RSB1       | 38           | GND                 | 72           | IO26RSB0            |
| 5            | IO95RSB1            | 39           | V <sub>CCI</sub> B1 | 73           | GBA2/IO25RSB0       |
| 6            | GAC2/IO94RSB1       | 40           | IO60RSB1            | 74           | VMV0                |
| 7            | IO93RSB1            | 41           | IO59RSB1            | 75           | GNDQ                |
| 8            | IO92RSB1            | 42           | IO58RSB1            | 76           | GBA1/IO24RSB0       |
| 9            | GND                 | 43           | IO57RSB1            | 77           | GBA0/IO23RSB0       |
| 10           | GFB1/IO87RSB1       | 44           | GDC2/IO56RSB1       | 78           | GBB1/IO22RSB0       |
| 11           | GFB0/IO86RSB1       | 45           | GDB2/IO55RSB1       | 79           | GBB0/IO21RSB0       |
| 12           | V <sub>COMPLF</sub> | 46           | GDA2/IO54RSB1       | 80           | GBC1/IO20RSB0       |
| 13           | GFA0/IO85RSB1       | 47           | TCK                 | 81           | GBC0/IO19RSB0       |
| 14           | V <sub>CCPLF</sub>  | 48           | TDI                 | 82           | IO18RSB0            |
| 15           | GFA1/IO84RSB1       | 49           | TMS                 | 83           | IO17RSB0            |
| 16           | GFA2/IO83RSB1       | 50           | VMV1                | 84           | IO15RSB0            |
| 17           | V <sub>CC</sub>     | 51           | GND                 | 85           | IO13RSB0            |
| 18           | V <sub>CCI</sub> B1 | 52           | V <sub>PUMP</sub>   | 86           | IO11RSB0            |
| 19           | GEC1/IO77RSB1       | 53           | NC                  | 87           | V <sub>CCI</sub> B0 |
| 20           | GEB1/IO75RSB1       | 54           | TDO                 | 88           | GND                 |
| 21           | GEB0/IO74RSB1       | 55           | TRST                | 89           | V <sub>CC</sub>     |
| 22           | GEA1/IO73RSB1       | 56           | V <sub>JTAG</sub>   | 90           | IO10RSB0            |
| 23           | GEA0/IO72RSB1       | 57           | GDA1/IO49RSB0       | 91           | IO09RSB0            |
| 24           | VMV1                | 58           | GDC0/IO46RSB0       | 92           | IO08RSB0            |
| 25           | GNDQ                | 59           | GDC1/IO45RSB0       | 93           | GAC1/IO07RSB0       |
| 26           | GEA2/IO71RSB1       | 60           | GCC2/IO43RSB0       | 94           | GAC0/IO06RSB0       |
| 27           | GEB2/IO70RSB1       | 61           | GCB2/IO42RSB0       | 95           | GAB1/IO05RSB0       |
| 28           | GEC2/IO69RSB1       | 62           | GCA0/IO40RSB0       | 96           | GAB0/IO04RSB0       |
| 29           | IO68RSB1            | 63           | GCA1/IO39RSB0       | 97           | GAA1/IO03RSB0       |
| 30           | IO67RSB1            | 64           | GCC0/IO36RSB0       | 98           | GAA0/IO02RSB0       |
| 31           | IO66RSB1            | 65           | GCC1/IO35RSB0       | 99           | IO01RSB0            |
| 32           | IO65RSB1            | 66           | V <sub>CCI</sub> B0 | 100          | IO00RSB0            |
| 33           | IO64RSB1            | 67           | GND                 |              |                     |
| 34           | IO63RSB1            | 68           | V <sub>CC</sub>     |              |                     |

| 100-Pin VQFP |                     | 100-Pin VQFP |                     | 100-Pin VQFP |                     |
|--------------|---------------------|--------------|---------------------|--------------|---------------------|
| Pin Number   | A3P250 Function     | Pin Number   | A3P250 Function     | Pin Number   | A3P250 Function     |
| 1            | GND                 | 35           | IO85RSB2            | 69           | IO43NDB1            |
| 2            | GAA2/IO118UDB3      | 36           | IO84RSB2            | 70           | GBC2/IO43PDB1       |
| 3            | IO118VDB3           | 37           | V <sub>CC</sub>     | 71           | GBB2/IO42PSB1       |
| 4            | GAB2/IO117UDB3      | 38           | GND                 | 72           | IO41NDB1            |
| 5            | IO117VDB3           | 39           | V <sub>CCI</sub> B2 | 73           | GBA2/IO41PDB1       |
| 6            | GAC2/IO116UDB3      | 40           | IO77RSB2            | 74           | VMV1                |
| 7            | IO116VDB3           | 41           | IO74RSB2            | 75           | GNDQ                |
| 8            | IO112PSB3           | 42           | IO71RSB2            | 76           | GBA1/IO40RSB0       |
| 9            | GND                 | 43           | GDC2/IO63RSB2       | 77           | GBA0/IO39RSB0       |
| 10           | GFB1/IO109PDB3      | 44           | GDB2/IO62RSB2       | 78           | GBB1/IO38RSB0       |
| 11           | GFB0/IO109NDB3      | 45           | GDA2/IO61RSB2       | 79           | GBB0/IO37RSB0       |
| 12           | V <sub>COMPLF</sub> | 46           | GNDQ                | 80           | GBC1/IO36RSB0       |
| 13           | GFA0/IO108NPB3      | 47           | TCK                 | 81           | GBC0/IO35RSB0       |
| 14           | V <sub>CCPLF</sub>  | 48           | TDI                 | 82           | IO29RSB0            |
| 15           | GFA1/IO108PPB3      | 49           | TMS                 | 83           | IO27RSB0            |
| 16           | GFA2/IO107PSB3      | 50           | VMV2                | 84           | IO25RSB0            |
| 17           | V <sub>CC</sub>     | 51           | GND                 | 85           | IO23RSB0            |
| 18           | V <sub>CCI</sub> B3 | 52           | V <sub>PUMP</sub>   | 86           | IO21RSB0            |
| 19           | GFC2/IO105PSB3      | 53           | NC                  | 87           | V <sub>CCI</sub> B0 |
| 20           | GEC1/IO100PDB3      | 54           | TDO                 | 88           | GND                 |
| 21           | GEC0/IO100NDB3      | 55           | TRST                | 89           | V <sub>CC</sub>     |
| 22           | GEA1/IO98PDB3       | 56           | V <sub>JTAG</sub>   | 90           | IO15RSB0            |
| 23           | GEA0/IO98NDB3       | 57           | GDA1/IO60USB1       | 91           | IO13RSB0            |
| 24           | VMV3                | 58           | GDC0/IO58VDB1       | 92           | IO11RSB0            |
| 25           | GNDQ                | 59           | GDC1/IO58UDB1       | 93           | GAC1/IO05RSB0       |
| 26           | GEA2/IO97RSB2       | 60           | IO52NDB1            | 94           | GAC0/IO04RSB0       |
| 27           | GEB2/IO96RSB2       | 61           | GCB2/IO52PDB1       | 95           | GAB1/IO03RSB0       |
| 28           | GEC2/IO95RSB2       | 62           | GCA1/IO50PDB1       | 96           | GAB0/IO02RSB0       |
| 29           | IO93RSB2            | 63           | GCA0/IO50NDB1       | 97           | GAA1/IO01RSB0       |
| 30           | IO92RSB2            | 64           | GCC0/IO48NDB1       | 98           | GAA0/IO00RSB0       |
| 31           | IO91RSB2            | 65           | GCC1/IO48PDB1       | 99           | GNDQ                |
| 32           | IO90RSB2            | 66           | V <sub>CCI</sub> B1 | 100          | VMV0                |
| 33           | IO88RSB2            | 67           | GND                 |              |                     |
| 34           | IO86RSB2            | 68           | V <sub>CC</sub>     |              |                     |

## 144-Pin FBGA



*Note:* This is the bottom view of the package.

### Note

For Package Manufacturing and Environmental information, visit the Resource Center at <http://www.actel.com/products/solutions/package/docs.aspx>.

| 144-Pin FBGA |                 | 144-Pin FBGA |                        | 144-Pin FBGA |                    |
|--------------|-----------------|--------------|------------------------|--------------|--------------------|
| Pin Number   | A3P060 Function | Pin Number   | A3P060 Function        | Pin Number   | A3P060 Function    |
| A1           | GNDQ            | D1           | IO91RSB1               | G1           | GFA1/IO84RSB1      |
| A2           | VMV0            | D2           | IO92RSB1               | G2           | GND                |
| A3           | GAB0/IO04RSB0   | D3           | IO93RSB1               | G3           | V <sub>CCPLF</sub> |
| A4           | GAB1/IO05RSB0   | D4           | GAA2/IO51RSB1          | G4           | GFA0/IO85RSB1      |
| A5           | IO08RSB0        | D5           | GAC0/IO06RSB0          | G5           | GND                |
| A6           | GND             | D6           | GAC1/IO07RSB0          | G6           | GND                |
| A7           | IO11RSB0        | D7           | GBC0/IO19RSB0          | G7           | GND                |
| A8           | V <sub>CC</sub> | D8           | GBC1/IO20RSB0          | G8           | GDC1/IO45RSB0      |
| A9           | IO16RSB0        | D9           | GBB2/IO27RSB0          | G9           | IO32RSB0           |
| A10          | GBA0/IO23RSB0   | D10          | IO18RSB0               | G10          | GCC2/IO43RSB0      |
| A11          | GBA1/IO24RSB0   | D11          | IO28RSB0               | G11          | IO31RSB0           |
| A12          | GNDQ            | D12          | GCB1/IO37RSB0          | G12          | GCB2/IO42RSB0      |
| B1           | GAB2/IO53RSB1   | E1           | V <sub>CC</sub>        | H1           | V <sub>CC</sub>    |
| B2           | GND             | E2           | GFC0/IO88RSB1          | H2           | GFB2/IO82RSB1      |
| B3           | GAA0/IO02RSB0   | E3           | GFC1/IO89RSB1          | H3           | GFC2/IO81RSB1      |
| B4           | GAA1/IO03RSB0   | E4           | V <sub>CC</sub> B1     | H4           | GEC1/IO77RSB1      |
| B5           | IO00RSB0        | E5           | IO52RSB1               | H5           | V <sub>CC</sub>    |
| B6           | IO10RSB0        | E6           | V <sub>CC</sub> B0     | H6           | IO34RSB0           |
| B7           | IO12RSB0        | E7           | V <sub>CC</sub> B0     | H7           | IO44RSB0           |
| B8           | IO14RSB0        | E8           | GCC1/IO35RSB0          | H8           | GDB2/IO55RSB1      |
| B9           | GBB0/IO21RSB0   | E9           | V <sub>CC</sub> B0     | H9           | GDC0/IO46RSB0      |
| B10          | GBB1/IO22RSB0   | E10          | V <sub>CC</sub>        | H10          | V <sub>CC</sub> B0 |
| B11          | GND             | E11          | GCA0/IO40RSB0          | H11          | IO33RSB0           |
| B12          | VMV0            | E12          | IO30RSB0               | H12          | V <sub>CC</sub>    |
| C1           | IO95RSB1        | F1           | GFB0/IO86RSB1          | J1           | GEB1/IO75RSB1      |
| C2           | GFA2/IO83RSB1   | F2           | V <sub>CC</sub> COMPLF | J2           | IO78RSB1           |
| C3           | GAC2/IO94RSB1   | F3           | GFB1/IO87RSB1          | J3           | V <sub>CC</sub> B1 |
| C4           | V <sub>CC</sub> | F4           | IO90RSB1               | J4           | GEC0/IO76RSB1      |
| C5           | IO01RSB0        | F5           | GND                    | J5           | IO79RSB1           |
| C6           | IO09RSB0        | F6           | GND                    | J6           | IO80RSB1           |
| C7           | IO13RSB0        | F7           | GND                    | J7           | V <sub>CC</sub>    |
| C8           | IO15RSB0        | F8           | GCC0/IO36RSB0          | J8           | TCK                |
| C9           | IO17RSB0        | F9           | GCB0/IO38RSB0          | J9           | GDA2/IO54RSB1      |
| C10          | GBA2/IO25RSB0   | F10          | GND                    | J10          | TDO                |
| C11          | IO26RSB0        | F11          | GCA1/IO39RSB0          | J11          | GDA1/IO49RSB0      |
| C12          | GBC2/IO29RSB0   | F12          | GCA2/IO41RSB0          | J12          | GDB1/IO47RSB0      |

| 144-Pin FBGA |                     |
|--------------|---------------------|
| Pin Number   | A3P060 Function     |
| K1           | GEB0/IO74RSB1       |
| K2           | GEA1/IO73RSB1       |
| K3           | GEA0/IO72RSB1       |
| K4           | GEA2/IO71RSB1       |
| K5           | IO65RSB1            |
| K6           | IO64RSB1            |
| K7           | GND                 |
| K8           | IO57RSB1            |
| K9           | GDC2/IO56RSB1       |
| K10          | GND                 |
| K11          | GDA0/IO50RSB0       |
| K12          | GDB0/IO48RSB0       |
| L1           | GND                 |
| L2           | VMV1                |
| L3           | GEB2/IO70RSB1       |
| L4           | IO67RSB1            |
| L5           | V <sub>CCI</sub> B1 |
| L6           | IO62RSB1            |
| L7           | IO59RSB1            |
| L8           | IO58RSB1            |
| L9           | TMS                 |
| L10          | V <sub>JTAG</sub>   |
| L11          | VMV1                |
| L12          | TRST                |
| M1           | GNDQ                |
| M2           | GEC2/IO69RSB1       |
| M3           | IO68RSB1            |
| M4           | IO66RSB1            |
| M5           | IO63RSB1            |
| M6           | IO61RSB1            |
| M7           | IO60RSB1            |
| M8           | NC                  |
| M9           | TDI                 |
| M10          | V <sub>CCI</sub> B1 |
| M11          | V <sub>PUMP</sub>   |
| M12          | GNDQ                |

| 144-Pin FBGA |                 | 144-Pin FBGA |                     | 144-Pin FBGA |                    |
|--------------|-----------------|--------------|---------------------|--------------|--------------------|
| Pin Number   | A3P125 Function | Pin Number   | A3P125 Function     | Pin Number   | A3P125 Function    |
| A1           | GNDQ            | D1           | IO128RSB1           | G1           | GFA1/IO121RSB1     |
| A2           | VMV0            | D2           | IO129RSB1           | G2           | GND                |
| A3           | GAB0/IO02RSB0   | D3           | IO130RSB1           | G3           | V <sub>CCPLF</sub> |
| A4           | GAB1/IO03RSB0   | D4           | GAA2/IO67RSB1       | G4           | GFA0/IO122RSB1     |
| A5           | IO11RSB0        | D5           | GAC0/IO04RSB0       | G5           | GND                |
| A6           | GND             | D6           | GAC1/IO05RSB0       | G6           | GND                |
| A7           | IO18RSB0        | D7           | GBC0/IO35RSB0       | G7           | GND                |
| A8           | V <sub>CC</sub> | D8           | GBC1/IO36RSB0       | G8           | GDC1/IO61RSB0      |
| A9           | IO25RSB0        | D9           | GBB2/IO43RSB0       | G9           | IO48RSB0           |
| A10          | GBA0/IO39RSB0   | D10          | IO28RSB0            | G10          | GCC2/IO59RSB0      |
| A11          | GBA1/IO40RSB0   | D11          | IO44RSB0            | G11          | IO47RSB0           |
| A12          | GNDQ            | D12          | GCB1/IO53RSB0       | G12          | GCB2/IO58RSB0      |
| B1           | GAB2/IO69RSB1   | E1           | V <sub>CC</sub>     | H1           | V <sub>CC</sub>    |
| B2           | GND             | E2           | GFC0/IO125RSB1      | H2           | GFB2/IO119RSB1     |
| B3           | GAA0/IO00RSB0   | E3           | GFC1/IO126RSB1      | H3           | GFC2/IO118RSB1     |
| B4           | GAA1/IO01RSB0   | E4           | V <sub>CCIB1</sub>  | H4           | GEC1/IO112RSB1     |
| B5           | IO08RSB0        | E5           | IO68RSB1            | H5           | V <sub>CC</sub>    |
| B6           | IO14RSB0        | E6           | V <sub>CCIB0</sub>  | H6           | IO50RSB0           |
| B7           | IO19RSB0        | E7           | V <sub>CCIB0</sub>  | H7           | IO60RSB0           |
| B8           | IO22RSB0        | E8           | GCC1/IO51RSB0       | H8           | GDB2/IO71RSB1      |
| B9           | GBB0/IO37RSB0   | E9           | V <sub>CCIB0</sub>  | H9           | GDC0/IO62RSB0      |
| B10          | GBB1/IO38RSB0   | E10          | V <sub>CC</sub>     | H10          | V <sub>CCIB0</sub> |
| B11          | GND             | E11          | GCA0/IO56RSB0       | H11          | IO49RSB0           |
| B12          | VMV0            | E12          | IO46RSB0            | H12          | V <sub>CC</sub>    |
| C1           | IO132RSB1       | F1           | GFB0/IO123RSB1      | J1           | GEB1/IO110RSB1     |
| C2           | GFA2/IO120RSB1  | F2           | V <sub>COMPLF</sub> | J2           | IO115RSB1          |
| C3           | GAC2/IO131RSB1  | F3           | GFB1/IO124RSB1      | J3           | V <sub>CCIB1</sub> |
| C4           | V <sub>CC</sub> | F4           | IO127RSB1           | J4           | GEC0/IO111RSB1     |
| C5           | IO10RSB0        | F5           | GND                 | J5           | IO116RSB1          |
| C6           | IO12RSB0        | F6           | GND                 | J6           | IO117RSB1          |
| C7           | IO21RSB0        | F7           | GND                 | J7           | V <sub>CC</sub>    |
| C8           | IO24RSB0        | F8           | GCC0/IO52RSB0       | J8           | TCK                |
| C9           | IO27RSB0        | F9           | GCB0/IO54RSB0       | J9           | GDA2/IO70RSB1      |
| C10          | GBA2/IO41RSB0   | F10          | GND                 | J10          | TDO                |
| C11          | IO42RSB0        | F11          | GCA1/IO55RSB0       | J11          | GDA1/IO65RSB0      |
| C12          | GBC2/IO45RSB0   | F12          | GCA2/IO57RSB0       | J12          | GDB1/IO63RSB0      |

| 144-Pin FBGA |                      |
|--------------|----------------------|
| Pin Number   | A3P125 Function      |
| K1           | GEB0/IO109RSB1       |
| K2           | GEA1/IO108RSB1       |
| K3           | GEA0/IO107RSB1       |
| K4           | GEA2/IO106RSB1       |
| K5           | IO100RSB1            |
| K6           | IO98RSB1             |
| K7           | GND                  |
| K8           | IO73RSB1             |
| K9           | GDC2/IO72RSB1        |
| K10          | GND                  |
| K11          | GDA0/IO66RSB0        |
| K12          | GDB0/IO64RSB0        |
| L1           | GND                  |
| L2           | VMV1                 |
| L3           | GEB2/IO105RSB1       |
| L4           | IO102RSB1            |
| L5           | V <sub>CC</sub> I B1 |
| L6           | IO95RSB1             |
| L7           | IO85RSB1             |
| L8           | IO74RSB1             |
| L9           | TMS                  |
| L10          | V <sub>JTAG</sub>    |
| L11          | VMV1                 |
| L12          | TRST                 |
| M1           | GNDQ                 |
| M2           | GEC2/IO104RSB1       |
| M3           | IO103RSB1            |
| M4           | IO101RSB1            |
| M5           | IO97RSB1             |
| M6           | IO94RSB1             |
| M7           | IO86RSB1             |
| M8           | IO75RSB1             |
| M9           | TDI                  |
| M10          | V <sub>CC</sub> I B1 |
| M11          | V <sub>PUMP</sub>    |
| M12          | GNDQ                 |

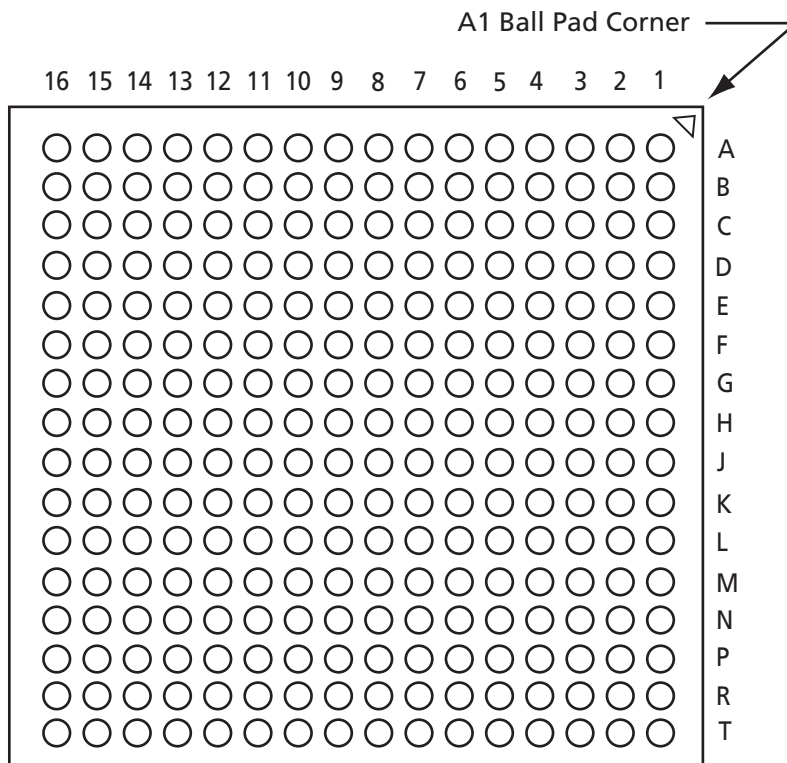
| 144-Pin FBGA |                 | 144-Pin FBGA |                        | 144-Pin FBGA |                    |
|--------------|-----------------|--------------|------------------------|--------------|--------------------|
| Pin Number   | A3P250 Function | Pin Number   | A3P250 Function        | Pin Number   | A3P250 Function    |
| A1           | GNDQ            | D1           | IO112NDB3              | G1           | GFA1/IO108PPB3     |
| A2           | VMV0            | D2           | IO112PDB3              | G2           | GND                |
| A3           | GAB0/IO02RSB0   | D3           | IO116VDB3              | G3           | V <sub>CCPLF</sub> |
| A4           | GAB1/IO03RSB0   | D4           | GAA2/IO118UPB3         | G4           | GFA0/IO108NPB3     |
| A5           | IO16RSB0        | D5           | GAC0/IO04RSB0          | G5           | GND                |
| A6           | GND             | D6           | GAC1/IO05RSB0          | G6           | GND                |
| A7           | IO29RSB0        | D7           | GBC0/IO35RSB0          | G7           | GND                |
| A8           | V <sub>CC</sub> | D8           | GBC1/IO36RSB0          | G8           | GDC1/IO58UPB1      |
| A9           | IO33RSB0        | D9           | GBB2/IO42PDB1          | G9           | IO53NDB1           |
| A10          | GBA0/IO39RSB0   | D10          | IO42NDB1               | G10          | GCC2/IO53PDB1      |
| A11          | GBA1/IO40RSB0   | D11          | IO43NPB1               | G11          | IO52NDB1           |
| A12          | GNDQ            | D12          | GCB1/IO49PPB1          | G12          | GCB2/IO52PDB1      |
| B1           | GAB2/IO117UDB3  | E1           | V <sub>CC</sub>        | H1           | V <sub>CC</sub>    |
| B2           | GND             | E2           | GFC0/IO110NDB3         | H2           | GFB2/IO106PDB3     |
| B3           | GAA0/IO00RSB0   | E3           | GFC1/IO110PDB3         | H3           | GFC2/IO105PSB3     |
| B4           | GAA1/IO01RSB0   | E4           | V <sub>CC</sub> B3     | H4           | GEC1/IO100PDB3     |
| B5           | IO14RSB0        | E5           | IO118VPB3              | H5           | V <sub>CC</sub>    |
| B6           | IO19RSB0        | E6           | V <sub>CC</sub> B0     | H6           | IO79RSB2           |
| B7           | IO22RSB0        | E7           | V <sub>CC</sub> B0     | H7           | IO65RSB2           |
| B8           | IO30RSB0        | E8           | GCC1/IO48PDB1          | H8           | GDB2/IO62RSB2      |
| B9           | GBB0/IO37RSB0   | E9           | V <sub>CC</sub> B1     | H9           | GDC0/IO58VPB1      |
| B10          | GBB1/IO38RSB0   | E10          | V <sub>CC</sub>        | H10          | V <sub>CC</sub> B1 |
| B11          | GND             | E11          | GCA0/IO50NDB1          | H11          | IO54PSB1           |
| B12          | VMV1            | E12          | IO51NDB1               | H12          | V <sub>CC</sub>    |
| C1           | IO117VDB3       | F1           | GFB0/IO109NPB3         | J1           | GEB1/IO99PDB3      |
| C2           | GFA2/IO107PPB3  | F2           | V <sub>CC</sub> COMPLF | J2           | IO106NDB3          |
| C3           | GAC2/IO116UDB3  | F3           | GFB1/IO109PPB3         | J3           | V <sub>CC</sub> B3 |
| C4           | V <sub>CC</sub> | F4           | IO107NPB3              | J4           | GEC0/IO100NDB3     |
| C5           | IO12RSB0        | F5           | GND                    | J5           | IO88RSB2           |
| C6           | IO17RSB0        | F6           | GND                    | J6           | IO81RSB2           |
| C7           | IO24RSB0        | F7           | GND                    | J7           | V <sub>CC</sub>    |
| C8           | IO31RSB0        | F8           | GCC0/IO48NDB1          | J8           | TCK                |
| C9           | IO34RSB0        | F9           | GCB0/IO49NPB1          | J9           | GDA2/IO61RSB2      |
| C10          | GBA2/IO41PDB1   | F10          | GND                    | J10          | TDO                |
| C11          | IO41NDB1        | F11          | GCA1/IO50PDB1          | J11          | GDA1/IO60UDB1      |
| C12          | GBC2/IO43PPB1   | F12          | GCA2/IO51PDB1          | J12          | GDB1/IO59UDB1      |

| 144-Pin FBGA |                     |
|--------------|---------------------|
| Pin Number   | A3P250 Function     |
| K1           | GEB0/IO99NDB3       |
| K2           | GEA1/IO98PDB3       |
| K3           | GEA0/IO98NDB3       |
| K4           | GEA2/IO97RSB2       |
| K5           | IO90RSB2            |
| K6           | IO84RSB2            |
| K7           | GND                 |
| K8           | IO66RSB2            |
| K9           | GDC2/IO63RSB2       |
| K10          | GND                 |
| K11          | GDA0/IO60VDB1       |
| K12          | GDB0/IO59VDB1       |
| L1           | GND                 |
| L2           | VMV3                |
| L3           | GEB2/IO96RSB2       |
| L4           | IO91RSB2            |
| L5           | V <sub>CCI</sub> B2 |
| L6           | IO82RSB2            |
| L7           | IO80RSB2            |
| L8           | IO72RSB2            |
| L9           | TMS                 |
| L10          | V <sub>JTAG</sub>   |
| L11          | VMV2                |
| L12          | TRST                |
| M1           | GNDQ                |
| M2           | GEC2/IO95RSB2       |
| M3           | IO92RSB2            |
| M4           | IO89RSB2            |
| M5           | IO87RSB2            |
| M6           | IO85RSB2            |
| M7           | IO78RSB2            |
| M8           | IO76RSB2            |
| M9           | TDI                 |
| M10          | V <sub>CCI</sub> B2 |
| M11          | V <sub>PUMP</sub>   |
| M12          | GNDQ                |

| 144-Pin FBGA |                  | 144-Pin FBGA |                     | 144-Pin FBGA |                    |
|--------------|------------------|--------------|---------------------|--------------|--------------------|
| Pin Number   | A3P1000 Function | Pin Number   | A3P1000 Function    | Pin Number   | A3P1000 Function   |
| A1           | GNDQ             | D1           | IO213PDB3           | G1           | GFA1/IO207PPB3     |
| A2           | VMV0             | D2           | IO213NDB3           | G2           | GND                |
| A3           | GAB0/IO02RSB0    | D3           | IO223NDB3           | G3           | V <sub>CCPLF</sub> |
| A4           | GAB1/IO03RSB0    | D4           | GAA2/IO225PPB3      | G4           | GFA0/IO207NPB3     |
| A5           | IO10RSB0         | D5           | GAC0/IO04RSB0       | G5           | GND                |
| A6           | GND              | D6           | GAC1/IO05RSB0       | G6           | GND                |
| A7           | IO44RSB0         | D7           | GBC0/IO72RSB0       | G7           | GND                |
| A8           | V <sub>CC</sub>  | D8           | GBC1/IO73RSB0       | G8           | GDC1/IO111PPB1     |
| A9           | IO69RSB0         | D9           | GBB2/IO79PDB1       | G9           | IO96NDB1           |
| A10          | GBA0/IO76RSB0    | D10          | IO79NDB1            | G10          | GCC2/IO96PDB1      |
| A11          | GBA1/IO77RSB0    | D11          | IO80NPB1            | G11          | IO95NDB1           |
| A12          | GNDQ             | D12          | GCB1/IO92PPB1       | G12          | GCB2/IO95PDB1      |
| B1           | GAB2/IO224PDB3   | E1           | V <sub>CC</sub>     | H1           | V <sub>CC</sub>    |
| B2           | GND              | E2           | GFC0/IO209NDB3      | H2           | GFB2/IO205PDB3     |
| B3           | GAA0/IO00RSB0    | E3           | GFC1/IO209PDB3      | H3           | GFC2/IO204PSB3     |
| B4           | GAA1/IO01RSB0    | E4           | VCCIB3              | H4           | GEC1/IO190PDB3     |
| B5           | IO13RSB0         | E5           | IO225NPB3           | H5           | V <sub>CC</sub>    |
| B6           | IO26RSB0         | E6           | V <sub>CC</sub> B0  | H6           | IO105PDB1          |
| B7           | IO35RSB0         | E7           | V <sub>CC</sub> B0  | H7           | IO105NDB1          |
| B8           | IO60RSB0         | E8           | GCC1/IO91PDB1       | H8           | GDB2/IO115RSB2     |
| B9           | GBB0/IO74RSB0    | E9           | V <sub>CC</sub> B1  | H9           | GDC0/IO111NPB1     |
| B10          | GBB1/IO75RSB0    | E10          | V <sub>CC</sub>     | H10          | V <sub>CC</sub> B1 |
| B11          | GND              | E11          | GCA0/IO93NDB1       | H11          | IO101PSB1          |
| B12          | VMV1             | E12          | IO94NDB1            | H12          | V <sub>CC</sub>    |
| C1           | IO224NDB3        | F1           | GFB0/IO208NPB3      | J1           | GEB1/IO189PDB3     |
| C2           | GFA2/IO206PPB3   | F2           | V <sub>COMPLF</sub> | J2           | IO205NDB3          |
| C3           | GAC2/IO223PDB3   | F3           | GFB1/IO208PPB3      | J3           | V <sub>CC</sub> B3 |
| C4           | V <sub>CC</sub>  | F4           | IO206NPB3           | J4           | GEC0/IO190NDB3     |
| C5           | IO16RSB0         | F5           | GND                 | J5           | IO160RSB2          |
| C6           | IO29RSB0         | F6           | GND                 | J6           | IO157RSB2          |
| C7           | IO32RSB0         | F7           | GND                 | J7           | V <sub>CC</sub>    |
| C8           | IO63RSB0         | F8           | GCC0/IO91NDB1       | J8           | TCK                |
| C9           | IO66RSB0         | F9           | GCB0/IO92NPB1       | J9           | GDA2/IO114RSB2     |
| C10          | GBA2/IO78PDB1    | F10          | GND                 | J10          | TDO                |
| C11          | IO78NDB1         | F11          | GCA1/IO93PDB1       | J11          | GDA1/IO113PDB1     |
| C12          | GBC2/IO80PPB1    | F12          | GCA2/IO94PDB1       | J12          | GDB1/IO112PDB1     |

| 144-Pin FBGA |                    |
|--------------|--------------------|
| Pin Number   | A3P1000 Function   |
| K1           | GEB0/IO189NDB3     |
| K2           | GEA1/IO188PDB3     |
| K3           | GEA0/IO188NDB3     |
| K4           | GEA2/IO187RSB2     |
| K5           | IO169RSB2          |
| K6           | IO152RSB2          |
| K7           | GND                |
| K8           | IO117RSB2          |
| K9           | GDC2/IO116RSB2     |
| K10          | GND                |
| K11          | GDA0/IO113NDB1     |
| K12          | GDB0/IO112NDB1     |
| L1           | GND                |
| L2           | VMV3               |
| L3           | GEB2/IO186RSB2     |
| L4           | IO172RSB2          |
| L5           | V <sub>CC</sub> B2 |
| L6           | IO153RSB2          |
| L7           | IO144RSB2          |
| L8           | IO140RSB2          |
| L9           | TMS                |
| L10          | V <sub>JTAG</sub>  |
| L11          | VMV2               |
| L12          | TRST               |
| M1           | GNDQ               |
| M2           | GEC2/IO185RSB2     |
| M3           | IO173RSB2          |
| M4           | IO168RSB2          |
| M5           | IO161RSB2          |
| M6           | IO156RSB2          |
| M7           | IO145RSB2          |
| M8           | IO141RSB2          |
| M9           | TDI                |
| M10          | V <sub>CC</sub> B2 |
| M11          | V <sub>PUMP</sub>  |
| M12          | GNDQ               |

## 256-Pin FBGA



*Note:* This is the bottom view of the package.

### Note

For Package Manufacturing and Environmental information, visit the Resource Center at <http://www.actel.com/products/solutions/package/docs.aspx>.

| 256-Pin FBGA |                 | 256-Pin FBGA |                    | 256-Pin FBGA |                    |
|--------------|-----------------|--------------|--------------------|--------------|--------------------|
| Pin Number   | A3P250 Function | Pin Number   | A3P250 Function    | Pin Number   | A3P250 Function    |
| A1           | GND             | C5           | GAC0/IO04RSB0      | E9           | IO24RSB0           |
| A2           | GAA0/IO00RSB0   | C6           | GAC1/IO05RSB0      | E10          | V <sub>CC</sub> B0 |
| A3           | GAA1/IO01RSB0   | C7           | IO13RSB0           | E11          | V <sub>CC</sub> B0 |
| A4           | GAB0/IO02RSB0   | C8           | IO17RSB0           | E12          | VMV1               |
| A5           | IO07RSB0        | C9           | IO22RSB0           | E13          | GBC2/IO43PDB1      |
| A6           | IO10RSB0        | C10          | IO27RSB0           | E14          | IO46RSB1           |
| A7           | IO11RSB0        | C11          | IO31RSB0           | E15          | NC                 |
| A8           | IO15RSB0        | C12          | GBC0/IO35RSB0      | E16          | IO45PDB1           |
| A9           | IO20RSB0        | C13          | IO34RSB0           | F1           | IO113NDB3          |
| A10          | IO25RSB0        | C14          | NC                 | F2           | IO112PPB3          |
| A11          | IO29RSB0        | C15          | IO42NPB1           | F3           | NC                 |
| A12          | IO33RSB0        | C16          | IO44PDB1           | F4           | IO115VDB3          |
| A13          | GBB1/IO38RSB0   | D1           | IO114VDB3          | F5           | V <sub>CC</sub> B3 |
| A14          | GBA0/IO39RSB0   | D2           | IO114UDB3          | F6           | GND                |
| A15          | GBA1/IO40RSB0   | D3           | GAC2/IO116UDB3     | F7           | V <sub>CC</sub>    |
| A16          | GND             | D4           | NC                 | F8           | V <sub>CC</sub>    |
| B1           | GAB2/IO117UDB3  | D5           | GNDQ               | F9           | V <sub>CC</sub>    |
| B2           | GAA2/IO118UDB3  | D6           | IO08RSB0           | F10          | V <sub>CC</sub>    |
| B3           | NC              | D7           | IO14RSB0           | F11          | GND                |
| B4           | GAB1/IO03RSB0   | D8           | IO18RSB0           | F12          | V <sub>CC</sub> B1 |
| B5           | IO06RSB0        | D9           | IO23RSB0           | F13          | IO43NDB1           |
| B6           | IO09RSB0        | D10          | IO28RSB0           | F14          | NC                 |
| B7           | IO12RSB0        | D11          | IO32RSB0           | F15          | IO47PPB1           |
| B8           | IO16RSB0        | D12          | GNDQ               | F16          | IO45NDB1           |
| B9           | IO21RSB0        | D13          | NC                 | G1           | IO111NDB3          |
| B10          | IO26RSB0        | D14          | GBB2/IO42PPB1      | G2           | IO111PDB3          |
| B11          | IO30RSB0        | D15          | NC                 | G3           | IO112NPB3          |
| B12          | GBC1/IO36RSB0   | D16          | IO44NDB1           | G4           | GFC1/IO110PPB3     |
| B13          | GBB0/IO37RSB0   | E1           | IO113PDB3          | G5           | V <sub>CC</sub> B3 |
| B14          | NC              | E2           | NC                 | G6           | V <sub>CC</sub>    |
| B15          | GBA2/IO41PDB1   | E3           | IO116VDB3          | G7           | GND                |
| B16          | IO41NDB1        | E4           | IO115UDB3          | G8           | GND                |
| C1           | IO117VDB3       | E5           | VMV0               | G9           | GND                |
| C2           | IO118VDB3       | E6           | V <sub>CC</sub> B0 | G10          | GND                |
| C3           | NC              | E7           | V <sub>CC</sub> B0 | G11          | V <sub>CC</sub>    |
| C4           | NC              | E8           | IO19RSB0           | G12          | V <sub>CC</sub> B1 |

| 256-Pin FBGA |                     | 256-Pin FBGA |                    | 256-Pin FBGA |                    |
|--------------|---------------------|--------------|--------------------|--------------|--------------------|
| Pin Number   | A3P250 Function     | Pin Number   | A3P250 Function    | Pin Number   | A3P250 Function    |
| G13          | GCC1/IO48PPB1       | K1           | GFC2/IO105PDB3     | M5           | VMV3               |
| G14          | IO47NPB1            | K2           | IO107NPB3          | M6           | V <sub>CC</sub> B2 |
| G15          | IO54PDB1            | K3           | IO104PPB3          | M7           | V <sub>CC</sub> B2 |
| G16          | IO54NDB1            | K4           | NC                 | M8           | NC                 |
| H1           | GFB0/IO109NPB3      | K5           | V <sub>CC</sub> B3 | M9           | IO74RSB2           |
| H2           | GFA0/IO108NDB3      | K6           | V <sub>CC</sub>    | M10          | V <sub>CC</sub> B2 |
| H3           | GFB1/IO109PPB3      | K7           | GND                | M11          | V <sub>CC</sub> B2 |
| H4           | V <sub>COMPLF</sub> | K8           | GND                | M12          | VMV2               |
| H5           | GFC0/IO110NPB3      | K9           | GND                | M13          | NC                 |
| H6           | V <sub>CC</sub>     | K10          | GND                | M14          | GDB1/IO59UPB1      |
| H7           | GND                 | K11          | V <sub>CC</sub>    | M15          | GDC1/IO58UDB1      |
| H8           | GND                 | K12          | V <sub>CC</sub> B1 | M16          | IO56NDB1           |
| H9           | GND                 | K13          | IO52NPB1           | N1           | IO103NDB3          |
| H10          | GND                 | K14          | IO55RSB1           | N2           | IO101PPB3          |
| H11          | V <sub>CC</sub>     | K15          | IO53NPB1           | N3           | GEC1/IO100PPB3     |
| H12          | GCC0/IO48NPB1       | K16          | IO51NDB1           | N4           | NC                 |
| H13          | GCB1/IO49PPB1       | L1           | IO105NDB3          | N5           | GNDQ               |
| H14          | GCA0/IO50NPB1       | L2           | IO104NPB3          | N6           | GEA2/IO97RSB2      |
| H15          | NC                  | L3           | NC                 | N7           | IO86RSB2           |
| H16          | GCB0/IO49NPB1       | L4           | IO102RSB3          | N8           | IO82RSB2           |
| J1           | GFA2/IO107PPB3      | L5           | V <sub>CC</sub> B3 | N9           | IO75RSB2           |
| J2           | GFA1/IO108PDB3      | L6           | GND                | N10          | IO69RSB2           |
| J3           | V <sub>CC</sub> PLF | L7           | V <sub>CC</sub>    | N11          | IO64RSB2           |
| J4           | IO106NDB3           | L8           | V <sub>CC</sub>    | N12          | GNDQ               |
| J5           | GFB2/IO106PDB3      | L9           | V <sub>CC</sub>    | N13          | NC                 |
| J6           | V <sub>CC</sub>     | L10          | V <sub>CC</sub>    | N14          | V <sub>JTAG</sub>  |
| J7           | GND                 | L11          | GND                | N15          | GDC0/IO58VDB1      |
| J8           | GND                 | L12          | V <sub>CC</sub> B1 | N16          | GDA1/IO60UDB1      |
| J9           | GND                 | L13          | GDB0/IO59VPB1      | P1           | GEB1/IO99PDB3      |
| J10          | GND                 | L14          | IO57VDB1           | P2           | GEB0/IO99NDB3      |
| J11          | V <sub>CC</sub>     | L15          | IO57UDB1           | P3           | NC                 |
| J12          | GCB2/IO52PPB1       | L16          | IO56PDB1           | P4           | NC                 |
| J13          | GCA1/IO50PPB1       | M1           | IO103PDB3          | P5           | IO92RSB2           |
| J14          | GCC2/IO53PPB1       | M2           | NC                 | P6           | IO89RSB2           |
| J15          | NC                  | M3           | IO101NPB3          | P7           | IO85RSB2           |
| J16          | GCA2/IO51PDB1       | M4           | GEC0/IO100NPB3     | P8           | IO81RSB2           |

| 256-Pin FBGA |                   |
|--------------|-------------------|
| Pin Number   | A3P250 Function   |
| P9           | IO76RSB2          |
| P10          | IO71RSB2          |
| P11          | IO66RSB2          |
| P12          | NC                |
| P13          | TCK               |
| P14          | V <sub>PUMP</sub> |
| P15          | TRST              |
| P16          | GDA0/IO60VDB1     |
| R1           | GEA1/IO98PDB3     |
| R2           | GEA0/IO98NDB3     |
| R3           | NC                |
| R4           | GEC2/IO95RSB2     |
| R5           | IO91RSB2          |
| R6           | IO88RSB2          |
| R7           | IO84RSB2          |
| R8           | IO80RSB2          |
| R9           | IO77RSB2          |
| R10          | IO72RSB2          |
| R11          | IO68RSB2          |
| R12          | IO65RSB2          |
| R13          | GDB2/IO62RSB2     |
| R14          | TDI               |
| R15          | NC                |
| R16          | TDO               |
| T1           | GND               |
| T2           | IO94RSB2          |
| T3           | GEB2/IO96RSB2     |
| T4           | IO93RSB2          |
| T5           | IO90RSB2          |
| T6           | IO87RSB2          |
| T7           | IO83RSB2          |
| T8           | IO79RSB2          |
| T9           | IO78RSB2          |
| T10          | IO73RSB2          |
| T11          | IO70RSB2          |
| T12          | GDC2/IO63RSB2     |

| 256-Pin FBGA |                 |
|--------------|-----------------|
| Pin Number   | A3P250 Function |
| T13          | IO67RSB2        |
| T14          | GDA2/IO61RSB2   |
| T15          | TMS             |
| T16          | GND             |

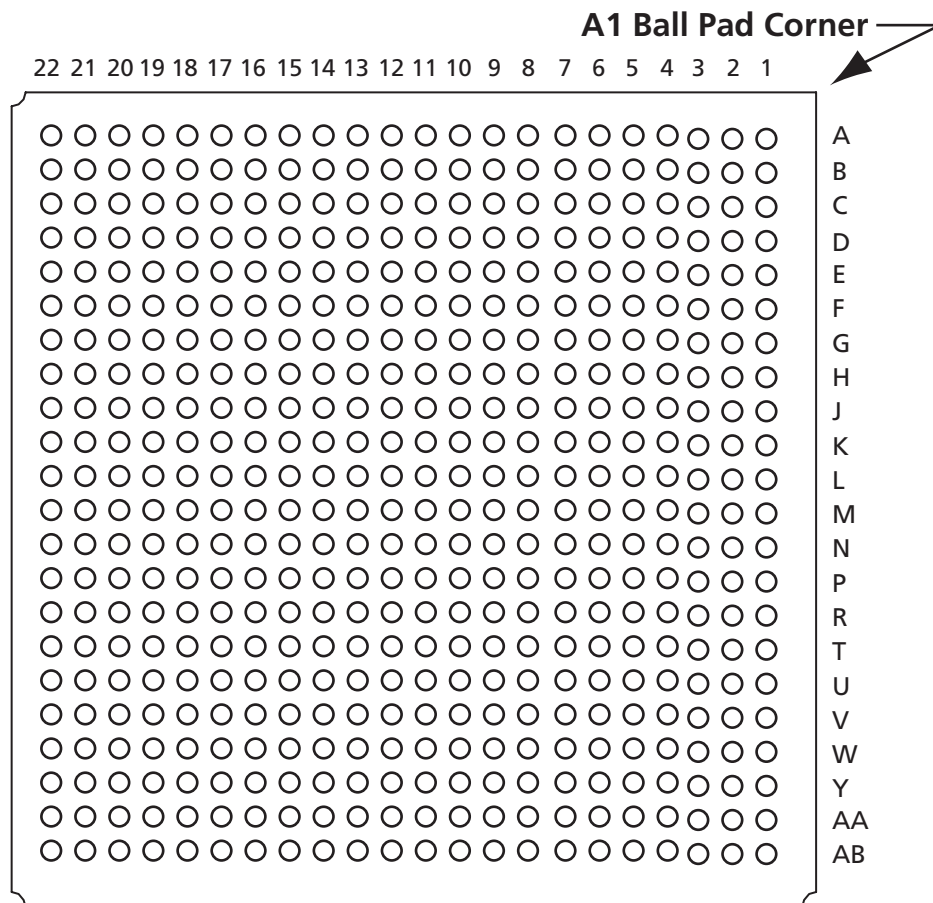
| 256-Pin FBGA |                  | 256-Pin FBGA |                     | 256-Pin FBGA |                     |
|--------------|------------------|--------------|---------------------|--------------|---------------------|
| Pin Number   | A3P1000 Function | Pin Number   | A3P1000 Function    | Pin Number   | A3P1000 Function    |
| A1           | GND              | C5           | GAC0/IO04RSB0       | E9           | IO47RSB0            |
| A2           | GAA0/IO00RSB0    | C6           | GAC1/IO05RSB0       | E10          | V <sub>CCI</sub> B0 |
| A3           | GAA1/IO01RSB0    | C7           | IO25RSB0            | E11          | V <sub>CCI</sub> B0 |
| A4           | GAB0/IO02RSB0    | C8           | IO36RSB0            | E12          | VMV1                |
| A5           | IO16RSB0         | C9           | IO42RSB0            | E13          | GBC2/IO80PDB1       |
| A6           | IO22RSB0         | C10          | IO49RSB0            | E14          | IO83PPB1            |
| A7           | IO28RSB0         | C11          | IO56RSB0            | E15          | IO86PPB1            |
| A8           | IO35RSB0         | C12          | GBC0/IO72RSB0       | E16          | IO87PDB1            |
| A9           | IO45RSB0         | C13          | IO62RSB0            | F1           | IO217NDB3           |
| A10          | IO50RSB0         | C14          | VMV0                | F2           | IO218NDB3           |
| A11          | IO55RSB0         | C15          | IO78NDB1            | F3           | IO216PDB3           |
| A12          | IO61RSB0         | C16          | IO81NDB1            | F4           | IO216NDB3           |
| A13          | GBB1/IO75RSB0    | D1           | IO222NDB3           | F5           | V <sub>CCI</sub> B3 |
| A14          | GBA0/IO76RSB0    | D2           | IO222PDB3           | F6           | GND                 |
| A15          | GBA1/IO77RSB0    | D3           | GAC2/IO223PDB3      | F7           | V <sub>CC</sub>     |
| A16          | GND              | D4           | IO223NDB3           | F8           | V <sub>CC</sub>     |
| B1           | GAB2/IO224PDB3   | D5           | GNDQ                | F9           | V <sub>CC</sub>     |
| B2           | GAA2/IO225PDB3   | D6           | IO23RSB0            | F10          | V <sub>CC</sub>     |
| B3           | GNDQ             | D7           | IO29RSB0            | F11          | GND                 |
| B4           | GAB1/IO03RSB0    | D8           | IO33RSB0            | F12          | V <sub>CCI</sub> B1 |
| B5           | IO17RSB0         | D9           | IO46RSB0            | F13          | IO83NPB1            |
| B6           | IO21RSB0         | D10          | IO52RSB0            | F14          | IO86NPB1            |
| B7           | IO27RSB0         | D11          | IO60RSB0            | F15          | IO90PPB1            |
| B8           | IO34RSB0         | D12          | GNDQ                | F16          | IO87NDB1            |
| B9           | IO44RSB0         | D13          | IO80NDB1            | G1           | IO210PSB3           |
| B10          | IO51RSB0         | D14          | GBB2/IO79PDB1       | G2           | IO213NDB3           |
| B11          | IO57RSB0         | D15          | IO79NDB1            | G3           | IO213PDB3           |
| B12          | GBC1/IO73RSB0    | D16          | IO82NSB1            | G4           | GFC1/IO209PPB3      |
| B13          | GBB0/IO74RSB0    | E1           | IO217PDB3           | G5           | V <sub>CCI</sub> B3 |
| B14          | IO71RSB0         | E2           | IO218PDB3           | G6           | V <sub>CC</sub>     |
| B15          | GBA2/IO78PDB1    | E3           | IO221NDB3           | G7           | GND                 |
| B16          | IO81PDB1         | E4           | IO221PDB3           | G8           | GND                 |
| C1           | IO224NDB3        | E5           | VMV0                | G9           | GND                 |
| C2           | IO225NDB3        | E6           | V <sub>CCI</sub> B0 | G10          | GND                 |
| C3           | VMV3             | E7           | V <sub>CCI</sub> B0 | G11          | V <sub>CC</sub>     |
| C4           | IO11RSB0         | E8           | IO38RSB0            | G12          | V <sub>CCI</sub> B1 |

| 256-Pin FBGA |                     | 256-Pin FBGA |                    | 256-Pin FBGA |                    |
|--------------|---------------------|--------------|--------------------|--------------|--------------------|
| Pin Number   | A3P1000 Function    | Pin Number   | A3P1000 Function   | Pin Number   | A3P1000 Function   |
| G13          | GCC1/IO91PPB1       | K1           | GFC2/IO204PDB3     | M5           | VMV3               |
| G14          | IO90NPB1            | K2           | IO204NDB3          | M6           | V <sub>CC</sub> B2 |
| G15          | IO88PDB1            | K3           | IO203NDB3          | M7           | V <sub>CC</sub> B2 |
| G16          | IO88NDB1            | K4           | IO203PDB3          | M8           | IO147RSB2          |
| H1           | GFB0/IO208NPB3      | K5           | V <sub>CC</sub> B3 | M9           | IO136RSB2          |
| H2           | GFA0/IO207NDB3      | K6           | V <sub>CC</sub>    | M10          | V <sub>CC</sub> B2 |
| H3           | GFB1/IO208PPB3      | K7           | GND                | M11          | V <sub>CC</sub> B2 |
| H4           | V <sub>COMPLF</sub> | K8           | GND                | M12          | VMV2               |
| H5           | GFC0/IO209NPB3      | K9           | GND                | M13          | IO110NDB1          |
| H6           | V <sub>CC</sub>     | K10          | GND                | M14          | GDB1/IO112PPB1     |
| H7           | GND                 | K11          | V <sub>CC</sub>    | M15          | GDC1/IO111PDB1     |
| H8           | GND                 | K12          | V <sub>CC</sub> B1 | M16          | IO107NDB1          |
| H9           | GND                 | K13          | IO95NPB1           | N1           | IO194PSB3          |
| H10          | GND                 | K14          | IO100NPB1          | N2           | IO192PPB3          |
| H11          | V <sub>CC</sub>     | K15          | IO102NDB1          | N3           | GEC1/IO190PPB3     |
| H12          | GCC0/IO91NPB1       | K16          | IO102PDB1          | N4           | IO192NPB3          |
| H13          | GCB1/IO92PPB1       | L1           | IO202NDB3          | N5           | GNDQ               |
| H14          | GCA0/IO93NPB1       | L2           | IO202PDB3          | N6           | GEA2/IO187RSB2     |
| H15          | IO96NPB1            | L3           | IO196PPB3          | N7           | IO161RSB2          |
| H16          | GCB0/IO92NPB1       | L4           | IO193PPB3          | N8           | IO155RSB2          |
| J1           | GFA2/IO206PSB3      | L5           | V <sub>CC</sub> B3 | N9           | IO141RSB2          |
| J2           | GFA1/IO207PDB3      | L6           | GND                | N10          | IO129RSB2          |
| J3           | V <sub>CC</sub> PLF | L7           | V <sub>CC</sub>    | N11          | IO124RSB2          |
| J4           | IO205NDB3           | L8           | V <sub>CC</sub>    | N12          | GNDQ               |
| J5           | GFB2/IO205PDB3      | L9           | V <sub>CC</sub>    | N13          | IO110PDB1          |
| J6           | V <sub>CC</sub>     | L10          | V <sub>CC</sub>    | N14          | V <sub>JTAG</sub>  |
| J7           | GND                 | L11          | GND                | N15          | GDC0/IO111NDB1     |
| J8           | GND                 | L12          | V <sub>CC</sub> B1 | N16          | GDA1/IO113PDB1     |
| J9           | GND                 | L13          | GDB0/IO112NPB1     | P1           | GEB1/IO189PDB3     |
| J10          | GND                 | L14          | IO106NDB1          | P2           | GEB0/IO189NDB3     |
| J11          | V <sub>CC</sub>     | L15          | IO106PDB1          | P3           | VMV2               |
| J12          | GCB2/IO95PPB1       | L16          | IO107PDB1          | P4           | IO179RSB2          |
| J13          | GCA1/IO93PPB1       | M1           | IO197NSB3          | P5           | IO171RSB2          |
| J14          | GCC2/IO96PPB1       | M2           | IO196NPB3          | P6           | IO165RSB2          |
| J15          | IO100PPB1           | M3           | IO193NPB3          | P7           | IO159RSB2          |
| J16          | GCA2/IO94PSB1       | M4           | GEC0/IO190NPB3     | P8           | IO151RSB2          |

| 256-Pin FBGA |                   |
|--------------|-------------------|
| Pin Number   | A3P1000 Function  |
| P9           | IO137RSB2         |
| P10          | IO134RSB2         |
| P11          | IO128RSB2         |
| P12          | VMV1              |
| P13          | TCK               |
| P14          | V <sub>PUMP</sub> |
| P15          | TRST              |
| P16          | GDA0/IO113NDB1    |
| R1           | GEA1/IO188PDB3    |
| R2           | GEA0/IO188NDB3    |
| R3           | IO184RSB2         |
| R4           | GEC2/IO185RSB2    |
| R5           | IO168RSB2         |
| R6           | IO163RSB2         |
| R7           | IO157RSB2         |
| R8           | IO149RSB2         |
| R9           | IO143RSB2         |
| R10          | IO138RSB2         |
| R11          | IO131RSB2         |
| R12          | IO125RSB2         |
| R13          | GDB2/IO115RSB2    |
| R14          | TDI               |
| R15          | GNDQ              |
| R16          | TDO               |
| T1           | GND               |
| T2           | IO183RSB2         |
| T3           | GEB2/IO186RSB2    |
| T4           | IO172RSB2         |
| T5           | IO170RSB2         |
| T6           | IO164RSB2         |
| T7           | IO158RSB2         |
| T8           | IO153RSB2         |
| T9           | IO142RSB2         |
| T10          | IO135RSB2         |
| T11          | IO130RSB2         |
| T12          | GDC2/IO116RSB2    |

| 256-Pin FBGA |                  |
|--------------|------------------|
| Pin Number   | A3P1000 Function |
| T13          | IO120RSB2        |
| T14          | GDA2/IO114RSB2   |
| T15          | TMS              |
| T16          | GND              |

## 484-Pin FBGA



*Note:* This is the bottom view of the package.

### Note

For Package Manufacturing and Environmental information, visit the Resource Center at <http://www.actel.com/products/solutions/package/docs.aspx>.

| 484-Pin FBGA* |                    | 484-Pin FBGA* |                    | 484-Pin FBGA* |                  |
|---------------|--------------------|---------------|--------------------|---------------|------------------|
| Pin Number    | A3P1000 Function   | Pin Number    | A3P1000 Function   | Pin Number    | A3P1000 Function |
| A1            | GND                | B15           | IO63RSB0           | D7            | GAB0/IO02RSB0    |
| A2            | GND                | B16           | IO66RSB0           | D8            | IO16RSB0         |
| A3            | V <sub>CC</sub> B0 | B17           | IO68RSB0           | D9            | IO22RSB0         |
| A4            | IO07RSB0           | B18           | IO70RSB0           | D10           | IO28RSB0         |
| A5            | IO09RSB0           | B19           | NC                 | D11           | IO35RSB0         |
| A6            | IO13RSB0           | B20           | NC                 | D12           | IO45RSB0         |
| A7            | IO18RSB0           | B21           | V <sub>CC</sub> B1 | D13           | IO50RSB0         |
| A8            | IO20RSB0           | B22           | GND                | D14           | IO55RSB0         |
| A9            | IO26RSB0           | C1            | V <sub>CC</sub> B3 | D15           | IO61RSB0         |
| A10           | IO32RSB0           | C2            | IO220PDB3          | D16           | GBB1/IO75RSB0    |
| A11           | IO40RSB0           | C3            | NC                 | D17           | GBA0/IO76RSB0    |
| A12           | IO41RSB0           | C4            | NC                 | D18           | GBA1/IO77RSB0    |
| A13           | IO53RSB0           | C5            | GND                | D19           | GND              |
| A14           | IO59RSB0           | C6            | IO10RSB0           | D20           | NC               |
| A15           | IO64RSB0           | C7            | IO14RSB0           | D21           | NC               |
| A16           | IO65RSB0           | C8            | V <sub>CC</sub>    | D22           | NC               |
| A17           | IO67RSB0           | C9            | V <sub>CC</sub>    | E1            | IO219NDB3        |
| A18           | IO69RSB0           | C10           | IO30RSB0           | E2            | NC               |
| A19           | NC                 | C11           | IO37RSB0           | E3            | GND              |
| A20           | V <sub>CC</sub> B0 | C12           | IO43RSB0           | E4            | GAB2/IO224PDB3   |
| A21           | GND                | C13           | NC                 | E5            | GAA2/IO225PDB3   |
| A22           | GND                | C14           | V <sub>CC</sub>    | E6            | GNDQ             |
| B1            | GND                | C15           | V <sub>CC</sub>    | E7            | GAB1/IO03RSB0    |
| B2            | V <sub>CC</sub> B3 | C16           | NC                 | E8            | IO17RSB0         |
| B3            | NC                 | C17           | NC                 | E9            | IO21RSB0         |
| B4            | IO06RSB0           | C18           | GND                | E10           | IO27RSB0         |
| B5            | IO08RSB0           | C19           | NC                 | E11           | IO34RSB0         |
| B6            | IO12RSB0           | C20           | NC                 | E12           | IO44RSB0         |
| B7            | IO15RSB0           | C21           | NC                 | E13           | IO51RSB0         |
| B8            | IO19RSB0           | C22           | V <sub>CC</sub> B1 | E14           | IO57RSB0         |
| B9            | IO24RSB0           | D1            | IO219PDB3          | E15           | GBC1/IO73RSB0    |
| B10           | IO31RSB0           | D2            | IO220NDB3          | E16           | GBB0/IO74RSB0    |
| B11           | IO39RSB0           | D3            | NC                 | E17           | IO71RSB0         |
| B12           | IO48RSB0           | D4            | GND                | E18           | GBA2/IO78PDB1    |
| B13           | IO54RSB0           | D5            | GAA0/IO00RSB0      | E19           | IO81PDB1         |
| B14           | IO58RSB0           | D6            | GAA1/IO01RSB0      | E20           | GND              |

| 484-Pin FBGA* |                  | 484-Pin FBGA* |                    | 484-Pin FBGA* |                    |
|---------------|------------------|---------------|--------------------|---------------|--------------------|
| Pin Number    | A3P1000 Function | Pin Number    | A3P1000 Function   | Pin Number    | A3P1000 Function   |
| E21           | NC               | G13           | IO52RSB0           | J5            | IO218NDB3          |
| E22           | IO84PDB1         | G14           | IO60RSB0           | J6            | IO216PDB3          |
| F1            | NC               | G15           | GNDQ               | J7            | IO216NDB3          |
| F2            | IO215PDB3        | G16           | IO80NDB1           | J8            | V <sub>CC</sub> B3 |
| F3            | IO215NDB3        | G17           | GBB2/IO79PDB1      | J9            | GND                |
| F4            | IO224NDB3        | G18           | IO79NDB1           | J10           | V <sub>CC</sub>    |
| F5            | IO225NDB3        | G19           | IO82NPB1           | J11           | V <sub>CC</sub>    |
| F6            | VMV3             | G20           | IO85PDB1           | J12           | V <sub>CC</sub>    |
| F7            | IO11RSB0         | G21           | IO85NDB1           | J13           | V <sub>CC</sub>    |
| F8            | GAC0/IO04RSB0    | G22           | NC                 | J14           | GND                |
| F9            | GAC1/IO05RSB0    | H1            | NC                 | J15           | V <sub>CC</sub> B1 |
| F10           | IO25RSB0         | H2            | NC                 | J16           | IO83NPB1           |
| F11           | IO36RSB0         | H3            | V <sub>CC</sub>    | J17           | IO86NPB1           |
| F12           | IO42RSB0         | H4            | IO217PDB3          | J18           | IO90PPB1           |
| F13           | IO49RSB0         | H5            | IO218PDB3          | J19           | IO87NDB1           |
| F14           | IO56RSB0         | H6            | IO221NDB3          | J20           | NC                 |
| F15           | GBC0/IO72RSB0    | H7            | IO221PDB3          | J21           | IO89PDB1           |
| F16           | IO62RSB0         | H8            | VMV0               | J22           | IO89NDB1           |
| F17           | VMV0             | H9            | V <sub>CC</sub> B0 | K1            | IO211PDB3          |
| F18           | IO78NDB1         | H10           | V <sub>CC</sub> B0 | K2            | IO211NDB3          |
| F19           | IO81NDB1         | H11           | IO38RSB0           | K3            | NC                 |
| F20           | IO82PPB1         | H12           | IO47RSB0           | K4            | IO210PPB3          |
| F21           | NC               | H13           | V <sub>CC</sub> B0 | K5            | IO213NDB3          |
| F22           | IO84NDB1         | H14           | V <sub>CC</sub> B0 | K6            | IO213PDB3          |
| G1            | IO214NDB3        | H15           | VMV1               | K7            | GFC1/IO209PPB3     |
| G2            | IO214PDB3        | H16           | GBC2/IO80PDB1      | K8            | V <sub>CC</sub> B3 |
| G3            | NC               | H17           | IO83PPB1           | K9            | V <sub>CC</sub>    |
| G4            | IO222NDB3        | H18           | IO86PPB1           | K10           | GND                |
| G5            | IO222PDB3        | H19           | IO87PDB1           | K11           | GND                |
| G6            | GAC2/IO223PDB3   | H20           | V <sub>CC</sub>    | K12           | GND                |
| G7            | IO223NDB3        | H21           | NC                 | K13           | GND                |
| G8            | GNDQ             | H22           | NC                 | K14           | V <sub>CC</sub>    |
| G9            | IO23RSB0         | J1            | IO212NDB3          | K15           | V <sub>CC</sub> B1 |
| G10           | IO29RSB0         | J2            | IO212PDB3          | K16           | GCC1/IO91PPB1      |
| G11           | IO33RSB0         | J3            | NC                 | K17           | IO90NPB1           |
| G12           | IO46RSB0         | J4            | IO217NDB3          | K18           | IO88PDB1           |

| 484-Pin FBGA* |                     | 484-Pin FBGA* |                     | 484-Pin FBGA* |                     |
|---------------|---------------------|---------------|---------------------|---------------|---------------------|
| Pin Number    | A3P1000 Function    | Pin Number    | A3P1000 Function    | Pin Number    | A3P1000 Function    |
| K19           | IO88NDB1            | M11           | GND                 | P3            | IO199NDB3           |
| K20           | IO94NPB1            | M12           | GND                 | P4            | IO202NDB3           |
| K21           | IO98NDB1            | M13           | GND                 | P5            | IO202PDB3           |
| K22           | IO98PDB1            | M14           | V <sub>CC</sub>     | P6            | IO196PPB3           |
| L1            | NC                  | M15           | GCB2/IO95PPB1       | P7            | IO193PPB3           |
| L2            | IO200PDB3           | M16           | GCA1/IO93PPB1       | P8            | V <sub>CCI</sub> B3 |
| L3            | IO210NPB3           | M17           | GCC2/IO96PPB1       | P9            | GND                 |
| L4            | GFB0/IO208NPB3      | M18           | IO100PPB1           | P10           | V <sub>CC</sub>     |
| L5            | GFA0/IO207NDB3      | M19           | GCA2/IO94PPB1       | P11           | V <sub>CC</sub>     |
| L6            | GFB1/IO208PPB3      | M20           | IO101PPB1           | P12           | V <sub>CC</sub>     |
| L7            | V <sub>COMPLF</sub> | M21           | IO99PPB1            | P13           | V <sub>CC</sub>     |
| L8            | GFC0/IO209NPB3      | M22           | NC                  | P14           | GND                 |
| L9            | V <sub>CC</sub>     | N1            | IO201NDB3           | P15           | V <sub>CCI</sub> B1 |
| L10           | GND                 | N2            | IO201PDB3           | P16           | GDB0/IO112NPB1      |
| L11           | GND                 | N3            | NC                  | P17           | IO106NDB1           |
| L12           | GND                 | N4            | GFC2/IO204PDB3      | P18           | IO106PDB1           |
| L13           | GND                 | N5            | IO204NDB3           | P19           | IO107PDB1           |
| L14           | V <sub>CC</sub>     | N6            | IO203NDB3           | P20           | NC                  |
| L15           | GCC0/IO91NPB1       | N7            | IO203PDB3           | P21           | IO104PDB1           |
| L16           | GCB1/IO92PPB1       | N8            | V <sub>CCI</sub> B3 | P22           | IO103NDB1           |
| L17           | GCA0/IO93NPB1       | N9            | V <sub>CC</sub>     | R1            | NC                  |
| L18           | IO96NPB1            | N10           | GND                 | R2            | IO197PPB3           |
| L19           | GCB0/IO92NPB1       | N11           | GND                 | R3            | V <sub>CC</sub>     |
| L20           | IO97PDB1            | N12           | GND                 | R4            | IO197NPB3           |
| L21           | IO97NDB1            | N13           | GND                 | R5            | IO196NPB3           |
| L22           | IO99NPB1            | N14           | V <sub>CC</sub>     | R6            | IO193NPB3           |
| M1            | NC                  | N15           | V <sub>CCI</sub> B1 | R7            | GEC0/IO190NPB3      |
| M2            | IO200NDB3           | N16           | IO95NPB1            | R8            | VMV3                |
| M3            | IO206NDB3           | N17           | IO100NPB1           | R9            | V <sub>CCI</sub> B2 |
| M4            | GFA2/IO206PDB3      | N18           | IO102NDB1           | R10           | V <sub>CCI</sub> B2 |
| M5            | GFA1/IO207PDB3      | N19           | IO102PDB1           | R11           | IO147RSB2           |
| M6            | V <sub>CCPLF</sub>  | N20           | NC                  | R12           | IO136RSB2           |
| M7            | IO205NDB3           | N21           | IO101NPB1           | R13           | V <sub>CCI</sub> B2 |
| M8            | GFB2/IO205PDB3      | N22           | IO103PDB1           | R14           | V <sub>CCI</sub> B2 |
| M9            | V <sub>CC</sub>     | P1            | NC                  | R15           | VMV2                |
| M10           | GND                 | P2            | IO199PDB3           | R16           | IO110NDB1           |

| 484-Pin FBGA* |                   | 484-Pin FBGA* |                   | 484-Pin FBGA* |                    |
|---------------|-------------------|---------------|-------------------|---------------|--------------------|
| Pin Number    | A3P1000 Function  | Pin Number    | A3P1000 Function  | Pin Number    | A3P1000 Function   |
| R17           | GDB1/IO112PPB1    | U9            | IO165RSB2         | W1            | NC                 |
| R18           | GDC1/IO111PDB1    | U10           | IO159RSB2         | W2            | IO191PDB3          |
| R19           | IO107NDB1         | U11           | IO151RSB2         | W3            | NC                 |
| R20           | V <sub>CC</sub>   | U12           | IO137RSB2         | W4            | GND                |
| R21           | IO104NDB1         | U13           | IO134RSB2         | W5            | IO183RSB2          |
| R22           | IO105PDB1         | U14           | IO128RSB2         | W6            | GEB2/IO186RSB2     |
| T1            | IO198PDB3         | U15           | VMV1              | W7            | IO172RSB2          |
| T2            | IO198NDB3         | U16           | TCK               | W8            | IO170RSB2          |
| T3            | NC                | U17           | V <sub>PUMP</sub> | W9            | IO164RSB2          |
| T4            | IO194PPB3         | U18           | TRST              | W10           | IO158RSB2          |
| T5            | IO192PPB3         | U19           | GDA0/IO113NDB1    | W11           | IO153RSB2          |
| T6            | GEC1/IO190PPB3    | U20           | NC                | W12           | IO142RSB2          |
| T7            | IO192NPB3         | U21           | IO108NDB1         | W13           | IO135RSB2          |
| T8            | GNDQ              | U22           | IO109PDB1         | W14           | IO130RSB2          |
| T9            | GEA2/IO187RSB2    | V1            | NC                | W15           | GDC2/IO116RSB2     |
| T10           | IO161RSB2         | V2            | NC                | W16           | IO120RSB2          |
| T11           | IO155RSB2         | V3            | GND               | W17           | GDA2/IO114RSB2     |
| T12           | IO141RSB2         | V4            | GEA1/IO188PDB3    | W18           | TMS                |
| T13           | IO129RSB2         | V5            | GEA0/IO188NDB3    | W19           | GND                |
| T14           | IO124RSB2         | V6            | IO184RSB2         | W20           | NC                 |
| T15           | GNDQ              | V7            | GEC2/IO185RSB2    | W21           | NC                 |
| T16           | IO110PDB1         | V8            | IO168RSB2         | W22           | NC                 |
| T17           | V <sub>JTAG</sub> | V9            | IO163RSB2         | Y1            | V <sub>CC</sub> B3 |
| T18           | GDC0/IO111NDB1    | V10           | IO157RSB2         | Y2            | IO191NDB3          |
| T19           | GDA1/IO113PDB1    | V11           | IO149RSB2         | Y3            | NC                 |
| T20           | NC                | V12           | IO143RSB2         | Y4            | IO182RSB2          |
| T21           | IO108PDB1         | V13           | IO138RSB2         | Y5            | GND                |
| T22           | IO105NDB1         | V14           | IO131RSB2         | Y6            | IO177RSB2          |
| U1            | IO195PDB3         | V15           | IO125RSB2         | Y7            | IO174RSB2          |
| U2            | IO195NDB3         | V16           | GDB2/IO115RSB2    | Y8            | V <sub>CC</sub>    |
| U3            | IO194NPB3         | V17           | TDI               | Y9            | V <sub>CC</sub>    |
| U4            | GEB1/IO189PDB3    | V18           | GNDQ              | Y10           | IO154RSB2          |
| U5            | GEB0/IO189NDB3    | V19           | TDO               | Y11           | IO148RSB2          |
| U6            | VMV2              | V20           | GND               | Y12           | IO140RSB2          |
| U7            | IO179RSB2         | V21           | NC                | Y13           | NC                 |
| U8            | IO171RSB2         | V22           | IO109NDB1         | Y14           | V <sub>CC</sub>    |

| 484-Pin FBGA* |                    |
|---------------|--------------------|
| Pin Number    | A3P1000 Function   |
| Y15           | V <sub>CC</sub>    |
| Y16           | NC                 |
| Y17           | NC                 |
| Y18           | GND                |
| Y19           | NC                 |
| Y20           | NC                 |
| Y21           | NC                 |
| Y22           | V <sub>CC</sub> B1 |
| AA1           | GND                |
| AA2           | V <sub>CC</sub> B3 |
| AA3           | NC                 |
| AA4           | IO181RSB2          |
| AA5           | IO178RSB2          |
| AA6           | IO175RSB2          |
| AA7           | IO169RSB2          |
| AA8           | IO166RSB2          |
| AA9           | IO160RSB2          |
| AA10          | IO152RSB2          |
| AA11          | IO146RSB2          |
| AA12          | IO139RSB2          |
| AA13          | IO133RSB2          |
| AA14          | NC                 |
| AA15          | NC                 |
| AA16          | IO122RSB2          |
| AA17          | IO119RSB2          |
| AA18          | IO117RSB2          |
| AA19          | NC                 |
| AA20          | NC                 |
| AA21          | V <sub>CC</sub> B1 |
| AA22          | GND                |
| AB1           | GND                |
| AB2           | GND                |
| AB3           | V <sub>CC</sub> B2 |
| AB4           | IO180RSB2          |
| AB5           | IO176RSB2          |
| AB6           | IO173RSB2          |

| 484-Pin FBGA* |                    |
|---------------|--------------------|
| Pin Number    | A3P1000 Function   |
| AB7           | IO167RSB2          |
| AB8           | IO162RSB2          |
| AB9           | IO156RSB2          |
| AB10          | IO150RSB2          |
| AB11          | IO145RSB2          |
| AB12          | IO144RSB2          |
| AB13          | IO132RSB2          |
| AB14          | IO127RSB2          |
| AB15          | IO126RSB2          |
| AB16          | IO123RSB2          |
| AB17          | IO121RSB2          |
| AB18          | IO118RSB2          |
| AB19          | NC                 |
| AB20          | V <sub>CC</sub> B2 |
| AB21          | GND                |
| AB22          | GND                |

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## Datasheet Categories

### Categories

In order to provide the latest information to designers, some datasheets are published before data has been fully characterized. Datasheets are designated as "Product Brief," "Advance," "Preliminary," and "Production." The definition of these categories are as follows:

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The product brief is a summarized version of a datasheet (advance or production) and contains general product information. This document gives an overview of specific device and family information.

#### Advance

This version contains initial estimated information based on simulation, other products, devices, or speed grades. This information can be used as estimates, but not for production. This label only applies to the DC and Switching Characteristics chapter of the datasheet and will only be used when the data has not been fully characterized.

#### Preliminary

The datasheet contains information based on simulation and/or initial characterization. The information is believed to be correct, but changes are possible.

#### Unmarked (production)

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