

# SmartFusion Customizable System-on-Chip (cSoC)

## Microcontroller Subsystem (MSS)

- Hard 100 MHz 32-Bit ARM® Cortex™-M3
  - 1.25 DMIPS/MHz Throughput from Zero Wait State Memory
  - Memory Protection Unit (MPU)
  - Single Cycle Multiplication, Hardware Divide
  - JTAG Debug (4 wires), Serial Wire Debug (SWD, 2 wires), and Single Wire Viewer (SWV) Interfaces
- Internal Memory
  - Embedded Nonvolatile Flash Memory (eNVM), 128 Kbytes to 512 Kbytes
  - Embedded High-Speed SRAM (eSRAM), 16 Kbytes to 64 Kbytes, Implemented in 2 Physical Blocks to Enable Simultaneous Access from 2 Different Masters
- Multi-Layer AHB Communications Matrix
  - Provides up to 16 Gbps of On-Chip Memory Bandwidth,<sup>1</sup> Allowing Multi-Master Schemes
- 10/100 Ethernet MAC with RMII Interface<sup>2</sup>
- Programmable External Memory Controller, Which Supports:
  - Asynchronous Memories
  - NOR Flash, SRAM, PSRAM
  - Synchronous SRAMs
- Two I<sup>2</sup>C Peripherals
- Two 16550 Compatible UARTs
- Two SPI Peripherals
- Two 32-Bit Timers
- 32-Bit Watchdog Timer
- 8-Channel DMA Controller to Offload the Cortex-M3 from Data Transactions
- Clock Sources
  - 32 KHz to 20 MHz Main Oscillator
  - Battery-Backed 32 KHz Low Power Oscillator with Real-Time Counter (RTC)
  - 100 MHz Embedded RC Oscillator; 1% Accurate
  - Embedded Analog PLL with 4 Output Phases (0, 90, 180, 270)

## High-Performance FPGA

- Based on proven ProASIC®3 FPGA Fabric
- Low Power, Firm-Error Immune 130-nm, 7-Layer Metal, Flash-Based CMOS Process
- Nonvolatile, Live at Power-Up, Retains Program When Powered Off
- 350 MHz System Performance
- Embedded SRAMs and FIFOs
  - Variable Aspect Ratio 4,608-Bit SRAM Blocks
  - x1, x2, x4, x9, and x18 Organizations
  - True Dual-Port SRAM (excluding x18)

- Programmable Embedded FIFO Control Logic
- Secure ISP with 128-Bit AES via JTAG
- FlashLock® to Secure FPGA Contents
- Five Clock Conditioning Circuits (CCCs) with up to 2 Integrated Analog PLLs
  - Phase Shift, Multiply/Divide, and Delay Capabilities
  - Frequency: Input 1.5–350 MHz, Output 0.75 to 350 MHz

## Programmable Analog Analog Front-End (AFE)

- Up to Three 12-Bit SAR ADCs
  - 500 Ksps in 12-Bit Mode
  - 550 Ksps in 10-Bit Mode
  - 600 Ksps in 8-Bit Mode
- Internal 2.56 V Reference or Optional External Reference
- One First-Order  $\Sigma\Delta$  DAC (sigma-delta) per ADC
  - 12-Bit 500 Ksps Update Rate
- Up to 5 High-Performance Analog Signal Conditioning Blocks (SCB) per Device, Each Including:
  - Two High-Voltage Bipolar Voltage Monitors (with 4 input ranges from  $\pm 2.5$  V to  $-11.5/+14$  V) with 1% Accuracy
  - High Gain Current Monitor, Differential Gain = 50, up to 14 V Common Mode
  - Temperature Monitor (Resolution =  $\frac{1}{4}^{\circ}\text{C}$  in 12-Bit Mode; Accurate from  $-55^{\circ}\text{C}$  to  $150^{\circ}\text{C}$ )
- Up to Ten High-Speed Voltage Comparators ( $t_{pd} = 15$  ns)

## Analog Compute Engine (ACE)

- Offloads Cortex-M3–Based MSS from Analog Initialization and Processing of ADC, DAC, and SCBs
- Sample Sequence Engine for ADC and DAC Parameter Set-Up
- Post-Processing Engine for Functions such as Low-Pass Filtering and Linear Transformation
- Easily Configured via GUI in Libero® Integrated Design (IDE) Software

## I/Os and Operating Voltage

- FPGA I/Os
  - LVDS, PCI, PCI-X, up to 24 mA IOH/IOL
  - Up to 350 MHz
- MSS I/Os
  - Schmitt Trigger, up to 6 mA IOH, 8 mA IOL
  - Up to 180 MHz
- Single 3.3 V Power Supply with On-Chip 1.5 V Regulator
- External 1.5 V Is Allowed by Bypassing Regulator (digital VCC = 1.5 V for FPGA and MSS, analog VCC = 3.3 V and 1.5 V)

<sup>1</sup> Theoretical maximum

<sup>2</sup> A2F200 and larger devices

## SmartFusion cSoC Family Product Table

| SmartFusion cSoC                           |                                             | A2F060                                   | A2F200  | A2F500          |
|--------------------------------------------|---------------------------------------------|------------------------------------------|---------|-----------------|
| FPGA Fabric                                | System Gates                                | 60,000                                   | 200,000 | 500,000         |
|                                            | Tiles (D-flip-flops)                        | 1,536                                    | 4,608   | 11,520          |
|                                            | RAM Blocks (4,608 bits)                     | 8                                        | 8       | 24              |
| Microcontroller Subsystem (MSS)            | Flash (Kbytes)                              | 128                                      | 256     | 512             |
|                                            | SRAM (Kbytes)                               | 16                                       | 64      | 64              |
|                                            | Cortex-M3 with memory protection unit (MPU) | Yes                                      |         |                 |
|                                            | 10/100 Ethernet MAC                         | No                                       | Yes     |                 |
|                                            | External Memory Controller (EMC)            | 24-bit address, 16-bit data <sup>1</sup> |         |                 |
|                                            | DMA                                         | 8 Ch                                     |         |                 |
|                                            | I <sup>2</sup> C                            | 2                                        |         |                 |
|                                            | SPI                                         | 2                                        |         |                 |
|                                            | 16550 UART                                  | 2                                        |         |                 |
|                                            | 32-Bit Timer                                | 2                                        |         |                 |
|                                            | PLL                                         | 1                                        | 1       | 2 <sup>2</sup>  |
|                                            | 32 KHz Low Power Oscillator                 | 1                                        |         |                 |
|                                            | 100 MHz On-Chip RC Oscillator               | 1                                        |         |                 |
|                                            | Main Oscillator (32 KHz to 20 MHz)          | 1                                        |         |                 |
|                                            | Programmable Analog                         | ADCs (8-/10-/12-bit SAR)                 | 1       | 2               |
| DACs (12-bit sigma-delta)                  |                                             | 1                                        | 2       | 3 <sup>4</sup>  |
| Signal Conditioning Blocks (SCBs)          |                                             | 1                                        | 4       | 5 <sup>4</sup>  |
| Comparator <sup>3</sup>                    |                                             | 2                                        | 8       | 10 <sup>4</sup> |
| Current Monitors <sup>3</sup>              |                                             | 1                                        | 4       | 5 <sup>4</sup>  |
| Temperature Monitors <sup>3</sup>          |                                             | 1                                        | 4       | 5 <sup>4</sup>  |
| Bipolar High Voltage Monitors <sup>3</sup> |                                             | 2                                        | 8       | 10 <sup>4</sup> |

### Notes:

1. Not available on A2F500 for the PQ208 package.
2. Two PLLs are available in CS288 and FG484 (one PLL in FG256 and PQ208).
3. These functions share I/O pins and may not all be available at the same time. See the "Analog Front-End Overview" section in the [SmartFusion Programmable Analog User's Guide](#) for details.
4. Available on FG484 only. PQ208, FG256, and CS288 packages offer the same programmable analog capabilities as A2F200.

## Package I/Os: MSS + FPGA I/Os

| Device                            | A2F060          |                 | A2F200 |       |       |       | A2F500 |       |       |                  |
|-----------------------------------|-----------------|-----------------|--------|-------|-------|-------|--------|-------|-------|------------------|
| Package                           | CS288           | FG256           | PQ208  | CS288 | FG256 | FG484 | PQ208  | CS288 | FG256 | FG484            |
| Direct Analog Inputs              | 11              | 11              | 8      | 8     | 8     | 8     | 8      | 8     | 8     | 12               |
| Shared Analog Inputs <sup>1</sup> | 4               | 4               | 16     | 16    | 16    | 16    | 16     | 16    | 16    | 20               |
| Total Analog Inputs               | 15              | 15              | 24     | 24    | 24    | 24    | 24     | 24    | 24    | 32               |
| Total Analog Outputs              | 1               | 1               | 1      | 2     | 2     | 2     | 1      | 2     | 2     | 3                |
| MSS I/Os <sup>2,3</sup>           | 28 <sup>4</sup> | 26 <sup>4</sup> | 22     | 31    | 25    | 41    | 22     | 31    | 25    | 41               |
| FPGA I/Os                         | 68              | 66              | 66     | 78    | 66    | 94    | 66     | 78    | 66    | 128 <sup>5</sup> |
| Total I/Os                        | 112             | 108             | 113    | 135   | 117   | 161   | 113    | 135   | 117   | 204              |

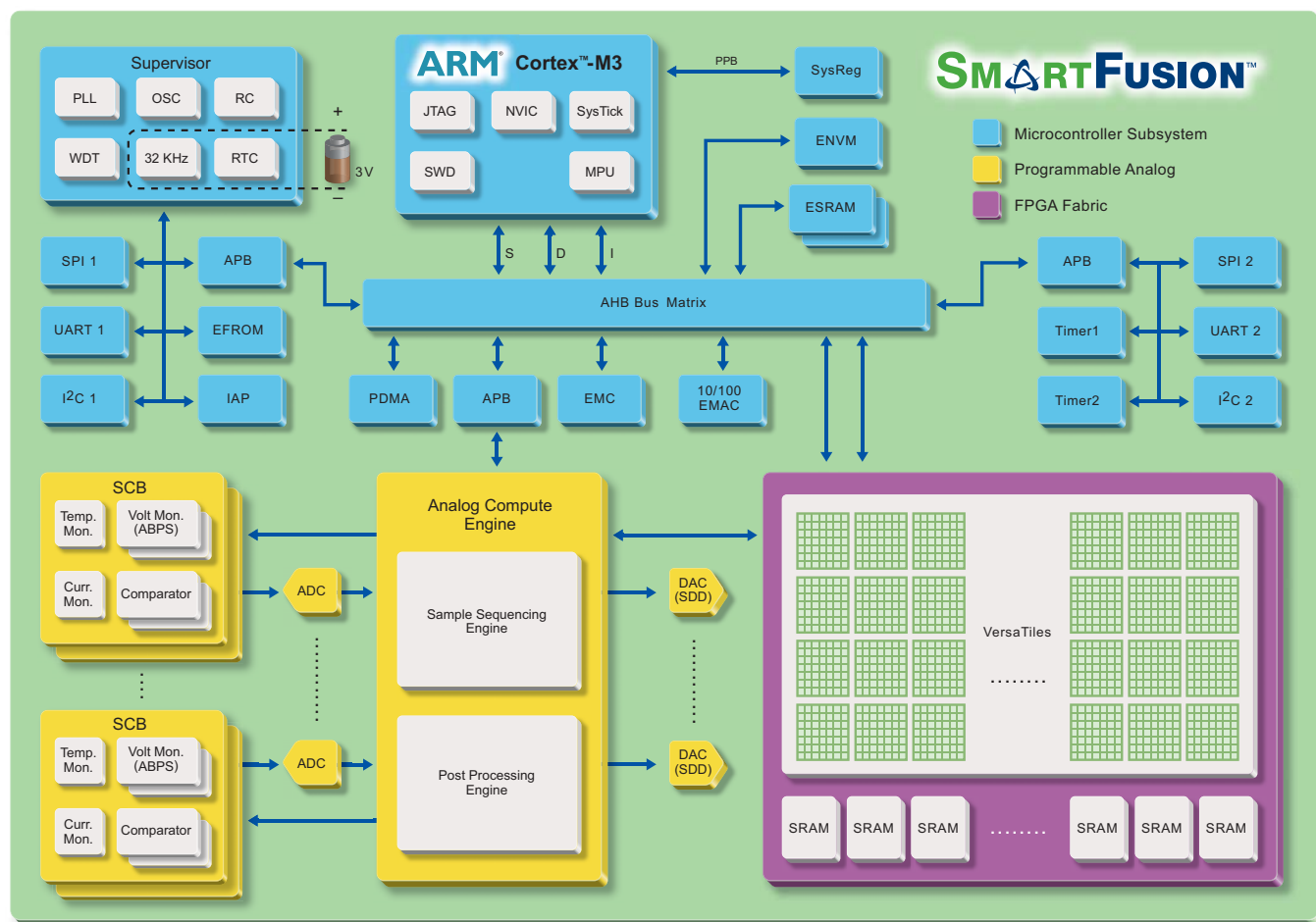
### Notes:

1. These pins are shared between direct analog inputs to the ADCs and voltage/current/temperature monitors.
2. 16 MSS I/Os are multiplexed and can be used as FPGA I/Os, if not needed for MSS. These I/Os support Schmitt triggers and support only LVTTTL and LVCMOS (1.5 / 1.8 / 2.5, 3.3 V) standards.
3. 9 MSS I/Os are primarily for 10/100 Ethernet MAC and are also multiplexed and can be used as FPGA I/Os if Ethernet MAC is not used in a design. These I/Os support Schmitt triggers and support only LVTTTL and LVCMOS (1.5 / 1.8 / 2.5, 3.3 V) standards.
4. 10/100 Ethernet MAC is not available on A2F060.
5. EMC is not available on the A2F500 PQ208 package.

## SmartFusion cSoC Device Status

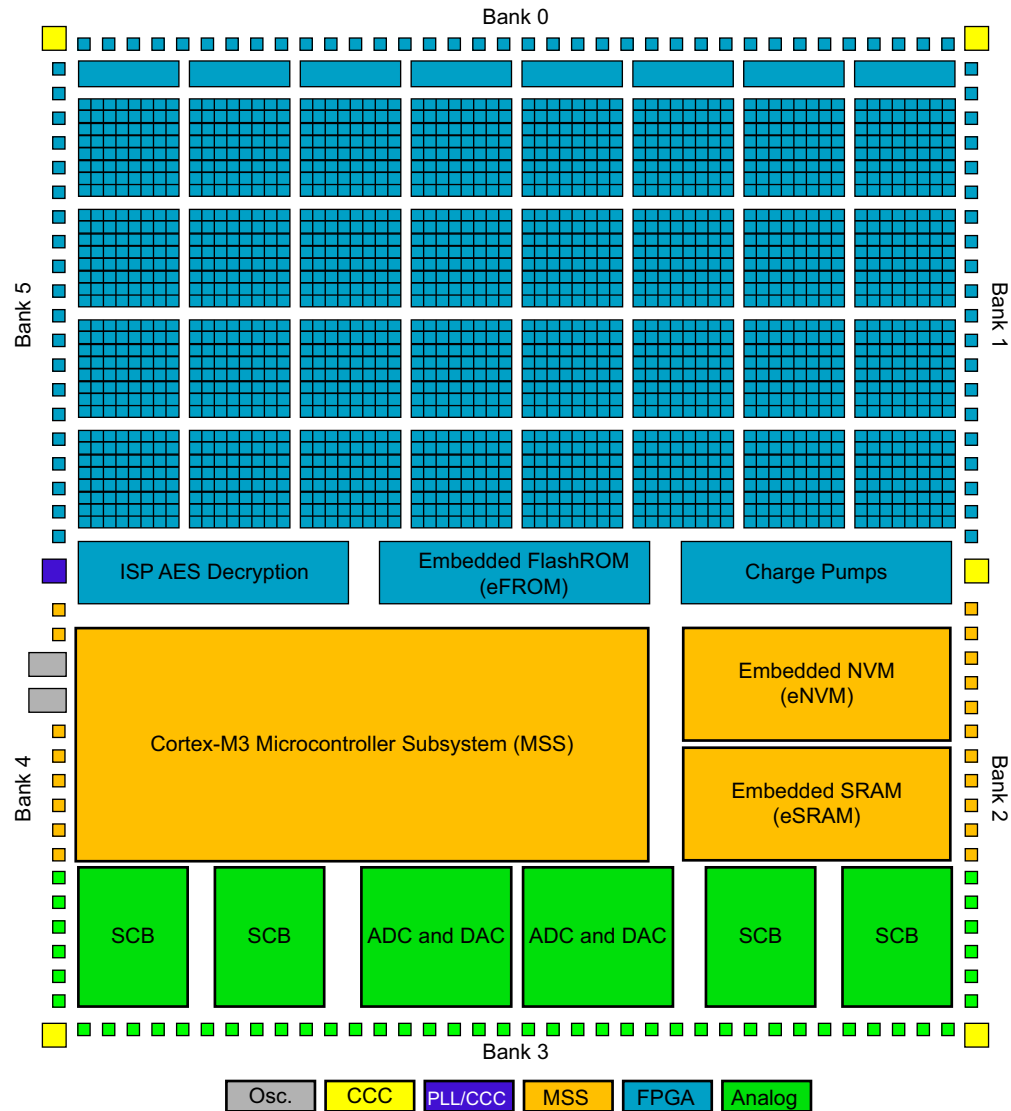
| Device | Status                                                |
|--------|-------------------------------------------------------|
| A2F060 | Preliminary: CS288, FG256                             |
| A2F200 | Production: FG256, FG484, PQ208<br>Preliminary: CS288 |
| A2F500 | Production: FG256, FG484, PQ208<br>Preliminary: CS288 |

## SmartFusion cSoC Block Diagram



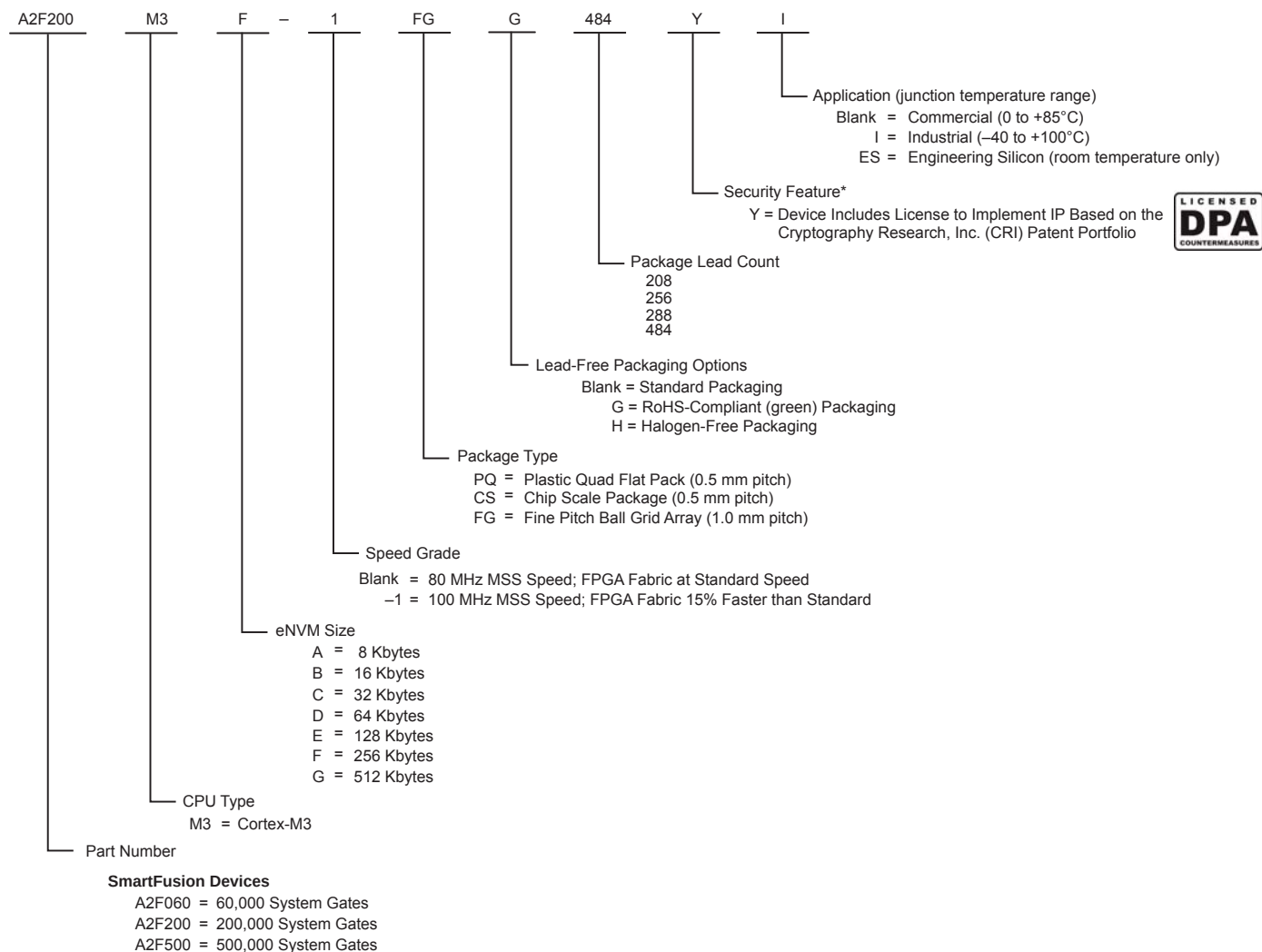


## SmartFusion cSoC System Architecture



*Note:* Architecture for A2F200

## Product Ordering Codes



**Note:** \*Most devices in the SmartFusion cSoC family can be ordered with the Y suffix. Devices with a package size greater or equal to 5x5 mm are supported. Contact your local Microsemi SoC Products Group sales representative for more information.

## Temperature Grade Offerings

| SmartFusion cSoC | A2F060 | A2F200 | A2F500 |
|------------------|--------|--------|--------|
| PQ208            | —      | C, I   | C, I   |
| CS288            | C, I   | C, I   | C, I   |
| FG256            | C, I   | C, I   | C, I   |
| FG484            | —      | C, I   | C, I   |

### Notes:

1. C = Commercial Temperature Range: 0°C to 85°C Junction
2. I = Industrial Temperature Range: -40°C to 100°C Junction

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# Table of Contents

---

## SmartFusion Family Overview

|                           |     |
|---------------------------|-----|
| Introduction .....        | 1-1 |
| General Description ..... | 1-1 |

## SmartFusion DC and Switching Characteristics

|                                                                   |      |
|-------------------------------------------------------------------|------|
| General Specifications .....                                      | 2-1  |
| Calculating Power Dissipation .....                               | 2-10 |
| User I/O Characteristics .....                                    | 2-19 |
| VersaTile Characteristics .....                                   | 2-55 |
| Global Resource Characteristics .....                             | 2-59 |
| RC Oscillator .....                                               | 2-61 |
| Main and Lower Power Crystal Oscillator .....                     | 2-62 |
| Clock Conditioning Circuits .....                                 | 2-63 |
| FPGA Fabric SRAM and FIFO Characteristics .....                   | 2-65 |
| Embedded Nonvolatile Memory Block (eNVM) .....                    | 2-74 |
| Embedded FlashROM (eFROM) .....                                   | 2-75 |
| JTAG 1532 Characteristics .....                                   | 2-75 |
| Programmable Analog Specifications .....                          | 2-76 |
| Serial Peripheral Interface (SPI) Characteristics .....           | 2-88 |
| Inter-Integrated Circuit (I <sup>2</sup> C) Characteristics ..... | 2-90 |

## SmartFusion Development Tools

|                             |     |
|-----------------------------|-----|
| Types of Design Tools ..... | 3-1 |
| SmartFusion Ecosystem ..... | 3-3 |
| Middleware .....            | 3-5 |

## SmartFusion Programming

|                                           |     |
|-------------------------------------------|-----|
| In-System Programming .....               | 4-7 |
| In-Application Programming .....          | 4-8 |
| Typical Programming and Erase Times ..... | 4-9 |
| References .....                          | 4-9 |

## Pin Descriptions

|                                                        |      |
|--------------------------------------------------------|------|
| Supply Pins .....                                      | 5-1  |
| User-Defined Supply Pins .....                         | 5-4  |
| User Pins .....                                        | 5-5  |
| Special Function Pins .....                            | 5-6  |
| JTAG Pins .....                                        | 5-8  |
| Microcontroller Subsystem (MSS) .....                  | 5-10 |
| Analog Front-End (AFE) .....                           | 5-12 |
| Analog Front-End Pin-Level Function Multiplexing ..... | 5-14 |
| CS288 .....                                            | 5-16 |
| PQ208 .....                                            | 5-26 |
| FG256 .....                                            | 5-33 |
| FG484 .....                                            | 5-42 |

## Datasheet Information

|                                                                                                            |      |
|------------------------------------------------------------------------------------------------------------|------|
| List of Changes .....                                                                                      | 6-1  |
| Datasheet Categories .....                                                                                 | 6-10 |
| Microsemi SoC Products Group Safety Critical, Life Support, and High-Reliability Applications Policy ..... | 6-10 |

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# 1 – SmartFusion Family Overview

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## Introduction

The SmartFusion® family of cSoCs builds on the technology first introduced with the Fusion mixed signal FPGAs. SmartFusion cSoCs are made possible by integrating FPGA technology with programmable high-performance analog and hardened ARM Cortex-M3 microcontroller blocks on a flash semiconductor process. The SmartFusion cSoC takes its name from the fact that these three discrete technologies are integrated on a single chip, enabling the lowest cost of ownership and smallest footprint solution to you.

## General Description

### Microcontroller Subsystem (MSS)

The MSS is composed of a 100 MHz Cortex-M3 processor and integrated peripherals, which are interconnected via a multi-layer AHB bus matrix (ABM). This matrix allows the Cortex-M3 processor, FPGA fabric master, Ethernet message authentication controller (MAC), when available, and peripheral DMA (PDMA) controller to act as masters to the integrated peripherals, FPGA fabric, embedded nonvolatile memory (eNVM), embedded synchronous RAM (eSRAM), external memory controller (EMC), and analog compute engine (ACE) blocks.

SmartFusion cSoCs of different densities offer various sets of integrated peripherals. Available peripherals include SPI, I<sup>2</sup>C, and UART serial ports, embedded FlashROM (EFROM), 10/100 Ethernet MAC, timers, phase-locked loops (PLLs), oscillators, real-time counters (RTC), and peripheral DMA controller (PDMA).

### Programmable Analog

#### **Analog Front-End (AFE)**

SmartFusion cSoCs offer an enhanced analog front-end compared to Fusion devices. The successive approximation register analog-to-digital converters (SAR ADC) are similar to those found on Fusion devices. SmartFusion cSoC also adds first order sigma-delta digital-to-analog converters (SDD DAC).

SmartFusion cSoCs can handle multiple analog signals simultaneously with its signal conditioning blocks (SCBs). SCBs are made of a combination of active bipolar prescalers (ABPS), comparators, current monitors and temperature monitors. ABPS modules allow larger bipolar voltages to be fed to the ADC. Current monitors take the voltage across an external sense resistor and convert it to a voltage suitable for the ADC input range. Similarly, the temperature monitor reads the current through an external PN-junction (diode or transistor) and converts it internally for the ADC. The SCB also includes comparators to monitor fast signal thresholds without using the ADC. The output of the comparators can be fed to the analog compute engine or the ADC.

#### **Analog Compute Engine (ACE)**

The mixed signal blocks found in SmartFusion cSoCs are controlled and connected to the rest of the system via a dedicated processor called the analog compute engine (ACE). The role of the ACE is to offload control of the analog blocks from the Cortex-M3, thus offering faster throughput or better power consumption compared to a system where the main processor is in charge of monitoring the analog resources. The ACE is built to handle sampling, sequencing, and post-processing of the ADCs, DACs, and SCBs.

## ProASIC3 FPGA Fabric

The SmartFusion cSoC family, based on the proven, low power, firm-error immune ProASIC®3 flash FPGA architecture, benefits from the advantages only flash-based devices offer:

### **Reduced Cost of Ownership**

Advantages to the designer extend beyond low unit cost, high performance, and ease of use. Flash-based SmartFusion cSoCs are live at power-up and do not need to be loaded from an external boot PROM at each power-up. On-board security mechanisms prevent access to the programming information and enable secure remote updates of the FPGA logic. Designers can perform secure remote in-system programming (ISP) to support future design iterations and critical field upgrades, with confidence that valuable IP cannot be compromised or copied. Secure ISP can be performed using the industry standard AES algorithm with MAC data authentication on the device.

### **Low Power**

Flash-based SmartFusion cSoCs exhibit power characteristics similar to those of an ASIC, making them an ideal choice for power-sensitive applications. With SmartFusion cSoCs, there is no power-on current and no high current transition, both of which are common with SRAM-based FPGAs.

SmartFusion cSoCs also have low dynamic power consumption and support very low power time-keeping mode, offering further power savings.

### **Security**

As the nonvolatile, flash-based SmartFusion cSoC family requires no boot PROM, there is no vulnerable external bitstream. SmartFusion cSoCs incorporate FlashLock®, which provides a unique combination of reprogrammability and design security without external overhead, advantages that only a device with nonvolatile flash programming can offer.

SmartFusion cSoCs utilize a 128-bit flash-based key lock and a separate AES key to provide security for programmed IP and configuration data. The FlashROM data in Fusion devices can also be encrypted prior to loading. Additionally, the flash memory blocks can be programmed during runtime using the AES-128 block cipher encryption standard (FIPS Publication 192).

SmartFusion cSoCs with AES-based security are designed to provide protection for remote field updates over public networks, such as the Internet, and help to ensure that valuable IP remains out of the hands of system overbuilders, system cloners, and IP thieves. As an additional security measure, the FPGA configuration data of a programmed Fusion device cannot be read back, although secure design verification is possible. During design, the user controls and defines both internal and external access to the flash memory blocks.

Security, built into the FPGA fabric, is an inherent component of the SmartFusion cSoC family. The flash cells are located beneath seven metal layers, and many device design and layout techniques have been used to make invasive attacks extremely difficult. SmartFusion cSoCs, with FlashLock and AES security, are unique in being highly resistant to both invasive and noninvasive attacks. Your valuable IP is protected with industry standard security measures, making remote ISP feasible. A SmartFusion cSoC provides the highest security available 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 SmartFusion cSoCs do not require system configuration components such as electrically erasable programmable read-only memories (EEPROMs) or microcontrollers to load device configuration data during power-up. This reduces bill-of-materials costs and PCB area, and increases system security and reliability.

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

Flash-based SmartFusion cSoCs are live at power-up (LAPU). LAPU SmartFusion cSoCs greatly simplify total system design and reduce total system cost by eliminating the need for complex programmable logic devices (CPLDs). SmartFusion LAPU clocking (PLLs) replace off-chip clocking resources. In addition, glitches and brownouts in system power will not corrupt the SmartFusion flash configuration. Unlike SRAM-based FPGAs, the device will not have to be reloaded when system power is restored. This enables reduction or complete removal of expensive voltage monitor and brownout

detection devices from the PCB design. Flash-based SmartFusion cSoCs simplify total system design and reduce cost and design risk, while increasing system reliability.

### ***Immunity to Firm Errors***

Firm errors occur most commonly when high-energy neutrons, generated in the 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 configuration behavior in an unpredictable way.

Another source of radiation-induced firm errors is alpha particles. For alpha radiation to cause a soft or firm error, its source must be in very close proximity to the affected circuit. The alpha source must be in the package molding compound or in the die itself. While low-alpha molding compounds are being used increasingly, this helps reduce but does not entirely eliminate alpha-induced firm errors.

Firm 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 occur in SmartFusion cSoCs. Once it is programmed, the flash cell configuration element of SmartFusion cSoCs cannot be altered by high energy neutrons and is therefore immune to errors from them. Recoverable (or soft) errors occur in the user data SRAMs of all FPGA devices. These can easily be mitigated by using error detection and correction (EDAC) circuitry built into the FPGA fabric.





## 2 – SmartFusion DC and Switching Characteristics

### General Specifications

#### Operating Conditions

Stresses beyond the operating conditions 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 Maximum Ratings 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 2-3 on page 2-3](#) is not implied.

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

| Symbol                        | Parameter                                                | Limits                                                                                                                                                                     | Units |
|-------------------------------|----------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| VCC                           | DC core supply voltage                                   | –0.3 to 1.65                                                                                                                                                               | V     |
| VJTAG                         | JTAG DC voltage                                          | –0.3 to 3.75                                                                                                                                                               | V     |
| VPP                           | Programming voltage                                      | –0.3 to 3.75                                                                                                                                                               | V     |
| VCCPLLx                       | Analog power supply (PLL)                                | –0.3 to 1.65                                                                                                                                                               | V     |
| VCCFPGAIOBx                   | DC FPGA I/O buffer supply voltage                        | –0.3 to 3.75                                                                                                                                                               | V     |
| VCCMSSIOBx                    | DC MSS I/O buffer supply voltage                         | –0.3 to 3.75                                                                                                                                                               | V     |
| VI                            | I/O input voltage                                        | –0.3 V to 3.6 V<br>(when I/O hot insertion mode is enabled)<br>–0.3 V to (VCCxxxIOBx + 1 V) or 3.6 V, whichever voltage is lower (when I/O hot-insertion mode is disabled) | V     |
| VCC33A                        | Analog clean 3.3 V supply to the analog circuitry        | –0.3 to 3.75                                                                                                                                                               | V     |
| VCC33ADCx                     | Analog 3.3 V supply to ADC                               | –0.3 to 3.75                                                                                                                                                               | V     |
| VCC33AP                       | Analog clean 3.3 V supply to the charge pump             | –0.3 to 3.75                                                                                                                                                               | V     |
| VCC33SDDx                     | Analog 3.3 V supply to the sigma-delta DAC               | –0.3 to 3.75                                                                                                                                                               | V     |
| VAREFx                        | Voltage reference for ADC                                | 1.0 to 3.75                                                                                                                                                                | V     |
| VCCRCOSC                      | Analog supply to the integrated RC oscillator            | –0.3 to 3.75                                                                                                                                                               | V     |
| VDDBAT                        | External battery supply                                  | –0.3 to 3.75                                                                                                                                                               | V     |
| VCCMAINXTAL                   | Analog supply to the main crystal oscillator             | –0.3 to 3.75                                                                                                                                                               | V     |
| VCCLPXTAL                     | Analog supply to the low power 32 kHz crystal oscillator | –0.3 to 3.75                                                                                                                                                               | V     |
| VCCENVM                       | Embedded nonvolatile memory supply                       | –0.3 to 1.65                                                                                                                                                               | V     |
| VCCESRAM                      | Embedded SRAM supply                                     | –0.3 to 1.65                                                                                                                                                               | V     |
| VCC15A                        | Analog 1.5 V supply to the analog circuitry              | –0.3 to 1.65                                                                                                                                                               | V     |
| VCC15ADCx                     | Analog 1.5 V supply to the ADC                           | –0.3 to 1.65                                                                                                                                                               | V     |
| T <sub>STG</sub> <sup>1</sup> | Storage temperature                                      | –65 to +150                                                                                                                                                                | °C    |
| T <sub>J</sub> <sup>1</sup>   | Junction temperature                                     | 125                                                                                                                                                                        | °C    |

**Notes:**

1. For flash programming and retention maximum limits, refer to [Table 2-4 on page 2-4](#). For recommended operating conditions, refer to [Table 2-3 on page 2-3](#).
2. 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 2-5 on page 2-4](#).

**Table 2-2 • Analog Maximum Ratings**

| Parameter                                | Conditions                                                                                                | Min.  | Max. | Units |
|------------------------------------------|-----------------------------------------------------------------------------------------------------------|-------|------|-------|
| ABPS[n] pad voltage (relative to ground) | GDEC[1:0] = 00 ( $\pm 15.36$ V range)                                                                     |       |      |       |
|                                          | Absolute maximum                                                                                          | –11.5 | 14.4 | V     |
|                                          | Recommended                                                                                               | –11   | 14   | V     |
|                                          | GDEC[1:0] = 01 ( $\pm 10.24$ V range)                                                                     | –11.5 | 12   | V     |
|                                          | GDEC[1:0] = 10 ( $\pm 5.12$ V range)                                                                      | –6    | 6    | V     |
|                                          | GDEC[1:0] = 11 ( $\pm 2.56$ V range)                                                                      | –3    | 3    | V     |
| CM[n] pad voltage relative to ground)    | CMB_DI_ON = 0 (ADC isolated)<br>COMP_EN = 0 (comparator off, for the associated even-numbered comparator) |       |      |       |
|                                          | Absolute maximum                                                                                          | –0.3  | 14.4 | V     |
|                                          | Recommended                                                                                               | –0.3  | 14   | V     |
|                                          | CMB_DI_ON = 0 (ADC isolated)<br>COMP_EN = 1 (comparator on)                                               | –0.3  | 3    | V     |
|                                          | TMB_DI_ON = 1 (direct ADC in)                                                                             | –0.3  | 3    | V     |
| TM[n] pad voltage (relative to ground)   | TMB_DI_ON = 0 (ADC isolated)<br>COMP_EN = 1 (comparator on)                                               | –0.3  | 3    | V     |
|                                          | TMB_DI_ON = 1 (direct ADC in)                                                                             | –0.3  | 3    | V     |
| ADC[n] pad voltage (relative to ground)  |                                                                                                           | –0.3  | 3.6  | V     |

**Table 2-3 • Recommended Operating Conditions**

| Symbol                                  | Parameter <sup>1</sup>                                   |                        | Commercial     | Industrial     | Units |
|-----------------------------------------|----------------------------------------------------------|------------------------|----------------|----------------|-------|
| T <sub>J</sub>                          | Junction temperature                                     |                        | 0 to +85       | –40 to +100    | °C    |
| VCC <sup>2</sup>                        | 1.5 V DC core supply voltage                             |                        | 1.425 to 1.575 | 1.425 to 1.575 | V     |
| VJTAG                                   | JTAG DC voltage                                          |                        | 1.425 to 3.6   | 1.425 to 3.6   | V     |
| VPP                                     | Programming voltage                                      | Programming mode       | 3.15 to 3.45   | 3.15 to 3.45   | V     |
|                                         |                                                          | Operation <sup>3</sup> | 0 to 3.6       | 0 to 3.6       | V     |
| VCCPLLx                                 | Analog power supply (PLL)                                |                        | 1.425 to 1.575 | 1.425 to 1.575 | V     |
| VCCFPGAIOBx/<br>VCCMSSIOBx <sup>4</sup> | 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 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     |
| VCC33A <sup>5</sup>                     | Analog clean 3.3 V supply to the analog circuitry        |                        | 3.15 to 3.45   | 3.15 to 3.45   | V     |
| VCC33ADCx <sup>5</sup>                  | Analog 3.3 V supply to ADC                               |                        | 3.15 to 3.45   | 3.15 to 3.45   | V     |
| VCC33AP <sup>5</sup>                    | Analog clean 3.3 V supply to the charge pump             |                        | 3.15 to 3.45   | 3.15 to 3.45   | V     |
| VCC33SDDx <sup>5</sup>                  | Analog 3.3 V supply to sigma-delta DAC                   |                        | 3.15 to 3.45   | 3.15 to 3.45   | V     |
| VAREF <sub>x</sub>                      | Voltage reference for ADC                                |                        | 2.527 to 3.3   | 2.527 to 3.3   | V     |
| VCCRCOSC                                | Analog supply to the integrated RC oscillator            |                        | 3.15 to 3.45   | 3.15 to 3.45   | V     |
| VDDBAT                                  | External battery supply                                  |                        | 2.7 to 3.63    | 2.7 to 3.63    | V     |
| VCCMAINXTAL <sup>5</sup>                | Analog supply to the main crystal oscillator             |                        | 3.15 to 3.45   | 3.15 to 3.45   | V     |
| VCCLPXTAL <sup>5</sup>                  | Analog supply to the low power 32 KHz crystal oscillator |                        | 3.15 to 3.45   | 3.15 to 3.45   | V     |
| VCCENVM                                 | Embedded nonvolatile memory supply                       |                        | 1.425 to 1.575 | 1.425 to 1.575 | V     |
| VCCESRAM                                | Embedded SRAM supply                                     |                        | 1.425 to 1.575 | 1.425 to 1.575 | V     |
| VCC15A <sup>2</sup>                     | Analog 1.5 V supply to the analog circuitry              |                        | 1.425 to 1.575 | 1.425 to 1.575 | V     |
| VCC15ADCx <sup>2</sup>                  | Analog 1.5 V supply to the ADC                           |                        | 1.425 to 1.575 | 1.425 to 1.575 | V     |

**Notes:**

1. All parameters representing voltages are measured with respect to GND unless otherwise specified.
2. The following 1.5 V supplies should be connected together while following proper noise filtering practices: VCC, VCC15A, and VCC15ADCx.
3. VPP can be left floating during operation (not programming mode).
4. The ranges given here are for power supplies only. The recommended input voltage ranges specific to each I/O standard are given in [Table 2-19 on page 2-23](#). VCCxxxIOBx should be at the same voltage within a given I/O bank.
5. The following 3.3 V supplies should be connected together while following proper noise filtering practices: VCC33A, VCC33ADCx, VCC33AP, VCC33SDDx, VCCMAINXTAL, and VCCLPXTAL.

**Table 2-4 • FPGA and Embedded Flash Programming, Storage and Operating Limits**

| Product Grade | Storage Temperature                                                  | Element        | Grade Programming Cycles | Retention |
|---------------|----------------------------------------------------------------------|----------------|--------------------------|-----------|
| Commercial    | Min. $T_J = 0^{\circ}\text{C}$<br>Min. $T_J = 85^{\circ}\text{C}$    | FPGA/FlashROM  | 500                      | 20 years  |
|               |                                                                      | Embedded Flash | < 1,000                  | 20 years  |
|               |                                                                      |                | < 10,000                 | 10 years  |
|               |                                                                      |                | < 15,000                 | 5 years   |
| Industrial    | Min. $T_J = -40^{\circ}\text{C}$<br>Min. $T_J = 100^{\circ}\text{C}$ | FPGA/FlashROM  | 500                      | 20 years  |
|               |                                                                      | Embedded Flash | < 1,000                  | 20 years  |
|               |                                                                      |                | < 10,000                 | 10 years  |
|               |                                                                      |                | < 15,000                 | 5 years   |

**Table 2-5 • Overshoot and Undershoot Limits <sup>1</sup>**

| VCCxxxxIOBx   | Average VCCxxxxIOBx–GND Overshoot or Undershoot Duration as a Percentage of Clock Cycle <sup>2</sup> | Maximum Overshoot/Undershoot <sup>2</sup> |
|---------------|------------------------------------------------------------------------------------------------------|-------------------------------------------|
| 2.7 V or less | 10%                                                                                                  | 1.4 V                                     |
|               | 5%                                                                                                   | 1.49 V                                    |
| 3 V           | 10%                                                                                                  | 1.1 V                                     |
|               | 5%                                                                                                   | 1.19 V                                    |
| 3.3 V         | 10%                                                                                                  | 0.79 V                                    |
|               | 5%                                                                                                   | 0.88 V                                    |
| 3.6 V         | 10%                                                                                                  | 0.45 V                                    |
|               | 5%                                                                                                   | 0.54 V                                    |

**Notes:**

1. Based on reliability requirements at  $85^{\circ}\text{C}$ .
2. The duration is allowed at one out of six clock cycles. If the overshoot/undershoot occurs at one out of two cycles, the maximum overshoot/undershoot has to be reduced by 0.15 V.
3. This table does not provide PCI overshoot/undershoot limits.

## Power Supply Sequencing Requirement

SmartFusion cSoCs have an on-chip 1.5 V regulator, but usage of an external 1.5 V supply is also allowed while the on-chip regulator is disabled. In that case, the 3.3 V supplies (VCC33A, etc.) should be powered before 1.5 V (VCC, etc.) supplies. The 1.5 V supplies should be enabled only after 3.3 V supplies reach a value higher than 2.7 V.

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

Sophisticated power-up management circuitry is designed into every SmartFusion cSoC. These circuits ensure easy transition from the powered-off state to the powered-up state of the device. In addition, the I/O will be in a known state through the power-up sequence. The basic principle is shown in [Figure 2-1 on page 2-6](#).

There are five regions to consider during power-up.

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

1. VCC and VCCxxxxIOBx are above the minimum specified trip points ([Figure 2-1 on page 2-6](#)).
2.  $VCC_{xxxxIOBx} > VCC - 0.75\text{ V}$  (typical)
3. Chip is in the SoC Mode.

**VCCxxxxIOBx Trip Point:**Ramping up:  $0.6\text{ V} < \text{trip\_point\_up} < 1.2\text{ V}$ Ramping down:  $0.5\text{ V} < \text{trip\_point\_down} < 1.1\text{ V}$ **VCC Trip Point:**Ramping up:  $0.6\text{ V} < \text{trip\_point\_up} < 1.1\text{ V}$ Ramping down:  $0.5\text{ V} < \text{trip\_point\_down} < 1\text{ V}$ 

VCC and VCCxxxxIOBx 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 VCCxxxxIOBx.
- JTAG supply, PLL power supplies, and charge pump VPUMP supply have no influence on I/O behavior.

**PLL Behavior at Brownout Condition**

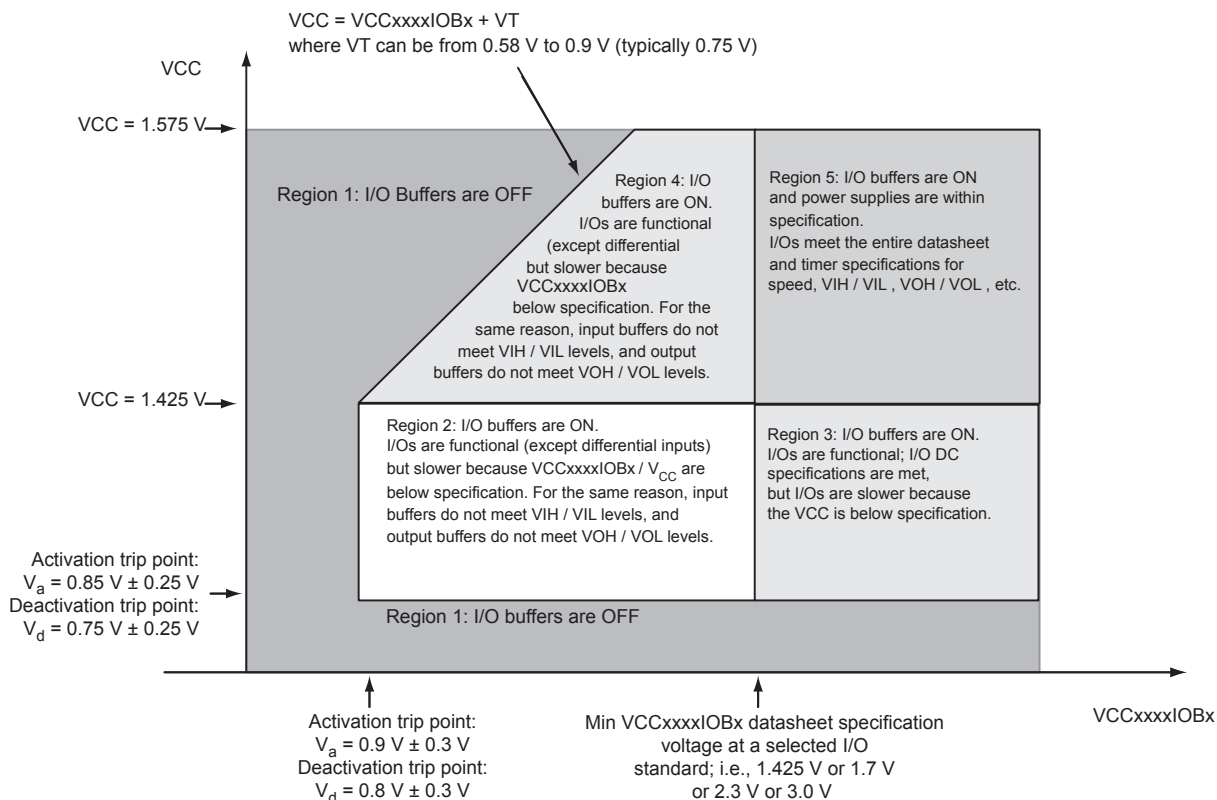
The Microsemi SoC Products Group recommends using monotonic power supplies or voltage regulators to ensure proper power-up behavior. Power ramp-up should be monotonic at least until VCC and VCCPLLx exceed brownout activation levels. The VCC activation level is specified as 1.1 V worst-case (see [Figure 2-1 on page 2-6](#) for more details).

When PLL power supply voltage and/or VCC levels drop below the VCC brownout levels ( $0.75\text{ V} \pm 0.25\text{ V}$ ), the PLL output lock signal goes low and/or the output clock is lost. Refer to the "Power-Up/-Down Behavior of Low Power Flash Devices" chapter of the [ProASIC3 FPGA Fabric User's Guide](#) for information on clock and lock recovery.

**Internal Power-Up Activation Sequence**

1. Core
2. Input buffers

Output buffers, after 200 ns delay from input buffer activation



**Figure 2-1 • I/O State as a Function of  $VCC_{xxxxIOBx}$  and VCC Voltage Levels**

## Thermal Characteristics

### Introduction

The temperature variable in the SoC Products Group Designer software refers to the junction temperature, not the ambient, case, or board temperatures. This is an important distinction because dynamic and static power consumption will cause the chip's junction temperature to be higher than the ambient, case, or board temperatures. EQ 1 through EQ 3 give the relationship between thermal resistance, temperature gradient, and power.

$$\theta_{JA} = \frac{T_J - T_A}{P}$$

EQ 1

$$\theta_{JB} = \frac{T_J - T_B}{P}$$

EQ 2

$$\theta_{JC} = \frac{T_J - T_C}{P}$$

EQ 3

where

- $\theta_{JA}$  = Junction-to-air thermal resistance
- $\theta_{JB}$  = Junction-to-board thermal resistance
- $\theta_{JC}$  = Junction-to-case thermal resistance
- $T_J$  = Junction temperature
- $T_A$  = Ambient temperature
- $T_B$  = Board temperature (measured 1.0 mm away from the package edge)
- $T_C$  = Case temperature
- $P$  = Total power dissipated by the device

**Table 2-6 • Package Thermal Resistance**

| Product         | Die Size<br>(mm)  | $\theta_{JA}$ |         |         | $\theta_{JC}$ | $\theta_{JB}$ | Units |
|-----------------|-------------------|---------------|---------|---------|---------------|---------------|-------|
|                 |                   | Still Air     | 1.0 m/s | 2.5 m/s |               |               |       |
| A2F200M3F-FG256 | X = 4.0; Y = 5.6  | 33.7          | 30.0    | 28.3    | 9.3           | 24.8          | °C/W  |
| A2F200M3F-FG484 | X = 5.10; Y = 7.3 | 21.8          | 18.2    | 16.7    | 7.7           | 16.8          | °C/W  |

### Theta-JA

Junction-to-ambient thermal resistance ( $\theta_{JA}$ ) is determined under standard conditions specified by JEDEC (JESD-51), but it has little relevance in actual performance of the product. It should be used with caution but is useful for comparing the thermal performance of one package to another.

A sample calculation showing the maximum power dissipation allowed for the A2F200-FG484 package under forced convection of 1.0 m/s and 75°C ambient temperature is as follows:

$$\text{Maximum Power Allowed} = \frac{T_{J(\text{MAX})} - T_{A(\text{MAX})}}{\theta_{JA}}$$

EQ 4

where

$\theta_{JA}$  = 19.00°C/W (taken from Table 2-6 on page 2-7).

$T_A$  = 75.00°C

$$\text{Maximum Power Allowed} = \frac{100.00^\circ\text{C} - 75.00^\circ\text{C}}{19.00^\circ\text{C/W}} = 1.3 \text{ W}$$

EQ 5

The power consumption of a device can be calculated using the Microsemi SoC Products Group power calculator. The device's power consumption must be lower than the calculated maximum power dissipation by the package. If the power consumption is higher than the device's maximum allowable power dissipation, a heat sink can be attached on top of the case, or the airflow inside the system must be increased.

### Theta-JB

Junction-to-board thermal resistance ( $\theta_{JB}$ ) measures the ability of the package to dissipate heat from the surface of the chip to the PCB. As defined by the JEDEC (JESD-51) standard, the thermal resistance from junction to board uses an isothermal ring cold plate zone concept. The ring cold plate is simply a means to generate an isothermal boundary condition at the perimeter. The cold plate is mounted on a JEDEC standard board with a minimum distance of 5.0 mm away from the package edge.

### Theta-JC

Junction-to-case thermal resistance ( $\theta_{JC}$ ) measures the ability of a device to dissipate heat from the surface of the chip to the top or bottom surface of the package. It is applicable for packages used with external heat sinks. Constant temperature is applied to the surface in consideration and acts as a boundary condition. This only applies to situations where all or nearly all of the heat is dissipated through the surface in consideration.

### Calculation for Heat Sink

For example, in a design implemented in an A2F200-FG484 package with 2.5 m/s airflow, the power consumption value using the power calculator is 3.00 W. The user-dependent  $T_a$  and  $T_j$  are given as follows:

$T_J$  = 100.00°C

$T_A$  = 70.00°C

From the datasheet:

$\theta_{JA}$  = 17.00°C/W

$\theta_{JC}$  = 8.28°C/W



$$P = \frac{T_J - T_A}{\theta_{JA}} = \frac{100^\circ\text{C} - 70^\circ\text{C}}{17.00^\circ\text{C/W}} = 1.76 \text{ W}$$

EQ 6

The 1.76 W power is less than the required 3.00 W. The design therefore requires a heat sink, or the airflow where the device is mounted should be increased. The design's total junction-to-air thermal resistance requirement can be estimated by EQ 7:

$$\theta_{JA(\text{total})} = \frac{T_J - T_A}{P} = \frac{100^\circ\text{C} - 70^\circ\text{C}}{3.00 \text{ W}} = 10.00^\circ\text{C/W}$$

EQ 7

Determining the heat sink's thermal performance proceeds as follows:

$$\theta_{JA(\text{TOTAL})} = \theta_{JC} + \theta_{CS} + \theta_{SA}$$

EQ 8

where

$$\theta_{JA} = 0.37^\circ\text{C/W}$$

= Thermal resistance of the interface material between the case and the heat sink, usually provided by the thermal interface manufacturer

$$\theta_{SA} = \text{Thermal resistance of the heat sink in } ^\circ\text{C/W}$$

$$\theta_{SA} = \theta_{JA(\text{TOTAL})} - \theta_{JC} - \theta_{CS}$$

EQ 9

$$\theta_{SA} = 13.33^\circ\text{C/W} - 8.28^\circ\text{C/W} - 0.37^\circ\text{C/W} = 5.01^\circ\text{C/W}$$

A heat sink with a thermal resistance of 5.01°C/W or better should be used. Thermal resistance of heat sinks is a function of airflow. The heat sink performance can be significantly improved with increased airflow.

Carefully estimating thermal resistance is important in the long-term reliability of an FPGA. Design engineers should always correlate the power consumption of the device with the maximum allowable power dissipation of the package selected for that device.

**Note:** The junction-to-air and junction-to-board thermal resistances are based on JEDEC standard (JESD-51) and assumptions made in building the model. It may not be realized in actual application and therefore should be used with a degree of caution. Junction-to-case thermal resistance assumes that all power is dissipated through the case.

## Temperature and Voltage Derating Factors

**Table 2-7 • Temperature and Voltage Derating Factors for Timing Delays**  
(normalized to  $T_J = 85^\circ\text{C}$ , worst-case VCC = 1.425 V)

| Array Voltage VCC (V) | Junction Temperature ( $^\circ\text{C}$ ) |                   |                    |                    |                    |                     |
|-----------------------|-------------------------------------------|-------------------|--------------------|--------------------|--------------------|---------------------|
|                       | $-40^\circ\text{C}$                       | $0^\circ\text{C}$ | $25^\circ\text{C}$ | $70^\circ\text{C}$ | $85^\circ\text{C}$ | $100^\circ\text{C}$ |
| 1.425                 | 0.86                                      | 0.91              | 0.93               | 0.98               | 1.00               | 1.02                |
| 1.500                 | 0.81                                      | 0.86              | 0.88               | 0.93               | 0.95               | 0.96                |
| 1.575                 | 0.78                                      | 0.83              | 0.85               | 0.90               | 0.91               | 0.93                |

## Calculating Power Dissipation

### Quiescent Supply Current

**Table 2-8 • Power Supplies Configuration**

| Modes and Power Supplies | VCCxxxIOBx<br>VCCFPGAIOBx<br>VCCMSSIOBx | VCC33A / VCC33ADCx<br>VCC33AP / VCC33SDDx<br>VCCMAINXTAL / VCCCLPXTAL | VCC / VCC15A / VCC15ADCx<br>VCCPLLx, VCCENVM,<br>VCCESRAM | VDDBAT | VCCRCOSC | VJTAG | VPP | eNVM (reset/off) | LPXTAL (enable/disable) | MAINXTAL (enable/disable) |
|--------------------------|-----------------------------------------|-----------------------------------------------------------------------|-----------------------------------------------------------|--------|----------|-------|-----|------------------|-------------------------|---------------------------|
| Time Keeping mode        | 0 V                                     | 0 V                                                                   | 0 V                                                       | 3.3 V  | 0 V      | 0 V   | 0 V | Off              | Enable                  | Disable                   |
| Standby mode             | On*                                     | 3.3 V                                                                 | 1.5 V                                                     | N/A    | 3.3 V    | N/A   | N/A | Reset            | Enable                  | Disable                   |
| SoC mode                 | On*                                     | 3.3 V                                                                 | 1.5 V                                                     | N/A    | 3.3 V    | N/A   | N/A | On               | Enable                  | Enable                    |

*Note:* \*On means proper voltage is applied. Refer to [Table 2-3 on page 2-3](#) for recommended operating conditions.

**Table 2-9 • Quiescent Supply Current Characteristics**

| Parameter | Modes             | A2F060       |              | A2F200       |              | A2F500       |              |
|-----------|-------------------|--------------|--------------|--------------|--------------|--------------|--------------|
|           |                   | 1.5 V Domain | 3.3 V Domain | 1.5 V Domain | 3.3 V Domain | 1.5 V Domain | 3.3 V Domain |
| IDC1      | SoC mode          | 3 mA         | 2 mA         | 7 mA         | 4 mA         | 16.5 mA      | 4 mA         |
| IDC2      | Standby mode      | 3 mA         | 2 mA         | 7 mA         | 4 mA         | 16.5 mA      | 4 mA         |
| IDC3      | Time Keeping mode | N/A          | 10 $\mu$ A   | N/A          | 10 $\mu$ A   | N/A          | 10 $\mu$ A   |

### Power per I/O Pin

**Table 2-10 • Summary of I/O Input Buffer Power (per pin) – Default I/O Software Settings**  
 Applicable to FPGA I/O Banks, I/O Assigned to EMC I/O Pins

|                             | VCCFPGAIOBx (V) | Static Power PDC7 (mW) | Dynamic Power PAC9 ( $\mu$ W/MHz) |
|-----------------------------|-----------------|------------------------|-----------------------------------|
| <b>Single-Ended</b>         |                 |                        |                                   |
| 3.3 V LVTTTL / 3.3 V LVCMOS | 3.3             | –                      | 17.55                             |
| 2.5 V LVCMOS                | 2.5             | –                      | 5.97                              |
| 1.8 V LVCMOS                | 1.8             | –                      | 2.88                              |
| 1.5 V LVCMOS (JESD8-11)     | 1.5             | –                      | 2.33                              |
| 3.3 V PCI                   | 3.3             | –                      | 19.21                             |
| 3.3 V PCI-X                 | 3.3             | –                      | 19.21                             |
| <b>Differential</b>         |                 |                        |                                   |
| LVDS                        | 2.5             | 2.26                   | 0.82                              |
| LVPECL                      | 3.3             | 5.72                   | 1.16                              |

**Table 2-11 • Summary of I/O Input Buffer Power (per pin) – Default I/O Software Settings**  
Applicable to MSS I/O Banks

|                                               | VCCMSSIOBx (V) | Static Power<br>PDC7 (mW) | Dynamic Power<br>PAC9 (μW/MHz) |
|-----------------------------------------------|----------------|---------------------------|--------------------------------|
| <b>Single-Ended</b>                           |                |                           |                                |
| 3.3 V LVTTTL / 3.3 V LVCMOS                   | 3.3            | –                         | 17.21                          |
| 3.3 V LVCMOS / 3.3 V LVCMOS – Schmitt trigger | 3.3            | –                         | 20.00                          |
| 2.5 V LVCMOS                                  | 2.5            | –                         | 5.55                           |
| 2.5 V LVCMOS – Schmitt trigger                | 2.5            | –                         | 7.03                           |
| 1.8 V LVCMOS                                  | 1.8            | –                         | 2.61                           |
| 1.8 V LVCMOS – Schmitt trigger                | 1.8            | –                         | 2.72                           |
| 1.5 V LVCMOS (JESD8-11)                       | 1.5            | –                         | 1.98                           |
| 1.5 V LVCMOS (JESD8-11) – Schmitt trigger     | 1.5            | –                         | 1.93                           |

**Table 2-12 • Summary of I/O Output Buffer Power (per pin) – Default I/O Software Settings\***  
Applicable to FPGA I/O Banks, I/O Assigned to EMC I/O Pins

|                             | C <sub>LOAD</sub> (pF) | VCCFPGAIOBx<br>(V) | Static Power<br>PDC8 (mW) | Dynamic Power<br>PAC10 (μW/MHz) |
|-----------------------------|------------------------|--------------------|---------------------------|---------------------------------|
| <b>Single-Ended</b>         |                        |                    |                           |                                 |
| 3.3 V LVTTTL / 3.3 V LVCMOS | 35                     | 3.3                | –                         | 475.66                          |
| 2.5 V LVCMOS                | 35                     | 2.5                | –                         | 270.50                          |
| 1.8 V LVCMOS                | 35                     | 1.8                | –                         | 152.17                          |
| 1.5 V LVCMOS (JESD8-11)     | 35                     | 1.5                | –                         | 104.44                          |
| 3.3 V PCI                   | 10                     | 3.3                | –                         | 202.69                          |
| 3.3 V PCI-X                 | 10                     | 3.3                | –                         | 202.69                          |
| <b>Differential</b>         |                        |                    |                           |                                 |
| LVDS                        | –                      | 2.5                | 7.74                      | 88.26                           |
| LVPECL                      | –                      | 3.3                | 19.54                     | 164.99                          |

*Note:* \*Dynamic power consumption is given for standard load and software default drive strength and output slew.

**Table 2-13 • Summary of I/O Output Buffer Power (per pin) – Default I/O Software Settings**  
Applicable to MSS I/O Banks

|                             | C <sub>LOAD</sub> (pF) | VCCMSSIOBx (V) | Static Power<br>PDC8 (mW) <sup>2</sup> | Dynamic Power<br>PAC10 (μW/MHz) <sup>3</sup> |
|-----------------------------|------------------------|----------------|----------------------------------------|----------------------------------------------|
| <b>Single-Ended</b>         |                        |                |                                        |                                              |
| 3.3 V LVTTTL / 3.3 V LVCMOS | 10                     | 3.3            | –                                      | 155.65                                       |
| 2.5 V LVCMOS                | 10                     | 2.5            | –                                      | 88.23                                        |
| 1.8 V LVCMOS                | 10                     | 1.8            | –                                      | 45.03                                        |
| 1.5 V LVCMOS (JESD8-11)     | 10                     | 1.5            | –                                      | 31.01                                        |

## Power Consumption of Various Internal Resources

**Table 2-14 • Different Components Contributing to Dynamic Power Consumption in SmartFusion cSoCs**

| Parameter | Definition                                                                | Power Supply                                                |                                                                                            | Device |        |        | Units  |
|-----------|---------------------------------------------------------------------------|-------------------------------------------------------------|--------------------------------------------------------------------------------------------|--------|--------|--------|--------|
|           |                                                                           | Name                                                        | Domain                                                                                     | A2F060 | A2F200 | A2F500 |        |
| PAC1      | Clock contribution of a Global Rib                                        | VCC                                                         | 1.5 V                                                                                      | 3.39   | 3.40   | 5.05   | μW/MHz |
| PAC2      | Clock contribution of a Global Spine                                      | VCC                                                         | 1.5 V                                                                                      | 1.14   | 1.83   | 2.50   | μW/MHz |
| PAC3      | Clock contribution of a VersaTile row                                     | VCC                                                         | 1.5 V                                                                                      | 1.15   | 1.15   | 1.15   | μW/MHz |
| PAC4      | Clock contribution of a VersaTile used as a sequential module             | VCC                                                         | 1.5 V                                                                                      | 0.12   | 0.12   | 0.12   | μW/MHz |
| PAC5      | First contribution of a VersaTile used as a sequential module             | VCC                                                         | 1.5 V                                                                                      | 0.07   | 0.07   | 0.07   | μW/MHz |
| PAC6      | Second contribution of a VersaTile used as a sequential module            | VCC                                                         | 1.5 V                                                                                      | 0.29   | 0.29   | 0.29   | μW/MHz |
| PAC7      | Contribution of a VersaTile used as a combinatorial module                | VCC                                                         | 1.5 V                                                                                      | 0.29   | 0.29   | 0.29   | μW/MHz |
| PAC8      | Average contribution of a routing net                                     | VCC                                                         | 1.5 V                                                                                      | 1.04   | 0.79   | 0.79   | μW/MHz |
| PAC9      | Contribution of an I/O input pin (standard dependent)                     | VCCxxxxIOBx/VCC                                             | See <a href="#">Table 2-10</a> and <a href="#">Table 2-11</a> on <a href="#">page 2-11</a> |        |        |        |        |
| PAC10     | Contribution of an I/O output pin (standard dependent)                    | VCCxxxxIOBx/VCC                                             | See <a href="#">Table 2-12</a> and <a href="#">Table 2-13</a> on <a href="#">page 2-11</a> |        |        |        |        |
| PAC11     | Average contribution of a RAM block during a read operation               | VCC                                                         | 1.5 V                                                                                      | 25.00  |        |        | μW/MHz |
| PAC12     | Average contribution of a RAM block during a write operation              | VCC                                                         | 1.5 V                                                                                      | 30.00  |        |        | μW/MHz |
| PAC13     | Dynamic Contribution for PLL                                              | VCC                                                         | 1.5 V                                                                                      | 2.60   |        |        | μW/MHz |
| PAC15     | Contribution of NVM block during a read operation (F < 33MHz)             | VCC                                                         | 1.5 V                                                                                      | 358.00 |        |        | μW/MHz |
| PAC16     | 1st contribution of NVM block during a read operation (F > 33MHz)         | VCC                                                         | 1.5 V                                                                                      | 12.88  |        |        | mW     |
| PAC17     | 2nd contribution of NVM block during a read operation (F > 33MHz)         | VCC                                                         | 1.5 V                                                                                      | 4.80   |        |        | μW/MHz |
| PAC18     | Main Crystal Oscillator contribution                                      | VCCMAINXTAL                                                 | 3.3 V                                                                                      | 1.98   |        |        | mW     |
| PAC19a    | RC Oscillator contribution                                                | VCCRCOSC                                                    | 3.3 V                                                                                      | 3.30   |        |        | mW     |
| PAC19b    | RC Oscillator contribution                                                | VCC                                                         | 1.5 V                                                                                      | 3.00   |        |        | mW     |
| PAC20a    | Analog Block Dynamic Power Contribution of the ADC                        | VCC33ADCx                                                   | 3.3 V                                                                                      | 8.25   |        |        | mW     |
| PAC20b    | Analog Block Dynamic Power Contribution of the ADC                        | VCC15ADCx                                                   | 1.5 V                                                                                      | 3.00   |        |        | mW     |
| PAC21     | Low Power Crystal Oscillator contribution                                 | VCCLPXTAL                                                   | 3.3 V                                                                                      | 33.00  |        |        | μW     |
| PAC22     | MSS Dynamic Power Contribution – Running Drysthone at 100MHz <sup>1</sup> | VCC                                                         | 1.5 V                                                                                      | 67.50  |        |        | mW     |
| PAC23     | Temperature Monitor Power Contribution                                    | See <a href="#">Table 2-94</a> on <a href="#">page 2-77</a> | –                                                                                          | 1.23   |        |        | mW     |

**Table 2-14 • Different Components Contributing to Dynamic Power Consumption in SmartFusion cSoCs**

| Parameter | Definition                                        | Power Supply                                 |        | Device |        |        | Units |
|-----------|---------------------------------------------------|----------------------------------------------|--------|--------|--------|--------|-------|
|           |                                                   | Name                                         | Domain | A2F060 | A2F200 | A2F500 |       |
| PAC24     | Current Monitor Power Contribution                | See <a href="#">Table 2-93 on page 2-76</a>  | –      | 1.03   |        |        | mW    |
| PAC25     | ABPS Power Contribution                           | See <a href="#">Table 2-97 on page 2-81</a>  | –      | 0.70   |        |        | mW    |
| PAC26     | Sigma-Delta DAC Power Contribution <sup>2</sup>   | See <a href="#">Table 2-99 on page 2-84</a>  | –      | 0.58   |        |        | mW    |
| PAC27     | Comparator Power Contribution                     | See <a href="#">Table 2-98 on page 2-83</a>  | –      | 1.02   |        |        | mW    |
| PAC28     | Voltage Regulator Power Contribution <sup>3</sup> | See <a href="#">Table 2-100 on page 2-86</a> | –      | 36.30  |        |        | mW    |

**Notes:**

1. For a different use of MSS peripherals and resources, refer to SmartPower.
2. Assumes Input = Half Scale Operation mode.
3. Assumes 100 mA load on 1.5 V domain.

**Table 2-15 • Different Components Contributing to the Static Power Consumption in SmartFusion cSoCs**

| Parameter | Definition                                                           | Power Supply                               |                                                                              | Device |        |        | Units |
|-----------|----------------------------------------------------------------------|--------------------------------------------|------------------------------------------------------------------------------|--------|--------|--------|-------|
|           |                                                                      | Name                                       | Domain                                                                       | A2F060 | A2F200 | A2F500 |       |
| PDC1      | Core static power contribution in SoC mode                           | VCC                                        | 1.5 V                                                                        | 11.10  | 23.70  | 37.95  | mW    |
| PDC2      | Device static power contribution in Standby Mode                     | See <a href="#">Table 2-8 on page 2-10</a> | –                                                                            | 11.10  | 23.70  | 37.95  | mW    |
| PDC3      | Device static power contribution in Time Keeping mode                | See <a href="#">Table 2-8 on page 2-10</a> | 3.3 V                                                                        | 33.00  | 33.00  | 33.00  | μW    |
| PDC7      | Static contribution per input pin (standard dependent contribution)  | VCCxxxxIOBx/VCC                            | See <a href="#">Table 2-10</a> and <a href="#">Table 2-11 on page 2-11</a> . |        |        |        |       |
| PDC8      | Static contribution per output pin (standard dependent contribution) | VCCxxxxIOBx/VCC                            | See <a href="#">Table 2-12</a> and <a href="#">Table 2-13 on page 2-11</a> . |        |        |        |       |
| PDC9      | Static contribution per PLL                                          | VCC                                        | 1.5 V                                                                        | 2.55   | 2.55   | 2.55   | mW    |

**Table 2-16 • eNVM Dynamic Power Consumption**

| Parameter  | Description                     | Condition      | Min.                                          | Typ. | Max. | Units  |
|------------|---------------------------------|----------------|-----------------------------------------------|------|------|--------|
| eNVMSystem | eNVM array operating power      | Idle           |                                               | 795  |      | μA     |
|            |                                 | Read operation | See <a href="#">Table 2-14 on page 2-12</a> . |      |      |        |
|            |                                 | Erase          |                                               | 900  |      | μA     |
|            |                                 | Write          |                                               | 900  |      | μA     |
| PNVMCTRL   | eNVM controller operating power |                |                                               | 20   |      | μW/MHz |

## 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 the Libero IDE software.

The power calculation methodology described below uses the following variables:

- The number of PLLs/CCCs 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
- The number of eNVM blocks used in the design
- The analog block used in the design, including the temperature monitor, current monitor, ABPS, sigma-delta DAC, comparator, low power crystal oscillator, RC oscillator and the main crystal oscillator
- Toggle rates of I/O pins as well as VersaTiles—guidelines are provided in [Table 2-17 on page 2-18](#).
- Enable rates of output buffers—guidelines are provided for typical applications in [Table 2-18 on page 2-18](#).
- Read rate and write rate to the memory—guidelines are provided for typical applications in [Table 2-18 on page 2-18](#).
- Read rate to the eNVM blocks

The calculation should be repeated for each clock domain defined in the design.

### Methodology

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

**SoC Mode, Standby Mode, and Time Keeping Mode.**

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

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

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

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

##### SoC Mode

$$P_{STAT} = P_{DC1} + (N_{INPUTS} * P_{DC7}) + (N_{OUTPUTS} * P_{DC8}) + (N_{PLLS} * P_{DC9})$$

$N_{INPUTS}$  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.

$N_{PLLS}$  is the number of PLLs available in the device.

##### Standby Mode

$$P_{STAT} = P_{DC2}$$

##### Time Keeping Mode

$$P_{STAT} = P_{DC3}$$

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

##### SoC Mode

$$P_{DYN} = P_{CLOCK} + P_{S-CELL} + P_{C-CELL} + P_{NET} + P_{INPUTS} + P_{OUTPUTS} + P_{MEMORY} + P_{PLL} + P_{eNVM} + P_{XTL-OSC} + P_{RC-OSC} + P_{AB} + P_{LPXTAL-OSC} + P_{MSS}$$

**Standby Mode**

$$P_{\text{DYN}} = P_{\text{RC-OSC}} + P_{\text{LPXTAL-OSC}}$$

**Time Keeping Mode**

$$P_{\text{DYN}} = P_{\text{LPXTAL-OSC}}$$

**Global Clock Dynamic Contribution— $P_{\text{CLOCK}}$** **SoC Mode**

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

$N_{\text{SPINE}}$  is the number of global spines used in the user design—guidelines are provided in [Table 2-17 on page 2-18](#).

$N_{\text{ROW}}$  is the number of VersaTile rows used in the design—guidelines are provided in [Table 2-17 on page 2-18](#).

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

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

**Standby Mode and Time Keeping Mode**

$$P_{\text{CLOCK}} = 0 \text{ W}$$

**Sequential Cells Dynamic Contribution— $P_{\text{S-CELL}}$** **SoC Mode**

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

$N_{\text{S-CELL}}$  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 2-17 on page 2-18](#).

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

**Standby Mode and Time Keeping Mode**

$$P_{\text{S-CELL}} = 0 \text{ W}$$

**Combinatorial Cells Dynamic Contribution— $P_{\text{C-CELL}}$** **SoC Mode**

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

$N_{\text{C-CELL}}$  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 2-17 on page 2-18](#).

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

**Standby Mode and Time Keeping Mode**

$$P_{\text{C-CELL}} = 0 \text{ W}$$

**Routing Net Dynamic Contribution— $P_{\text{NET}}$** **SoC Mode**

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

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

$N_{\text{C-CELL}}$  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 2-17 on page 2-18](#).

$F_{\text{CLK}}$  is the frequency of the clock driving the logic including these nets.

### Standby Mode and Time Keeping Mode

$$P_{NET} = 0 \text{ W}$$

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

#### SoC Mode

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

Where:

$N_{INPUTS}$  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 2-17 on page 2-18](#).

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

### Standby Mode and Time Keeping Mode

$$P_{INPUTS} = 0 \text{ W}$$

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

#### SoC Mode

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

Where:

$N_{OUTPUTS}$  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 2-17 on page 2-18](#).

$\beta_1$  is the I/O buffer enable rate—guidelines are provided in [Table 2-18 on page 2-18](#).

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

### Standby Mode and Time Keeping Mode

$$P_{OUTPUTS} = 0 \text{ W}$$

### FPGA Fabric SRAM Dynamic Contribution— $P_{MEMORY}$

#### SoC Mode

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

Where:

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

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

$\beta_2$  is the RAM enable rate for read operations—guidelines are provided in [Table 2-18 on page 2-18](#).

$\beta_3$  the RAM enable rate for write operations—guidelines are provided in [Table 2-18 on page 2-18](#).

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

### Standby Mode and Time Keeping Mode

$$P_{MEMORY} = 0 \text{ W}$$

### PLL/CCC Dynamic Contribution— $P_{PLL}$

#### SoC Mode

$$P_{PLL} = P_{AC13} * F_{CLKOUT}$$

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

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

### Standby Mode and Time Keeping Mode

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 output clock by adding its corresponding contribution ( $P_{AC14} * F_{CLKOUT}$  product) to the total PLL contribution.



$$P_{PLL} = 0 \text{ W}$$

### **Embedded Nonvolatile Memory Dynamic Contribution— $P_{eNVM}$**

#### **SoC Mode**

The eNVM dynamic power consumption is a piecewise linear function of frequency.

$$P_{eNVM} = N_{eNVM-BLOCKS} * \beta_4 * P_{AC15} * F_{READ-eNVM} \text{ when } F_{READ-eNVM} \leq 33 \text{ MHz,}$$

$$P_{eNVM} = N_{eNVM-BLOCKS} * \beta_4 * (P_{AC16} + P_{AC17} * F_{READ-eNVM}) \text{ when } F_{READ-eNVM} > 33 \text{ MHz}$$

Where:

$N_{eNVM-BLOCKS}$  is the number of eNVM blocks used in the design.

$\beta_4$  is the eNVM enable rate for read operations. Default is 0 (eNVM mainly in idle state).

$F_{READ-eNVM}$  is the eNVM read clock frequency.

#### **Standby Mode and Time Keeping Mode**

$$P_{eNVM} = 0 \text{ W}$$

### **Main Crystal Oscillator Dynamic Contribution— $P_{XTL-OSC}$**

#### **SoC Mode**

$$P_{XTL-OSC} = P_{AC18}$$

#### **Standby Mode**

$$P_{XTL-OSC} = 0 \text{ W}$$

#### **Time Keeping Mode**

$$P_{XTL-OSC} = 0 \text{ W}$$

### **Low Power Oscillator Crystal Dynamic Contribution— $P_{LPXTAL-OSC}$**

#### **Operating, Standby, and Time Keeping Mode**

$$P_{LPXTAL-OSC} = P_{AC21}$$

### **RC Oscillator Dynamic Contribution— $P_{RC-OSC}$**

#### **SoC Mode**

$$P_{RC-OSC} = P_{AC19A} + P_{AC19B}$$

#### **Standby Mode and Time Keeping Mode**

$$P_{RC-OSC} = 0 \text{ W}$$

### **Analog System Dynamic Contribution— $P_{AB}$**

#### **SoC Mode**

$$P_{AB} = P_{AC23} * N_{TM} + P_{AC24} * N_{CM} + P_{AC25} * N_{ABPS} + P_{AC26} * N_{SDD} + P_{AC27} * N_{COMP} + P_{ADC} * N_{ADC} + P_{VR}$$

Where:

$N_{CM}$  is the number of current monitor blocks

$N_{TM}$  is the number of temperature monitor blocks

$N_{SDD}$  is the number of sigma-delta DAC blocks

$N_{ABPS}$  is the number of ABPS blocks

$N_{ADC}$  is the number of ADC blocks

$N_{COMP}$  is the number of comparator blocks

$$P_{VR} = P_{AC28}$$

$$P_{ADC} = P_{AC20A} + P_{AC20B}$$

## Microcontroller Subsystem Dynamic Contribution— $P_{MSS}$

### SoC Mode

$$P_{MSS} = P_{AC22}$$

## 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 the net switches at half the clock frequency. Below are some examples:

- The average toggle rate of a shift register is 100%, as 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 =  $(100\% + 50\% + 25\% + 12.5\% + \dots 0.78125\%) / 8$ .

### Enable Rate Definition

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

**Table 2-17 • Toggle Rate Guidelines Recommended for Power Calculation**

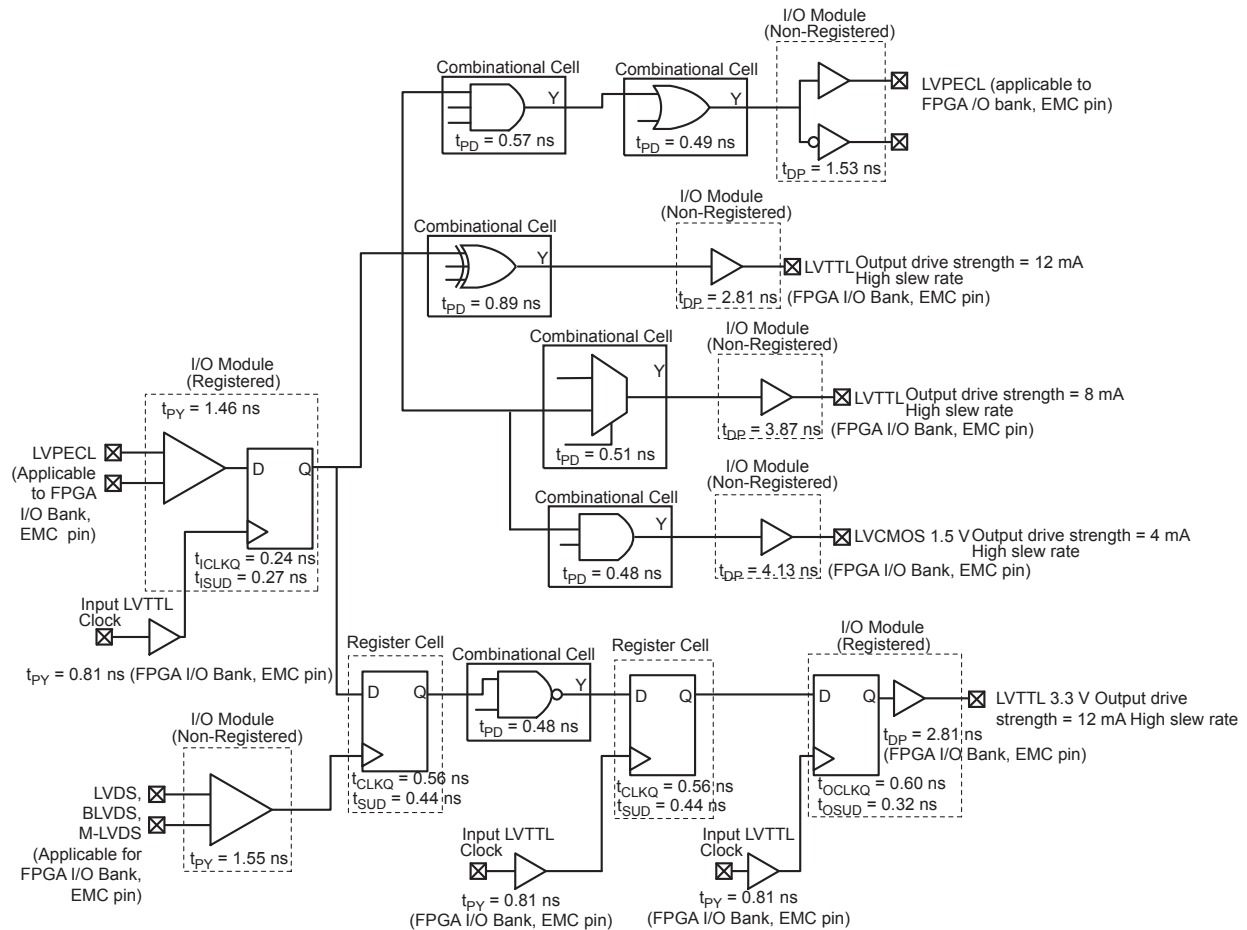
| Component  | Definition                       | Guideline |
|------------|----------------------------------|-----------|
| $\alpha_1$ | Toggle rate of VersaTile outputs | 10%       |
| $\alpha_2$ | I/O buffer toggle rate           | 10%       |

**Table 2-18 • Enable Rate Guidelines Recommended for Power Calculation**

| Component | Definition                                        | Guideline                                          |
|-----------|---------------------------------------------------|----------------------------------------------------|
| $\beta_1$ | I/O output buffer enable rate                     | Toggle rate of the logic driving the output buffer |
| $\beta_2$ | FPGA fabric SRAM enable rate for read operations  | 12.5%                                              |
| $\beta_3$ | FPGA fabric SRAM enable rate for write operations | 12.5%                                              |
| $\beta_4$ | eNVM enable rate for read operations              | < 5%                                               |

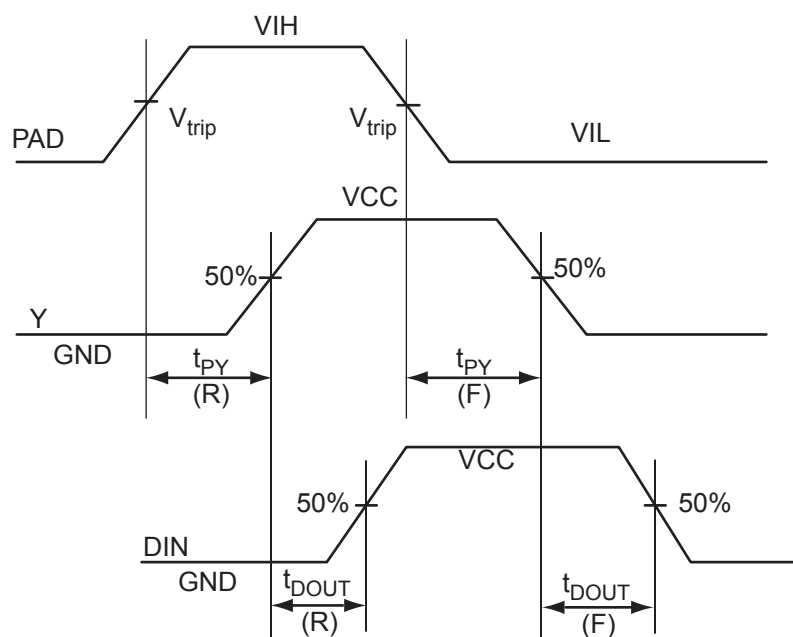
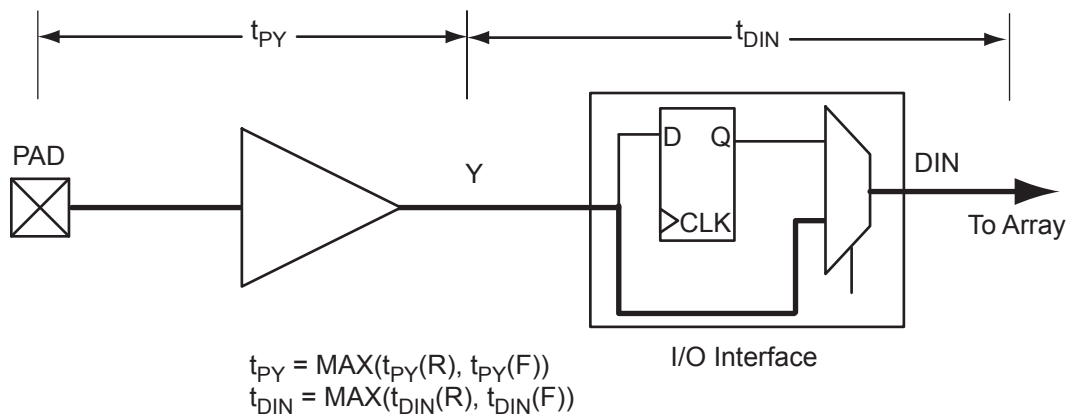
# User I/O Characteristics

## Timing Model

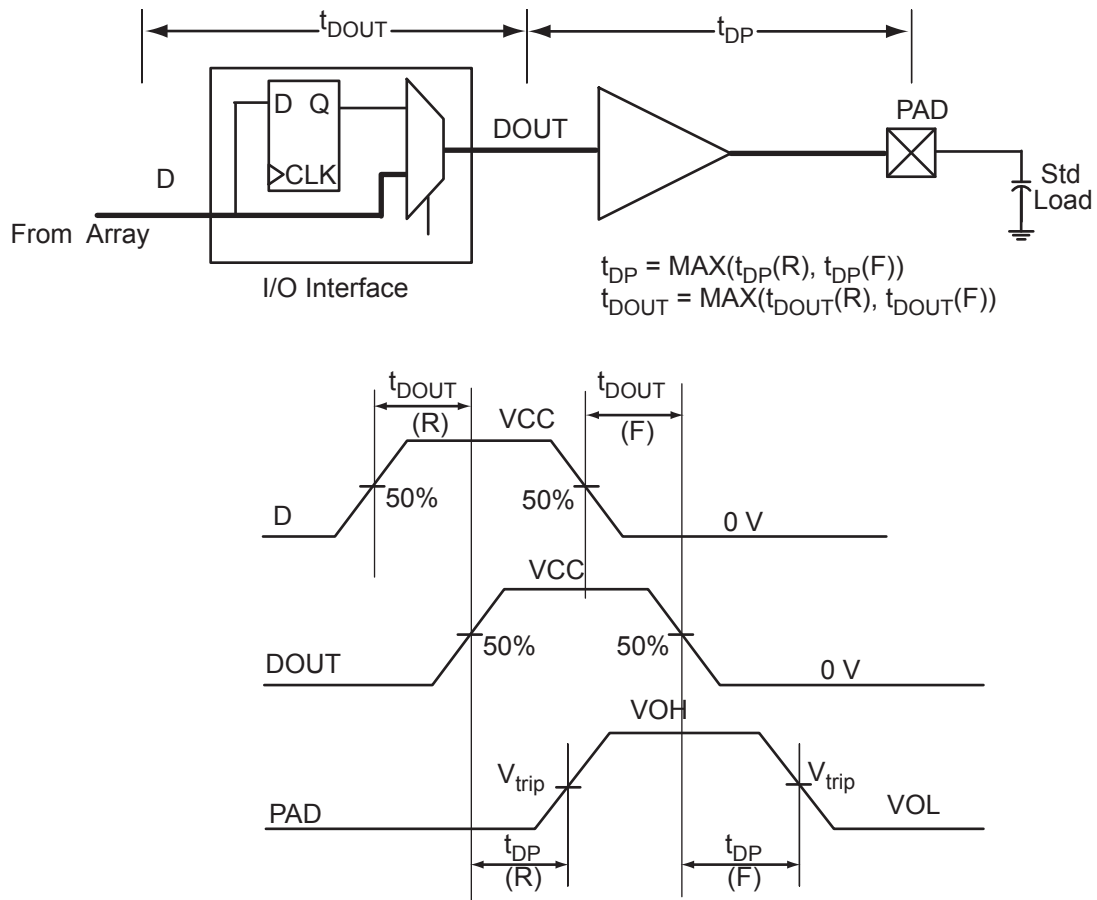


**Figure 2-2 • Timing Model**

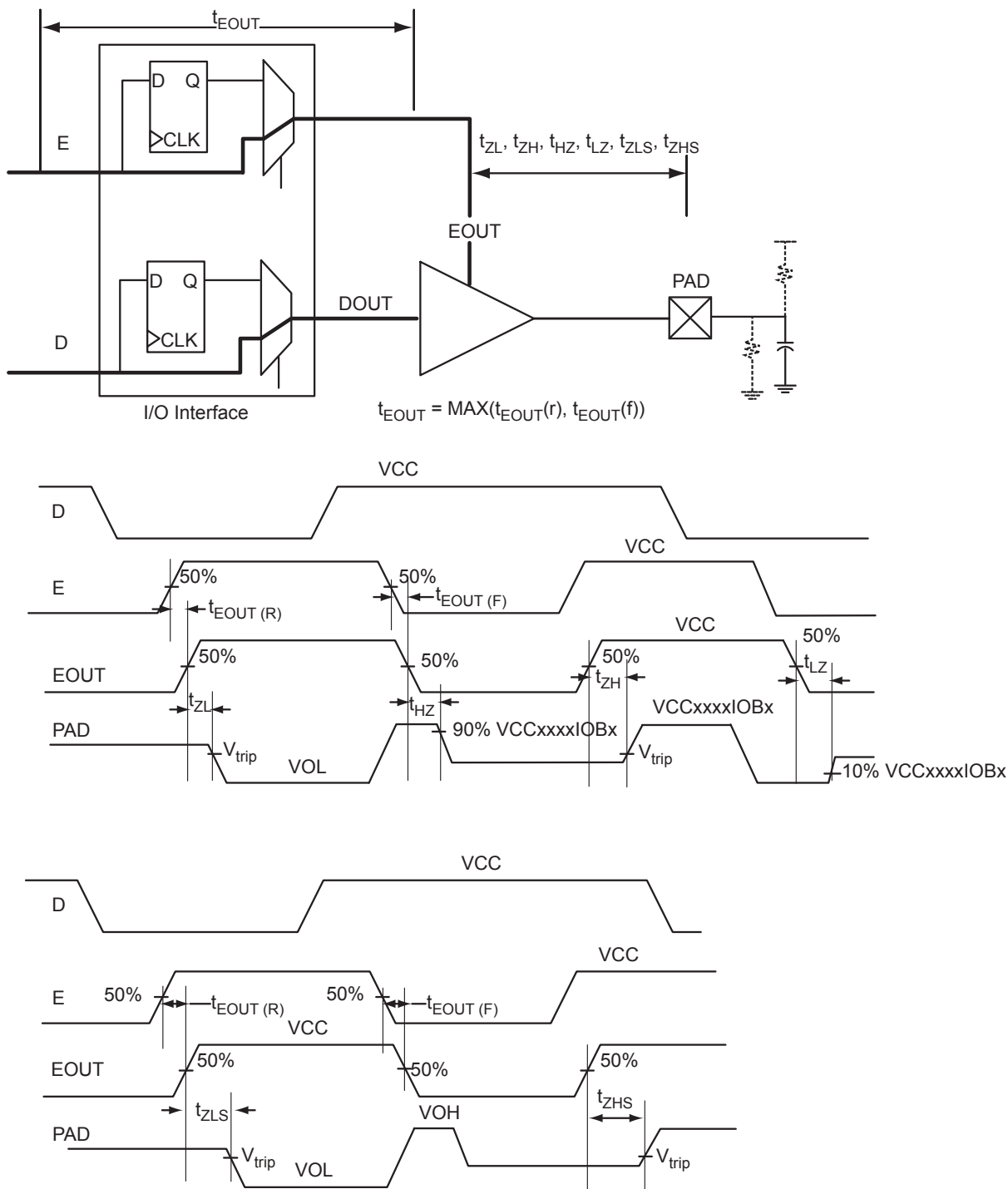
**Operating Conditions: -1 Speed, Commercial Temperature Range ( $T_J = 85^\circ\text{C}$ ), Worst Case VCC = 1.425 V**



**Figure 2-3 • Input Buffer Timing Model and Delays (example)**



**Figure 2-4 • Output Buffer Model and Delays (example)**



**Figure 2-5 • 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 2-19 • Summary of Maximum and Minimum DC Input and Output Levels Applicable to Commercial Conditions—Software Default Settings**  
Applicable to FPGA I/O Banks

| I/O Standard                | Drive Strgth.            | Slew Rate | VIL    |                       | VIH                  |        | VOL                   | VOH                   | I <sub>OL</sub> <sup>1</sup> | I <sub>OH</sub> <sup>1</sup> |
|-----------------------------|--------------------------|-----------|--------|-----------------------|----------------------|--------|-----------------------|-----------------------|------------------------------|------------------------------|
|                             |                          |           | 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 *<br>VCCxxxxIOBx | 0.65*<br>VCCxxxxIOBx | 3.6    | 0.45                  | VCCxxxxIOBx<br>− 0.45 | 12                           | 12                           |
| 1.5 V LVCMOS                | 12 mA                    | High      | −0.3   | 0.35 *<br>VCCxxxxIOBx | 0.65*<br>VCCxxxxIOBx | 3.6    | 0.25 *<br>VCCxxxxIOBx | 0.75*<br>VCCxxxxIOBx  | 12                           | 12                           |
| 3.3 V PCI                   | Per PCI specifications   |           |        |                       |                      |        |                       |                       |                              |                              |
| 3.3 V PCI-X                 | Per PCI-X specifications |           |        |                       |                      |        |                       |                       |                              |                              |

**Notes:**

1. Currents are measured at 85°C junction temperature.
2. Output slew rate can be extracted by the IBIS Models.

**Table 2-20 • Summary of Maximum and Minimum DC Input and Output Levels Applicable to Commercial Conditions—Software Default Settings**  
Applicable to MSS I/O Banks

| I/O Standard                | Drive Strgth. | Slew Rate | VIL    |                      | VIH                  |        | VOL                  | VOH                   | I <sub>OL</sub> <sup>1</sup> | I <sub>OH</sub> <sup>1</sup> |
|-----------------------------|---------------|-----------|--------|----------------------|----------------------|--------|----------------------|-----------------------|------------------------------|------------------------------|
|                             |               |           | 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*<br>VCCxxxxIOBx | 0.65*<br>VCCxxxxIOBx | 3.6    | 0.45                 | VCCxxxxIOBx<br>− 0.45 | 4                            | 4                            |
| 1.5 V LVCMOS                | 2 mA          | High      | −0.3   | 0.35*<br>VCCxxxxIOBx | 0.65*<br>VCCxxxxIOBx | 3.6    | 0.25*<br>VCCxxxxIOBx | 0.75*<br>VCCxxxxIOBx  | 2                            | 2                            |

**Notes:**

1. Currents are measured at 85°C junction temperature.
2. Output slew rate can be extracted by the IBIS Models.

**Table 2-21 • Summary of Maximum and Minimum DC Input Levels**  
 Applicable to Commercial Conditions in all I/O Bank Types

| DC I/O Standards            | Commercial |          |
|-----------------------------|------------|----------|
|                             | $I_{IL}$   | $I_{IH}$ |
|                             | $\mu A$    | $\mu A$  |
| 3.3 V LVTTTL / 3.3 V LVCMOS | 15         | 15       |
| 2.5 V LVCMOS                | 15         | 15       |
| 1.8 V LVCMOS                | 15         | 15       |
| 1.5 V LVCMOS                | 15         | 15       |
| 3.3 V PCI                   | 15         | 15       |
| 3.3 V PCI-X                 | 15         | 15       |

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

**Table 2-22 • Summary of AC Measuring Points Applicable to All I/O Bank Types**

| Standard                    | Measuring Trip Point ( $V_{trip}$ ) |
|-----------------------------|-------------------------------------|
| 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                   | $0.285 * VCC_{xxxIOBx} (RR)$        |
|                             | $0.615 * VCC_{xxxIOBx} (FF)$        |
| 3.3 V PCI-X                 | $0.285 * VCC_{xxxIOBx} (RR)$        |
|                             | $0.615 * VCC_{xxxIOBx} (FF)$        |
| LVDS                        | Cross point                         |
| LVPECL                      | Cross point                         |

**Table 2-23 • I/O AC Parameter Definitions**

| Parameter  | Parameter Definition                                                        |
|------------|-----------------------------------------------------------------------------|
| $t_{DP}$   | Data to pad delay through the output buffer                                 |
| $t_{PY}$   | Pad to data delay through the input buffer                                  |
| $t_{DOUT}$ | Data to output buffer delay through the I/O interface                       |
| $t_{EOUT}$ | Enable to output buffer tristate control delay through the I/O interface    |
| $t_{DIN}$  | Input buffer to data delay through the I/O interface                        |
| $t_{HZ}$   | Enable to pad delay through the output buffer—High to Z                     |
| $t_{ZH}$   | Enable to pad delay through the output buffer—Z to High                     |
| $t_{LZ}$   | Enable to pad delay through the output buffer—Low to Z                      |
| $t_{ZL}$   | Enable to pad delay through the output buffer—Z to Low                      |
| $t_{ZHS}$  | Enable to pad delay through the output buffer with delayed enable—Z to High |
| $t_{ZLS}$  | Enable to pad delay through the output buffer with delayed enable—Z to Low  |



**Table 2-24 • Summary of I/O Timing Characteristics—Software Default Settings**

–1 Speed Grade, Worst Commercial-Case Conditions:  $T_J = 85^{\circ}\text{C}$ , Worst Case VCC = 1.425 V,  
Worst-Case VCCxxxxIOBx (per standard)  
Applicable to FPGA I/O Banks, Assigned to EMC I/O Pins

| I/O Standard                   | Drive Strength    | Slew Rate | Capacitive Load (pF) | External Resistor ( $\Omega$ ) | $t_{\text{DOUT}}$ (ns) | $t_{\text{DP}}$ (ns) | $t_{\text{DIN}}$ (ns) | $t_{\text{PY}}$ (ns) | $t_{\text{EOUT}}$ (ns) | $t_{\text{ZL}}$ (ns) | $t_{\text{ZH}}$ (ns) | $t_{\text{LZ}}$ (ns) | $t_{\text{HZ}}$ (ns) | $t_{\text{ZLS}}$ (ns) | $t_{\text{ZHS}}$ (ns) | Units |
|--------------------------------|-------------------|-----------|----------------------|--------------------------------|------------------------|----------------------|-----------------------|----------------------|------------------------|----------------------|----------------------|----------------------|----------------------|-----------------------|-----------------------|-------|
| 3.3 V LVTTTL /<br>3.3 V LVCMOS | 12 mA             | High      | 35                   | –                              | 0.50                   | 2.81                 | 0.03                  | 0.81                 | 0.32                   | 2.86                 | 2.23                 | 2.55                 | 2.82                 | 4.58                  | 3.94                  | ns    |
| 2.5 V LVCMOS                   | 12 mA             | High      | 35                   | –                              | 0.50                   | 2.73                 | 0.03                  | 1.03                 | 0.32                   | 2.88                 | 2.69                 | 2.62                 | 2.70                 | 4.60                  | 4.41                  | ns    |
| 1.8 V LVCMOS                   | 12 mA             | High      | 35                   | –                              | 0.50                   | 2.81                 | 0.03                  | 0.95                 | 0.32                   | 2.87                 | 2.38                 | 2.92                 | 3.18                 | 4.58                  | 4.10                  | ns    |
| 1.5 V LVCMOS                   | 12 mA             | High      | 35                   | –                              | 0.50                   | 3.24                 | 0.03                  | 1.12                 | 0.32                   | 3.30                 | 2.79                 | 3.10                 | 3.27                 | 5.02                  | 4.50                  | ns    |
| 3.3 V PCI                      | Per PCI spec      | High      | 10                   | 25 <sup>1</sup>                | 0.50                   | 2.11                 | 0.03                  | 0.68                 | 0.32                   | 2.15                 | 1.57                 | 2.55                 | 2.82                 | 3.87                  | 3.28                  | ns    |
| 3.3 V PCI-X                    | Per PCI-X<br>spec | High      | 10                   | 25 <sup>1</sup>                | 0.50                   | 2.11                 | 0.03                  | 0.64                 | 0.32                   | 2.15                 | 1.57                 | 2.55                 | 2.82                 | 3.87                  | 3.28                  | ns    |
| LVDS                           | 24 mA             | High      | –                    | –                              | 0.50                   | 1.53                 | 0.03                  | 1.55                 | –                      | –                    | –                    | –                    | –                    | –                     | –                     | ns    |
| LVPECL                         | 24 mA             | High      | –                    | –                              | 0.50                   | 1.46                 | 0.03                  | 1.46                 | –                      | –                    | –                    | –                    | –                    | –                     | –                     | ns    |

**Notes:**

- Resistance is used to measure I/O propagation delays as defined in PCI specifications. See [Figure 2-10 on page 2-39](#) for connectivity. This resistor is not required during normal operation.
- For specific junction temperature and voltage supply levels, refer to [Table 2-7 on page 2-9](#) for derating values.

**Table 2-25 • Summary of I/O Timing Characteristics—Software Default Settings**

–1 Speed Grade, Worst Commercial-Case Conditions:  $T_J = 85^{\circ}\text{C}$ , Worst Case VCC = 1.425 V,  
Worst-Case VCCxxxxIOBx (per standard)  
Applicable to MSS I/O Banks

| I/O Standard                   | Drive Strength | Slew Rate | Capacitive Load (pF) | External Resistor | $t_{\text{DOUT}}$ (ns) | $t_{\text{DP}}$ (ns) | $t_{\text{DIN}}$ (ns) | $t_{\text{PY}}$ (ns) | $t_{\text{PVS}}$ (ns) | $t_{\text{EOUT}}$ (ns) | $t_{\text{ZL}}$ (ns) | $t_{\text{ZH}}$ (ns) | $t_{\text{LZ}}$ (ns) | $t_{\text{HZ}}$ (ns) | Units |
|--------------------------------|----------------|-----------|----------------------|-------------------|------------------------|----------------------|-----------------------|----------------------|-----------------------|------------------------|----------------------|----------------------|----------------------|----------------------|-------|
| 3.3 V LVTTTL /<br>3.3 V LVCMOS | 8 mA           | High      | 10                   | –                 | 0.18                   | 1.92                 | 0.07                  | 0.78                 | 1.09                  | 0.18                   | 1.96                 | 1.55                 | 1.83                 | 2.04                 | ns    |
| 2.5 V LVCMOS                   | 8 mA           | High      | 10                   | –                 | 0.18                   | 1.96                 | 0.07                  | 0.99                 | 1.16                  | 0.18                   | 2.00                 | 1.82                 | 1.82                 | 1.93                 | ns    |
| 1.8 V LVCMOS                   | 4 mA           | High      | 10                   | –                 | 0.18                   | 2.31                 | 0.07                  | 0.91                 | 1.37                  | 0.18                   | 2.35                 | 2.27                 | 1.84                 | 1.87                 | ns    |
| 1.5 V LVCMOS                   | 2 mA           | High      | 10                   | –                 | 0.18                   | 2.70                 | 0.07                  | 1.07                 | 1.55                  | 0.18                   | 2.75                 | 2.67                 | 1.87                 | 1.85                 | ns    |

**Notes:**

- Resistance is used to measure I/O propagation delays as defined in PCI specifications. See [Figure 2-10 on page 2-39](#) for connectivity. This resistor is not required during normal operation.
- For specific junction temperature and voltage supply levels, refer to [Table 2-7 on page 2-9](#) for derating values.

## Detailed I/O DC Characteristics

**Table 2-26 • 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 2-27 • I/O Output Buffer Maximum Resistances<sup>1</sup>**  
 Applicable to FPGA 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                                        |
|                             | 4 mA                        | 100                                          | 200                                        |
|                             | 6 mA                        | 50                                           | 100                                        |
|                             | 8 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 information only. Minimum output buffer resistance values depend on  $V_{CCxxxIOBx}$ , drive strength selection, temperature, and process. For board design considerations and detailed output buffer resistances, use the corresponding IBIS models located on the Microsemi SoC Products Group website at <http://www.actel.com/download/ibis/default.aspx> (also generated by the SoC Products Group Libero IDE toolset).
2.  $R_{(PULL-DOWN-MAX)} = (V_{OLspec}) / I_{OLspec}$
3.  $R_{(PULL-UP-MAX)} = (V_{CCImax} - V_{OHspec}) / I_{OHspec}$

**Table 2-28 • I/O Output Buffer Maximum Resistances<sup>1</sup>**  
Applicable to MSS 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 | 8mA            | 50                                         | 150                                      |
| 2.5 V LVCMOS                | 8 mA           | 50                                         | 100                                      |
| 1.8 V LVCMOS                | 4 mA           | 100                                        | 112                                      |
| 1.5 V LVCMOS                | 2 mA           | 200                                        | 224                                      |

**Notes:**

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

**Table 2-29 • I/O Weak Pull-Up/Pull-Down Resistances**  
Minimum and Maximum Weak Pull-Up/Pull-Down Resistance Values

| VCCxxxIOBx | 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.  $R_{(WEAK PULL-DOWN-MAX)} = (V_{OLspec}) / I_{(WEAK PULL-DOWN-MIN)}$
2.  $R_{(WEAK PULL-UP-MAX)} = (V_{CCI_{max}} - V_{OHspec}) / I_{(WEAK PULL-UP-MIN)}$

**Table 2-30 • I/O Short Currents  $I_{OSH}/I_{OSL}$**   
 Applicable to FPGA 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             |
| 2.5 V LVCMOS                | 2 mA                        | 18              | 16              |
|                             | 4 mA                        | 18              | 16              |
|                             | 6 mA                        | 37              | 32              |
|                             | 8 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             |

Note: \* $T_J = 85^\circ\text{C}$ .

**Table 2-31 • I/O Short Currents  $I_{OSH}/I_{OSL}$**   
 Applicable to MSS I/O Banks

|                             | Drive Strength | $I_{OSL}$ (mA)* | $I_{OSH}$ (mA)* |
|-----------------------------|----------------|-----------------|-----------------|
| 3.3 V LVTTTL / 3.3 V LVCMOS | 8 mA           | 54              | 51              |
| 2.5 V LVCMOS                | 8 mA           | 37              | 32              |
| 1.8 V LVCMOS                | 4 mA           | 22              | 17              |
| 1.5 V LVCMOS                | 2 mA           | 16              | 13              |

Note: \* $T_J = 85^\circ\text{C}$

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 100°C, the short current condition would have to be sustained for more than 2200 operation hours 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 2-32 • Duration of Short Circuit Event before Failure**

| Temperature | Time before Failure |
|-------------|---------------------|
| –40°C       | > 20 years          |
| 0°C         | > 20 years          |
| 25°C        | > 20 years          |
| 70°C        | 5 years             |
| 85°C        | 2 years             |
| 100°C       | 6 months            |

**Table 2-33 • Schmitt Trigger Input Hysteresis**  
Hysteresis Voltage Value (typical) for Schmitt Mode Input Buffers

| Input Buffer Configuration                                 | Hysteresis Value (typical) |
|------------------------------------------------------------|----------------------------|
| 3.3 V LVTTTL / LVCMOS / PCI / PCI-X (Schmitt trigger mode) | 240 mV                     |
| 2.5 V LVCMOS (Schmitt trigger mode)                        | 140 mV                     |
| 1.8 V LVCMOS (Schmitt trigger mode)                        | 80 mV                      |
| 1.5 V LVCMOS (Schmitt trigger mode)                        | 60 mV                      |

**Table 2-34 • 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 (100°C) |
| LVDS/B-LVDS/<br>M-LVDS/LVPECL | No requirement              | 10 ns *                     | 10 years (100°C) |

**Note:** \*The maximum input rise/fall time is related to the noise induced into the input buffer trace. If the noise is low, then 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. Microsemi SoC Products Group recommends signal integrity evaluation/characterization of the system to ensure that there is no excessive noise coupling into input signals.

## Single-Ended I/O Characteristics

### 3.3 V LVTTL / 3.3 V LVCMOS

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

**Table 2-35 • Minimum and Maximum DC Input and Output Levels**  
Applicable to FPGA I/O Banks

| 3.3 V LVTTL /<br>3.3 V LVCMOS | VIL       |           | VIH       |           | VOL       | VOH       | IOL | IOH | IOSL                    | IOSH                    | IIL             | IiH             |
|-------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----|-----|-------------------------|-------------------------|-----------------|-----------------|
| Drive Strength                | Min.<br>V | Max.<br>V | Min.<br>V | Max.<br>V | Max.<br>V | Min.<br>V | mA  | mA  | Max.<br>mA <sup>1</sup> | Max.<br>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                      | 15              | 15              |
| 4 mA                          | −0.3      | 0.8       | 2         | 3.6       | 0.4       | 2.4       | 4   | 4   | 27                      | 25                      | 15              | 15              |
| 6 mA                          | −0.3      | 0.8       | 2         | 3.6       | 0.4       | 2.4       | 6   | 6   | 54                      | 51                      | 15              | 15              |
| 8 mA                          | −0.3      | 0.8       | 2         | 3.6       | 0.4       | 2.4       | 8   | 8   | 54                      | 51                      | 15              | 15              |
| 12 mA                         | −0.3      | 0.8       | 2         | 3.6       | 0.4       | 2.4       | 12  | 12  | 109                     | 103                     | 15              | 15              |
| 16 mA                         | −0.3      | 0.8       | 2         | 3.6       | 0.4       | 2.4       | 16  | 16  | 127                     | 132                     | 15              | 15              |
| 24 mA                         | −0.3      | 0.8       | 2         | 3.6       | 0.4       | 2.4       | 24  | 24  | 181                     | 268                     | 10              | 10              |

**Notes:**

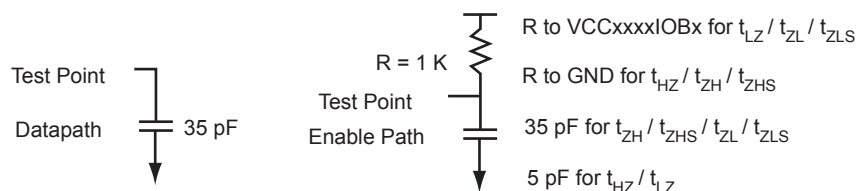
1. Currents are measured at 100°C junction temperature and maximum voltage.
2. Currents are measured at 85°C junction temperature.
3. Software default selection highlighted in gray.

**Table 2-36 • Minimum and Maximum DC Input and Output Levels**  
Applicable to MSS I/O Banks

| 3.3 V LVTTL /<br>3.3 V LVCMOS | VIL       |           | VIH       |           | VOL       | VOH       | IOL | IOH | IOSL                    | IOSH                    | IIL             | IiH             |
|-------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----|-----|-------------------------|-------------------------|-----------------|-----------------|
| Drive Strength                | Min.<br>V | Max.<br>V | Min.<br>V | Max.<br>V | Max.<br>V | Min.<br>V | mA  | mA  | Max.<br>mA <sup>1</sup> | Max.<br>mA <sup>1</sup> | μA <sup>2</sup> | μA <sup>2</sup> |
| 8 mA                          | −0.3      | 0.8       | 2         | 3.6       | 0.4       | 2.4       | 8   | 8   | 54                      | 51                      | 15              | 15              |

**Notes:**

1. Currents are measured at 100°C junction temperature and maximum voltage.
2. Currents are measured at 85°C junction temperature.
3. Software default selection highlighted in gray.



**Figure 2-6 • AC Loading**

**Table 2-37 • AC Waveforms, Measuring Points, and Capacitive Loads**

| Input Low (V) | Input High (V) | Measuring Point* (V) | VREF (typ.) (V) | CLOAD (pF) |
|---------------|----------------|----------------------|-----------------|------------|
| 0             | 3.3            | 1.4                  | —               | 35         |

**Note:** \*Measuring point =  $V_{trip}$ . See Table 2-22 on page 2-24 for a complete table of trip points.

### Timing Characteristics

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

Worst Commercial-Case Conditions:  $T_J = 85^\circ\text{C}$ , Worst-Case VCC = 1.425 V,

Worst-Case VCCxxxxIOBx = 3.0 V

Applicable to FPGA I/O Banks, I/O Assigned to EMC I/O Pins

| 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.        | 0.60       | 7.20     | 0.04      | 0.97     | 0.39       | 7.34     | 6.18     | 2.52     | 2.46     | 9.39      | 8.23      | ns    |
|                | –1          | 0.50       | 6.00     | 0.03      | 0.81     | 0.32       | 6.11     | 5.15     | 2.10     | 2.05     | 7.83      | 6.86      | ns    |
| 8 mA           | Std.        | 0.60       | 4.64     | 0.04      | 0.97     | 0.39       | 4.73     | 3.84     | 2.85     | 3.02     | 6.79      | 5.90      | ns    |
|                | –1          | 0.50       | 3.87     | 0.03      | 0.81     | 0.32       | 3.94     | 3.20     | 2.37     | 2.52     | 5.65      | 4.91      | ns    |
| 12 mA          | Std.        | 0.60       | 3.37     | 0.04      | 0.97     | 0.39       | 3.43     | 2.67     | 3.07     | 3.39     | 5.49      | 4.73      | ns    |
|                | –1          | 0.50       | 2.81     | 0.03      | 0.81     | 0.32       | 2.86     | 2.23     | 2.55     | 2.82     | 4.58      | 3.94      | ns    |
| 16 mA          | Std.        | 0.60       | 3.18     | 0.04      | 0.97     | 0.39       | 3.24     | 2.43     | 3.11     | 3.48     | 5.30      | 4.49      | ns    |
|                | –1          | 0.50       | 2.65     | 0.03      | 0.81     | 0.32       | 2.70     | 2.03     | 2.59     | 2.90     | 4.42      | 3.74      | ns    |
| 24 mA          | Std.        | 0.60       | 2.93     | 0.04      | 0.97     | 0.39       | 2.99     | 2.03     | 3.17     | 3.83     | 5.05      | 4.09      | ns    |
|                | –1          | 0.50       | 2.45     | 0.03      | 0.81     | 0.32       | 2.49     | 1.69     | 2.64     | 3.19     | 4.21      | 3.41      | ns    |

Notes:

- Software default selection highlighted in gray.
- For specific junction temperature and voltage supply levels, refer to [Table 2-7 on page 2-9](#) for derating values.

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

Worst Commercial-Case Conditions:  $T_J = 85^\circ\text{C}$ , Worst-Case VCC = 1.425 V,

Worst-Case VCCxxxxIOBx = 3.0 V

Applicable to FPGA I/O Banks, I/O Assigned to EMC I/O Pins

| 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.        | 0.60       | 9.75     | 0.04      | 0.97     | 0.39       | 9.93     | 8.22     | 2.52     | 2.31     | 11.99     | 10.28     | ns    |
|                | –1          | 0.50       | 8.12     | 0.03      | 0.81     | 0.32       | 8.27     | 6.85     | 2.10     | 1.93     | 9.99      | 8.57      | ns    |
| 8 mA           | Std.        | 0.60       | 6.96     | 0.04      | 0.97     | 0.39       | 7.09     | 5.85     | 2.84     | 2.87     | 9.15      | 7.91      | ns    |
|                | –1          | 0.50       | 5.80     | 0.03      | 0.81     | 0.32       | 5.91     | 4.88     | 2.37     | 2.39     | 7.62      | 6.59      | ns    |
| 12 mA          | Std.        | 0.60       | 5.35     | 0.04      | 0.97     | 0.39       | 5.45     | 4.58     | 3.06     | 3.23     | 7.51      | 6.64      | ns    |
|                | –1          | 0.50       | 4.46     | 0.03      | 0.81     | 0.32       | 4.54     | 3.82     | 2.55     | 2.69     | 6.26      | 5.53      | ns    |
| 16 mA          | Std.        | 0.60       | 5.01     | 0.04      | 0.97     | 0.39       | 5.10     | 4.30     | 3.11     | 3.32     | 7.16      | 6.36      | ns    |
|                | –1          | 0.50       | 4.17     | 0.03      | 0.81     | 0.32       | 4.25     | 3.58     | 2.59     | 2.77     | 5.97      | 5.30      | ns    |
| 24 mA          | Std.        | 0.60       | 4.67     | 0.04      | 0.97     | 0.39       | 4.75     | 4.28     | 3.16     | 3.66     | 6.81      | 6.34      | ns    |
|                | –1          | 0.50       | 3.89     | 0.03      | 0.81     | 0.32       | 3.96     | 3.57     | 2.64     | 3.05     | 5.68      | 5.28      | ns    |

Note: For specific junction temperature and voltage supply levels, refer to [Table 2-7 on page 2-9](#) for derating values.

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

Worst Commercial-Case Conditions:  $T_J = 85^\circ\text{C}$ , Worst-Case VCC = 1.425 V,

Worst-Case VCCxxxxIOBx = 3.0 V

Applicable to MSS I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{PYS}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|-----------|------------|----------|----------|----------|----------|-------|
| 8 mA           | Std.        | 0.22       | 2.31     | 0.09      | 0.94     | 1.30      | 0.22       | 2.35     | 1.86     | 2.20     | 2.45     | ns    |
|                | –1          | 0.18       | 1.92     | 0.07      | 0.78     | 1.09      | 0.18       | 1.96     | 1.55     | 1.83     | 2.04     | ns    |

Notes:

- Software default selection highlighted in gray.
- For specific junction temperature and voltage supply levels, refer to [Table 2-7 on page 2-9](#) 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 2-41 • Minimum and Maximum DC Input and Output Levels**  
Applicable to FPGA I/O Banks

| 2.5 V LVCMOS   | VIL    |        | VIH    |        | VOL    | VOH    | IOL | IOH | IOSL                 | IOSH                 | IIL             | IIH             |
|----------------|--------|--------|--------|--------|--------|--------|-----|-----|----------------------|----------------------|-----------------|-----------------|
| 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   | 0.7    | 1.7    | 2.7    | 0.7    | 1.7    | 2   | 2   | 18                   | 16                   | 15              | 15              |
| 4 mA           | −0.3   | 0.7    | 1.7    | 2.7    | 0.7    | 1.7    | 4   | 4   | 18                   | 16                   | 15              | 15              |
| 6 mA           | −0.3   | 0.7    | 1.7    | 2.7    | 0.7    | 1.7    | 6   | 6   | 37                   | 32                   | 15              | 15              |
| 8 mA           | −0.3   | 0.7    | 1.7    | 2.7    | 0.7    | 1.7    | 8   | 8   | 37                   | 32                   | 15              | 15              |
| 12 mA          | −0.3   | 0.7    | 1.7    | 2.7    | 0.7    | 1.7    | 12  | 12  | 74                   | 65                   | 15              | 15              |
| 16 mA          | −0.3   | 0.7    | 1.7    | 2.7    | 0.7    | 1.7    | 16  | 16  | 87                   | 83                   | 15              | 15              |
| 24 mA          | −0.3   | 0.7    | 1.7    | 2.7    | 0.7    | 1.7    | 24  | 24  | 124                  | 169                  | 15              | 15              |

**Notes:**

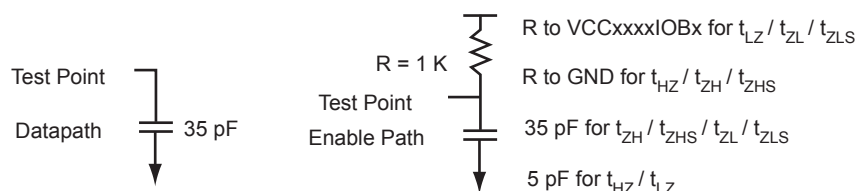
1. Currents are measured at high temperature (100°C junction temperature) and maximum voltage.
2. Currents are measured at 85°C junction temperature.
3. Software default selection highlighted in gray.

**Table 2-42 • Minimum and Maximum DC Input and Output Levels**  
Applicable to MSS I/O Banks

| 2.5 V LVCMOS   | VIL    |        | VIH    |        | VOL    | VOH    | IOL | IOH | IOSL                 | IOSH                 | IIL             | IIH             |
|----------------|--------|--------|--------|--------|--------|--------|-----|-----|----------------------|----------------------|-----------------|-----------------|
| 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> |
| 8 mA           | −0.3   | 0.7    | 1.7    | 3.6    | 0.7    | 1.7    | 8   | 8   | 37                   | 32                   | 15              | 15              |

**Notes:**

1. Currents are measured at high temperature (100°C junction temperature) and maximum voltage.
2. Currents are measured at 85°C junction temperature.
3. Software default selection highlighted in gray.



**Figure 2-7 • AC Loading**

**Table 2-43 • AC Waveforms, Measuring Points, and Capacitive Loads**

| Input Low (V) | Input High (V) | Measuring Point* (V) | V <sub>REF</sub> (typ.) (V) | C <sub>LOAD</sub> (pF) |
|---------------|----------------|----------------------|-----------------------------|------------------------|
| 0             | 2.5            | 1.2                  | —                           | 35                     |

\* Measuring point = V<sub>trip</sub>. See Table 2-22 on page 2-24 for a complete table of trip points.



### Timing Characteristics

**Table 2-44 • 2.5 V LVCMOS High Slew**

Worst Commercial-Case Conditions:  $T_J = 85^\circ\text{C}$ , Worst-Case VCC = 1.425 V,

Worst-Case VCCxxxIOBx = 2.3 V

Applicable to FPGA I/O Banks, I/O Assigned to EMC I/O Pins

| Drive Strength | Speed Grade | $t_{\text{DOUT}}$ | $t_{\text{DP}}$ | $t_{\text{DIN}}$ | $t_{\text{PY}}$ | $t_{\text{EOUT}}$ | $t_{\text{ZL}}$ | $t_{\text{ZH}}$ | $t_{\text{LZ}}$ | $t_{\text{HZ}}$ | $t_{\text{ZLS}}$ | $t_{\text{ZHS}}$ | Units |
|----------------|-------------|-------------------|-----------------|------------------|-----------------|-------------------|-----------------|-----------------|-----------------|-----------------|------------------|------------------|-------|
| 4 mA           | Std.        | 0.55              | 8.10            | 0.04             | 1.23            | 0.39              | 7.37            | 8.10            | 2.54            | 2.17            | 9.43             | 10.15            | ns    |
|                | –1          | 0.46              | 6.75            | 0.03             | 1.03            | 0.32              | 6.14            | 6.75            | 2.12            | 1.81            | 7.85             | 8.46             | ns    |
| 8 mA           | Std.        | 0.55              | 4.85            | 0.04             | 1.23            | 0.39              | 4.76            | 4.85            | 2.90            | 2.83            | 6.82             | 6.91             | ns    |
|                | –1          | 0.46              | 4.04            | 0.03             | 1.03            | 0.32              | 3.97            | 4.04            | 2.42            | 2.36            | 5.68             | 5.76             | ns    |
| 12 mA          | Std.        | 0.60              | 3.28            | 0.04             | 1.23            | 0.39              | 3.46            | 3.23            | 3.15            | 3.24            | 5.52             | 5.29             | ns    |
|                | –1          | 0.50              | 2.73            | 0.03             | 1.03            | 0.32              | 2.88            | 2.69            | 2.62            | 2.70            | 4.60             | 4.41             | ns    |
| 16 mA          | Std.        | 0.60              | 3.09            | 0.04             | 1.23            | 0.39              | 3.27            | 2.88            | 3.20            | 3.35            | 5.33             | 4.94             | ns    |
|                | –1          | 0.50              | 2.57            | 0.03             | 1.03            | 0.32              | 2.72            | 2.40            | 2.67            | 2.79            | 4.44             | 4.12             | ns    |
| 24 mA          | Std.        | 0.60              | 2.95            | 0.04             | 1.23            | 0.39              | 3.01            | 2.31            | 3.27            | 3.76            | 5.07             | 4.37             | ns    |
|                | –1          | 0.50              | 2.46            | 0.03             | 1.03            | 0.32              | 2.51            | 1.93            | 2.73            | 3.13            | 4.22             | 3.64             | ns    |

Notes:

1. Software default selection highlighted in gray.
2. For specific junction temperature and voltage supply levels, refer to [Table 2-7 on page 2-9](#) for derating values.

**Table 2-45 • 2.5 V LVCMOS Low Slew**

Worst Commercial-Case Conditions:  $T_J = 85^\circ\text{C}$ , Worst-Case VCC = 1.425 V,

Worst-Case VCCxxxIOBx = 2.3 V

Applicable to FPGA I/O Banks, I/O Assigned to EMC I/O Pins

| Drive Strength | Speed Grade | $t_{\text{DOUT}}$ | $t_{\text{DP}}$ | $t_{\text{DIN}}$ | $t_{\text{PY}}$ | $t_{\text{EOUT}}$ | $t_{\text{ZL}}$ | $t_{\text{ZH}}$ | $t_{\text{LZ}}$ | $t_{\text{HZ}}$ | $t_{\text{ZLS}}$ | $t_{\text{ZHS}}$ | Units |
|----------------|-------------|-------------------|-----------------|------------------|-----------------|-------------------|-----------------|-----------------|-----------------|-----------------|------------------|------------------|-------|
| 4 mA           | Std.        | 0.55              | 10.50           | 0.04             | 1.23            | 0.39              | 10.69           | 10.50           | 2.54            | 2.07            | 12.75            | 12.56            | ns    |
|                | –1          | 0.46              | 8.75            | 0.03             | 1.03            | 0.32              | 8.91            | 8.75            | 2.12            | 1.73            | 10.62            | 10.47            | ns    |
| 8 mA           | Std.        | 0.55              | 7.61            | 0.04             | 1.23            | 0.39              | 7.46            | 7.19            | 2.81            | 2.66            | 9.52             | 9.25             | ns    |
|                | –1          | 0.46              | 6.34            | 0.03             | 1.03            | 0.32              | 6.22            | 5.99            | 2.34            | 2.22            | 7.93             | 7.71             | ns    |
| 12 mA          | Std.        | 0.60              | 5.92            | 0.04             | 1.23            | 0.39              | 5.79            | 5.45            | 3.04            | 3.06            | 7.85             | 7.51             | ns    |
|                | –1          | 0.50              | 4.93            | 0.03             | 1.03            | 0.32              | 4.83            | 4.54            | 2.53            | 2.55            | 6.54             | 6.26             | ns    |
| 16 mA          | Std.        | 0.60              | 5.53            | 0.04             | 1.23            | 0.39              | 5.40            | 5.09            | 3.09            | 3.16            | 7.46             | 7.14             | ns    |
|                | –1          | 0.50              | 4.61            | 0.03             | 1.03            | 0.32              | 4.50            | 4.24            | 2.58            | 2.64            | 6.22             | 5.95             | ns    |
| 24 mA          | Std.        | 0.60              | 5.18            | 0.04             | 1.23            | 0.39              | 5.28            | 5.14            | 3.27            | 3.64            | 7.34             | 7.20             | ns    |
|                | –1          | 0.50              | 4.32            | 0.03             | 1.03            | 0.32              | 4.40            | 4.29            | 2.72            | 3.03            | 6.11             | 6.00             | ns    |

Note: For specific junction temperature and voltage supply levels, refer to [Table 2-7 on page 2-9](#) for derating values.

**Table 2-46 • 2.5 V LVCMOS High Slew**

Worst Commercial-Case Conditions:  $T_J = 85^\circ\text{C}$ , Worst-Case VCC = 1.425 V,

Worst-Case VCCxxxIOBx = 3.0 V

Applicable to MSS I/O Banks

| Drive Strength | Speed Grade | $t_{\text{DOUT}}$ | $t_{\text{DP}}$ | $t_{\text{DIN}}$ | $t_{\text{PY}}$ | $t_{\text{PYS}}$ | $t_{\text{EOUT}}$ | $t_{\text{ZL}}$ | $t_{\text{ZH}}$ | $t_{\text{LZ}}$ | $t_{\text{HZ}}$ | Units |
|----------------|-------------|-------------------|-----------------|------------------|-----------------|------------------|-------------------|-----------------|-----------------|-----------------|-----------------|-------|
| 8 mA           | Std.        | 0.22              | 2.35            | 0.09             | 1.18            | 1.39             | 0.22              | 2.40            | 2.18            | 2.19            | 2.32            | ns    |
|                | –1          | 0.18              | 1.96            | 0.07             | 0.99            | 1.16             | 0.18              | 2.00            | 1.82            | 1.82            | 1.93            | ns    |

Notes:

1. Software default selection highlighted in gray.
2. For specific junction temperature and voltage supply levels, refer to [Table 2-7 on page 2-9](#) 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 2-47 • Minimum and Maximum DC Input and Output Levels**  
Applicable to FPGA I/O Banks

| 1.8 V LVCMOS   | VIL    |                       | VIH                   |        | VOL    | VOH                | 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   | 0.35 *<br>VCCxxxxIOBx | 0.65 *<br>VCCxxxxIOBx | 1.9    | 0.45   | VCCxxxxIOBx − 0.45 | 2               | 2               | 11                   | 9                    | 15              | 15              |
| 4 mA           | −0.3   | 0.35 *<br>VCCxxxxIOBx | 0.65 *<br>VCCxxxxIOBx | 1.9    | 0.45   | VCCxxxxIOBx − 0.45 | 4               | 4               | 22                   | 17                   | 15              | 15              |
| 6 mA           | −0.3   | 0.35 *<br>VCCxxxxIOBx | 0.65 *<br>VCCxxxxIOBx | 1.9    | 0.45   | VCCxxxxIOBx − 0.45 | 6               | 6               | 44                   | 35                   | 15              | 15              |
| 8 mA           | −0.3   | 0.35 *<br>VCCxxxxIOBx | 0.65 *<br>VCCxxxxIOBx | 1.9    | 0.45   | VCCxxxxIOBx − 0.45 | 8               | 8               | 51                   | 45                   | 15              | 15              |
| 12 mA          | −0.3   | 0.35 *<br>VCCxxxxIOBx | 0.65 *<br>VCCxxxxIOBx | 1.9    | 0.45   | VCCxxxxIOBx − 0.45 | 12              | 12              | 74                   | 91                   | 15              | 15              |
| 16 mA          | −0.3   | 0.35 *<br>VCCxxxxIOBx | 0.65 *<br>VCCxxxxIOBx | 1.9    | 0.45   | VCCxxxxIOBx − 0.45 | 16              | 16              | 74                   | 91                   | 15              | 15              |

Notes:

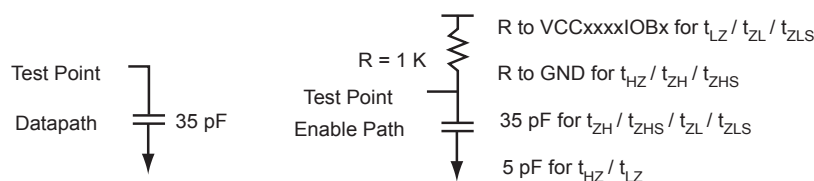
1. Currents are measured at high temperature (100°C junction temperature) and maximum voltage.
2. Currents are measured at 85°C junction temperature.
3. Software default selection highlighted in gray.

**Table 2-48 • Minimum and Maximum DC Input and Output Levels**  
Applicable to MSS I/O Banks

| 1.8 V LVCMOS   | VIL    |                       | VIH                   |        | VOL    | VOH                | 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> |
| 4 mA           | −0.3   | 0.35 *<br>VCCxxxxIOBx | 0.65 *<br>VCCxxxxIOBx | 3.6    | 0.45   | VCCxxxxIOBx − 0.45 | 4               | 4               | 22                   | 17                   | 15              | 15              |

Notes:

1. Currents are measured at high temperature (100°C junction temperature) and maximum voltage.
2. Currents are measured at 85°C junction temperature.
3. Software default selection highlighted in gray.



**Figure 2-8 • AC Loading**

**Table 2-49 • AC Waveforms, Measuring Points, and Capacitive Loads**

| Input Low (V) | Input High (V) | Measuring Point* (V) | V <sub>REF</sub> (typ.) (V) | C <sub>LOAD</sub> (pF) |
|---------------|----------------|----------------------|-----------------------------|------------------------|
| 0             | 1.8            | 0.9                  | —                           | 35                     |

\* Measuring point = V<sub>trip</sub>. See Table 2-22 on page 2-24 for a complete table of trip points.

### Timing Characteristics

**Table 2-50 • 1.8 V LVCMOS High Slew**

Worst Commercial-Case Conditions:  $T_J = 85^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ ,

Worst-Case  $V_{CC} \times \text{IOBx} = 1.7\text{ V}$ 

Applicable to FPGA I/O Banks, I/O Assigned to EMC I/O Pins

| 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.        | 0.60       | 11.06    | 0.04      | 1.14     | 0.39       | 8.61     | 11.06    | 2.61     | 1.59     | 10.67     | 13.12     | ns    |
|                | –1          | 0.50       | 9.22     | 0.03      | 0.95     | 0.32       | 7.17     | 9.22     | 2.18     | 1.33     | 8.89      | 10.93     | ns    |
| 4 mA           | Std.        | 0.60       | 6.46     | 0.04      | 1.14     | 0.39       | 5.53     | 6.46     | 3.04     | 2.66     | 7.59      | 8.51      | ns    |
|                | –1          | 0.50       | 5.38     | 0.03      | 0.95     | 0.32       | 4.61     | 5.38     | 2.54     | 2.22     | 6.33      | 7.10      | ns    |
| 6 mA           | Std.        | 0.60       | 4.16     | 0.04      | 1.14     | 0.39       | 3.99     | 4.16     | 3.34     | 3.18     | 6.05      | 6.22      | ns    |
|                | –1          | 0.50       | 3.47     | 0.03      | 0.95     | 0.32       | 3.32     | 3.47     | 2.78     | 2.65     | 5.04      | 5.18      | ns    |
| 8 mA           | Std.        | 0.60       | 3.69     | 0.04      | 1.14     | 0.39       | 3.76     | 3.67     | 3.40     | 3.31     | 5.81      | 5.73      | ns    |
|                | –1          | 0.50       | 3.07     | 0.03      | 0.95     | 0.32       | 3.13     | 3.06     | 2.84     | 2.76     | 4.85      | 4.78      | ns    |
| 12 mA          | Std.        | 0.60       | 3.38     | 0.04      | 1.14     | 0.39       | 3.44     | 2.86     | 3.50     | 3.82     | 5.50      | 4.91      | ns    |
|                | –1          | 0.50       | 2.81     | 0.03      | 0.95     | 0.32       | 2.87     | 2.38     | 2.92     | 3.18     | 4.58      | 4.10      | ns    |
| 16 mA          | Std.        | 0.60       | 3.38     | 0.04      | 1.14     | 0.39       | 3.44     | 2.86     | 3.50     | 3.82     | 5.50      | 4.91      | ns    |
|                | –1          | 0.50       | 2.81     | 0.03      | 0.95     | 0.32       | 2.87     | 2.38     | 2.92     | 3.18     | 4.58      | 4.10      | ns    |

#### Notes:

- Software default selection highlighted in gray.
- For specific junction temperature and voltage supply levels, refer to [Table 2-7 on page 2-9](#) for derating values.

**Table 2-51 • 1.8 V LVCMOS Low Slew**

Worst Commercial-Case Conditions:  $T_J = 85^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ ,

Worst-Case  $V_{CC} \times \text{IOBx} = 1.7\text{ V}$ 

Applicable to FPGA I/O Banks, I/O Assigned to EMC I/O Pins

| 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.        | 0.60       | 14.24    | 0.04      | 1.14     | 0.39       | 13.47    | 14.24    | 2.62     | 1.54     | 15.53     | 16.30     | ns    |
|                | –1          | 0.50       | 11.87    | 0.03      | 0.95     | 0.32       | 11.23    | 11.87    | 2.18     | 1.28     | 12.94     | 13.59     | ns    |
| 4 mA           | Std.        | 0.60       | 9.74     | 0.04      | 1.14     | 0.39       | 9.92     | 9.62     | 3.05     | 2.57     | 11.98     | 11.68     | ns    |
|                | –1          | 0.50       | 8.11     | 0.03      | 0.95     | 0.32       | 8.26     | 8.02     | 2.54     | 2.14     | 9.98      | 9.74      | ns    |
| 6 mA           | Std.        | 0.60       | 7.67     | 0.04      | 1.14     | 0.39       | 7.81     | 7.24     | 3.34     | 3.08     | 9.87      | 9.30      | ns    |
|                | –1          | 0.50       | 6.39     | 0.03      | 0.95     | 0.32       | 6.51     | 6.03     | 2.79     | 2.56     | 8.23      | 7.75      | ns    |
| 8 mA           | Std.        | 0.60       | 7.15     | 0.04      | 1.14     | 0.39       | 7.29     | 6.75     | 3.41     | 3.21     | 9.34      | 8.80      | ns    |
|                | –1          | 0.50       | 5.96     | 0.03      | 0.95     | 0.32       | 6.07     | 5.62     | 2.84     | 2.68     | 7.79      | 7.34      | ns    |
| 12 mA          | Std.        | 0.60       | 6.76     | 0.04      | 1.14     | 0.39       | 6.89     | 6.75     | 3.50     | 3.70     | 8.95      | 8.81      | ns    |
|                | –1          | 0.50       | 5.64     | 0.03      | 0.95     | 0.32       | 5.74     | 5.62     | 2.92     | 3.08     | 7.46      | 7.34      | ns    |
| 16 mA          | Std.        | 0.60       | 6.76     | 0.04      | 1.14     | 0.39       | 6.89     | 6.75     | 3.50     | 3.70     | 8.95      | 8.81      | ns    |
|                | –1          | 0.50       | 5.64     | 0.03      | 0.95     | 0.32       | 5.74     | 5.62     | 2.92     | 3.08     | 7.46      | 7.34      | ns    |

**Note:** For specific junction temperature and voltage supply levels, refer to [Table 2-7 on page 2-9](#) for derating values.

**Table 2-52 • 1.8 V LVCMOS High Slew**  
**Worst Commercial-Case Conditions:  $T_J = 85^\circ\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ ,**  
**Worst-Case  $V_{CC} \times \text{IOBx} = 1.7\text{ V}$**   
**Applicable to MSS I/O Banks**

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{PYS}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|-----------|------------|----------|----------|----------|----------|-------|
| 4 mA           | Std.        | 0.22       | 2.77     | 0.09      | 1.09     | 1.64      | 0.22       | 2.82     | 2.72     | 2.21     | 2.25     | ns    |
|                | –1          | 0.18       | 2.31     | 0.07      | 0.91     | 1.37      | 0.18       | 2.35     | 2.27     | 1.84     | 1.87     | ns    |

*Notes:*

1. Software default selection highlighted in gray.
2. For specific junction temperature and voltage supply levels, refer to [Table 2-7 on page 2-9](#) 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 2-53 • Minimum and Maximum DC Input and Output Levels**  
Applicable to FPGA I/O Banks

| 1.5 V LVCMOS   | VIL    |                       | VIH                   |        | VOL                   | VOH                   | 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   | 0.35 *<br>VCCxxxxIOBx | 0.65 *<br>VCCxxxxIOBx | 1.575  | 0.25*<br>VCCxxxxIOBx  | 0.75 *<br>VCCxxxxIOBx | 2               | 2               | 16                   | 13                   | 15              | 15              |
| 4 mA           | −0.3   | 0.35*<br>VCCxxxxIOBx  | 0.65 *<br>VCCxxxxIOBx | 1.575  | 0.25*<br>VCCxxxxIOBx  | 0.75 *<br>VCCxxxxIOBx | 4               | 4               | 33                   | 25                   | 15              | 15              |
| 6 mA           | −0.3   | 0.35 *<br>VCCxxxxIOBx | 0.65 *<br>VCCxxxxIOBx | 1.575  | 0.25*<br>VCCxxxxIOBx  | 0.75 *<br>VCCxxxxIOBx | 6               | 6               | 39                   | 32                   | 15              | 15              |
| 8 mA           | −0.3   | 0.35 *<br>VCCxxxxIOBx | 0.65 *<br>VCCxxxxIOBx | 1.575  | 0.25* VCC             | 0.75 *<br>VCCxxxxIOBx | 8               | 8               | 55                   | 66                   | 15              | 15              |
| 12 mA          | −0.3   | 0.35 *<br>VCCxxxxIOBx | 0.65 *<br>VCCxxxxIOBx | 1.575  | 0.25 *<br>VCCxxxxIOBx | 0.75 *<br>VCCxxxxIOBx | 12              | 12              | 55                   | 66                   | 15              | 15              |

Notes:

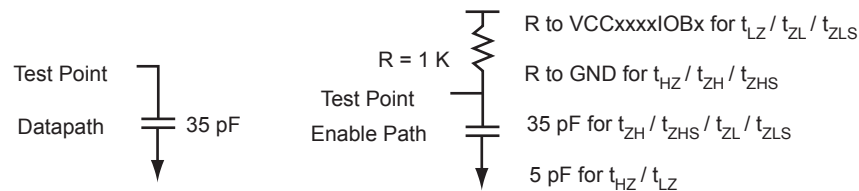
1. Currents are measured at high temperature (100°C junction temperature) and maximum voltage.
2. Currents are measured at 85°C junction temperature.
3. Software default selection highlighted in gray.

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

| 1.5 V LVCMOS   | VIL    |                       | VIH                   |        | VOL                   | VOH                   | 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   | 0.35 *<br>VCCxxxxIOBx | 0.65 *<br>VCCxxxxIOBx | 1.575  | 0.25 *<br>VCCxxxxIOBx | 0.75 *<br>VCCxxxxIOBx | 2               | 2               | 16                   | 13                   | 15              | 15              |

Notes:

1. Currents are measured at high temperature (100°C junction temperature) and maximum voltage.
2. Currents are measured at 85°C junction temperature.
3. Software default selection highlighted in gray.



**Figure 2-9 • AC Loading**

**Table 2-55 • AC Waveforms, Measuring Points, and Capacitive Loads**

| Input Low (V) | Input High (V) | Measuring Point* (V) | V <sub>REF</sub> (typ.) (V) | C <sub>LOAD</sub> (pF) |
|---------------|----------------|----------------------|-----------------------------|------------------------|
| 0             | 1.5            | 0.75                 | −                           | 35                     |

\* Measuring point = V<sub>trip</sub>. See Table 2-22 on page 2-24 for a complete table of trip points.

### Timing Characteristics

**Table 2-56 • 1.5 V LVCMOS High Slew**

Worst Commercial-Case Conditions:  $T_J = 85^\circ\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ ,  
 Worst-Case  $V_{CC} \times \text{IOBx} = 1.425\text{ V}$   
 Applicable to FPGA I/O Banks, I/O Assigned to EMC I/O Pins

| 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 m            | Std.        | 0.60       | 7.79     | 0.04      | 1.34     | 0.39       | 6.43     | 7.79     | 3.19     | 2.59     | 8.49      | 9.85      | ns    |
|                | –1          | 0.50       | 6.49     | 0.03      | 1.12     | 0.32       | 5.36     | 6.49     | 2.66     | 2.16     | 7.08      | 8.21      | ns    |
| 4 mA           | Std.        | 0.60       | 4.95     | 0.04      | 1.34     | 0.39       | 4.61     | 4.96     | 3.53     | 3.19     | 6.67      | 7.02      | ns    |
|                | –1          | 0.50       | 4.13     | 0.03      | 1.12     | 0.32       | 3.85     | 4.13     | 2.94     | 2.66     | 5.56      | 5.85      | ns    |
| 6 mA           | Std.        | 0.60       | 4.36     | 0.04      | 1.34     | 0.39       | 4.34     | 4.36     | 3.60     | 3.34     | 6.40      | 6.42      | ns    |
|                | –1          | 0.50       | 3.64     | 0.03      | 1.12     | 0.32       | 3.62     | 3.64     | 3.00     | 2.78     | 5.33      | 5.35      | ns    |
| 8 mA           | Std.        | 0.60       | 3.89     | 0.04      | 1.34     | 0.39       | 3.96     | 3.34     | 3.72     | 3.92     | 6.02      | 5.40      | ns    |
|                | –1          | 0.50       | 3.24     | 0.03      | 1.12     | 0.32       | 3.30     | 2.79     | 3.10     | 3.27     | 5.02      | 4.50      | ns    |
| 12 mA          | Std.        | 0.60       | 3.89     | 0.04      | 1.34     | 0.39       | 3.96     | 3.34     | 3.72     | 3.92     | 6.02      | 5.40      | ns    |
|                | –1          | 0.50       | 3.24     | 0.03      | 1.12     | 0.32       | 3.30     | 2.79     | 3.10     | 3.27     | 5.02      | 4.50      | ns    |

**Notes:**

1. Software default selection highlighted in gray.
2. For specific junction temperature and voltage supply levels, refer to [Table 2-7 on page 2-9](#) for derating values.

**Table 2-57 • 1.5 V LVCMOS Low Slew**

Worst Commercial-Case Conditions:  $T_J = 85^\circ\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ ,  
 Worst-Case  $V_{CC} \times \text{IOBx} = 1.4\text{ V}$   
 Applicable to FPGA I/O Banks, I/O Assigned to EMC I/O Pins

| 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.        | 0.60       | 11.96    | 0.04      | 1.34     | 0.39       | 12.18    | 11.70    | 3.20     | 2.47     | 14.24     | 13.76     | ns    |
|                | –1          | 0.50       | 9.96     | 0.03      | 1.12     | 0.32       | 10.15    | 9.75     | 2.67     | 2.06     | 11.86     | 11.46     | ns    |
| 4 mA           | Std.        | 0.60       | 9.51     | 0.04      | 1.34     | 0.39       | 9.68     | 8.76     | 3.54     | 3.07     | 11.74     | 10.82     | ns    |
|                | –1          | 0.50       | 7.92     | 0.03      | 1.12     | 0.32       | 8.07     | 7.30     | 2.95     | 2.56     | 9.79      | 9.02      | ns    |
| 6 mA           | Std.        | 0.60       | 8.86     | 0.04      | 1.34     | 0.39       | 9.03     | 8.17     | 3.61     | 3.22     | 11.08     | 10.23     | ns    |
|                | –1          | 0.50       | 7.39     | 0.03      | 1.12     | 0.32       | 7.52     | 6.81     | 3.01     | 2.68     | 9.24      | 8.52      | ns    |
| 8 mA           | Std.        | 0.60       | 8.44     | 0.04      | 1.34     | 0.39       | 8.60     | 8.18     | 3.73     | 3.78     | 10.66     | 10.24     | ns    |
|                | –1          | 0.50       | 7.04     | 0.03      | 1.12     | 0.32       | 7.17     | 6.82     | 3.11     | 3.15     | 8.88      | 8.53      | ns    |
| 12 mA          | Std.        | 0.60       | 8.44     | 0.04      | 1.34     | 0.39       | 8.60     | 8.18     | 3.73     | 3.78     | 10.66     | 10.24     | ns    |
|                | –1          | 0.50       | 7.04     | 0.03      | 1.12     | 0.32       | 7.17     | 6.82     | 3.11     | 3.15     | 8.88      | 8.53      | ns    |

**Note:** For specific junction temperature and voltage supply levels, refer to [Table 2-7 on page 2-9](#) for derating values.

**Table 2-58 • 1.5 V LVCMOS High Slew**

Worst Commercial-Case Conditions:  $T_J = 85^\circ\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ ,  
 Worst-Case  $V_{CC} \times \text{IOBx} = 3.0\text{ V}$   
 Applicable to MSS I/O Banks

| Drive Strength | Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | $t_{PYS}$ | $t_{EOUT}$ | $t_{ZL}$ | $t_{ZH}$ | $t_{LZ}$ | $t_{HZ}$ | Units |
|----------------|-------------|------------|----------|-----------|----------|-----------|------------|----------|----------|----------|----------|-------|
| 2 mA           | Std.        | 0.22       | 3.24     | 0.09      | 1.28     | 1.86      | 0.22       | 3.30     | 3.20     | 2.24     | 2.21     | ns    |
|                | –1          | 0.18       | 2.70     | 0.07      | 1.07     | 1.55      | 0.18       | 2.75     | 2.67     | 1.87     | 1.85     | ns    |

**Notes:**

1. Software default selection highlighted in gray.
2. For specific junction temperature and voltage supply levels, refer to [Table 2-7 on page 2-9](#) for derating values.

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

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

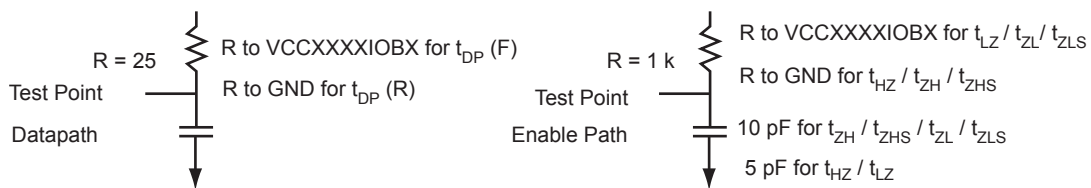
**Table 2-59 • Minimum and Maximum DC Input and Output Levels**

| 3.3 V PCI/PCI-X       | VIL            |           | VIH       |           | VOL       | VOH       | IO <sub>L</sub> | IO <sub>H</sub> | I <sub>OSL</sub>        | I <sub>OSH</sub>        | I <sub>IL</sub> | I <sub>IH</sub> |
|-----------------------|----------------|-----------|-----------|-----------|-----------|-----------|-----------------|-----------------|-------------------------|-------------------------|-----------------|-----------------|
| Drive Strength        | Min.<br>V      | Max.<br>V | Min.<br>V | Max.<br>V | Max.<br>V | Min.<br>V | mA              | mA              | Max.<br>mA <sup>1</sup> | Max.<br>mA <sup>1</sup> | μA <sup>2</sup> | μA <sup>2</sup> |
| Per PCI specification | Per PCI curves |           |           |           |           |           |                 |                 |                         |                         | 15              | 15              |

**Notes:**

1. Currents are measured at high temperature (100°C junction temperature) and maximum voltage.
2. Currents are measured at 85°C junction temperature.

AC loadings are defined per the PCI/PCI-X specifications for the datapath; SoC Products Group loadings for enable path characterization are described in [Figure 2-10](#).



**Figure 2-10 • AC Loading**

AC loadings are defined per PCI/PCI-X specifications for the datapath; SoC Products Group loading for tristate is described in [Table 2-60](#).

**Table 2-60 • AC Waveforms, Measuring Points, and Capacitive Loads**

| Input Low (V) | Input High (V) | Measuring Point* (V)                                                                   | V <sub>REF</sub> (typ.) (V) | C <sub>LOAD</sub> (pF) |
|---------------|----------------|----------------------------------------------------------------------------------------|-----------------------------|------------------------|
| 0             | 3.3            | 0.285 * VCCxxxIOBx for t <sub>DP(R)</sub><br>0.615 * VCCxxxIOBx for t <sub>DP(F)</sub> | –                           | 10                     |

\* Measuring point = V<sub>trip</sub>. See [Table 2-22 on page 2-24](#) for a complete table of trip points.

### Timing Characteristics

**Table 2-61 • 3.3 V PCI**

Worst Commercial-Case Conditions: T<sub>J</sub> = 85°C, Worst-Case VCC = 1.425 V,

Worst-Case VCCxxxIOBx = 3.0 V

Applicable to FPGA I/O Banks, I/O Assigned to EMC I/O Pins

| 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.        | 0.60              | 2.54            | 0.04             | 0.82            | 0.39              | 2.58            | 1.88            | 3.06            | 3.39            | 4.64             | 3.94             | ns    |
| –1          | 0.50              | 2.11            | 0.03             | 0.68            | 0.32              | 2.15            | 1.57            | 2.55            | 2.82            | 3.87             | 3.28             | ns    |

**Note:** For specific junction temperature and voltage supply levels, refer to [Table 2-7 on page 2-9](#) for derating values.

**Table 2-62 • 3.3 V PCI-X**

Worst Commercial-Case Conditions: T<sub>J</sub> = 85°C, Worst-Case VCC = 1.425 V,

Worst-Case VCCxxxIOBx = 3.0 V

Applicable to FPGA I/O Banks, I/O Assigned to EMC I/O Pins

| 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.        | 0.60              | 2.54            | 0.04             | 0.77            | 0.39              | 2.58            | 1.88            | 3.06            | 3.39            | 4.64             | 3.94             | ns    |
| –1          | 0.50              | 2.11            | 0.03             | 0.64            | 0.32              | 2.15            | 1.57            | 2.55            | 2.82            | 3.87             | 3.28             | ns    |

**Note:** For specific junction temperature and voltage supply levels, refer to [Table 2-7 on page 2-9](#) for derating values.

## Differential I/O Characteristics

### Physical Implementation

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

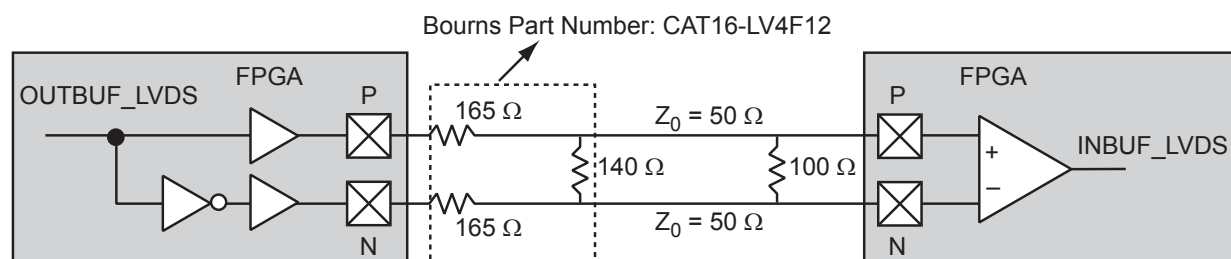
Differential I/Os can also be used in conjunction with the embedded Input Register (InReg), Output Register (OutReg), Enable Register (EnReg), and Double Data Rate (DDR). However, there is no support for bidirectional I/Os or tristates with the LVPECL standards.

### 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 2-11](#). 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, SmartFusion cSoCs also support bus LVDS structure and multipoint LVDS (M-LVDS) configuration (up to 40 nodes).



**Figure 2-11 • LVDS Circuit Diagram and Board-Level Implementation**



**Table 2-63 • LVDS Minimum and Maximum DC Input and Output Levels**

| DC Parameter       | Description                 | Min.  | Typ.  | Max.  | Units   |
|--------------------|-----------------------------|-------|-------|-------|---------|
| VCCFPGAIOBx        | Supply voltage              | 2.375 | 2.5   | 2.625 | V       |
| VOL                | Output low voltage          | 0.9   | 1.075 | 1.25  | V       |
| VOH                | Output high voltage         | 1.25  | 1.425 | 1.6   | V       |
| $I_{OL}^1$         | Output lower current        | 0.65  | 0.91  | 1.16  | mA      |
| $I_{OH}^1$         | Output high current         | 0.65  | 0.91  | 1.16  | mA      |
| VI                 | Input voltage               | 0     |       | 2.925 | V       |
| $I_{IH}^2$         | Input high leakage current  |       |       | 15    | $\mu$ A |
| $I_{IL}^2$         | Input low leakage current   |       |       | 15    | $\mu$ A |
| V <sub>ODIFF</sub> | Differential output voltage | 250   | 350   | 450   | mV      |
| V <sub>OCM</sub>   | Output common mode voltage  | 1.125 | 1.25  | 1.375 | V       |
| V <sub>ICM</sub>   | Input common mode voltage   | 0.05  | 1.25  | 2.35  | V       |
| V <sub>IDIFF</sub> | Input differential voltage  | 100   | 350   |       | mV      |

**Notes:**

- $I_{OL}/I_{OH}$  defined by  $V_{ODIFF}/(\text{resistor network})$ .
- Currents are measured at 85°C junction temperature.

**Table 2-64 • AC Waveforms, Measuring Points, and Capacitive Loads**

| Input Low (V) | Input High (V) | Measuring Point* (V) | V <sub>REF</sub> (typ.) (V) |
|---------------|----------------|----------------------|-----------------------------|
| 1.075         | 1.325          | Cross point          | –                           |

\* Measuring point =  $V_{trip}$ . See Table 2-22 on page 2-24 for a complete table of trip points.

### Timing Characteristics

**Table 2-65 • LVDS**

Worst Commercial-Case Conditions:  $T_J = 85^\circ\text{C}$ , Worst-Case VCC = 1.425 V,

Worst-Case VCCFPGAIOBx = 2.3 V

Applicable to FPGA I/O Banks, I/O Assigned to EMC I/O Pins

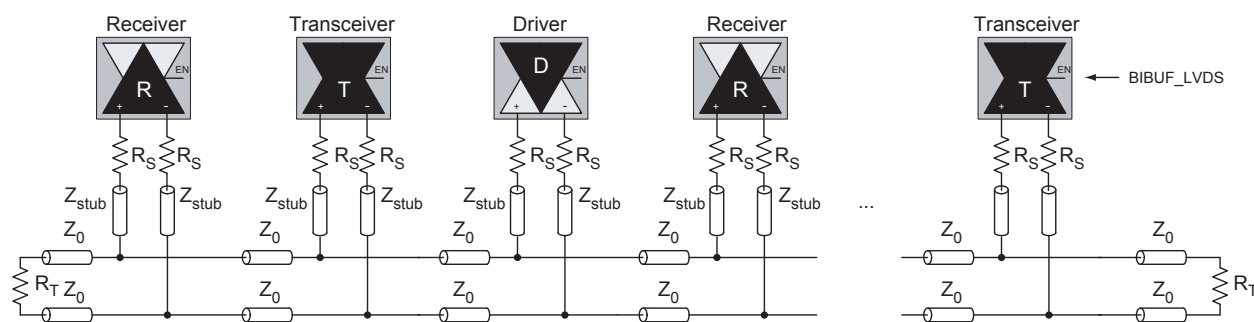
| Speed Grade | $t_{DOUT}$ | $t_{DP}$ | $t_{DIN}$ | $t_{PY}$ | Units |
|-------------|------------|----------|-----------|----------|-------|
| Std.        | 0.60       | 1.83     | 0.04      | 1.87     | ns    |
| –1          | 0.50       | 1.53     | 0.03      | 1.55     | ns    |

**Note:** For the derating values at specific junction temperature and voltage supply levels, refer to Table 2-7 on page 2-9 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. SoC Products Group 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 SoC Products Group LVDS macros can achieve up to 200 MHz with a maximum of 20 loads. A sample application is given in Figure 2-12. The input and output buffer delays are available in the LVDS section in Table 2-65.

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

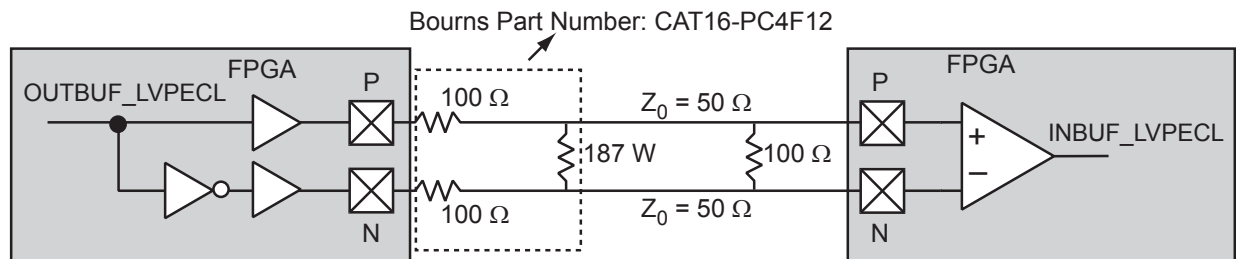


**Figure 2-12 • B-LVDS/M-LVDS Multipoint Application Using LVDS I/O Buffers**

## 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 2-13](#). 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 2-13 • LVPECL Circuit Diagram and Board-Level Implementation**

**Table 2-66 • Minimum and Maximum DC Input and Output Levels**

| DC Parameter                      | Description                    | Min.  | Max. | Min.  | Max. | Min.  | Max. | Units |
|-----------------------------------|--------------------------------|-------|------|-------|------|-------|------|-------|
| VCCFPGAIOBx                       | Supply Voltage                 | 3.0   |      | 3.3   |      | 3.6   |      | V     |
| VOL                               | Output Low Voltage             | 0.96  | 1.27 | 1.06  | 1.43 | 1.30  | 1.57 | V     |
| VOH                               | Output High Voltage            | 1.8   | 2.11 | 1.92  | 2.28 | 2.13  | 2.41 | V     |
| V <sub>IL</sub> , V <sub>IH</sub> | Input Low, Input High Voltages | 0     | 3.3  | 0     | 3.6  | 0     | 3.9  | V     |
| V <sub>ODIFF</sub>                | Differential Output Voltage    | 0.625 | 0.97 | 0.625 | 0.97 | 0.625 | 0.97 | V     |
| V <sub>OCM</sub>                  | Output Common-Mode Voltage     | 1.762 | 1.98 | 1.762 | 1.98 | 1.762 | 1.98 | V     |
| V <sub>ICM</sub>                  | Input Common-Mode Voltage      | 1.01  | 2.57 | 1.01  | 2.57 | 1.01  | 2.57 | V     |
| V <sub>IDIFF</sub>                | Input Differential Voltage     | 300   |      | 300   |      | 300   |      | mV    |

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

| Input Low (V) | Input High (V) | Measuring Point* (V) | V <sub>REF</sub> (typ.) (V) |
|---------------|----------------|----------------------|-----------------------------|
| 1.64          | 1.94           | Cross point          | —                           |

\* Measuring point = V<sub>trip</sub>. See [Table 2-22 on page 2-24](#) for a complete table of trip points.

## Timing Characteristics

**Table 2-68 • LVPECL**

Worst Commercial-Case Conditions: T<sub>J</sub> = 85°C, Worst-Case VCC = 1.425 V,

Worst-Case VCCFPGAIOBx = 3.0 V

Applicable to FPGA I/O Banks, I/O Assigned to EMC I/O Pins

| Speed Grade | t <sub>DOUT</sub> | t <sub>DP</sub> | t <sub>DIN</sub> | t <sub>py</sub> | Units |
|-------------|-------------------|-----------------|------------------|-----------------|-------|
| Std.        | 0.60              | 1.76            | 0.04             | 1.76            | ns    |
| –1          | 0.50              | 1.46            | 0.03             | 1.46            | ns    |

*Note:* For the derating values at specific junction temperature and voltage supply levels, refer to [Table 2-7 on page 2-9](#) for derating values.

## I/O Register Specifications

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

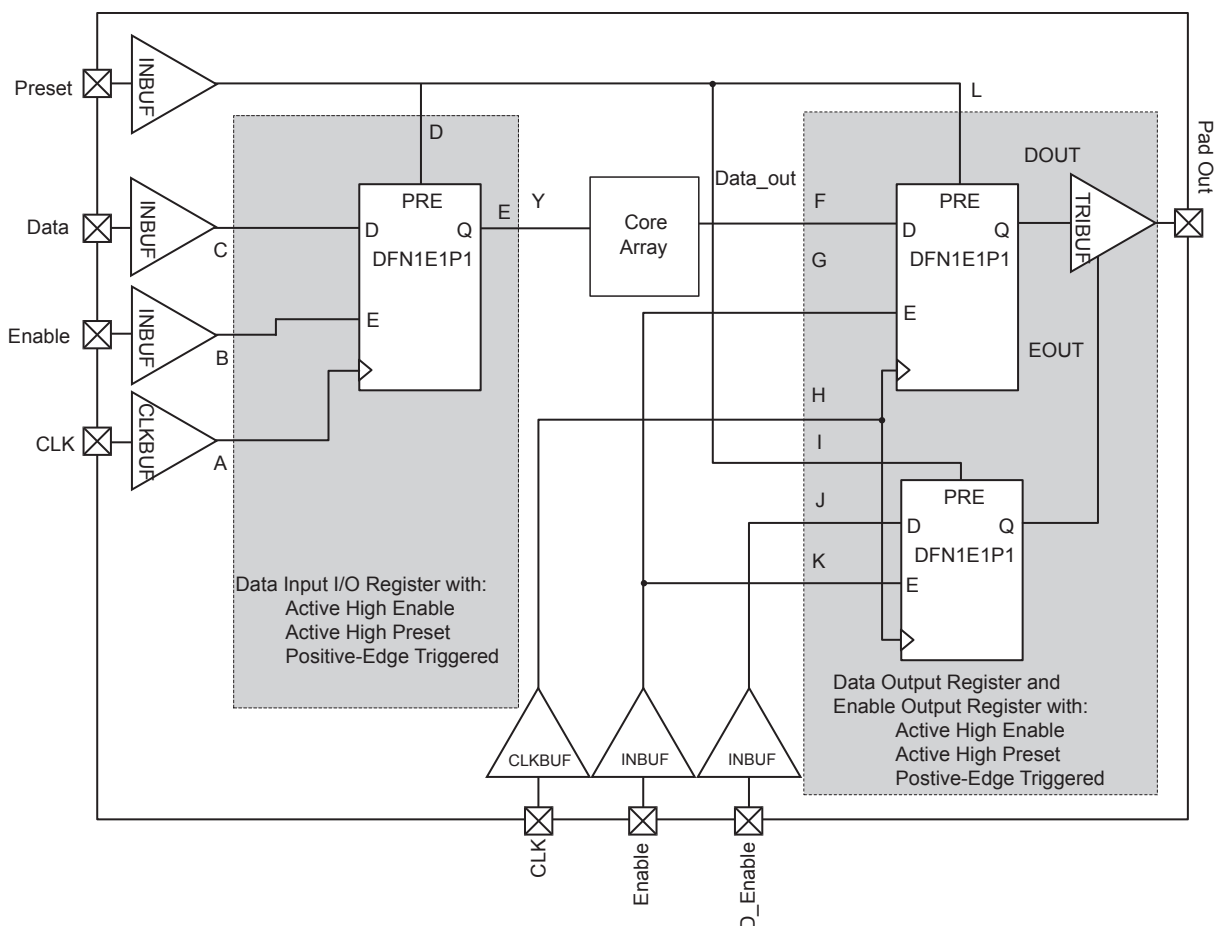


Figure 2-14 • Timing Model of Registered I/O Buffers with Synchronous Enable and Asynchronous Preset

**Table 2-69 • Parameter Definition and Measuring Nodes**

| Parameter Name | Parameter Definition                                             | Measuring Nodes (from, to)* |
|----------------|------------------------------------------------------------------|-----------------------------|
| $t_{OCLKQ}$    | Clock-to-Q of the Output Data Register                           | H, DOUT                     |
| $t_{OSUD}$     | Data Setup Time for the Output Data Register                     | F, H                        |
| $t_{OHD}$      | Data Hold Time for the Output Data Register                      | F, H                        |
| $t_{OSUE}$     | Enable Setup Time for the Output Data Register                   | G, H                        |
| $t_{OHE}$      | Enable Hold Time for the Output Data Register                    | G, H                        |
| $t_{OPRE2Q}$   | Asynchronous Preset-to-Q of the Output Data Register             | L, DOUT                     |
| $t_{OREMPRE}$  | Asynchronous Preset Removal Time for the Output Data Register    | L, H                        |
| $t_{ORECPRE}$  | Asynchronous Preset Recovery Time for the Output Data Register   | L, H                        |
| $t_{OECLKQ}$   | Clock-to-Q of the Output Enable Register                         | H, EOUT                     |
| $t_{OESUD}$    | Data Setup Time for the Output Enable Register                   | J, H                        |
| $t_{OEHD}$     | Data Hold Time for the Output Enable Register                    | J, H                        |
| $t_{OESUE}$    | Enable Setup Time for the Output Enable Register                 | K, H                        |
| $t_{OEHE}$     | Enable Hold Time for the Output Enable Register                  | K, H                        |
| $t_{OEPRE2Q}$  | Asynchronous Preset-to-Q of the Output Enable Register           | I, EOUT                     |
| $t_{OEREMPRE}$ | Asynchronous Preset Removal Time for the Output Enable Register  | I, H                        |
| $t_{OERECPRE}$ | Asynchronous Preset Recovery Time for the Output Enable Register | I, H                        |
| $t_{ICLKQ}$    | Clock-to-Q of the Input Data Register                            | A, E                        |
| $t_{ISUD}$     | Data Setup Time for the Input Data Register                      | C, A                        |
| $t_{IHD}$      | Data Hold Time for the Input Data Register                       | C, A                        |
| $t_{ISUE}$     | Enable Setup Time for the Input Data Register                    | B, A                        |
| $t_{IHE}$      | Enable Hold Time for the Input Data Register                     | B, A                        |
| $t_{IPRE2Q}$   | Asynchronous Preset-to-Q of the Input Data Register              | D, E                        |
| $t_{IREMPRE}$  | Asynchronous Preset Removal Time for the Input Data Register     | D, A                        |
| $t_{IRECPRE}$  | Asynchronous Preset Recovery Time for the Input Data Register    | D, A                        |

\* See [Figure 2-14 on page 2-44](#) for more information.

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

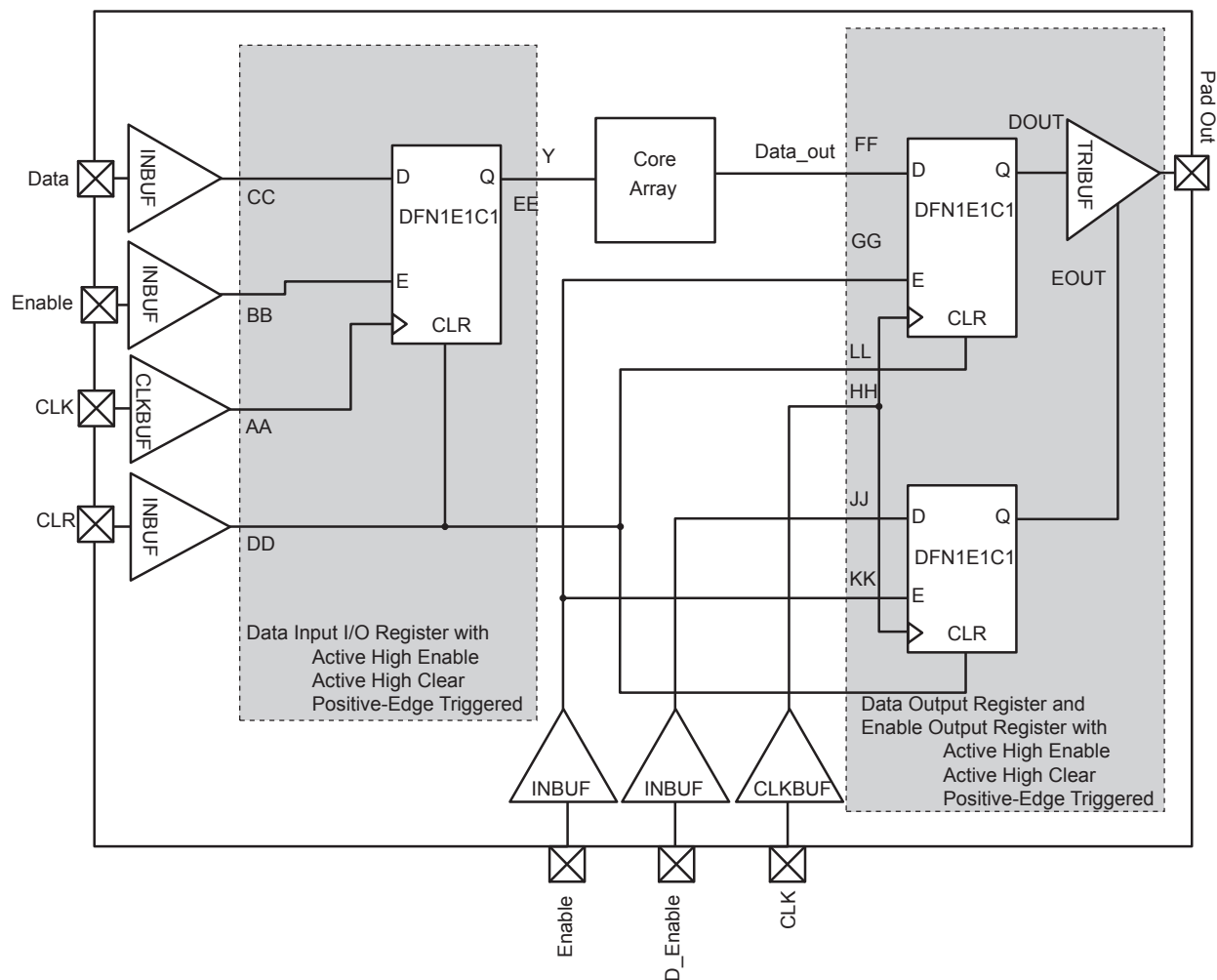


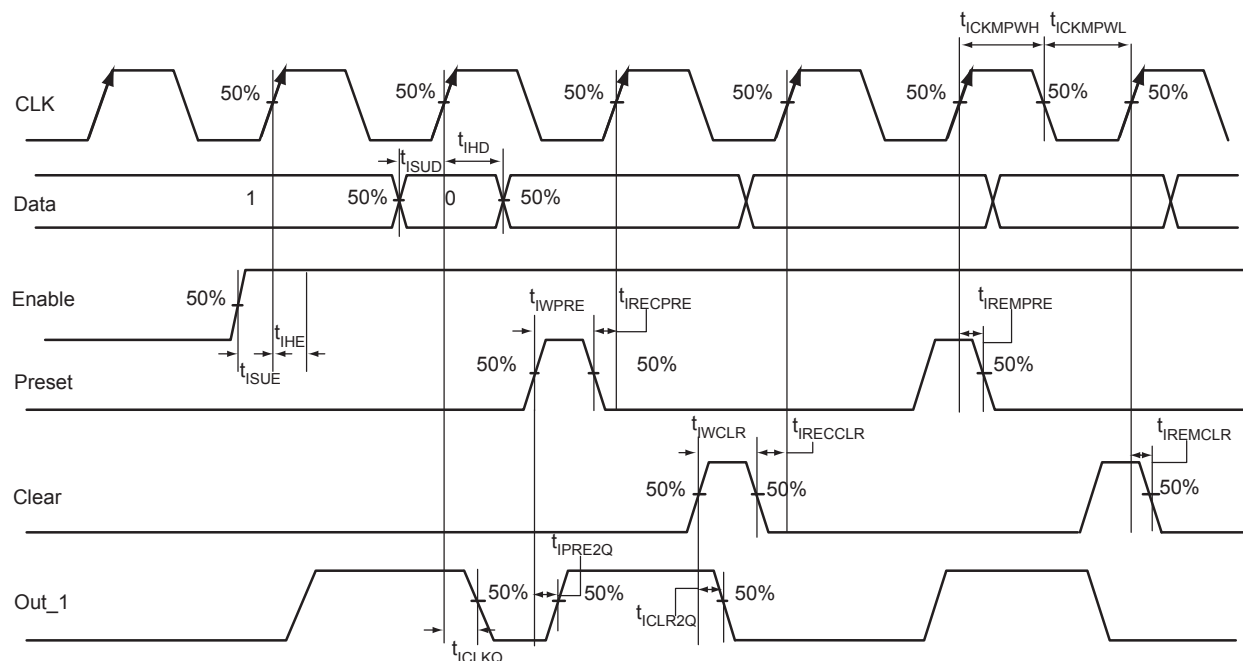
Figure 2-15 • Timing Model of the Registered I/O Buffers with Synchronous Enable and Asynchronous Clear

**Table 2-70 • Parameter Definition and Measuring Nodes**

| Parameter Name | Parameter Definition                                            | Measuring Nodes (from, to)* |
|----------------|-----------------------------------------------------------------|-----------------------------|
| $t_{OCLKQ}$    | Clock-to-Q of the Output Data Register                          | HH, DOUT                    |
| $t_{OSUD}$     | Data Setup Time for the Output Data Register                    | FF, HH                      |
| $t_{OHD}$      | Data Hold Time for the Output Data Register                     | FF, HH                      |
| $t_{OSUE}$     | Enable Setup Time for the Output Data Register                  | GG, HH                      |
| $t_{OHE}$      | Enable Hold Time for the Output Data Register                   | GG, HH                      |
| $t_{OCLR2Q}$   | Asynchronous Clear-to-Q of the Output Data Register             | LL, DOUT                    |
| $t_{OREMCLR}$  | Asynchronous Clear Removal Time for the Output Data Register    | LL, HH                      |
| $t_{ORECCLR}$  | Asynchronous Clear Recovery Time for the Output Data Register   | LL, HH                      |
| $t_{OECLKQ}$   | Clock-to-Q of the Output Enable Register                        | HH, EOUT                    |
| $t_{OESUD}$    | Data Setup Time for the Output Enable Register                  | JJ, HH                      |
| $t_{OEHD}$     | Data Hold Time for the Output Enable Register                   | JJ, HH                      |
| $t_{OESUE}$    | Enable Setup Time for the Output Enable Register                | KK, HH                      |
| $t_{OEHE}$     | Enable Hold Time for the Output Enable Register                 | KK, HH                      |
| $t_{OECLR2Q}$  | Asynchronous Clear-to-Q of the Output Enable Register           | II, EOUT                    |
| $t_{OEREMCLR}$ | Asynchronous Clear Removal Time for the Output Enable Register  | II, HH                      |
| $t_{OERECCLR}$ | Asynchronous Clear Recovery Time for the Output Enable Register | II, HH                      |
| $t_{ICLKQ}$    | Clock-to-Q of the Input Data Register                           | AA, EE                      |
| $t_{ISUD}$     | Data Setup Time for the Input Data Register                     | CC, AA                      |
| $t_{IHD}$      | Data Hold Time for the Input Data Register                      | CC, AA                      |
| $t_{ISUE}$     | Enable Setup Time for the Input Data Register                   | BB, AA                      |
| $t_{IHE}$      | Enable Hold Time for the Input Data Register                    | BB, AA                      |
| $t_{ICLR2Q}$   | Asynchronous Clear-to-Q of the Input Data Register              | DD, EE                      |
| $t_{IREMCLR}$  | Asynchronous Clear Removal Time for the Input Data Register     | DD, AA                      |
| $t_{IRECCLR}$  | Asynchronous Clear Recovery Time for the Input Data Register    | DD, AA                      |

\* See [Figure 2-15 on page 2-46](#) for more information.

## Input Register



**Figure 2-16 • Input Register Timing Diagram**

### Timing Characteristics

**Table 2-71 • Input Data Register Propagation Delays**

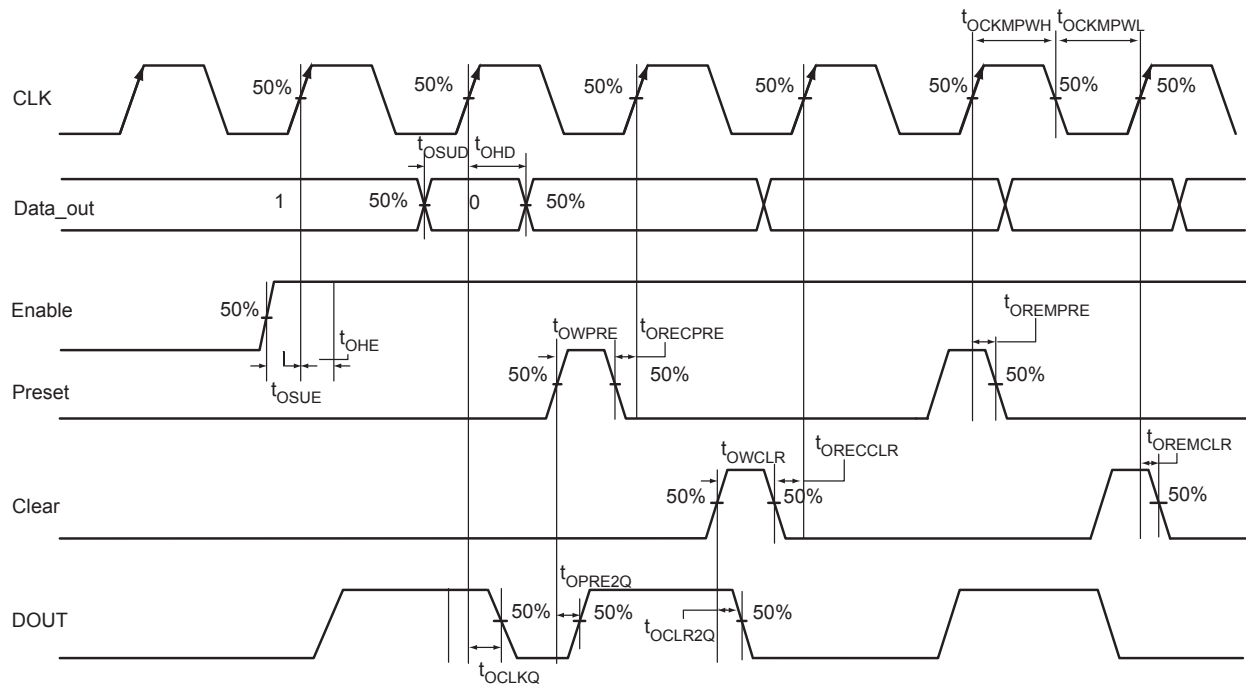
Worst Commercial-Case Conditions:  $T_J = 85^\circ\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$

| Parameter            | Description                                                         | -1   | Std. | Units |
|----------------------|---------------------------------------------------------------------|------|------|-------|
| $t_{\text{ICLKQ}}$   | Clock-to-Q of the Input Data Register                               | 0.24 | 0.29 | ns    |
| $t_{\text{ISUD}}$    | Data Setup Time for the Input Data Register                         | 0.27 | 0.32 | 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                       | 0.38 | 0.45 | 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                  | 0.46 | 0.55 | ns    |
| $t_{\text{IPRE2Q}}$  | Asynchronous Preset-to-Q of the Input Data Register                 | 0.46 | 0.55 | 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        | 0.23 | 0.27 | 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       | 0.23 | 0.27 | ns    |
| $t_{\text{IWCLR}}$   | Asynchronous Clear Minimum Pulse Width for the Input Data Register  | 0.22 | 0.22 | ns    |
| $t_{\text{IWPRE}}$   | Asynchronous Preset Minimum Pulse Width for the Input Data Register | 0.22 | 0.22 | ns    |
| $t_{\text{ICKMPWH}}$ | Clock Minimum Pulse Width High for the Input Data Register          | 0.36 | 0.36 | ns    |
| $t_{\text{ICKMPWL}}$ | Clock Minimum Pulse Width Low for the Input Data Register           | 0.32 | 0.32 | ns    |

**Note:** For the derating values at specific junction temperature and voltage supply levels, refer to [Table 2-7 on page 2-9](#) for derating values.



## Output Register



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

### Timing Characteristics

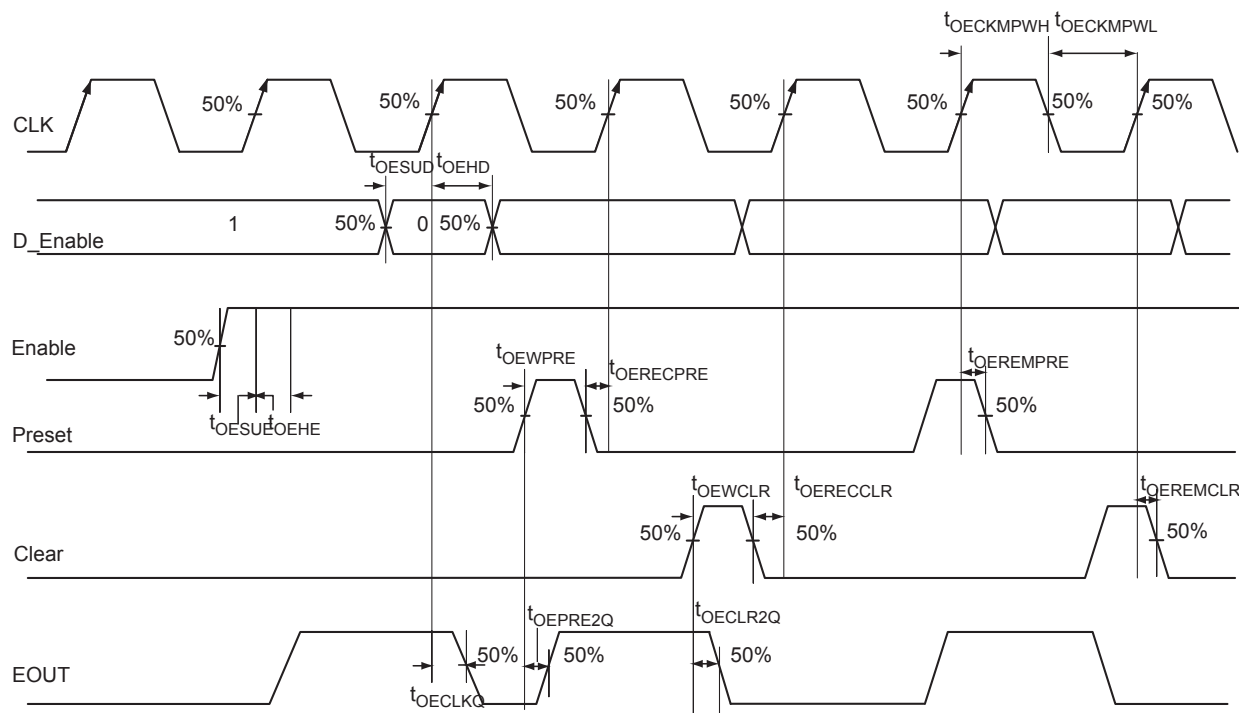
**Table 2-72 • Output Data Register Propagation Delays**

Worst Commercial-Case Conditions:  $T_J = 85^\circ\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$

| Parameter     | Description                                                          | -1   | Std. | Units |
|---------------|----------------------------------------------------------------------|------|------|-------|
| $t_{OCLKQ}$   | Clock-to-Q of the Output Data Register                               | 0.60 | 0.72 | ns    |
| $t_{OSUD}$    | Data Setup Time for the Output Data Register                         | 0.32 | 0.38 | ns    |
| $t_{OHD}$     | Data Hold Time for the Output Data Register                          | 0.00 | 0.00 | ns    |
| $t_{OSUE}$    | Enable Setup Time for the Output Data Register                       | 0.44 | 0.53 | ns    |
| $t_{OHE}$     | Enable Hold Time for the Output Data Register                        | 0.00 | 0.00 | ns    |
| $t_{OCLR2Q}$  | Asynchronous Clear-to-Q of the Output Data Register                  | 0.82 | 0.98 | ns    |
| $t_{OPRE2Q}$  | Asynchronous Preset-to-Q of the Output Data Register                 | 0.82 | 0.98 | ns    |
| $t_{OREMCLR}$ | Asynchronous Clear Removal Time for the Output Data Register         | 0.00 | 0.00 | ns    |
| $t_{ORECCLR}$ | Asynchronous Clear Recovery Time for the Output Data Register        | 0.23 | 0.27 | ns    |
| $t_{OREMPRE}$ | Asynchronous Preset Removal Time for the Output Data Register        | 0.00 | 0.00 | ns    |
| $t_{ORECPRE}$ | Asynchronous Preset Recovery Time for the Output Data Register       | 0.23 | 0.27 | ns    |
| $t_{OWCLR}$   | Asynchronous Clear Minimum Pulse Width for the Output Data Register  | 0.22 | 0.22 | ns    |
| $t_{OWPRE}$   | Asynchronous Preset Minimum Pulse Width for the Output Data Register | 0.22 | 0.22 | ns    |
| $t_{OCKMPWH}$ | Clock Minimum Pulse Width High for the Output Data Register          | 0.36 | 0.36 | ns    |
| $t_{OCKMPWL}$ | Clock Minimum Pulse Width Low for the Output Data Register           | 0.32 | 0.32 | ns    |

**Note:** For the derating values at specific junction temperature and voltage supply levels, refer to [Table 2-7 on page 2-9](#) for derating values.

## Output Enable Register



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

### Timing Characteristics

**Table 2-73 • Output Enable Register Propagation Delays**

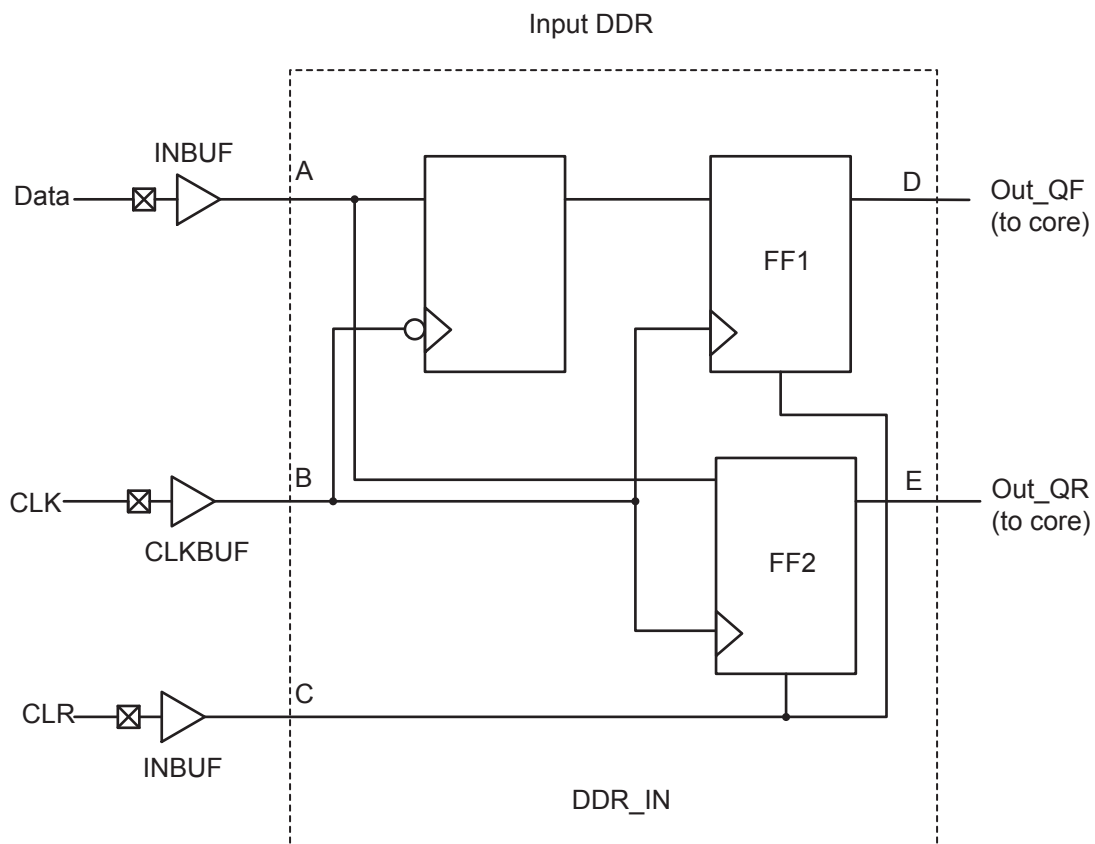
Worst Commercial-Case Conditions:  $T_J = 85^\circ\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$

| Parameter      | Description                                                            | -1   | Std. | Units |
|----------------|------------------------------------------------------------------------|------|------|-------|
| $t_{OECLKQ}$   | Clock-to-Q of the Output Enable Register                               | 0.45 | 0.54 | ns    |
| $t_{OESUD}$    | Data Setup Time for the Output Enable Register                         | 0.32 | 0.38 | 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                       | 0.44 | 0.53 | 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                  | 0.68 | 0.81 | ns    |
| $t_{OEPRE2Q}$  | Asynchronous Preset-to-Q of the Output Enable Register                 | 0.68 | 0.81 | 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        | 0.23 | 0.27 | 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       | 0.23 | 0.27 | ns    |
| $t_{OEWCCLR}$  | Asynchronous Clear Minimum Pulse Width for the Output Enable Register  | 0.22 | 0.22 | ns    |
| $t_{OEWPPE}$   | Asynchronous Preset Minimum Pulse Width for the Output Enable Register | 0.22 | 0.22 | ns    |
| $t_{OECKMPWH}$ | Clock Minimum Pulse Width High for the Output Enable Register          | 0.36 | 0.36 | ns    |
| $t_{OECKMPWL}$ | Clock Minimum Pulse Width Low for the Output Enable Register           | 0.32 | 0.32 | ns    |

*Note:* For specific junction temperature and voltage supply levels, refer to [Table 2-7 on page 2-9](#) for derating values.

## DDR Module Specifications

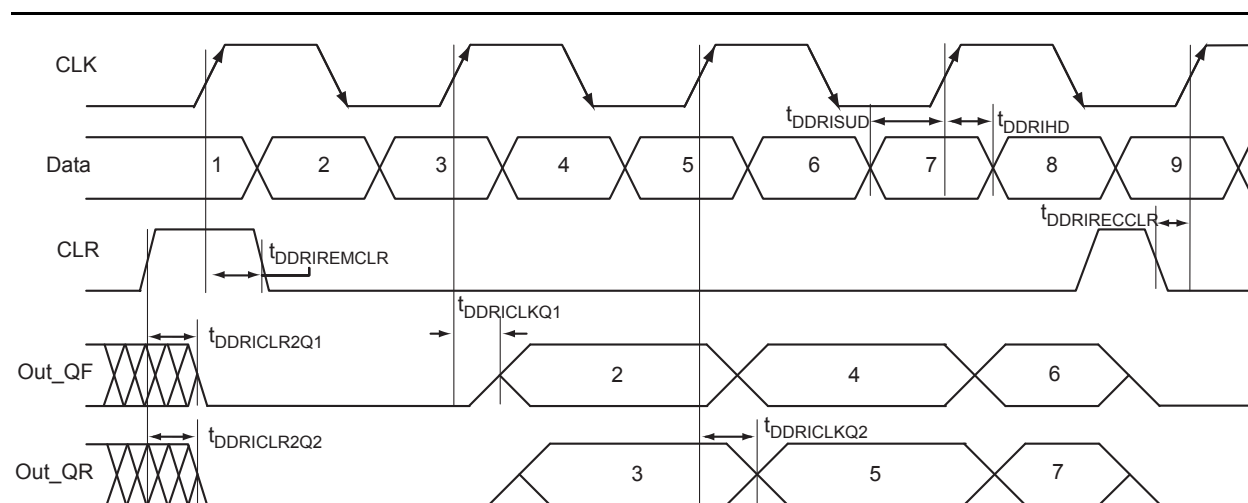
### Input DDR Module



**Figure 2-19 • Input DDR Timing Model**

**Table 2-74 • 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 2-20 • Input DDR Timing Diagram**

### Timing Characteristics

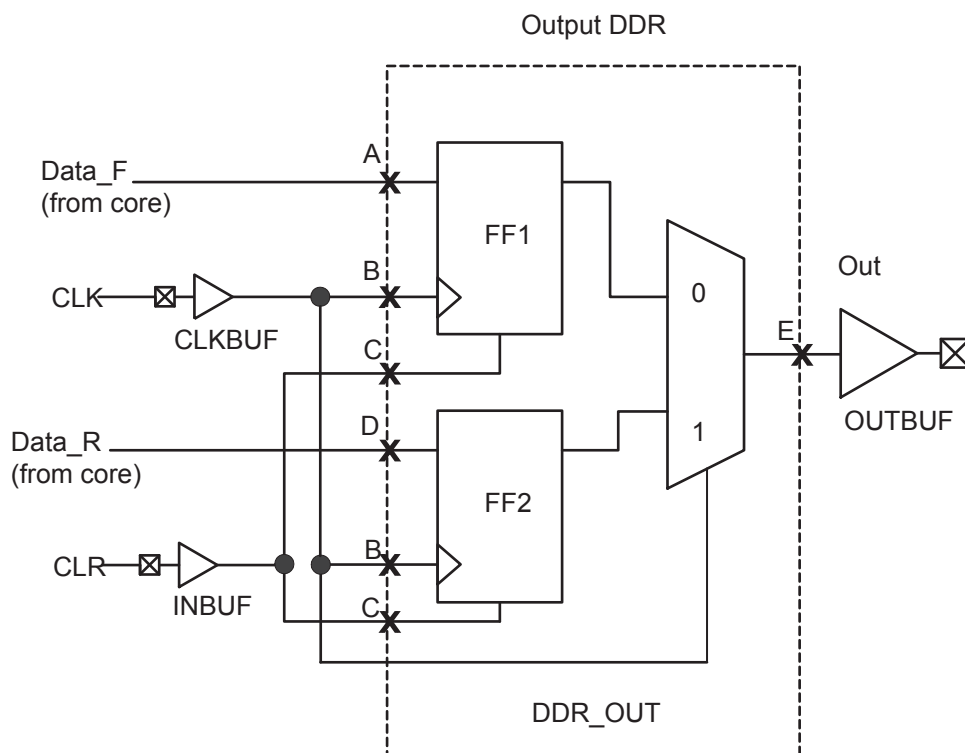
**Table 2-75 • Input DDR Propagation Delays**

Worst Commercial-Case Conditions:  $T_J = 85^\circ\text{C}$ , Worst Case  $V_{CC} = 1.425\text{ V}$

| Parameter        | Description                                          | -1   | Units |
|------------------|------------------------------------------------------|------|-------|
| $t_{DDRICKQ1}$   | Clock-to-Out Out_QR for Input DDR                    | 0.39 | ns    |
| $t_{DDRICKQ2}$   | Clock-to-Out Out_QF for Input DDR                    | 0.28 | ns    |
| $t_{DDRISUD}$    | Data Setup for Input DDR                             | 0.29 | ns    |
| $t_{DDRIHD}$     | Data Hold for Input DDR                              | 0.00 | ns    |
| $t_{DDRICKR2Q1}$ | Asynchronous Clear-to-Out Out_QR for Input DDR       | 0.58 | ns    |
| $t_{DDRICKR2Q2}$ | Asynchronous Clear-to-Out Out_QF for Input DDR       | 0.47 | ns    |
| $t_{DDRIMCLR}$   | Asynchronous Clear Removal time for Input DDR        | 0.00 | ns    |
| $t_{DDRIRECCLR}$ | Asynchronous Clear Recovery time for Input DDR       | 0.23 | ns    |
| $t_{DDRIMCLR}$   | Asynchronous Clear Minimum Pulse Width for Input DDR | 0.22 | ns    |
| $t_{DDRICKMPWH}$ | Clock Minimum Pulse Width High for Input DDR         | 0.36 | ns    |
| $t_{DDRICKMPWL}$ | Clock Minimum Pulse Width Low for Input DDR          | 0.32 | ns    |
| $F_{DDRIMAX}$    | Maximum Frequency for Input DDR                      | 350  | MHz   |

**Note:** For derating values at specific junction temperature and voltage-supply levels, refer to [Table 2-7 on page 2-9](#) for derating values.

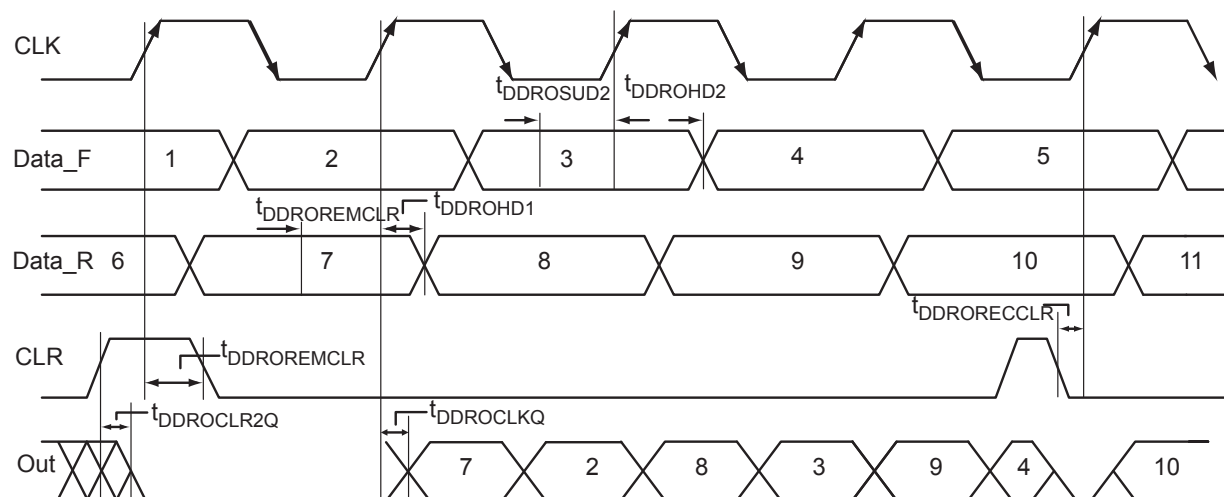
## Output DDR Module



**Figure 2-21 • Output DDR Timing Model**

**Table 2-76 • Parameter Definitions**

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



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

### Timing Characteristics

**Table 2-77 • Output DDR Propagation Delays**

Worst Commercial-Case Conditions:  $T_J = 85^\circ\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$

| Parameter               | Description                                           | -1   | Units |
|-------------------------|-------------------------------------------------------|------|-------|
| $t_{\text{DDROCLKQ}}$   | Clock-to-Out of DDR for Output DDR                    | 0.71 | ns    |
| $t_{\text{DDROSUD1}}$   | Data_F Data Setup for Output DDR                      | 0.38 | ns    |
| $t_{\text{DDROSUD2}}$   | Data_R Data Setup for Output DDR                      | 0.38 | ns    |
| $t_{\text{DDROHD1}}$    | Data_F Data Hold for Output DDR                       | 0.00 | ns    |
| $t_{\text{DDROHD2}}$    | Data_R Data Hold for Output DDR                       | 0.00 | ns    |
| $t_{\text{DDROCLR2Q}}$  | Asynchronous Clear-to-Out for Output DDR              | 0.81 | ns    |
| $t_{\text{DDROEMCLR}}$  | Asynchronous Clear Removal Time for Output DDR        | 0.00 | ns    |
| $t_{\text{DDROECCLR}}$  | Asynchronous Clear Recovery Time for Output DDR       | 0.23 | ns    |
| $t_{\text{DDROWCLR1}}$  | Asynchronous Clear Minimum Pulse Width for Output DDR | 0.22 | ns    |
| $t_{\text{DDROCKMPWH}}$ | Clock Minimum Pulse Width High for the Output DDR     | 0.36 | ns    |
| $t_{\text{DDROCKMPWL}}$ | Clock Minimum Pulse Width Low for the Output DDR      | 0.32 | ns    |
| $F_{\text{DDOMAX}}$     | Maximum Frequency for the Output DDR                  | 350  | MHz   |

*Note:* For specific junction temperature and voltage supply levels, refer to [Table 2-7 on page 2-9](#) for derating values.

## VersaTile Characteristics

### VersaTile Specifications as a Combinatorial Module

The SmartFusion 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 *IGLOO/e*, *Fusion*, *ProASIC3/E*, and *SmartFusion Macro Library Guide*.

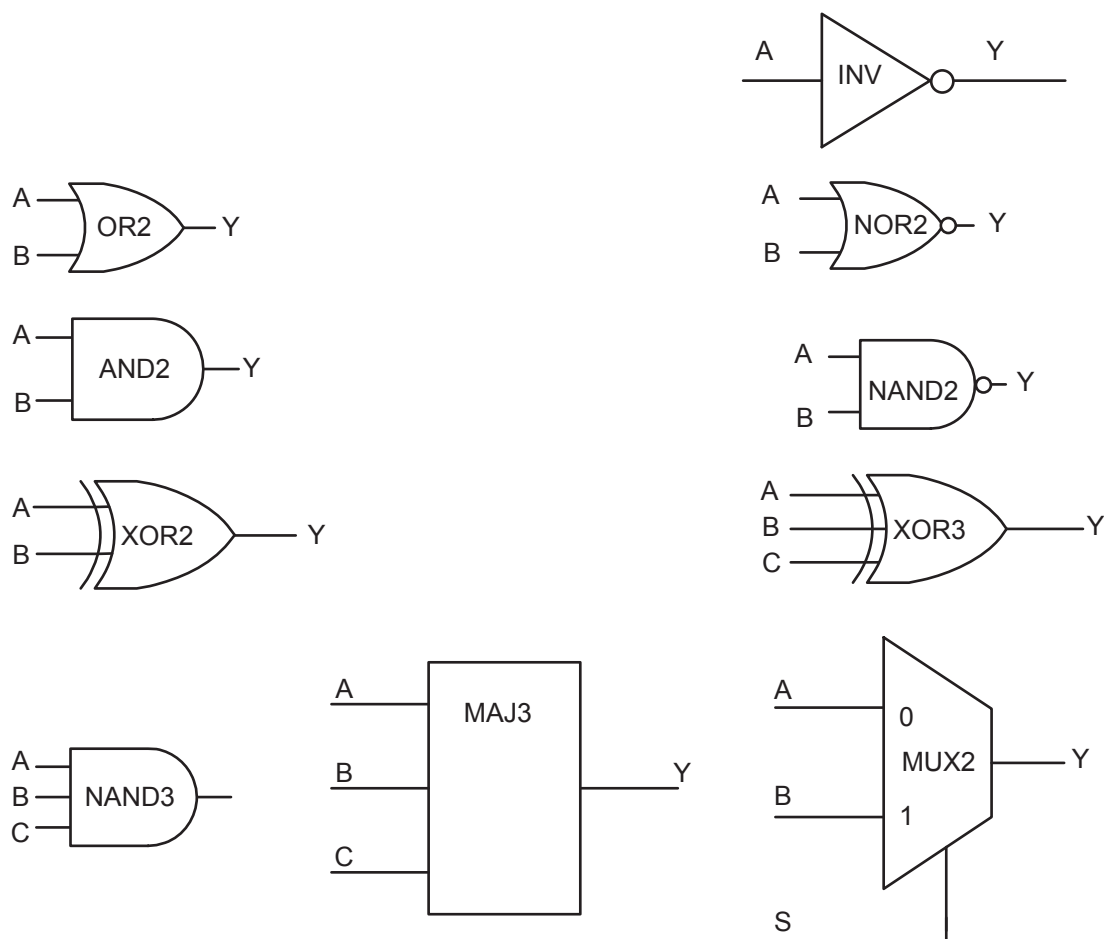
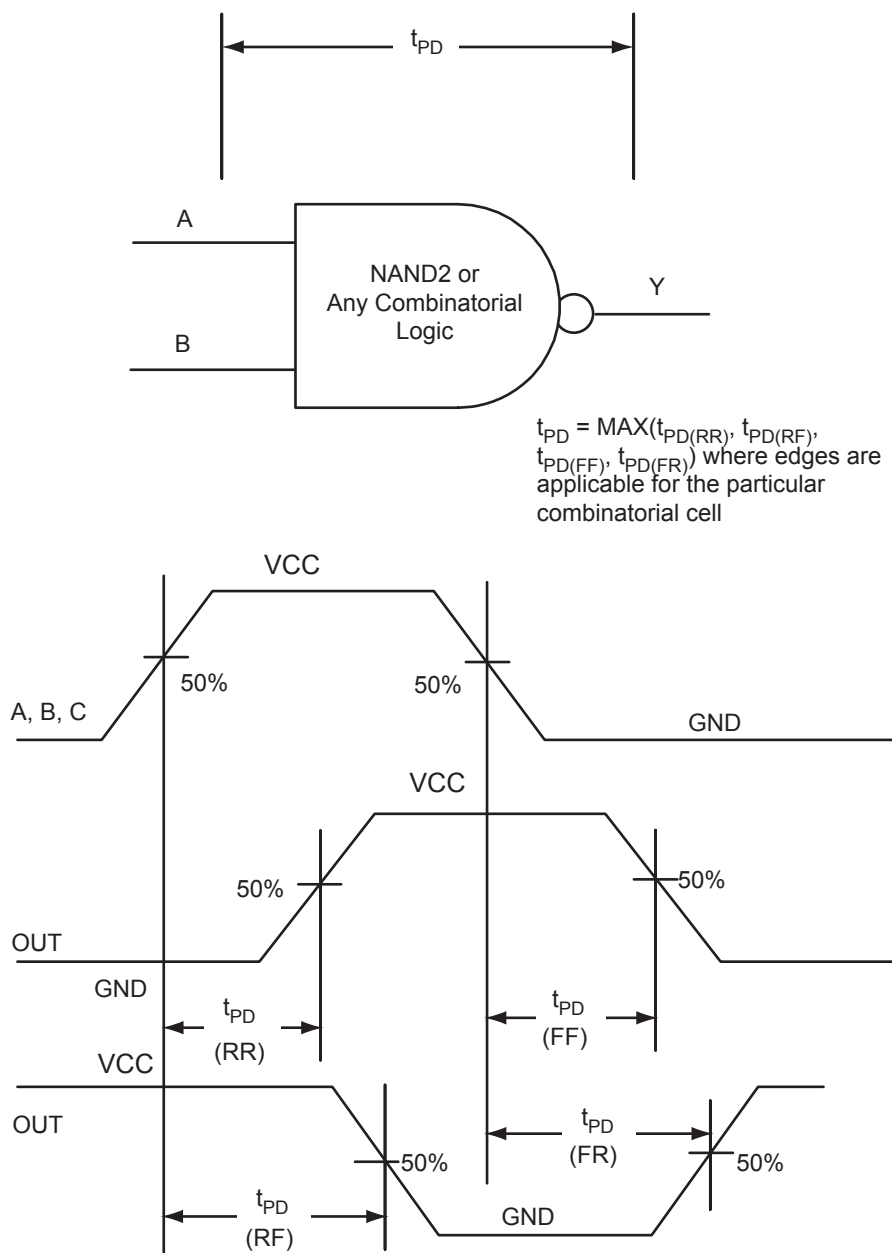


Figure 2-23 • Sample of Combinatorial Cells



**Figure 2-24 • Timing Model and Waveforms**



## Timing Characteristics

**Table 2-78 • Combinatorial Cell Propagation Delays**

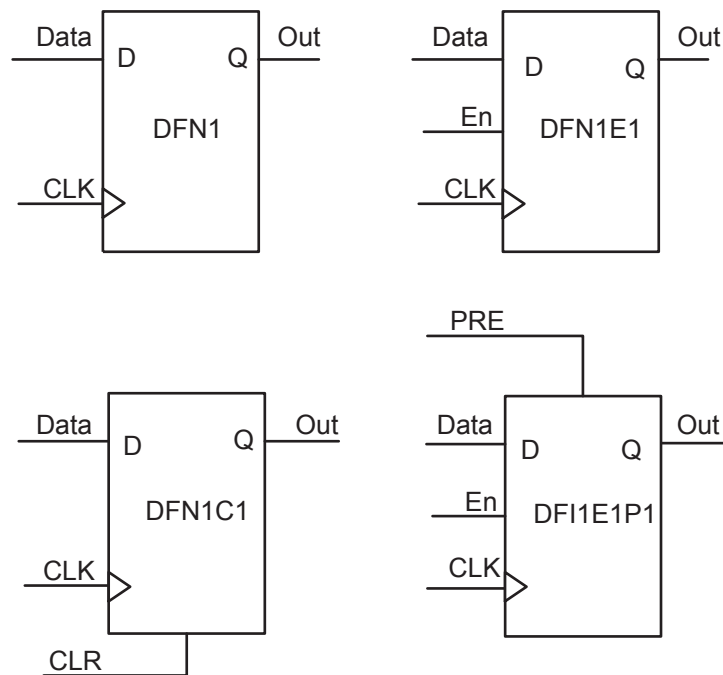
Worst Commercial-Case Conditions:  $T_J = 85^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$

| Combinatorial Cell | Equation                          | Parameter | -1   | Std. | Units |
|--------------------|-----------------------------------|-----------|------|------|-------|
| INV                | $Y = !A$                          | $t_{PD}$  | 0.41 | 0.49 | ns    |
| AND2               | $Y = A \cdot B$                   | $t_{PD}$  | 0.48 | 0.57 | ns    |
| NAND2              | $Y = !(A \cdot B)$                | $t_{PD}$  | 0.48 | 0.57 | ns    |
| OR2                | $Y = A + B$                       | $t_{PD}$  | 0.49 | 0.59 | ns    |
| NOR2               | $Y = !(A + B)$                    | $t_{PD}$  | 0.49 | 0.59 | ns    |
| XOR2               | $Y = A \oplus B$                  | $t_{PD}$  | 0.75 | 0.90 | ns    |
| MAJ3               | $Y = \text{MAJ}(A, B, C)$         | $t_{PD}$  | 0.71 | 0.85 | ns    |
| XOR3               | $Y = A \oplus B \oplus C$         | $t_{PD}$  | 0.89 | 1.07 | ns    |
| MUX2               | $Y = A \text{ IS } + B \text{ S}$ | $t_{PD}$  | 0.51 | 0.62 | ns    |
| AND3               | $Y = A \cdot B \cdot C$           | $t_{PD}$  | 0.57 | 0.68 | ns    |

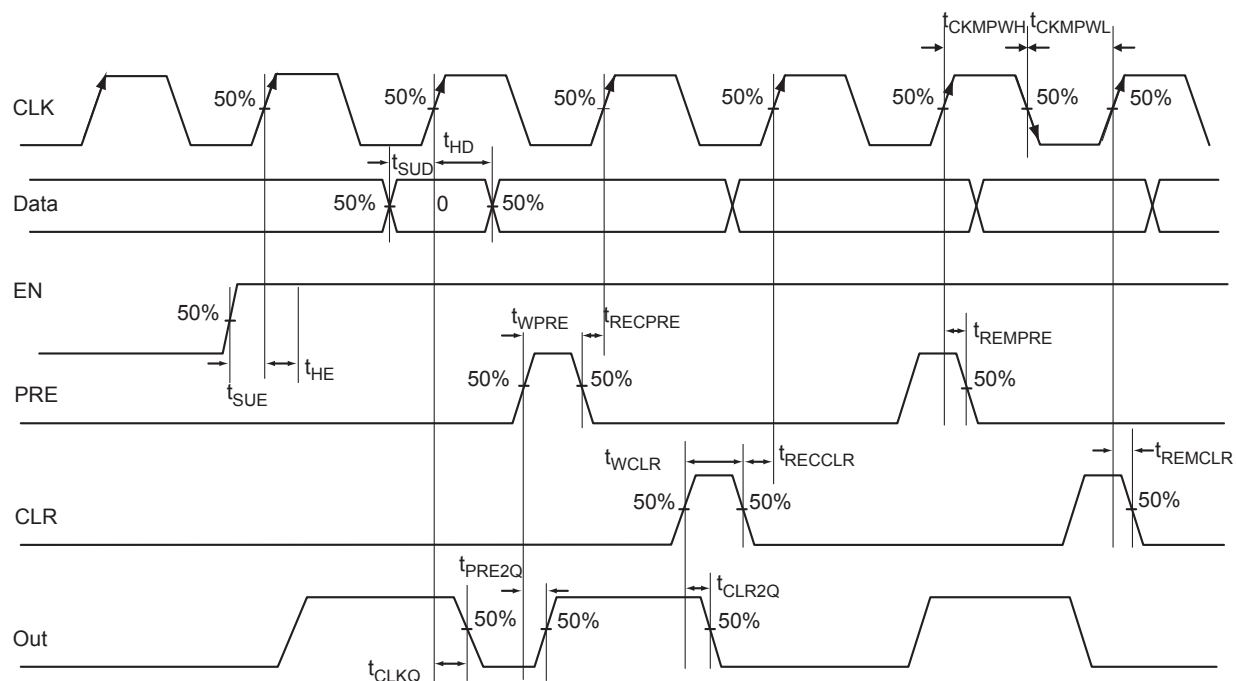
*Note:* For specific junction temperature and voltage supply levels, refer to [Table 2-7 on page 2-9](#) for derating values.

## VersaTile Specifications as a Sequential Module

The SmartFusion 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 [IGLOO/e](#), [Fusion](#), [ProASIC3/E](#), and [SmartFusion Macro Library Guide](#).



**Figure 2-25 • Sample of Sequential Cells**



**Figure 2-26 • Timing Model and Waveforms**

### Timing Characteristics

**Table 2-79 • Register Delays**

Worst Commercial-Case Conditions:  $T_J = 85^\circ\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$

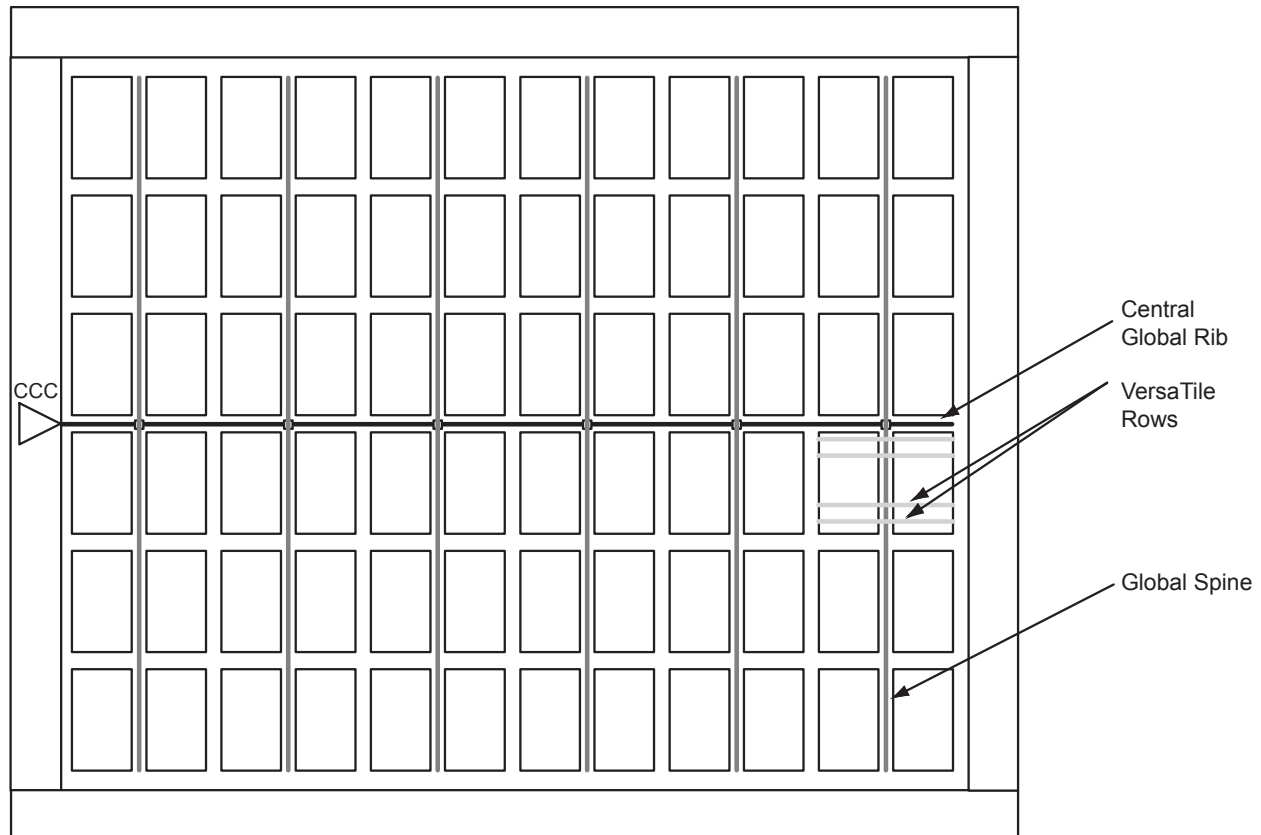
| Parameter    | Description                                                   | -1   | Std. | Units |
|--------------|---------------------------------------------------------------|------|------|-------|
| $t_{CLKQ}$   | Clock-to-Q of the Core Register                               | 0.56 | 0.67 | ns    |
| $t_{SUD}$    | Data Setup Time for the Core Register                         | 0.44 | 0.52 | ns    |
| $t_{HD}$     | Data Hold Time for the Core Register                          | 0.00 | 0.00 | ns    |
| $t_{SUE}$    | Enable Setup Time for the Core Register                       | 0.46 | 0.55 | 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                  | 0.41 | 0.49 | ns    |
| $t_{PRE2Q}$  | Asynchronous Preset-to-Q of the Core Register                 | 0.41 | 0.49 | 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        | 0.23 | 0.27 | 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       | 0.23 | 0.27 | ns    |
| $t_{WCLR}$   | Asynchronous Clear Minimum Pulse Width for the Core Register  | 0.22 | 0.22 | ns    |
| $t_{WPRE}$   | Asynchronous Preset Minimum Pulse Width for the Core Register | 0.22 | 0.22 | ns    |
| $t_{CKMPWH}$ | Clock Minimum Pulse Width High for the Core Register          | 0.32 | 0.32 | ns    |
| $t_{CKMPWL}$ | Clock Minimum Pulse Width Low for the Core Register           | 0.36 | 0.36 | ns    |

*Note:* For specific junction temperature and voltage supply levels, refer to [Table 2-7 on page 2-9](#) for derating values.

## Global Resource Characteristics

### A2F200 Clock Tree Topology

Clock delays are device-specific. [Figure 2-27](#) is an example of a global tree used for clock routing. The global tree presented in [Figure 2-27](#) is driven by a CCC located on the west side of the A2F200 device. It is used to drive all D-flip-flops in the device.



**Figure 2-27 • Example of Global Tree Use in an A2F200 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 2-63](#). [Table 2-80](#) through [Table 2-82 on page 2-61](#) present minimum and maximum global clock delays for the SmartFusion cSoCs. Minimum and maximum delays are measured with minimum and maximum loading.

## Timing Characteristics

**Table 2-80 • A2F500 Global Resource**

**Worst Commercial-Case Conditions:  $T_J = 85^\circ\text{C}$ ,  $V_{CC} = 1.425\text{ V}$**

| 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          | 1.54              | 1.73              | 1.84              | 2.08              | ns    |
| $t_{RCKH}$    | Input High Delay for Global Clock         | 1.53              | 1.76              | 1.84              | 2.12              | 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             |                   | 0.23              |                   | 0.28              | 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 2-7 on page 2-9](#) for derating values.

**Table 2-81 • A2F200 Global Resource**

**Worst Commercial-Case Conditions:  $T_J = 85^\circ\text{C}$ ,  $V_{CC} = 1.425\text{ V}$**

| 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          | 0.74              | 0.99              | 0.88              | 1.19              | ns    |
| $t_{RCKH}$    | Input High Delay for Global Clock         | 0.76              | 1.05              | 0.91              | 1.26              | 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             |                   | 0.29              |                   | 0.35              | 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 2-7 on page 2-9](#) for derating values.

**Table 2-82 • A2F060 Global Resource**

Worst Commercial-Case Conditions:  $T_J = 85^{\circ}\text{C}$ ,  $V_{CC} = 1.425\text{ V}$ 

| 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          | 0.75              | 0.96              | 0.90              | 1.15              | ns    |
| $t_{\text{RCKH}}$    | Input High Delay for Global Clock         | 0.72              | 0.98              | 0.86              | 1.17              | 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             |                   | 0.26              |                   | 0.31              | 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 2-7 on page 2-9](#) for derating values.

## RC Oscillator

The table below describes the electrical characteristics of the RC oscillator.

### RC Oscillator Characteristics

**Table 2-83 • Electrical Characteristics of the RC Oscillator**

| Parameter | Description         | Condition                                                                                    | Min. | Typ. | Max. | Units |
|-----------|---------------------|----------------------------------------------------------------------------------------------|------|------|------|-------|
| FRC       | Operating frequency |                                                                                              |      | 100  |      | MHz   |
|           | Accuracy            | Temperature: $0^{\circ}\text{C}$ to $85^{\circ}\text{C}$<br>Voltage: $3.3\text{ V} \pm 5\%$  |      | 1    |      | %     |
|           | Output jitter       | Period jitter (at 5 K cycles)                                                                |      | 100  |      | ps    |
|           |                     | Cycle-to-cycle jitter (at 5 K cycles)                                                        |      | 100  |      | ps    |
|           |                     | Period jitter (at 5 K cycles) with 1 KHz / 300 mV peak-to-peak noise on power supply         |      | 150  |      | ps    |
|           |                     | Cycle-to-cycle jitter (at 5 K cycles) with 1 KHz / 300 mV peak-to-peak noise on power supply |      | 150  |      | ps    |
|           | Output duty cycle   |                                                                                              |      | 50   |      | %     |
| IDYNRC    | Operating current   | 3.3 V domain                                                                                 |      | 1    |      | mA    |
|           |                     | 1.5 V domain                                                                                 |      | 2    |      | mA    |

## Main and Lower Power Crystal Oscillator

The tables below describes the electrical characteristics of the main and low power crystal oscillator.

**Table 2-84 • Electrical Characteristics of the Main Crystal Oscillator**

| Parameter | Description                           | Condition               | Min.       | Typ. | Max.       | Units  |
|-----------|---------------------------------------|-------------------------|------------|------|------------|--------|
|           | Operating frequency                   | Using external crystal  | 0.032      |      | 20         | MHz    |
|           |                                       | Using ceramic resonator | 0.5        |      | 8          | MHz    |
|           |                                       | Using RC Network        | 0.032      |      | 4          | MHz    |
|           | Output duty cycle                     |                         |            | 50   |            | %      |
|           | Output jitter                         | With 10 MHz crystal     |            | 50   |            | ps RMS |
| IDYNXTAL  | Operating current                     | RC                      |            | 0.6  |            | mA     |
|           |                                       | 0.032–0.2               |            | 0.6  |            | mA     |
|           |                                       | 0.2–2.0                 |            | 0.6  |            | mA     |
|           |                                       | 2.0–20.0                |            | 0.6  |            | mA     |
| ISTBXTAL  | Standby current of crystal oscillator |                         |            | 10   |            | μA     |
| PSRRXTAL  | Power supply noise tolerance          |                         |            | 0.5  |            | Vp-p   |
| VIHXTAL   | Input logic level High                |                         | 90% of VCC |      |            | V      |
| VILXTAL   | Input logic level Low                 |                         |            |      | 10% of VCC | V      |
|           | Startup time                          | RC                      |            |      |            | μs     |
|           |                                       | 0.032–0.2               |            |      |            | μs     |
|           |                                       | 0.2–2.0                 |            |      |            | μs     |
|           |                                       | 2.0–20.0                |            |      |            | μs     |

**Table 2-85 • Electrical Characteristics of the Low Power Oscillator**

| Parameter | Description                           | Condition             | Min.       | Typ. | Max.       | Units  |
|-----------|---------------------------------------|-----------------------|------------|------|------------|--------|
|           | Operating frequency                   |                       |            | 32   |            | KHz    |
|           | Output duty cycle                     |                       |            | 50   |            | %      |
|           | Output jitter                         |                       |            | 50   |            | ps RMS |
| IDYNXTAL  | Operating current                     | 32 KHz                |            | 10   |            | μA     |
| ISTBXTAL  | Standby current of crystal oscillator |                       |            |      |            | μA     |
| PSRRXTAL  | Power supply noise tolerance          |                       |            | 0.5  |            | Vp-p   |
| VIHXTAL   | Input logic level High                |                       | 90% of VCC |      |            | V      |
| VILXTAL   | Input logic level Low                 |                       |            |      | 10% of VCC | V      |
|           | Startup time                          | Test load used: 20 pF |            | 2.5  |            | s      |

# Clock Conditioning Circuits

## CCC Electrical Specifications

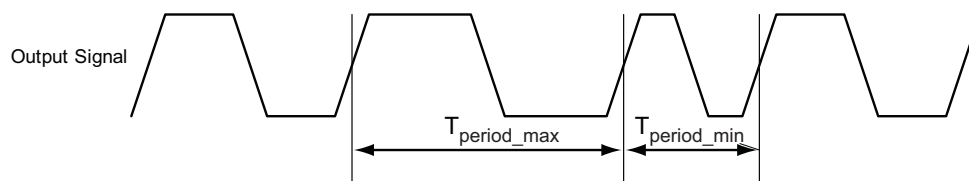
### Timing Characteristics

**Table 2-86 • SmartFusion 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 <sup>1</sup> |       | MHz      |       |
| Delay Increments in Programmable Delay Blocks <sup>2, 3</sup>       |                                    |      | 160     |       |                  |       | ps       |       |
| Number of Programmable Values in Each Programmable Delay Block      |                                    |      |         |       | 32               |       |          |       |
| Input Period Jitter                                                 |                                    |      |         |       | 1.5              |       | ns       |       |
| Acquisition Time                                                    |                                    |      |         |       |                  |       |          |       |
| LockControl = 0                                                     |                                    |      |         |       | 300              |       | μs       |       |
| LockControl = 1                                                     |                                    |      |         |       | 6.0              |       | ms       |       |
| Tracking Jitter <sup>4</sup>                                        |                                    |      |         |       |                  |       |          |       |
| LockControl = 0                                                     |                                    |      |         |       | 1.6              |       | ns       |       |
| LockControl = 1                                                     |                                    |      |         |       | 0.8              |       | ns       |       |
| Output Duty Cycle                                                   | 48.5                               |      |         |       | 5.15             |       | %        |       |
| Delay Range in Block: Programmable Delay 1 <sup>2,3</sup>           | 0.6                                |      |         |       | 5.56             |       | ns       |       |
| Delay Range in Block: Programmable Delay 2 <sup>2,3</sup>           | 0.025                              |      |         |       | 5.56             |       | ns       |       |
| Delay Range in Block: Fixed Delay <sup>2,3</sup>                    |                                    |      | 2.2     |       |                  |       | ns       |       |
| CCC Output Peak-to-Peak Period Jitter $F_{CCC\_OUT}$ <sup>5,6</sup> | Maximum Peak-to-Peak Period Jitter |      |         |       |                  |       |          |       |
|                                                                     | SSO ≤ 2                            |      | SSO ≤ 4 |       | SSO ≤ 8          |       | SSO ≤ 16 |       |
|                                                                     | FG/CS                              | PQ   | FG/CS   | PQ    | FG/CS            | PQ    | FG/CS    | PQ    |
| 0.75 MHz to 50 MHz                                                  | 0.5%                               | 1.6% | 0.9%    | 1.6%  | 0.9%             | 1.6%  | 0.9%     | 1.8%  |
| 50 MHz to 250 MHz                                                   | 1.75%                              | 3.5% | 9.3%    | 9.3%  | 9.3%             | 17.9% | 10.0%    | 17.9% |
| 250 MHz to 350 MHz                                                  | 2.5%                               | 5.2% | 13.0%   | 13.0% | 13.0%            | 25.0% | 14.0%    | 25.0% |

#### Notes:

- One of the CCC outputs (GLA0) is used as an MSS clock and is limited to 100 MHz (maximum) by software. Details regarding CCC/PLL are in the "PLLs, Clock Conditioning Circuitry, and On-Chip Crystal Oscillators" chapter of the [SmartFusion Microcontroller Subsystem User's Guide](#).
- This delay is a function of voltage and temperature. See [Table 2-7 on page 2-9](#) for deratings.
- $T_J = 25^\circ\text{C}$ ,  $V_{CC} = 1.5\text{ V}$
- 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.
- Measurement done with LVTTTL 3.3 V 12 mA I/O drive strength and High slew rate.  $V_{CC}/V_{CCPLL} = 1.425\text{ V}$ ,  $V_{CCI} = 3.3\text{V}$ , 20 pF output load. All I/Os are placed outside of the PLL bank.
- SSOs are outputs that are synchronous to a single clock domain and have their clock-to-out within  $\pm 200\text{ ps}$  of each other.
- VCO output jitter is calculated as a percentage of the VCO frequency. The jitter (in ps) can be calculated by multiplying the VCO period by the % jitter. The VCO jitter (in ps) applies to CCC\_OUT regardless of the output divider settings. For example, if the jitter on VCO is 300 ps, the jitter on CCC\_OUT is also 300 ps.



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

**Figure 2-28 • Peak-to-Peak Jitter Definition**

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# FPGA Fabric SRAM and FIFO Characteristics

## FPGA Fabric SRAM

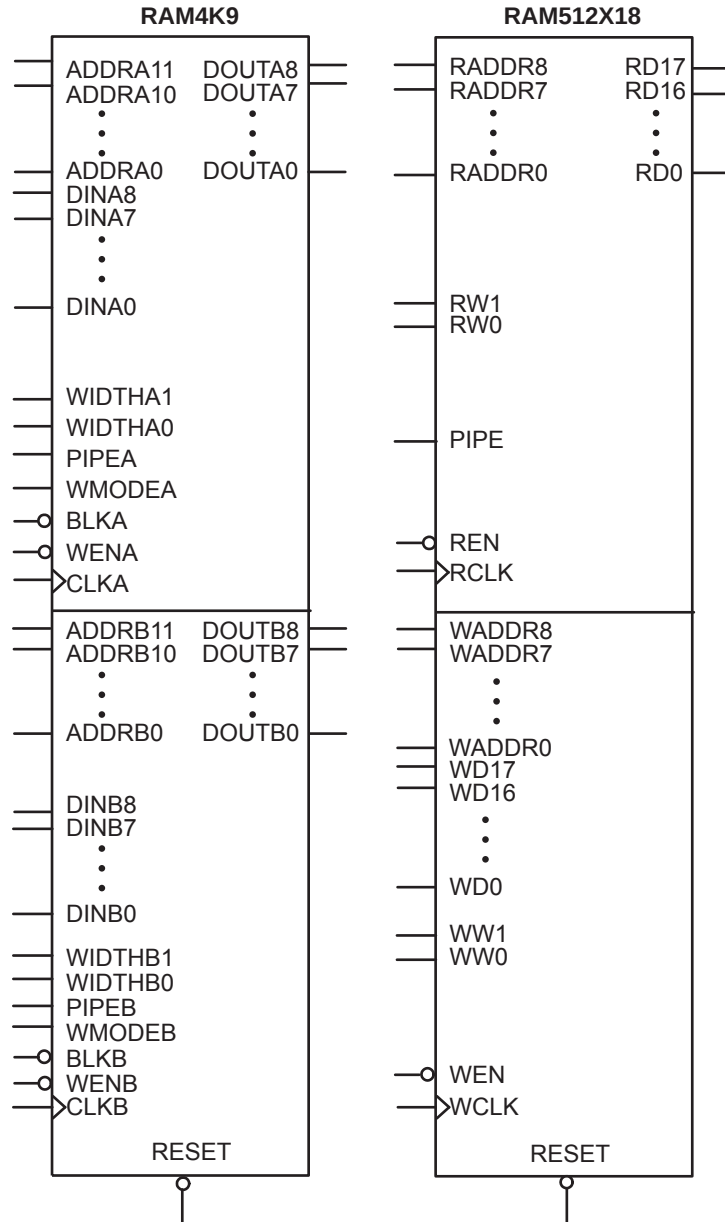
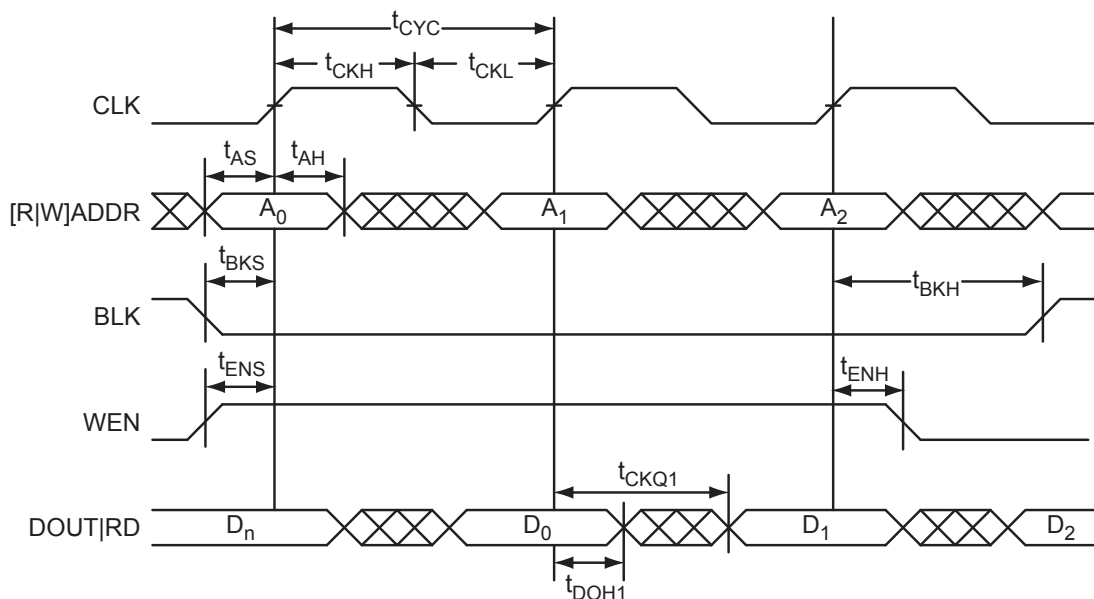
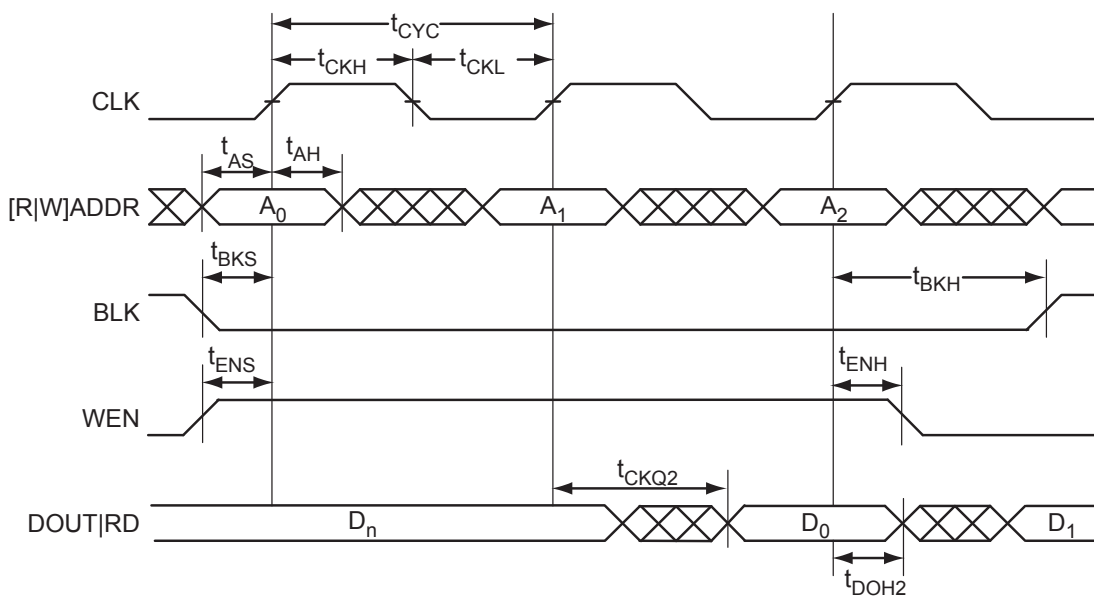


Figure 2-29 • RAM Models

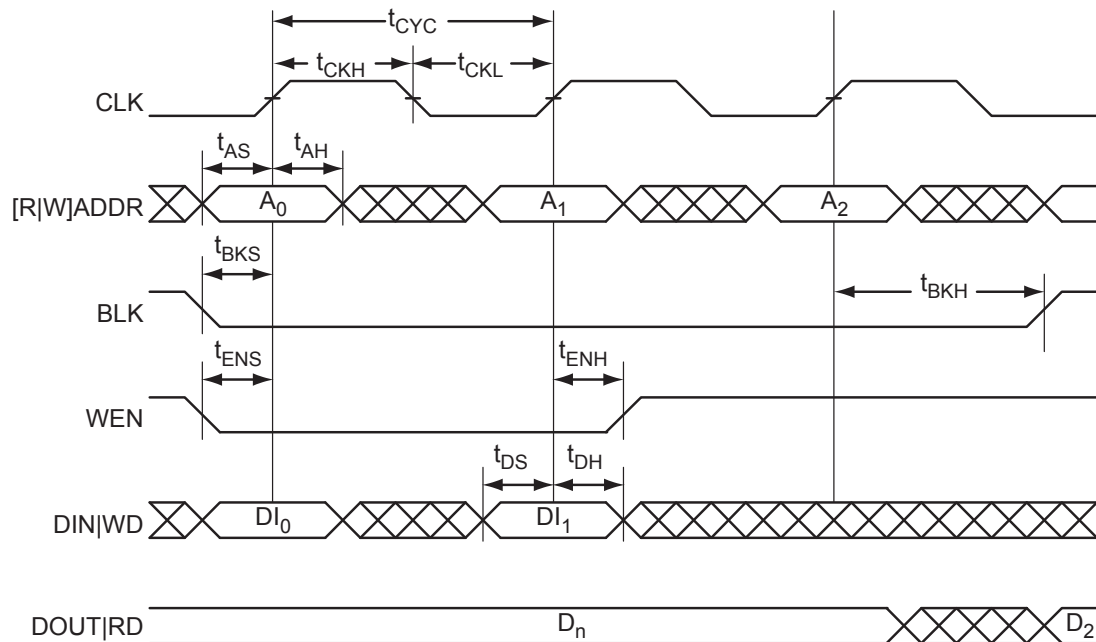
## Timing Waveforms



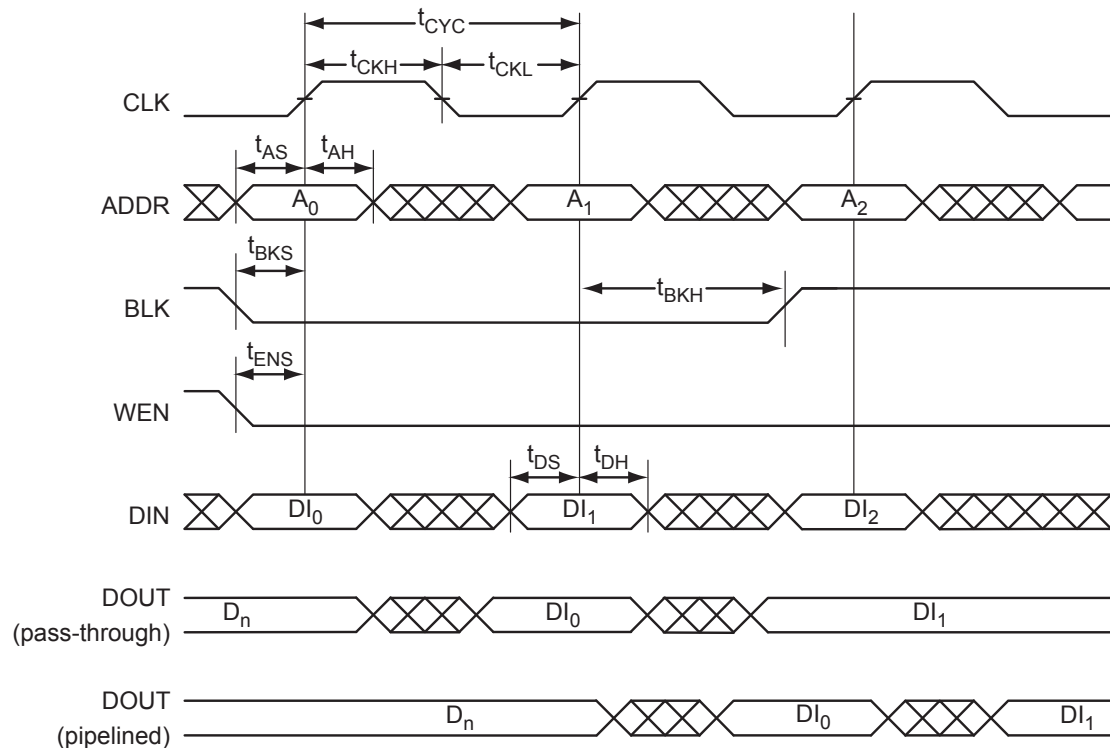
**Figure 2-30 • RAM Read for Pass-Through Output. Applicable to both RAM4K9 and RAM512x18.**



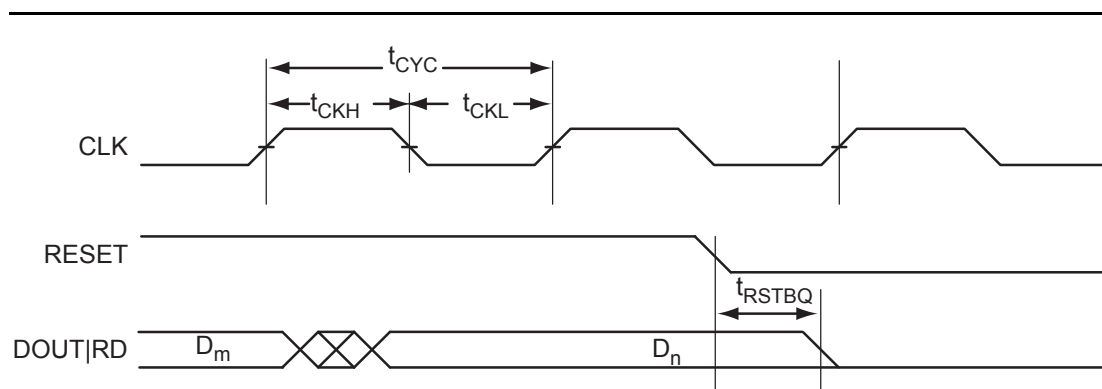
**Figure 2-31 • RAM Read for Pipelined Output Applicable to both RAM4K9 and RAM512x18.**



**Figure 2-32 • RAM Write, Output Retained. Applicable to both RAM4K9 and RAM512x18.**



**Figure 2-33 • RAM Write, Output as Write Data (WMODE = 1). Applicable to RAM4K9 only.**



**Figure 2-34 • RAM Reset. Applicable to both RAM4K9 and RAM512x18.**

## Timing Characteristics

**Table 2-87 • RAM4K9**

Worst Commercial-Case Conditions:  $T_J = 85^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$ 

| Parameter     | Description                                                                                                         | –1   | Std. | Units |
|---------------|---------------------------------------------------------------------------------------------------------------------|------|------|-------|
| $t_{AS}$      | Address setup time                                                                                                  | 0.25 | 0.30 | ns    |
| $t_{AH}$      | Address hold time                                                                                                   | 0.00 | 0.00 | ns    |
| $t_{ENS}$     | REN, WEN setup time                                                                                                 | 0.15 | 0.17 | ns    |
| $t_{ENH}$     | REN, WEN hold time                                                                                                  | 0.10 | 0.12 | ns    |
| $t_{BKS}$     | BLK setup time                                                                                                      | 0.24 | 0.28 | ns    |
| $t_{BKH}$     | BLK hold time                                                                                                       | 0.02 | 0.02 | ns    |
| $t_{DS}$      | Input data (DIN) setup time                                                                                         | 0.19 | 0.22 | ns    |
| $t_{DH}$      | Input data (DIN) hold time                                                                                          | 0.00 | 0.00 | ns    |
| $t_{CKQ1}$    | Clock High to new data valid on DOUT (output retained, WMODE = 0)                                                   | 1.81 | 2.18 | ns    |
|               | Clock High to new data valid on DOUT (flow-through, WMODE = 1)                                                      | 2.39 | 2.87 | ns    |
| $t_{CKQ2}$    | Clock High to new data valid on DOUT (pipelined)                                                                    | 0.91 | 1.09 | ns    |
| $t_{C2CWWH}$  | Address collision clk-to-clk delay for reliable write after write on same address—applicable to rising edge         | 0.30 | 0.35 | ns    |
| $t_{C2CRWH}$  | Address collision clk-to-clk delay for reliable read access after write on same address—applicable to opening edge  | 0.45 | 0.52 | ns    |
| $t_{C2CWRH}$  | Address collision clk-to-clk delay for reliable write access after read on same address— applicable to opening edge | 0.49 | 0.57 | ns    |
| $t_{RSTBQ}$   | RESET Low to data out Low on DOUT (flow-through)                                                                    | 0.94 | 1.12 | ns    |
|               | RESET Low to Data Out Low on DOUT (pipelined)                                                                       | 0.94 | 1.12 | ns    |
| $t_{REMRSTB}$ | RESET removal                                                                                                       | 0.29 | 0.35 | ns    |
| $t_{RECRSTB}$ | RESET recovery                                                                                                      | 1.52 | 1.83 | ns    |
| $t_{MPWRSTB}$ | RESET minimum pulse width                                                                                           | 0.22 | 0.22 | ns    |
| $t_{CYC}$     | Clock cycle time                                                                                                    | 3.28 | 3.28 | ns    |
| $F_{MAX}$     | Maximum clock frequency                                                                                             | 305  | 305  | MHz   |

*Note:* For the derating values at specific junction temperature and voltage supply levels, refer to [Table 2-7](#) on [page 2-9](#) for derating values.

**Table 2-88 • RAM512X18**
**Worst Commercial-Case Conditions:  $T_J = 85^\circ\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$** 

| Parameter     | Description                                                                                                        | –1   | Std. | Units |
|---------------|--------------------------------------------------------------------------------------------------------------------|------|------|-------|
| $t_{AS}$      | Address setup time                                                                                                 | 0.25 | 0.30 | ns    |
| $t_{AH}$      | Address hold time                                                                                                  | 0.00 | 0.00 | ns    |
| $t_{ENS}$     | REN, WEN setup time                                                                                                | 0.09 | 0.11 | ns    |
| $t_{ENH}$     | REN, WEN hold time                                                                                                 | 0.06 | 0.07 | ns    |
| $t_{DS}$      | Input data (WD) setup time                                                                                         | 0.19 | 0.22 | ns    |
| $t_{DH}$      | Input data (WD) hold time                                                                                          | 0.00 | 0.00 | ns    |
| $t_{CKQ1}$    | Clock High to new data valid on RD (output retained, WMODE = 0)                                                    | 2.19 | 2.63 | ns    |
| $t_{CKQ2}$    | Clock High to new data valid on RD (pipelined)                                                                     | 0.91 | 1.09 | ns    |
| $t_{C2CRWH}$  | Address collision clk-to-clk delay for reliable read access after write on same address—applicable to opening edge | 0.50 | 0.58 | ns    |
| $t_{C2CWRH}$  | Address collision clk-to-clk delay for reliable write access after read on same address—applicable to opening edge | 0.59 | 0.67 | ns    |
| $t_{RSTBQ}$   | RESET Low to data out Low on RD (flow-through)                                                                     | 0.94 | 1.12 | ns    |
|               | RESET Low to data out Low on RD (pipelined)                                                                        | 0.94 | 1.12 | ns    |
| $t_{REMRSTB}$ | RESET removal                                                                                                      | 0.29 | 0.35 | ns    |
| $t_{RECRSTB}$ | RESET recovery                                                                                                     | 1.52 | 1.83 | ns    |
| $t_{MPWRSTB}$ | RESET minimum pulse width                                                                                          | 0.22 | 0.22 | ns    |
| $t_{CYC}$     | Clock cycle time                                                                                                   | 3.28 | 3.28 | ns    |
| $F_{MAX}$     | Maximum clock frequency                                                                                            | 305  | 305  | MHz   |

*Note:* For the derating values at specific junction temperature and voltage supply levels, refer to [Table 2-7](#) on [page 2-9](#) for derating values.

## FIFO

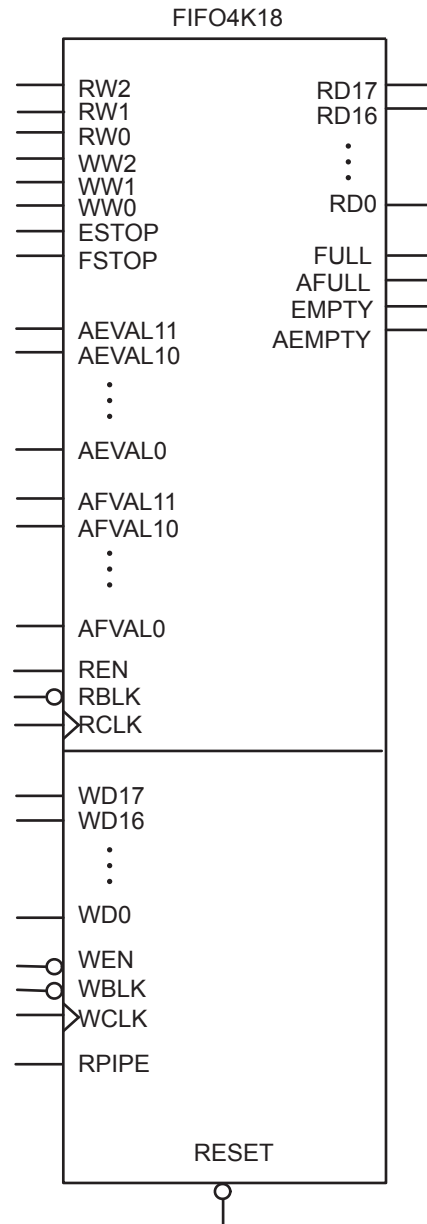
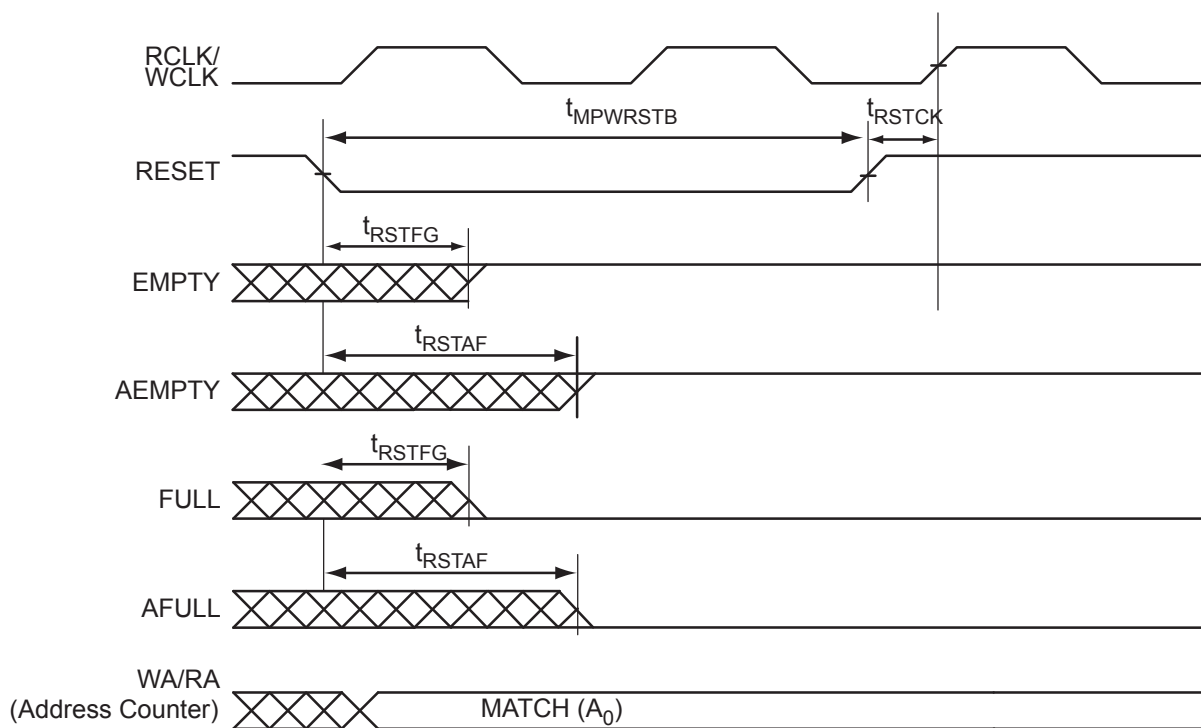
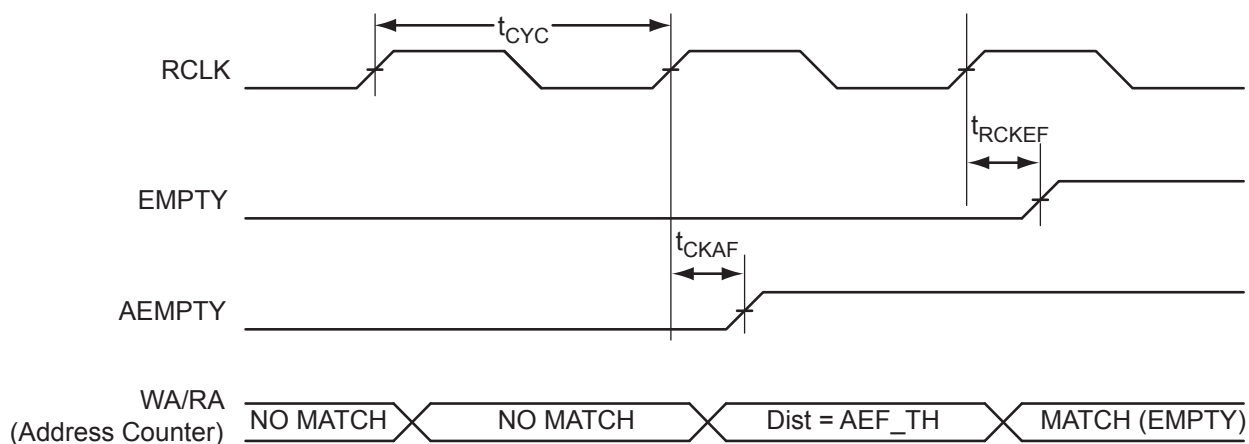


Figure 2-35 • FIFO Model

## Timing Waveforms

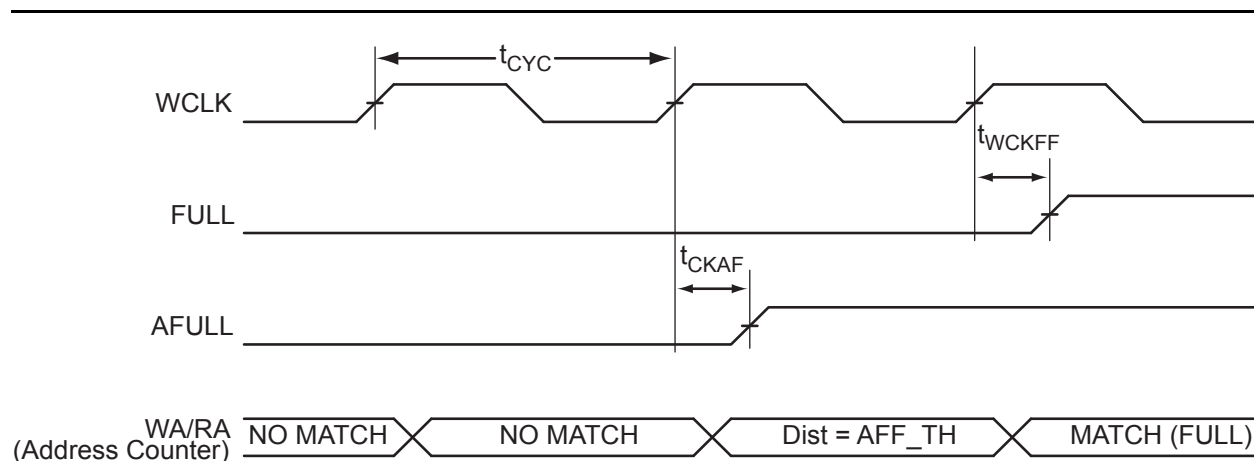
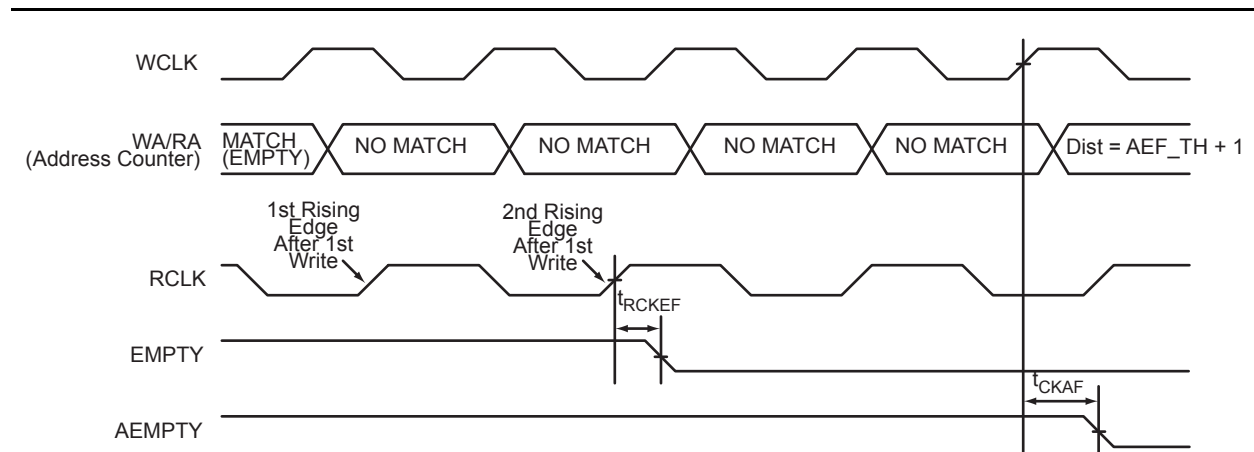
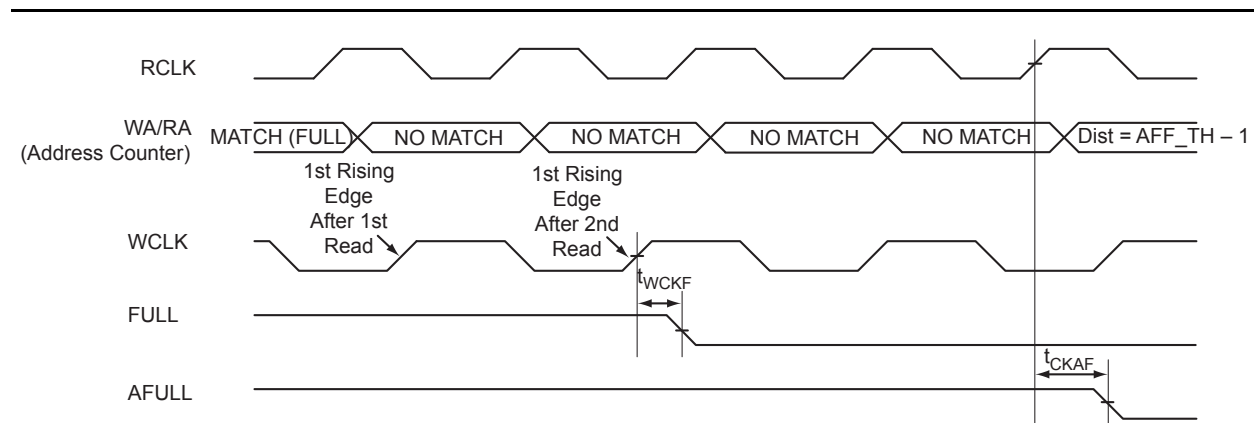


**Figure 2-36 • FIFO Reset**



**Figure 2-37 • FIFO EMPTY Flag and AEMPTY Flag Assertion**




**Figure 2-38 • FIFO FULL Flag and AFULL Flag Assertion**

**Figure 2-39 • FIFO EMPTY Flag and AEMPTY Flag Deassertion**

**Figure 2-40 • FIFO FULL Flag and AFULL Flag Deassertion**

## Timing Characteristics

**Table 2-89 • FIFO**

**Worst Commercial-Case Conditions:  $T_J = 85^\circ\text{C}$ ,  $V_{CC} = 1.425\text{ V}$**

| Parameter     | Description                                       | –1   | Std. | Units |
|---------------|---------------------------------------------------|------|------|-------|
| $t_{ENS}$     | REN, WEN Setup Time                               | 1.40 | 1.68 | ns    |
| $t_{ENH}$     | REN, WEN Hold Time                                | 0.02 | 0.02 | ns    |
| $t_{BKS}$     | BLK Setup Time                                    | 0.19 | 0.19 | ns    |
| $t_{BKH}$     | BLK Hold Time                                     | 0.00 | 0.00 | ns    |
| $t_{DS}$      | Input Data (WD) Setup Time                        | 0.19 | 0.22 | ns    |
| $t_{DH}$      | Input Data (WD) Hold Time                         | 0.00 | 0.00 | ns    |
| $t_{CKQ1}$    | Clock High to New Data Valid on RD (flow-through) | 2.39 | 2.87 | ns    |
| $t_{CKQ2}$    | Clock High to New Data Valid on RD (pipelined)    | 0.91 | 1.09 | ns    |
| $t_{RCKEF}$   | RCLK High to Empty Flag Valid                     | 1.74 | 2.09 | ns    |
| $t_{WCKFF}$   | WCLK High to Full Flag Valid                      | 1.66 | 1.99 | ns    |
| $t_{CKAF}$    | Clock HIGH to Almost Empty/Full Flag Valid        | 6.29 | 7.54 | ns    |
| $t_{RSTFG}$   | RESET Low to Empty/Full Flag Valid                | 1.72 | 2.06 | ns    |
| $t_{RSTAF}$   | RESET Low to Almost Empty/Full Flag Valid         | 6.22 | 7.47 | ns    |
| $t_{RSTBQ}$   | RESET Low to Data Out Low on RD (flow-through)    | 0.94 | 1.12 | ns    |
|               | RESET Low to Data Out Low on RD (pipelined)       | 0.94 | 1.12 | ns    |
| $t_{REMRSTB}$ | RESET Removal                                     | 0.29 | 0.35 | ns    |
| $t_{RECRSTB}$ | RESET Recovery                                    | 1.52 | 1.83 | ns    |
| $t_{MPWRSTB}$ | RESET Minimum Pulse Width                         | 0.22 | 0.22 | ns    |
| $t_{CYC}$     | Clock Cycle Time                                  | 3.28 | 3.28 | ns    |
| $F_{MAX}$     | Maximum Frequency for FIFO                        | 305  | 305  | MHz   |

*Note:* For specific junction temperature and voltage supply levels, refer to [Table 2-7 on page 2-9](#) for derating values.

## Embedded Nonvolatile Memory Block (eNVM)

### Electrical Characteristics

[Table 2-90](#) describes the eNVM maximum performance.

**Table 2-90 • eNVM Block Timing, Worst Commercial Case Conditions:  $T_J = 85^\circ\text{C}$ ,  $V_{CC} = 1.425\text{ V}$**

| Parameter         | Description                                                             | A2F060 |      | A2F200 |      | A2F500 |      | Units |
|-------------------|-------------------------------------------------------------------------|--------|------|--------|------|--------|------|-------|
|                   |                                                                         | –1     | Std. | –1     | Std. | –1     | Std. |       |
| $t_{FMAXCLKeNVM}$ | Maximum frequency for clock for the control logic – 5 cycles (5:1:1:1*) | 80     | 80   | 80     | 80   | 50     | 50   | MHz   |
| $t_{FMAXCLKeNVM}$ | Maximum frequency for clock for the control logic – 6 cycles (6:1:1:1*) | 100    | 80   | 100    | 80   | 100    | 80   | MHz   |

*Note:* \*6:1:1:1 indicates 6 cycles for the first access and 1 each for the next three accesses. 5:1:1:1 indicates 5 cycles for the first access and 1 each for the next three accesses.

## Embedded FlashROM (eFROM)

### Electrical Characteristics

Table 2-91 describes the eFROM maximum performance

**Table 2-91 • FlashROM Access Time, Worse Commercial Case Conditions:  $T_J = 85^{\circ}\text{C}$ ,  $V_{CC} = 1.425\text{ V}$**

| Parameter  | Description                     | –1    | Std.  | Units |
|------------|---------------------------------|-------|-------|-------|
| $t_{CK2Q}$ | Clock to out per configuration* | 28.68 | 32.98 | ns    |
| $F_{\max}$ | Maximum Clock frequency         | 15.00 | 15.00 | 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 2-19 for more details.

#### Timing Characteristics

**Table 2-92 • JTAG 1532**

**Worst Commercial-Case Conditions:  $T_J = 85^{\circ}\text{C}$ , Worst-Case  $V_{CC} = 1.425\text{ V}$**

| Parameter     | Description                 | –1    | Std.  | Units |
|---------------|-----------------------------|-------|-------|-------|
| $t_{DISU}$    | Test Data Input Setup Time  | 0.67  | 0.77  | ns    |
| $t_{DIHD}$    | Test Data Input Hold Time   | 1.33  | 1.53  | ns    |
| $t_{TMSSU}$   | Test Mode Select Setup Time | 0.67  | 0.77  | ns    |
| $t_{TMDHD}$   | Test Mode Select Hold Time  | 1.33  | 1.53  | ns    |
| $t_{TCK2Q}$   | Clock to Q (data out)       | 8.00  | 9.20  | ns    |
| $t_{RSTB2Q}$  | Reset to Q (data out)       | 26.67 | 30.67 | ns    |
| $F_{TCKMAX}$  | TCK Maximum Frequency       | 19.00 | 21.85 | MHz   |
| $t_{TRSTREM}$ | ResetB Removal Time         | 0.00  | 0.00  | ns    |
| $t_{TRSTREC}$ | ResetB Recovery Time        | 0.27  | 0.31  | ns    |
| $t_{TRSTMPW}$ | ResetB Minimum Pulse        | TBD   | TBD   | ns    |

*Note:* For specific junction temperature and voltage supply levels, refer to Table 2-7 on page 2-9 for derating values.

## Programmable Analog Specifications

### Current Monitor

Unless otherwise noted, current monitor performance is specified at 25°C with nominal power supply voltages, with the output measured using the internal voltage reference with the internal ADC in 12-bit mode and 91 Ksps, after digital compensation. All results are based on averaging over 16 samples.

**Table 2-93 • Current Monitor Performance Specification**

| Specification                                                                                                                         | Test Conditions                                                                         | Min.   | Typical        | Max.          | Units             |
|---------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|--------|----------------|---------------|-------------------|
| Input voltage range (for driving ADC over full range)                                                                                 |                                                                                         | 0 – 48 | 0 – 50         | 1 – 51        | mV                |
| Analog gain                                                                                                                           | From the differential voltage across the input pads to the ADC input                    |        | 50             |               | V/V               |
| Input referred offset voltage                                                                                                         | Input referred offset voltage                                                           | 0      | 0.1            | 0.5           | mV                |
|                                                                                                                                       | –40°C to +100°C                                                                         | 0      | 0.1            | 0.5           | mV                |
| Gain error                                                                                                                            | Slope of BFSL vs. 50 V/V                                                                |        | ±0.1           | ±0.5          | % nom.            |
|                                                                                                                                       | –40°C to +100°C                                                                         |        |                | ±0.5          | % nom.            |
| Overall Accuracy                                                                                                                      | Peak error from ideal transfer function, 25°C                                           |        | ±(0.1 + 0.25%) | ±(0.4 + 1.5%) | mV plus % reading |
| Input referred noise                                                                                                                  | 0 VDC input (no output averaging)                                                       | 0.3    | 0.4            | 0.5           | mVrms             |
| Common-mode rejection ratio                                                                                                           | 0 V to 12 VDC common-mode voltage                                                       | –86    | –87            |               | dB                |
| Analog settling time                                                                                                                  | To 0.1% of final value (with ADC load)                                                  |        |                |               |                   |
|                                                                                                                                       | From CM_STB (High)                                                                      | 5      |                |               | µs                |
|                                                                                                                                       | From ADC_START (High)                                                                   | 5      |                | 200           | µs                |
| Input capacitance                                                                                                                     |                                                                                         |        | 8              |               | pF                |
| Input biased current                                                                                                                  | CM[n] or TM[n] pad, –40°C to +100°C over maximum input voltage range (plus is into pad) |        |                |               |                   |
|                                                                                                                                       | Strobe = 0; IBIAS on CM[n]                                                              |        | 0              |               | µA                |
|                                                                                                                                       | Strobe = 1; IBIAS on CM[n]                                                              |        | 1              |               | µA                |
|                                                                                                                                       | Strobe = 0; IBIAS on TM[n]                                                              |        | 2              |               | µA                |
|                                                                                                                                       | Strobe = 1; IBIAS on TM[n]                                                              |        | 1              |               | µA                |
| Power supply rejection ratio                                                                                                          | DC (0 – 10 KHz)                                                                         | 41     | 42             |               | dB                |
| Incremental operational current monitor power supply current requirements (per current monitor instance, not including ADC or VAREFx) | VCC33A                                                                                  |        | 150            |               | µA                |
|                                                                                                                                       | VCC33AP                                                                                 |        | 140            |               | µA                |
|                                                                                                                                       | VCC15A                                                                                  |        | 50             |               | µA                |

**Note:** Under no condition should the TM pad ever be greater than 10 mV above than the CM pad.

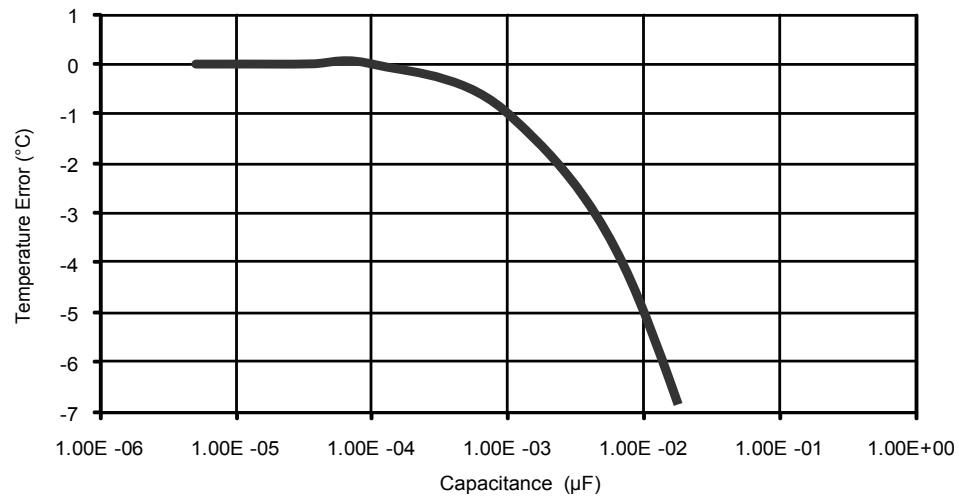
## Temperature Monitor

Unless otherwise noted, temperature monitor performance is specified with a 2N3904 diode-connected bipolar transistor from National Semiconductor or Infineon Technologies, nominal power supply voltages, with the output measured using the internal voltage reference with the internal ADC in 12-bit mode and 62.5 Ksps. After digital compensation. Unless otherwise noted, the specifications pertain to conditions where the SmartFusion cSoC and the sensing diode are at the same temperature.

**Table 2-94 • Temperature Monitor Performance Specifications**

| Specification                                                                                                                                       | Test Conditions                                                                                   | Min.  | Typical | Max.   | Units  |
|-----------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|-------|---------|--------|--------|
| Input diode temperature range                                                                                                                       |                                                                                                   | –55   |         | 150    | °C     |
|                                                                                                                                                     |                                                                                                   | 233.2 |         | 378.15 | K      |
| Temperature sensitivity                                                                                                                             |                                                                                                   |       | 2.5     |        | mV/K   |
| Intercept                                                                                                                                           | Extrapolated to 0K                                                                                |       | 0       |        | V      |
| Input referred temperature offset error                                                                                                             | At 25°C (298.15K)                                                                                 |       | ±1      | 1.5    | °C     |
| Gain error                                                                                                                                          | Slope of BFSL vs. 2.5 mV/K                                                                        |       | ±1      | 2.5    | % nom. |
| Overall accuracy                                                                                                                                    | Peak error from ideal transfer function                                                           |       | ±2      | ±3     | °C     |
| Input referred noise                                                                                                                                | At 25°C (298.15K) – no output averaging                                                           |       | 4       |        | °C rms |
| Output current                                                                                                                                      | Idle mode                                                                                         |       | 100     |        | μA     |
|                                                                                                                                                     | Final measurement phases                                                                          |       | 10      |        | μA     |
| Analog settling time                                                                                                                                | Measured to 0.1% of final value, (with ADC load)                                                  |       |         |        |        |
|                                                                                                                                                     | From TM_STB (High)                                                                                | 5     |         |        | μs     |
|                                                                                                                                                     | From ADC_START (High)                                                                             | 5     |         | 105    | μs     |
| AT parasitic capacitance                                                                                                                            |                                                                                                   |       |         | 500    | pF     |
| Power supply rejection ratio                                                                                                                        | DC (0–10 KHz)                                                                                     | 1.2   | 0.7     |        | °C/V   |
| Input referred temperature sensitivity error                                                                                                        | Variation due to device temperature (–40°C to +100°C). External temperature sensor held constant. |       | 0.005   | 0.008  | °C/°C  |
| Temperature monitor (TM) operational power supply current requirements (per temperature monitor instance, not including ADC or VAREF <sub>x</sub> ) | VCC33A                                                                                            |       | 200     |        | μA     |
|                                                                                                                                                     | VCC33AP                                                                                           |       | 150     |        | μA     |
|                                                                                                                                                     | VCC15A                                                                                            |       | 50      |        | μA     |

*Note:* All results are based on averaging over 64 samples.



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**Figure 2-41 • Temperature Error Versus External Capacitance**

## Analog-to-Digital Converter (ADC)

Unless otherwise noted, ADC direct input performance is specified at 25°C with nominal power supply voltages, with the output measured using the external voltage reference with the internal ADC in 12-bit mode and 500 KHz sampling frequency, after trimming and digital compensation.

**Table 2-95 • ADC Specifications**

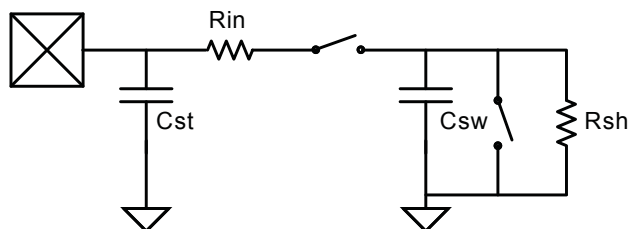
| Specification                                                                                                       | Test Conditions                                                                | Min. | Typ. | Max. | Units |
|---------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|------|------|------|-------|
| Input voltage range (for driving ADC over its full range)                                                           |                                                                                |      | 2.56 |      | V     |
| Gain error                                                                                                          |                                                                                |      | ±0.4 | ±0.7 | %     |
|                                                                                                                     | –40°C to +100°C                                                                |      | ±0.4 | ±0.7 | %     |
| Input referred offset voltage                                                                                       |                                                                                |      | ±1   | ±2   | mV    |
|                                                                                                                     | –40°C to +100°C                                                                |      | ±1   | ±2   |       |
| Integral non-linearity (INL)                                                                                        | RMS deviation from BFSL                                                        |      |      |      |       |
|                                                                                                                     | 12-bit mode                                                                    |      | 1.71 |      | LSB   |
|                                                                                                                     | 10-bit mode                                                                    |      | 0.60 | 1.00 | LSB   |
|                                                                                                                     | 8-bit mode                                                                     |      | 0.2  | 0.33 | LSB   |
| Differential non-linearity (DNL)                                                                                    | 12-bit mode                                                                    |      | 2.4  |      | LSB   |
|                                                                                                                     | 10-bit mode                                                                    |      | 0.80 | 0.94 | LSB   |
|                                                                                                                     | 8-bit mode                                                                     |      | 0.2  | 0.23 | LSB   |
| Signal to noise ratio                                                                                               |                                                                                | 62   | 64   |      | dB    |
| Effective number of bits (ENOB)<br>$\text{ENOB} = \frac{\text{SINAD} - 1.76 \text{ dB}}{6.02 \text{ dB/bit}}$ EQ 10 | –1 dBFS input                                                                  |      |      |      |       |
|                                                                                                                     | 12-bit mode 10 KHz                                                             | 9.9  | 10   |      | Bits  |
|                                                                                                                     | 12-bit mode 100 KHz                                                            | 9.9  | 10   |      | Bits  |
|                                                                                                                     | 10-bit mode 10 KHz                                                             | 9.5  | 9.6  |      | Bits  |
|                                                                                                                     | 10-bit mode 100 KHz                                                            | 9.5  | 9.6  |      | Bits  |
|                                                                                                                     | 8-bit mode 10 KHz                                                              | 7.8  | 7.9  |      | Bits  |
|                                                                                                                     | 8-bit mode 100 KHz                                                             | 7.8  | 7.9  |      | Bits  |
| Full power bandwidth                                                                                                | At –3 dB; –1 dBFS input                                                        | 300  |      |      | KHz   |
| Analog settling time                                                                                                | To 0.1% of final value (with 1 Kohm source impedance and with ADC load)        |      | 2    |      | µs    |
| Input capacitance                                                                                                   | Switched capacitance (ADC sample capacitor)                                    |      | 12   | 15   | pF    |
|                                                                                                                     | Cs: Static capacitance (Figure 2-42 on page 2-80)                              |      |      |      |       |
|                                                                                                                     | CM[n] input                                                                    |      | 5    | 7    | pF    |
|                                                                                                                     | TM[n] input                                                                    |      | 5    | 7    | pF    |
|                                                                                                                     | ADC[n] input                                                                   |      | 5    | 7    | pF    |
| Input resistance                                                                                                    | Rin: Series resistance (Figure 2-42)                                           |      | 2    |      | KΩ    |
|                                                                                                                     | Rsh: Shunt resistance, exclusive of switched capacitance effects (Figure 2-42) | 10   |      |      | MΩ    |

**Note:** All 3.3 V supplies are tied together and varied from 3.0 V to 3.6 V. 1.5 V supplies are held constant.

**Table 2-95 • ADC Specifications (continued)**

| Specification                                     | Test Conditions | Min. | Typ. | Max. | Units |
|---------------------------------------------------|-----------------|------|------|------|-------|
| Input leakage current                             | –40°C to +100°C |      | 1    |      | μA    |
| Power supply rejection ratio                      | DC              | 44   | 53   |      | dB    |
| ADC power supply operational current requirements | VCC33ADCx       |      |      | 2.5  | mA    |
|                                                   | VCC15A          |      |      | 2    | mA    |

*Note:* All 3.3 V supplies are tied together and varied from 3.0 V to 3.6 V. 1.5 V supplies are held constant.



**Figure 2-42 • ADC Input Model**

**Table 2-96 • VAREF Stabilization Time**

| VAREF Capacitor Value (μF) | Required Settling Time for 8-Bit and 10-Bit Mode (ms) | Required Settling Time for 12-Bit Mode (ms) |
|----------------------------|-------------------------------------------------------|---------------------------------------------|
| 0.01                       | 1                                                     | 1                                           |
| 0.1                        | 3                                                     | 4                                           |
| 0.2                        | 6                                                     | 8                                           |
| 0.3                        | 10                                                    | 11                                          |
| 0.5                        | 17                                                    | 20                                          |
| 0.7                        | 18                                                    | 21                                          |
| 1                          | 32                                                    | 37                                          |
| 2.2                        | 62                                                    | 73                                          |
| 3.3                        | 99                                                    | 117                                         |
| 10                         | 275                                                   | 325                                         |
| 22                         | 635                                                   | 751                                         |
| 47                         | 1318                                                  | 1557                                        |



## Analog Bipolar Prescaler (ABPS)

With the ABPS set to its high range setting (GDEC = 00), a hypothetical input voltage in the range –15.36 V to +15.36 V is scaled and offset by the ABPS input amplifier to match the ADC full range of 0 V to 2.56 V using a nominal gain of –0.08333 V/V. However, due to reliability considerations, the voltage applied to the ABPS input should never be outside the range of –11.5 V to +14.4 V, restricting the usable ADC input voltage to 2.238 V to 0.080 V and the corresponding 12-bit output codes to the range of 3581 to 128 (decimal), respectively.

Unless otherwise noted, ABPS performance is specified at 25°C with nominal power supply voltages, with the output measured using the internal voltage reference with the internal ADC in 12-bit mode and 100 KHz sampling frequency, after trimming and digital compensation; and applies to all ranges.

**Table 2-97 • ABPS Performance Specifications**

| Specification                                                                                                                 | Test Conditions                                | Min.  | Typ.       | Max. | Units |
|-------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|-------|------------|------|-------|
| Input voltage range (for driving ADC over its full range)                                                                     | GDEC[1:0] = 11                                 |       | ±2.56      |      | V     |
|                                                                                                                               | GDEC[1:0] = 10                                 |       | ±5.12      |      | V     |
|                                                                                                                               | GDEC[1:0] = 01                                 |       | ±10.24     |      | V     |
|                                                                                                                               | GDEC[1:0] = 00 (limited by maximum rating)     |       | See note 1 |      | V     |
| Analog gain (from input pad to ADC input)                                                                                     | GDEC[1:0] = 11                                 |       | –0.5       |      | V/V   |
|                                                                                                                               | GDEC[1:0] = 10                                 |       | –0.25      |      | V/V   |
|                                                                                                                               | GDEC[1:0] = 01                                 |       | –0.125     |      | V/V   |
|                                                                                                                               | GDEC[1:0] = 00                                 |       | –0.0833    |      | V/V   |
| Gain error                                                                                                                    |                                                | –2.8  | –0.4       | 0.7  | %     |
|                                                                                                                               | –40°C to +100°C                                | –2.8  | –0.4       | 0.7  | %     |
| Input referred offset voltage                                                                                                 |                                                |       |            |      |       |
|                                                                                                                               | GDEC[1:0] = 11                                 | –0.31 | –0.07      | 0.31 | % FR  |
|                                                                                                                               | –40°C to +100°C                                | –1.00 |            | 1.47 | % FR  |
|                                                                                                                               | GDEC[1:0] = 10                                 | –0.34 | –0.07      | 0.34 | % FR  |
|                                                                                                                               | –40°C to +100°C                                | –0.90 |            | 1.37 | % FR  |
|                                                                                                                               | GDEC[1:0] = 01                                 | –0.61 | –0.07      | 0.35 | % FR  |
|                                                                                                                               | –40°C to +100°C                                | –1.05 |            | 1.35 | % FR  |
|                                                                                                                               | GDEC[1:0] = 00                                 | –0.39 | –0.07      | 0.35 | % FR  |
|                                                                                                                               | –40°C to +100°C                                | –1.06 |            | 1.38 | % FR  |
| SINAD                                                                                                                         |                                                | 53    | 56         |      | dB    |
| Non-linearity                                                                                                                 | RMS deviation from BFUL                        |       |            | 0.5  | % FR  |
| Effective number of bits (ENOB)<br>$\text{ENOB} = \frac{\text{SINAD} - 1.76 \text{ dB}}{6.02 \text{ dB/bit}}$<br><i>EQ 11</i> | GDEC[1:0] = 11<br>(±2.56 range), –1 dBFS input |       |            |      |       |
|                                                                                                                               | 12-bit mode 10 KHz                             | 8.6   | 9.1        |      | Bits  |
|                                                                                                                               | 12-bit mode 100 KHz                            | 8.6   | 9.1        |      | Bits  |
|                                                                                                                               | 10-bit mode 10 KHz                             | 8.5   | 8.9        |      | Bits  |
|                                                                                                                               | 10-bit mode 100 KHz                            | 8.5   | 8.9        |      | Bits  |
|                                                                                                                               | 8-bit mode 10 KHz                              | 7.7   | 7.8        |      | Bits  |
|                                                                                                                               | 8-bit mode 100 KHz                             | 7.7   | 7.8        |      | Bits  |
| Large-signal bandwidth                                                                                                        | –1 dBFS input                                  |       | 1          |      | MHz   |

**Table 2-97 • ABPS Performance Specifications (continued)**

| Specification                                                                     | Test Conditions                        | Min. | Typ. | Max. | Units |
|-----------------------------------------------------------------------------------|----------------------------------------|------|------|------|-------|
| Analog settling time                                                              | To 0.1% of final value (with ADC load) |      |      | 10   | μs    |
| Input resistance                                                                  |                                        |      | 1    |      | MΩ    |
| Power supply rejection ratio                                                      | DC (0–1 KHz)                           | 38   | 40   |      | dB    |
| ABPS power supply current requirements (not including ADC or VAREF <sub>x</sub> ) | ABPS_EN = 1 (operational mode)         |      |      |      |       |
|                                                                                   | VCC33A                                 |      | 123  | 134  | μA    |
|                                                                                   | VCC33AP                                |      | 89   | 94   | μA    |
|                                                                                   | VCC15A                                 |      | 1    |      | μA    |

## Comparator

Unless otherwise specified, performance is specified at 25°C with nominal power supply voltages.

**Table 2-98 • Comparator Performance Specifications**

| Specification                                                                 | Test Conditions                                |                                      | Min. | Typ.  | Max. | Units |
|-------------------------------------------------------------------------------|------------------------------------------------|--------------------------------------|------|-------|------|-------|
| Input voltage range                                                           | Minimum                                        |                                      |      | 0     |      | V     |
|                                                                               | Maximum                                        |                                      |      | 2.56  |      | V     |
| Input offset voltage                                                          | HYS[1:0] = 00<br>(no hysteresis)               |                                      |      | ±1    | ±3   | mV    |
| Input bias current                                                            | Comparator 1, 3, 5, 7, 9 (measured at 2.56 V)  |                                      |      | 40    | 60   | nA    |
|                                                                               | Comparator 0, 2, 4, 6, 8 (measured at 2.56 V)  |                                      |      | 150   | 300  | nA    |
| Input resistance                                                              |                                                |                                      | 10   |       |      | MΩ    |
| Power supply rejection ratio                                                  | DC (0 – 10 KHz)                                |                                      | 50   | 60    |      | dB    |
| Propagation delay                                                             | 100 mV overdrive                               |                                      |      |       |      |       |
|                                                                               | HYS[1:0] = 00                                  |                                      |      |       |      |       |
|                                                                               | (no hysteresis)                                |                                      |      | 15    | 18   | ns    |
|                                                                               | 100 mV overdrive                               |                                      |      |       |      |       |
|                                                                               | HYS[1:0] = 10                                  |                                      |      |       |      |       |
|                                                                               | (with hysteresis)                              |                                      |      | 25    | 30   | ns    |
| Hysteresis<br>(± refers to rising and falling threshold shifts, respectively) | HYS[1:0] = 00                                  | Typical (25°C)                       | 0    | 0     | ±5   | mV    |
|                                                                               |                                                | Across all corners (–40°C to +100°C) | 0    |       | ±5   | mV    |
|                                                                               | HYS[1:0] = 01                                  | Typical (25°C)                       | ±3   | ± 16  | ±30  | mV    |
|                                                                               |                                                | Across all corners (–40°C to +100°C) | 0    |       | ±36  | mV    |
|                                                                               | HYS[1:0] = 10                                  | Typical (25°C)                       | ±19  | ± 31  | ±48  | mV    |
|                                                                               |                                                | Across all corners (–40°C to +100°C) | ±12  |       | ±54  | mV    |
|                                                                               | HYS[1:0] = 11                                  | Typical (25°C)                       | ±80  | ± 105 | ±190 | mV    |
|                                                                               |                                                | Across all corners (–40°C to +100°C) | ±80  |       | ±194 | mV    |
| Comparator current requirements<br>(per comparator)                           | VCC33A = 3.3 V (operational mode); COMP_EN = 1 |                                      |      |       |      |       |
|                                                                               | VCC33A                                         |                                      |      | 150   | 165  | μA    |
|                                                                               | VCC33AP                                        |                                      |      | 140   | 165  | μA    |
|                                                                               | VCC15A                                         |                                      |      | 1     | 3    | μA    |

## Analog Sigma-Delta Digital to Analog Converter (DAC)

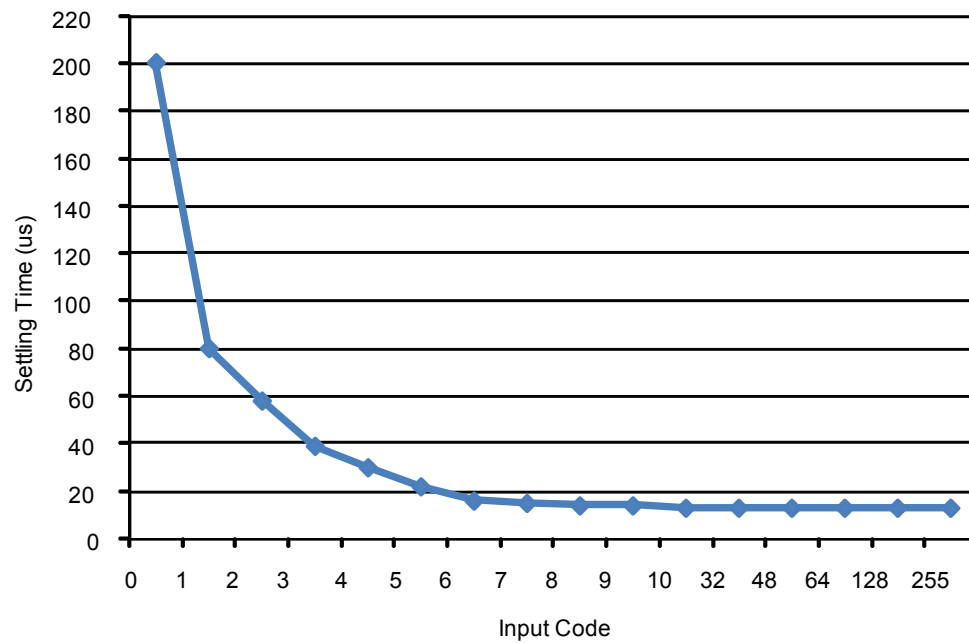
Unless otherwise noted, sigma-delta DAC performance is specified at 25°C with nominal power supply voltages, using the internal sigma-delta modulators with 16-bit inputs, HCLK = 100 MHz, modulator inputs updated at a 100 KHz rate, in voltage output mode with an external 160 pF capacitor to ground, after trimming and digital [pre-]compensation.

**Table 2-99 • Analog Sigma-Delta DAC**

| Specification                | Test Conditions         | Min.  | Typ.                                    | Max.  | Units |
|------------------------------|-------------------------|-------|-----------------------------------------|-------|-------|
| Resolution                   |                         | 8     |                                         | 24    | Bits  |
| Output range                 |                         |       | 0 to 2.56                               |       | V     |
|                              | Current output mode     |       | 0 to 256                                |       | μA    |
| Output Impedance             |                         | 6     | 10                                      | 12    | KΩ    |
|                              | Current output mode     | 10    |                                         |       | MΩ    |
| Output voltage compliance    | Current output mode     |       | 0–3.0                                   |       | V     |
|                              | –40°C to +100°C         | 0–2.7 |                                         | 0–3.4 | V     |
| Gain error                   | Voltage output mode     |       | 0.3                                     | ±2    | %     |
|                              | A2F060: –40°C to +100°C |       | 0.3                                     | ±2    | %     |
|                              | A2F200: –40°C to +100°C |       | 1.2                                     | ±5.3  | %     |
|                              | A2F500: –40°C to +100°C |       | 0.3                                     | ±2    | %     |
|                              | Current output mode     |       | 0.3                                     | ±2    | %     |
|                              | A2F060: –40°C to +100°C |       | 0.3                                     | ±2    | %     |
|                              | A2F200: –40°C to +100°C |       | 1.2                                     | ±5.3  | %     |
|                              | A2F500: –40°C to +100°C |       | 0.3                                     | ±2    | %     |
| Output referred offset       | DACBYTE0 = h'00 (8-bit) |       | 0.25                                    | ±1    | mV    |
|                              | –40°C to +100°C         |       | 1                                       | ±2.5  | mV    |
|                              | Current output mode     |       | 0.3                                     | ±1    | μA    |
|                              | –40°C to +100°C         |       | 1                                       | ±2.5  | μA    |
| Integral non-linearity       | RMS deviation from BFSL |       | 0.1                                     | 0.3   | % FR  |
| Differential non-linearity   |                         |       | 0.05                                    | 0.4   | % FR  |
| Analog settling time         |                         |       | Refer to<br>Figure 2-43 on<br>page 2-85 |       | μs    |
| Power supply rejection ratio | DC, full scale output   | 33    | 34                                      |       | dB    |

**Table 2-99 • Analog Sigma-Delta DAC (continued)**

| Specification                                                            | Test Conditions                                  | Min. | Typ. | Max. | Units   |
|--------------------------------------------------------------------------|--------------------------------------------------|------|------|------|---------|
| Sigma-delta DAC power supply current requirements (not including VAREFx) | Input = 0, EN = 1<br>(operational mode)          |      |      |      |         |
|                                                                          | VCC33SDDx                                        |      | 30   | 35   | $\mu$ A |
|                                                                          | VCC15A                                           |      | 3    | 5    | $\mu$ A |
|                                                                          | Input = Half scale, EN = 1<br>(operational mode) |      |      |      |         |
|                                                                          | VCC33SDDx                                        |      | 160  | 165  | $\mu$ A |
|                                                                          | VCC15A                                           |      | 33   | 35   | $\mu$ A |
|                                                                          | Input = Full scale, EN = 1<br>(operational mode) |      |      |      |         |
|                                                                          | VCC33SDDx                                        |      | 280  | 285  | $\mu$ A |
|                                                                          | VCC15A                                           |      | 70   | 75   | $\mu$ A |

**Sigma Delta DAC Settling Time**

**Figure 2-43 • Sigma-Delta DAC Settling Time**

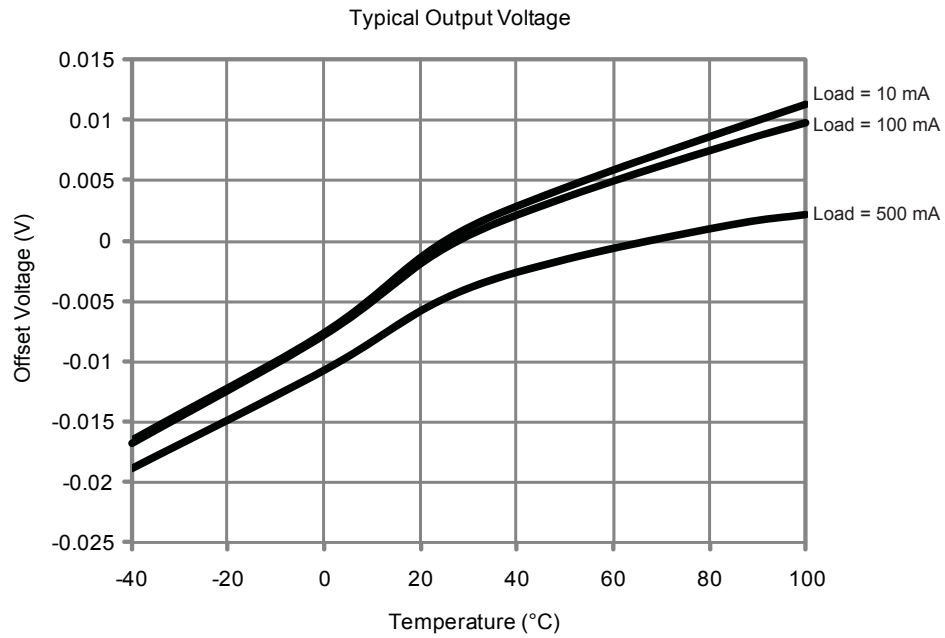
## Voltage Regulator

**Table 2-100 • Voltage Regulator**

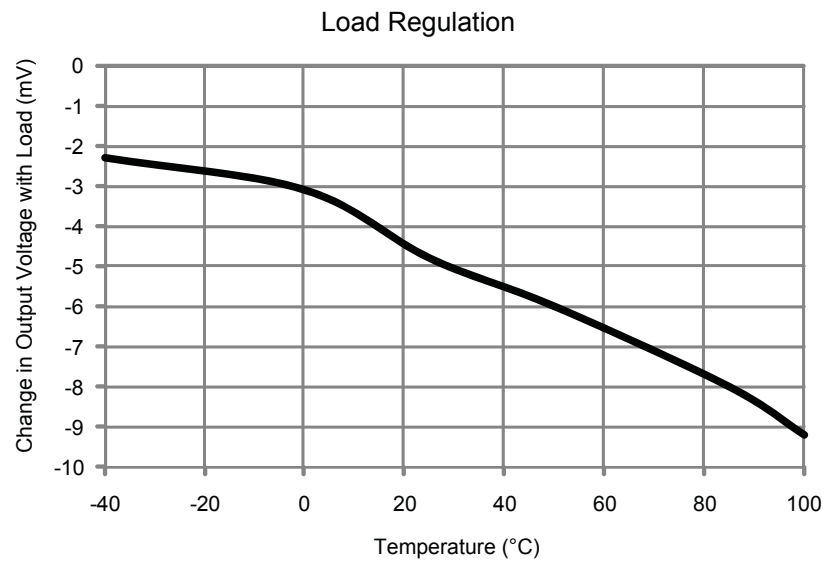
| Symbol           | Parameter                    | Test Conditions            |                                                                            | Min.  | Typ. | Max.  | Unit          |
|------------------|------------------------------|----------------------------|----------------------------------------------------------------------------|-------|------|-------|---------------|
| $V_{OUT}$        | Output voltage               | $T_J = 25^{\circ}\text{C}$ |                                                                            | 1.425 | 1.5  | 1.575 | V             |
| $V_{OS}$         | Output offset voltage        | $T_J = 25^{\circ}\text{C}$ |                                                                            |       | 11   |       | mV            |
| $I_{CC33A}$      | Operation current            | $T_J = 25^{\circ}\text{C}$ | $I_{LOAD} = 1\text{ mA}$                                                   |       | 3.4  |       | mA            |
|                  |                              |                            | $I_{LOAD} = 100\text{ mA}$                                                 |       | 11   |       | mA            |
|                  |                              |                            | $I_{LOAD} = 0.5\text{ A}$                                                  |       | 21   |       | mA            |
| $\Delta V_{OUT}$ | Load regulation              | $T_J = 25^{\circ}\text{C}$ | $I_{LOAD} = 1\text{ mA to }0.5\text{ A}$                                   |       | 5.8  |       | mV            |
| $\Delta V_{OUT}$ | Line regulation              | $T_J = 25^{\circ}\text{C}$ | $V_{CC33A} = 2.97\text{ V to }3.63\text{ V}$<br>$I_{LOAD} = 1\text{ mA}$   |       | 5.3  |       | mV/V          |
|                  |                              |                            | $V_{CC33A} = 2.97\text{ V to }3.63\text{ V}$<br>$I_{LOAD} = 100\text{ mA}$ |       | 5.3  |       | mV/V          |
|                  |                              |                            | $V_{CC33A} = 2.97\text{ V to }3.63\text{ V}$<br>$I_{LOAD} = 500\text{ mA}$ |       | 5.3  |       | mV/V          |
|                  | Dropout voltage <sup>1</sup> | $T_J = 25^{\circ}\text{C}$ | $I_{LOAD} = 1\text{ mA}$                                                   |       | 0.63 |       | V             |
|                  |                              |                            | $I_{LOAD} = 100\text{ mA}$                                                 |       | 0.84 |       | V             |
|                  |                              |                            | $I_{LOAD} = 0.5\text{ A}$                                                  |       | 1.35 |       | V             |
| $I_{PTBASE}$     | PTBase current               | $T_J = 25^{\circ}\text{C}$ | $I_{LOAD} = 1\text{ mA}$                                                   |       | 48   |       | $\mu\text{A}$ |
|                  |                              |                            | $I_{LOAD} = 100\text{ mA}$                                                 |       | 736  |       | $\mu\text{A}$ |
|                  |                              |                            | $I_{LOAD} = 0.5\text{ A}$                                                  |       | 12   |       | mA            |
|                  | Startup time <sup>2</sup>    | $T_J = 25^{\circ}\text{C}$ |                                                                            |       | 200  |       | ms            |

**Notes:**

1. Dropout voltage is defined as the minimum  $V_{CC33A}$  voltage. The parameter is specified with respect to the output voltage. The specification represents the minimum input-to-output differential voltage required to maintain regulation.
2. Assumes  $10\text{ }\mu\text{F}$ .



**Figure 2-44 • Typical Output Voltage**



**Figure 2-45 • Load Regulation**

## Serial Peripheral Interface (SPI) Characteristics

This section describes the DC and switching of the SPI interface. Unless otherwise noted, all output characteristics given for a 35 pF load on the pins and all sequential timing characteristics are related to SPI\_x\_CLK. For timing parameter definitions, refer to [Figure 2-46 on page 2-89](#).

**Table 2-101 • SPI Characteristics**

**Commercial Case Conditions: T<sub>J</sub> = 85°C, VDD = 1.425 V, –1 Speed Grade**

| Symbol | Description and Condition                                      | A2F060 | A2F200 | A2F500 | Unit |
|--------|----------------------------------------------------------------|--------|--------|--------|------|
| sp1    | SPI_x_CLK minimum period                                       |        |        |        |      |
|        | SPI_x_CLK = PCLK/2                                             | 20     | NA     | 20     | ns   |
|        | SPI_x_CLK = PCLK/4                                             | 40     | 40     | 40     | ns   |
|        | SPI_x_CLK = PCLK/8                                             | 80     | 80     | 80     | ns   |
|        | SPI_x_CLK = PCLK/16                                            | 0.16   | 0.16   | 0.16   | μs   |
|        | SPI_x_CLK = PCLK/32                                            | 0.32   | 0.32   | 0.32   | μs   |
|        | SPI_x_CLK = PCLK/64                                            | 0.64   | 0.64   | 0.64   | μs   |
|        | SPI_x_CLK = PCLK/128                                           | 1.28   | 1.28   | 1.28   | μs   |
|        | SPI_x_CLK = PCLK/256                                           | 2.56   | 2.56   | 2.56   | μs   |
| sp2    | SPI_x_CLK minimum pulse width high                             |        |        |        |      |
|        | SPI_x_CLK = PCLK/2                                             | 10     | NA     | 10     | ns   |
|        | SPI_x_CLK = PCLK/4                                             | 20     | 20     | 20     | ns   |
|        | SPI_x_CLK = PCLK/8                                             | 40     | 40     | 40     | ns   |
|        | SPI_x_CLK = PCLK/16                                            | 0.08   | 0.08   | 0.08   | μs   |
|        | SPI_x_CLK = PCLK/32                                            | 0.16   | 0.16   | 0.16   | μs   |
|        | SPI_x_CLK = PCLK/64                                            | 0.32   | 0.32   | 0.32   | μs   |
|        | SPI_x_CLK = PCLK/128                                           | 0.64   | 0.64   | 0.64   | μs   |
|        | SPI_x_CLK = PCLK/256                                           | 1.28   | 1.28   | 1.28   | us   |
| sp3    | SPI_x_CLK minimum pulse width low                              |        |        |        |      |
|        | SPI_x_CLK = PCLK/2                                             | 10     | NA     | 10     | ns   |
|        | SPI_x_CLK = PCLK/4                                             | 20     | 20     | 20     | ns   |
|        | SPI_x_CLK = PCLK/8                                             | 40     | 40     | 40     | ns   |
|        | SPI_x_CLK = PCLK/16                                            | 0.08   | 0.08   | 0.08   | μs   |
|        | SPI_x_CLK = PCLK/32                                            | 0.16   | 0.16   | 0.16   | μs   |
|        | SPI_x_CLK = PCLK/64                                            | 0.32   | 0.32   | 0.32   | μs   |
|        | SPI_x_CLK = PCLK/128                                           | 0.64   | 0.64   | 0.64   | μs   |
|        | SPI_x_CLK = PCLK/256                                           | 1.28   | 1.28   | 1.28   | μs   |
| sp4    | SPI_x_CLK, SPI_x_DO, SPI_x_SS rise time (10%-90%) <sup>1</sup> | 4.7    | 4.7    | 4.7    | ns   |
| sp5    | SPI_x_CLK, SPI_x_DO, SPI_x_SS fall time (10%-90%) <sup>1</sup> | 3.4    | 3.4    | 3.4    | ns   |

**Notes:**

1. These values are provided for a load of 35 pF. For board design considerations and detailed output buffer resistances, use the corresponding IBIS models located on the Microsemi SoC Products Group website: <http://www.actel.com/download/ibis/default.aspx>.
2. For allowable pclk configurations, refer to the Serial Peripheral Interface Controller section in the [SmartFusion Microcontroller Subsystem User's Guide](#).



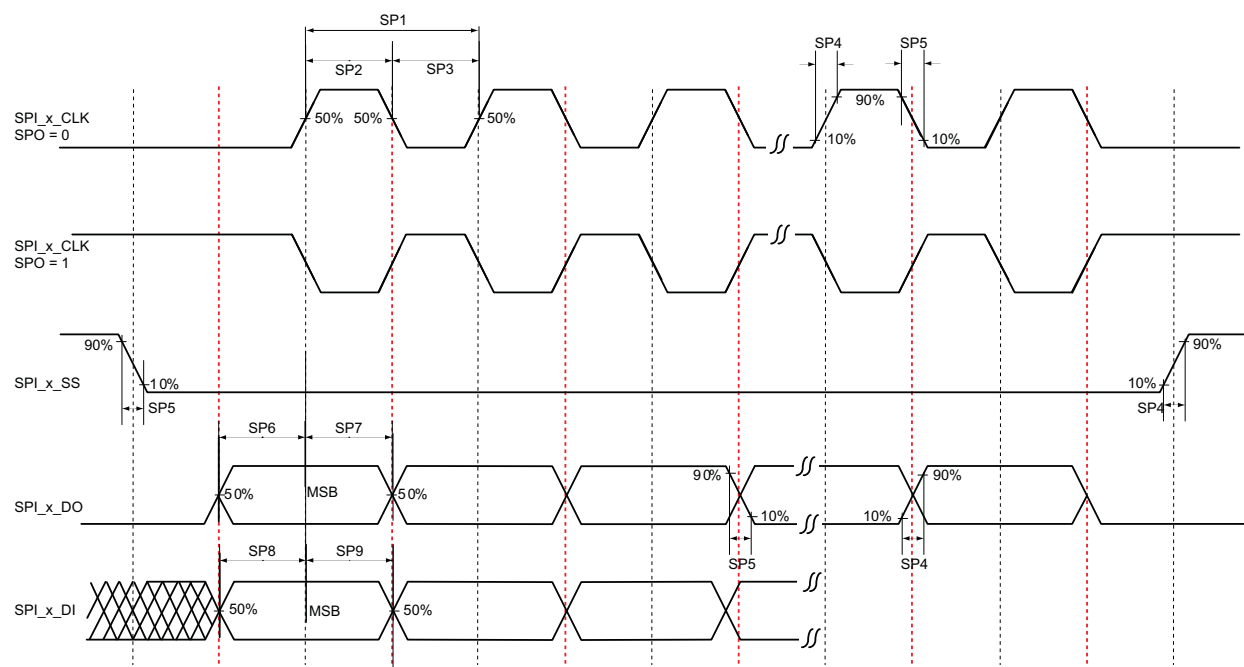
**Table 2-101 • SPI Characteristics**

Commercial Case Conditions:  $T_J = 85^{\circ}\text{C}$ ,  $V_{DD} = 1.425\text{ V}$ , -1 Speed Grade (continued)

| Symbol | Description and Condition                           | A2F060 | A2F200 | A2F500 | Unit       |
|--------|-----------------------------------------------------|--------|--------|--------|------------|
| sp6    | Data from master (SPI_x_DO) setup time <sup>2</sup> | 1      | 1      | 1      | clk cycles |
| sp7    | Data from master (SPI_x_DO) hold time <sup>2</sup>  | 1      | 1      | 1      | clk cycles |
| sp8    | SPI_x_DI setup time <sup>2</sup>                    | 1      | 1      | 1      | clk cycles |
| sp9    | SPI_x_DI hold time <sup>2</sup>                     | 1      | 1      | 1      | clk cycles |

**Notes:**

1. These values are provided for a load of 35 pF. For board design considerations and detailed output buffer resistances, use the corresponding IBIS models located on the Microsemi SoC Products Group website:  
<http://www.actel.com/download/ibis/default.aspx>.
2. For allowable clk configurations, refer to the Serial Peripheral Interface Controller section in the *SmartFusion Microcontroller Subsystem User's Guide*.


**Figure 2-46 • SPI Timing for a Single Frame Transfer in Motorola Mode (SPH = 1)**

## Inter-Integrated Circuit (I<sup>2</sup>C) Characteristics

This section describes the DC and switching of the I<sup>2</sup>C interface. Unless otherwise noted, all output characteristics given are for a 100 pF load on the pins. For timing parameter definitions, refer to [Figure 2-47 on page 2-91](#).

**Table 2-102 • I<sup>2</sup>C Characteristics**

Commercial Case Conditions: T<sub>J</sub> = 85°C, V<sub>DD</sub> = 1.425 V, –1 Speed Grade

| Parameter              | Definition                                              | Condition                                    | Value                                       | Unit       |
|------------------------|---------------------------------------------------------|----------------------------------------------|---------------------------------------------|------------|
| V <sub>IL</sub>        | Minimum input low voltage                               | –                                            | See <a href="#">Table 2-36 on page 2-30</a> | –          |
|                        | Maximum input low voltage                               | –                                            | See <a href="#">Table 2-36</a>              | –          |
| V <sub>IH</sub>        | Minimum input high voltage                              | –                                            | See <a href="#">Table 2-36</a>              | –          |
|                        | Maximum input high voltage                              | –                                            | See <a href="#">Table 2-36</a>              | –          |
| V <sub>OL</sub>        | Maximum output voltage low                              | I <sub>OL</sub> = 8 mA                       | See <a href="#">Table 2-36</a>              | –          |
| I <sub>IL</sub>        | Input current high                                      | –                                            | See <a href="#">Table 2-36</a>              | –          |
| I <sub>IH</sub>        | Input current low                                       | –                                            | See <a href="#">Table 2-36</a>              | –          |
| V <sub>hyst</sub>      | Hysteresis of Schmitt trigger inputs                    | –                                            | See <a href="#">Table 2-33 on page 2-29</a> | V          |
| T <sub>FALL</sub>      | Fall time <sup>2</sup>                                  | VIHmin to VILMax, C <sub>load</sub> = 400 pF | 15.0                                        | ns         |
|                        |                                                         | VIHmin to VILMax, C <sub>load</sub> = 100 pF | 4.0                                         | ns         |
| T <sub>RISE</sub>      | Rise time <sup>2</sup>                                  | VILMax to VIHmin, C <sub>load</sub> = 400pF  | 19.5                                        | ns         |
|                        |                                                         | VILMax to VIHmin, C <sub>load</sub> = 100pF  | 5.2                                         | ns         |
| C <sub>in</sub>        | Pin capacitance                                         | VIN = 0, f = 1.0 MHz                         | 8.0                                         | pF         |
| R <sub>pull-up</sub>   | Output buffer maximum pull-down Resistance <sup>1</sup> | –                                            | 50                                          | Ω          |
| R <sub>pull-down</sub> | Output buffer maximum pull-up Resistance <sup>1</sup>   | –                                            | 150                                         | Ω          |
| D <sub>max</sub>       | Maximum data rate                                       | Fast mode                                    | 400                                         | Kbps       |
| t <sub>LOW</sub>       | Low period of I2C_x_SCL <sup>3</sup>                    | –                                            | 1                                           | clk cycles |
| t <sub>HIGH</sub>      | High period of I2C_x_SCL <sup>3</sup>                   | –                                            | 1                                           | clk cycles |
| t <sub>HD;STA</sub>    | START hold time <sup>3</sup>                            | –                                            | 1                                           | clk cycles |
| t <sub>SU;STA</sub>    | START setup time <sup>3</sup>                           | –                                            | 1                                           | clk cycles |
| t <sub>HD;DAT</sub>    | DATA hold time <sup>3</sup>                             | –                                            | 1                                           | clk cycles |
| t <sub>SU;DAT</sub>    | DATA setup time <sup>3</sup>                            | –                                            | 1                                           | clk cycles |

**Notes:**

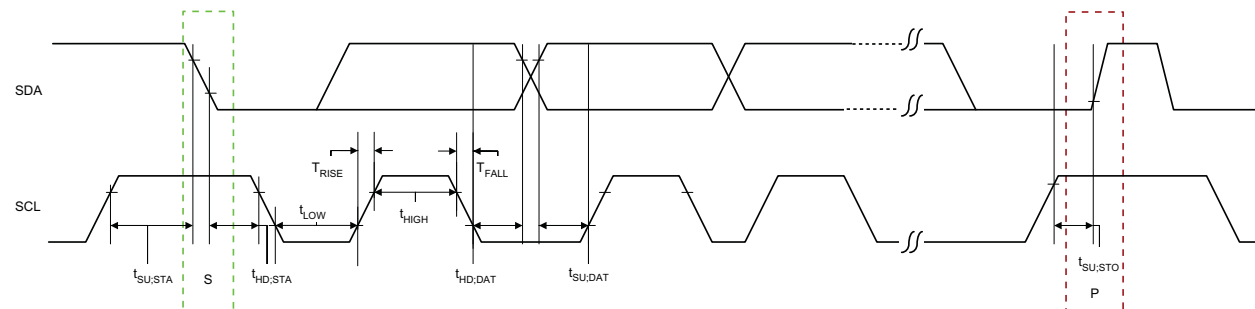
1. These maximum values are provided for information only. Minimum output buffer resistance values depend on VCCxxxIOBx, drive strength selection, temperature, and process. For board design considerations and detailed output buffer resistances, use the corresponding IBIS models located on the SoC Products Group website at <http://www.actel.com/download/ibis/default.aspx>.
2. These values are provided for a load of 100 pF and 400 pF. For board design considerations and detailed output buffer resistances, use the corresponding IBIS models located on the SoC Products Group website at <http://www.actel.com/download/ibis/default.aspx>.
3. For allowable Pclk configurations, refer to the Inter-Integrated Circuit (I<sup>2</sup>C) Peripherals section in the [SmartFusion Microcontroller Subsystem User's Guide](#).

**Table 2-102 • I<sup>2</sup>C Characteristics**
**Commercial Case Conditions: T<sub>J</sub> = 85°C, V<sub>DD</sub> = 1.425 V, -1 Speed Grade (continued)**

| Parameter           | Definition                   | Condition | Value | Unit        |
|---------------------|------------------------------|-----------|-------|-------------|
| t <sub>SU;STO</sub> | STOP setup time <sup>3</sup> | —         | 1     | pclk cycles |
| t <sub>FILT</sub>   | Maximum spike width filtered | —         | 50    | ns          |

**Notes:**

1. These maximum values are provided for information only. Minimum output buffer resistance values depend on VCCxxxxIOBx, drive strength selection, temperature, and process. For board design considerations and detailed output buffer resistances, use the corresponding IBIS models located on the SoC Products Group website at <http://www.actel.com/download/ibis/default.aspx>.
2. These values are provided for a load of 100 pF and 400 pF. For board design considerations and detailed output buffer resistances, use the corresponding IBIS models located on the SoC Products Group website at <http://www.actel.com/download/ibis/default.aspx>.
3. For allowable Pclk configurations, refer to the Inter-Integrated Circuit (I<sup>2</sup>C) Peripherals section in the [SmartFusion Microcontroller Subsystem User's Guide](#).


**Figure 2-47 • I2C Timing Parameter Definition**

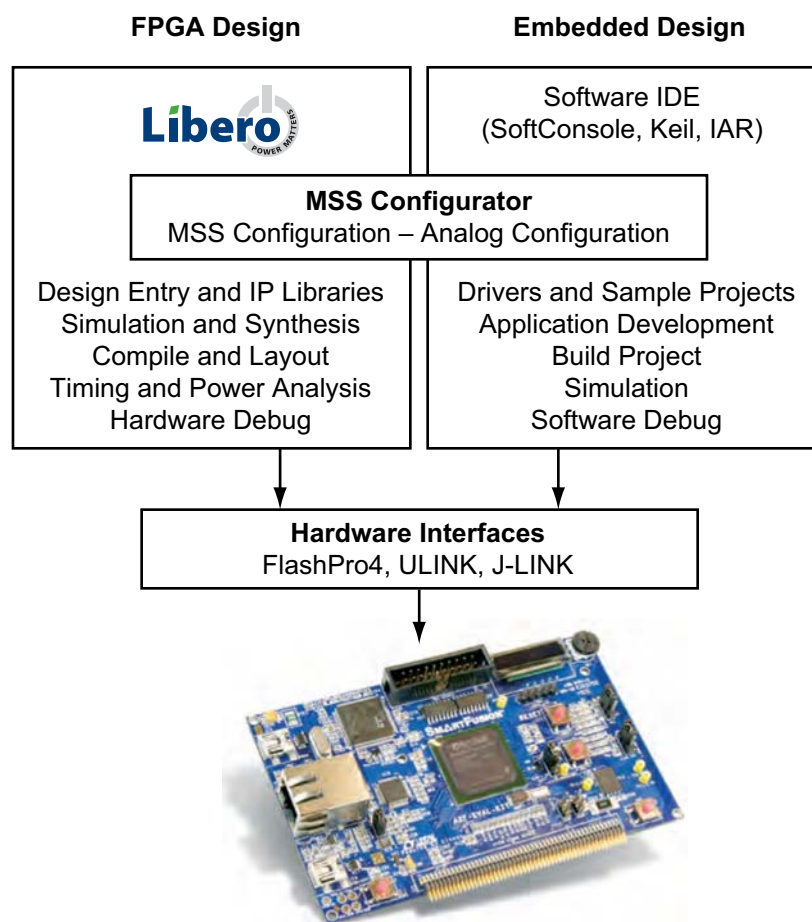


## 3 – SmartFusion Development Tools

Designing with SmartFusion cSoCs involves three different types of design: FPGA design, embedded design and analog design. These roles can be filled by three different designers, two designers or even a single designer, depending on company structure and project complexity.

### Types of Design Tools

Microsemi has developed design tools and flows to meet the needs of these three types of designers so they can work together smoothly on a single project ([Figure 3-1](#)).



**Figure 3-1 • Three Design Roles**

### FPGA Design

Libero Integrated Design Environment (IDE) is Microsemi's comprehensive software toolset for designing with all Microsemi FPGAs and cSoCs. Libero IDE includes industry-leading synthesis, simulation and debug tools from Synopsys® and Mentor Graphics®, as well as innovative timing and power optimization and analysis.

## Embedded Design

Microsemi offers FREE SoftConsole Eclipse based IDE, which includes the GNU C/C++ compiler and GDB debugger. Microsemi also offers evaluation versions of software from Keil and IAR, with full versions available from respective suppliers.

## Analog Design

The MSS configurator provides graphical configuration for current, voltage and temperature monitors, sample sequencing setup and post-processing configuration, as well as DAC output.

The MSS configurator creates a bridge between the FPGA fabric and embedded designers so device configuration can be easily shared between multiple developers.

The MSS configurator includes the following:

- A simple configurator for the embedded designer to control the MSS peripherals and I/Os
- A method to import and view a hardware configuration from the FPGA flow into the embedded flow containing the memory map
- Automatic generation of drivers for any peripherals or soft IP used in the system configuration
- Comprehensive analog configuration for the programmable analog components
- Creation of a standard MSS block to be used in SmartDesign for connection of FPGA fabric designs and IP

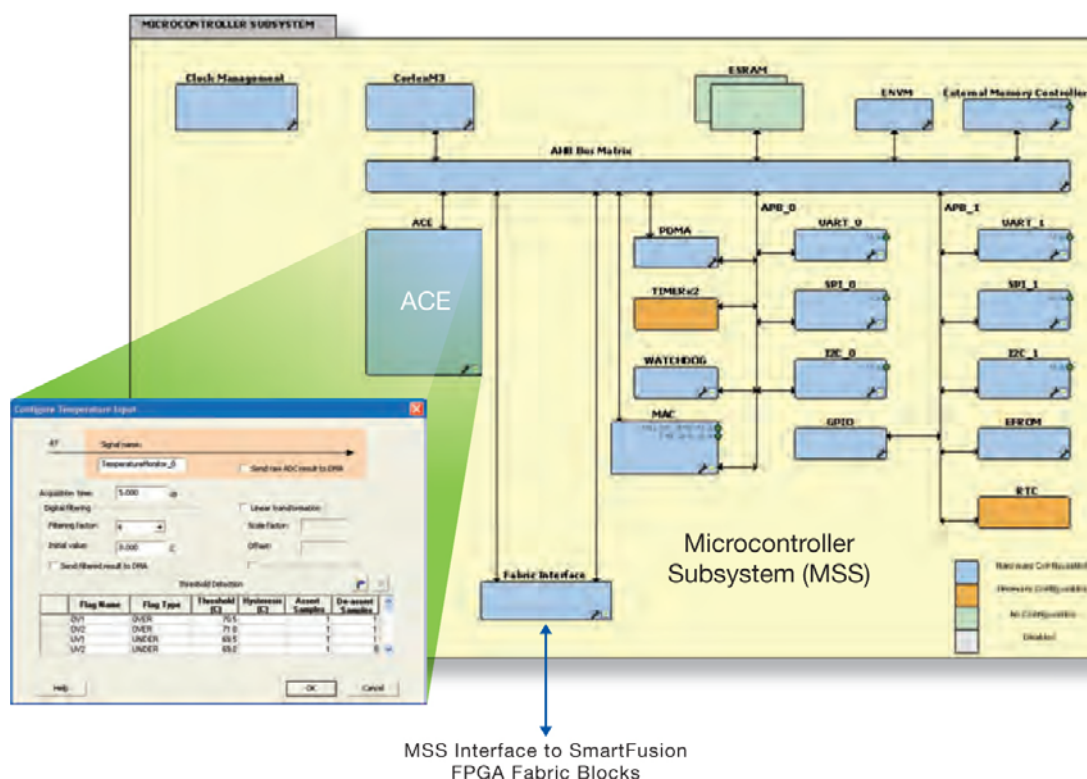


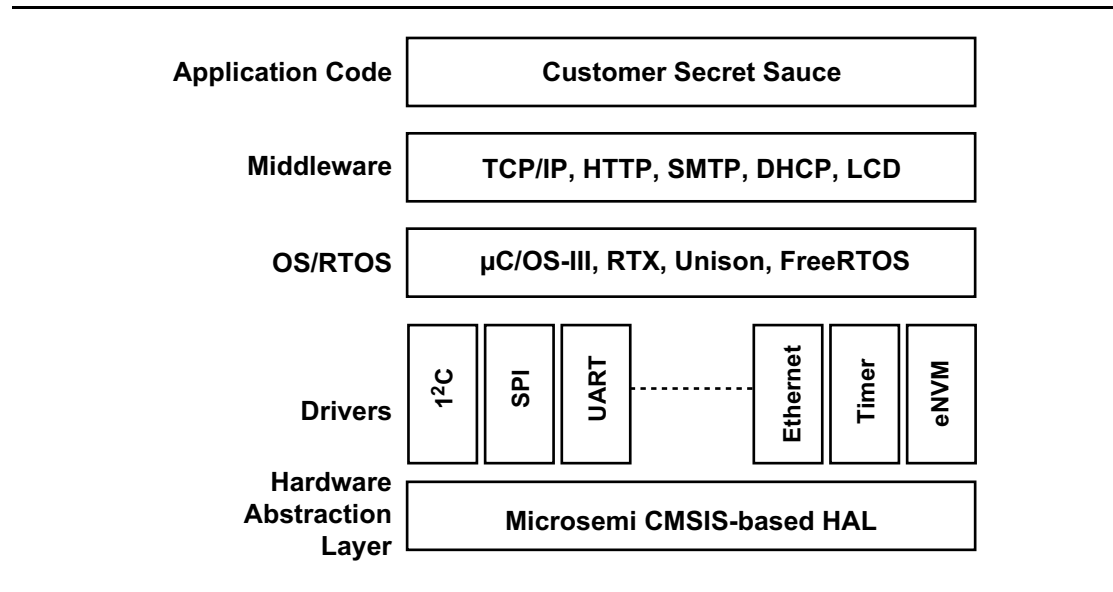
Figure 3-2 • MSS Configurator

## SmartFusion Ecosystem

The Microsemi SoC Products Group (formerly Actel) has a long history of supplying comprehensive FPGA development tools and recognizes the benefit of partnering with industry leaders to deliver the optimum usability and productivity to customers. Taking the same approach with processor development, Microsemi has partnered with key industry leaders in the microcontroller space to provide the robust SmartFusion ecosystem.

Microsemi is partnering with Keil and IAR to provide Software IDE support to SmartFusion system designers. The result is a robust solution that can be easily adopted by developers who are already doing embedded design. The learning path is straightforward for FPGA designers.

Support for the SoC Products Group device and ecosystem resources is represented in [Figure 3-3](#).



**Figure 3-3 • SmartFusion Ecosystem**

[Figure 3-3](#) shows the SmartFusion stack with examples of drivers, RTOS, and middleware from Microsemi and partners. By leveraging the SmartFusion stack, designers can decide at which level to add their own customization to their design, thus speeding time to market and reducing overhead in the design.

## ARM

Because an ARM processor was chosen for SmartFusion cSoCs, Microsemi's customers can benefit from the extensive ARM ecosystem. By building on Microsemi supplied hardware abstraction layer (HAL) and drivers, third party vendors can easily port RTOS and middleware for the SmartFusion cSoC.

- [ARM Cortex-M Series Processors](#)
- [ARM Cortex-M3 Processor Resource](#)
- [ARM Cortex-M3 Technical Reference Manual](#)
- [ARM Cortex-M3 Processor Software Development for ARM7TDMI Processor Programmers White Paper](#)

## Compile and Debug

Microsemi's SoftConsole is a free Eclipse-based IDE that enables the rapid production of C and C++ executables for Microsemi FPGA and cSoCs using Cortex-M3, Cortex-M1 and Core8051s. For SmartFusion support, SoftConsole includes the GNU C/C++ compiler and GDB debugger. Additional examples can be found on the SoftConsole page:

- [Using UART with SmartFusion: SoftConsole Standalone Flow Tutorial](#)
  - [Design Files](#)
- [Displaying POT Level with LEDs: Libero IDE and SoftConsole Flow Tutorial for SmartFusion](#)
  - [Design Files](#)

IAR Embedded Workbench® for ARM/Cortex is an integrated development environment for building and debugging embedded ARM applications using assembler, C and C++. It includes a project manager, editor, build and debugger tools with support for RTOS-aware debugging on hardware or in a simulator.

- [Designing SmartFusion cSoC with IAR Systems](#)
- [IAR Embedded Workbench IDE User Guide for ARM](#)
- [Download Evaluation or Kickstart version of IAR Embedded Workbench for ARM](#)

Keil's Microcontroller Development Kit comes in two editions: MDK-ARM and MDK Basic. Both editions feature  $\mu$ Vision®, the ARM Compiler, MicroLib, and RTX, but the MDK Basic edition is limited to 256K so that small applications are more affordable.

- [Designing SmartFusion cSoC with Keil](#)
- [Using Keil  \$\mu\$ Vision and Microsemi SmartFusion cSoC](#)
  - [Programming file for use with this tutorial](#)
- [Keil Microcontroller Development Kit for ARM Product Manuals](#)
- [Download Evaluation version of Keil MDK-ARM](#)

|                                                                                     |                                                                                     |                                                                                      |                                                                                       |
|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|  |  |  |  |
| <b>Software IDE</b>                                                                 | <b>SoftConsole</b>                                                                  | <b>Vision IDE</b>                                                                    | <b>Embedded Workbench</b>                                                             |
| <b>Website</b>                                                                      | <a href="http://www.actel.com">www.actel.com</a>                                    | <a href="http://www.keil.com">www.keil.com</a>                                       | <a href="http://www.iar.com">www.iar.com</a>                                          |
| <b>Free versions from SoC Products Group</b>                                        | Free with Libero IDE                                                                | 32 K code limited                                                                    | 32 K code limited                                                                     |
| <b>Available from Vendor</b>                                                        | N/A                                                                                 | Full version                                                                         | Full version                                                                          |
| <b>Compiler</b>                                                                     | GNU GCC                                                                             | RealView C/C++                                                                       | IAR ARM Compiler                                                                      |
| <b>Debugger</b>                                                                     | GDB debug                                                                           | Vision Debugger                                                                      | C-SPY Debugger                                                                        |
| <b>Instruction Set Simulator</b>                                                    | No                                                                                  | Vision Simulator                                                                     | Yes                                                                                   |
| <b>Debug Hardware</b>                                                               | FlashPro4                                                                           | ULINK2 or ULINK-ME                                                                   | J-LINK or J-LINK Lite                                                                 |

## Operating Systems

FreeRTOS™ is a portable, open source, royalty free, mini real-time kernel (a free-to-download and free-to-deploy RTOS that can be used in commercial applications without any requirement to expose your proprietary source code). FreeRTOS is scalable and designed specifically for small embedded systems. This FreeRTOS version ported by Microsemi is 6.0.1. For more information, visit the FreeRTOS website: [www.freertos.org](http://www.freertos.org)

- [SmartFusion Webserver Demo Using uIP and FreeRTOS](#)
- [SmartFusion cSoC: Running Webserver, TFTP on lwIP TCP/IP Stack Application Note](#)



Emcraft Systems provides porting of the open-source U-boot firmware and uClinux™ kernel to the SmartFusion cSoC, a Linux®-based cross-development framework, and other complementary components. Combined with the release of its A2F-Linux Evaluation Kit, this provides a low-cost platform for evaluation and development of Linux (uClinux) on the Cortex-M3 CPU core of the Microsemi SmartFusion cSoC.

- [Emcraft Linux on Microsemi's SmartFusion cSoC](#)

Keil offers the RTX Real-Time Kernel as a royalty-free, deterministic RTOS designed for ARM and Cortex-M devices. It allows you to create programs that simultaneously perform multiple functions and helps to create applications which are better structured and more easily maintained.

- The RTX Real-Time Kernel is included with MDK-ARM. Download the [Evaluation version of Keil MDK-ARM](#).
- RTX source code is available as part of [Keil/ARM Real-Time Library \(RL-ARM\)](#), a group of tightly-coupled libraries designed to solve the real-time and communication challenges of embedded systems based on ARM-powered microcontroller devices. The RL-ARM library now supports SmartFusion cSoCs and designers with additional key features listed in the ["Middleware" section on page 3-5](#).

Micrium supports SmartFusion cSoCs with the company's flagship µC/OS family, recognized for a variety of features and benefits, including unparalleled reliability, performance, dependability, impeccable source code and vast documentation. Micrium supports the following products for SmartFusion cSoCs and continues to work with Microsemi on additional projects.

- [SmartFusion Quickstart Guide for Micrium µC/OS-III Examples](#)
  - [Design Files](#)

µC/OS-III™, Micrium's newest RTOS, is designed to save time on your next embedded project and puts greater control of the software in your hands.

RoweBots provides an ultra tiny Linux-compatible RTOS called Unison for SmartFusion. Unison consists of a set of modular software components, which, like Linux, are either free or commercially licensed. Unison offers POSIX® and Linux compatibility with hard real-time performance, complete I/O modules and an easily understood environment for device driver programming. Seamless integration with FPGA and analog features are fast and easy.

- [Unison V4](#)-based products include a free Unison V4 Linux and POSIX-compatible kernel with serial I/O, file system, six demonstration programs, upgraded documentation and source code for Unison V4, and free (for non-commercial use) Unison V4 TCP/IP server. Commercial license upgrade is available for Unison V4 TCP/IP server with three demonstration programs, DHCP client and source code.
- [Unison V5](#)-based products include commercial Unison V5 Linux- and POSIX-compatible kernel with serial I/O, file system, extensive feature set, full documentation, source code and more than 20 demonstration programs, Unison V5 TCP/IPv4 with extended feature set, sockets interface, multiple network interfaces, PPP support, DHCP client, documentation, source code and six demonstration programs, and multiple other features.

## Middleware

Microsemi has ported both uIP and lwIP for Ethernet support as well as including TFTP file service.

- [SmartFusion Webserver Demo Using uIP and FreeRTOS](#)
- [SmartFusion: Running Webserver, TFTP on lwIP TCP/IP Stack Application Note](#)

The [Keil/ARM Real-Time Library \(RL-ARM\)](#)<sup>1</sup>, in addition to RTX source, includes the following:

- [RL-TCPnet \(TCP/IP\)](#) – The Keil RL-TCPnet library, supporting full TCP/IP and UDP protocols, is a full networking suite specifically written for small ARM and Cortex-M processor-based microcontrollers. TCPnet is now ported to and supports SmartFusion Cortex-M3. It is highly optimized, has a small code footprint, and gives excellent performance, providing a wide range of application level protocols and examples such as FTP, SNMP, SOAP and AJAX. An [HTTP server example](#) of TCPnet working in a SmartFusion design is available.

---

1. The CAN and USB functions within RL-ARM are not supported for SmartFusion cSoC.

- Flash File System (RL-Flash) allows your embedded applications to create, save, read, and modify files in standard storage devices such as ROM, RAM, or FlashROM, using a standard serial peripheral interface (SPI). Many ARM-based microcontrollers have a practical requirement for a standard file system. With RL-FlashFS you can implement new features in embedded applications such as data logging, storing program state during standby modes, or storing firmware upgrades.

Micrium, in addition to  $\mu\text{C}/\text{OS-III}^{\text{®}}$ , offers the following support for SmartFusion cSoC:

- $\mu\text{C}/\text{TCP-IP}^{\text{™}}$  is a compact, reliable, and high-performance stack built from the ground up by Micrium and has the quality, scalability, and reliability that translates into a rapid configuration of network options, remarkable ease-of-use, and rapid time-to-market.
- $\mu\text{C}/\text{Probe}^{\text{™}}$  is one of the most useful tools in embedded systems design and puts you in the driver's seat, allowing you to take charge of virtually any variable, memory location, and I/O port in your embedded product, while your system is running.

## 4 – SmartFusion Programming

SmartFusion cSoCs have three separate flash areas that can be programmed:

1. The FPGA fabric
2. The embedded nonvolatile memories (eNVMs)
3. The embedded flash ROM (eFROM)

There are essentially three methodologies for programming these areas:

1. In-system programming (ISP)
2. In-application programming (IAP)—only the FPGA fabric and the eNVM
3. Pre-programming (non-ISP)

Programming, whether ISP or IAP methodologies are employed, can be done in two ways:

1. Securely using the on chip AES decryption logic
2. In plain text

### In-System Programming

In-System Programming is performed with the aid of external JTAG programming hardware. [Table 4-1](#) describes the JTAG programming hardware that will program a SmartFusion cSoC and [Table 4-2](#) defines the JTAG pins that provide the interface for the programming hardware.

**Table 4-1 • Supported JTAG Programming Hardware**

| Dongle      | Source                   | JTAG | SWD <sup>1</sup> | SWV <sup>2</sup> | Program<br>FPGA  | Program<br>eFROM | Program<br>eNVM |
|-------------|--------------------------|------|------------------|------------------|------------------|------------------|-----------------|
| FlashPro3/4 | SoC<br>Products<br>Group | Yes  | No               | No               | Yes              | Yes              | Yes             |
| ULINK Pro   | Keil                     | Yes  | Yes              | Yes              | Yes <sup>3</sup> | Yes <sup>3</sup> | Yes             |
| ULINK2      | Keil                     | Yes  | Yes              | Yes              | Yes <sup>3</sup> | Yes <sup>3</sup> | Yes             |
| IAR J-Link  | IAR                      | Yes  | Yes              | Yes              | Yes <sup>3</sup> | Yes <sup>3</sup> | Yes             |

**Notes:**

1. SWD = ARM Serial Wire Debug
2. SWV = ARM Serial Wire Viewer
3. Planned support

**Table 4-2 • JTAG Pin Descriptions**

| Pin Name | Description                                                       |
|----------|-------------------------------------------------------------------|
| JTAGSEL  | ARM Cortex-M3 or FPGA test access port (TAP) controller selection |
| TRSTB    | Test reset bar                                                    |
| TCK      | Test clock                                                        |
| TMS      | Test mode select                                                  |
| TDI      | Test data input                                                   |
| TDO      | Test data output                                                  |

The JTAGSEL pin selects the FPGA TAP controller or the Cortex-M3 debug logic. When JTAGSEL is asserted, the FPGA TAP controller is selected and the TRSTB input into the Cortex-M3 is held in a reset state (logic 0), as depicted in Figure 4-1. Users should tie the JTAGSEL pin high externally.

Microsemi's free Eclipse-based IDE, SoftConsole, has the ability to control the JTAGSEL pin directly with the FlashPro4 programmer. Manual jumpers are provided on the evaluation and development kits to allow manual selection of this function for the J-Link and ULINK debuggers.

**Note:** Standard ARM JTAG connectors do not have access to the JTAGSEL pin. SoftConsole automatically selects the appropriate TAP controller using the CTXSELECT JTAG command. When using SoftConsole, the state of JTAGSEL is a "don't care."

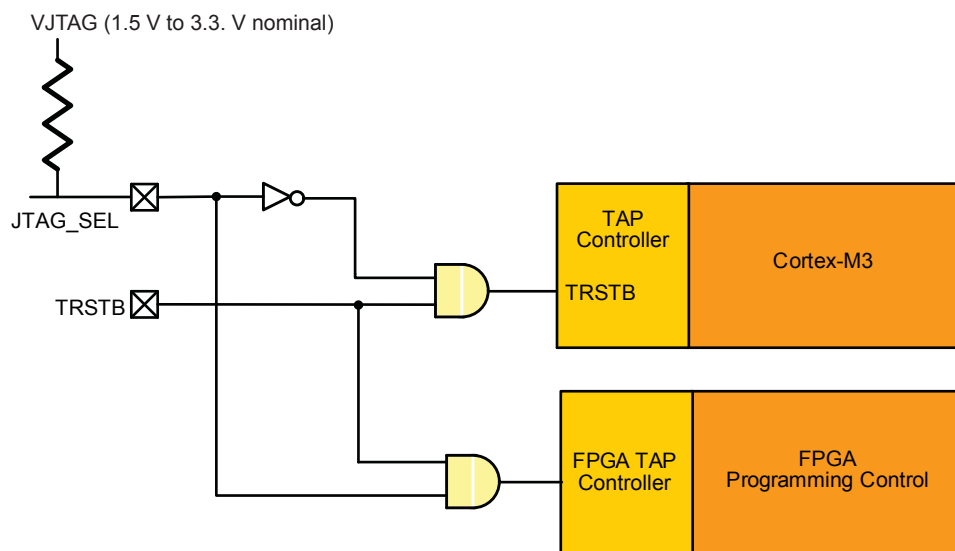


Figure 4-1 • TRSTB Logic

## In-Application Programming

In-application programming refers to the ability to reprogram the various flash areas under direct supervision of the Cortex-M3.

### Reprogramming the FPGA Fabric Using the Cortex-M3

In this mode, the Cortex-M3 is executing the programming algorithm on-chip. The IAP driver can be incorporated into the design project and executed from eNVM or eSRAM. The SoC Products Group provides working example projects for SoftConsole, IAR, and Keil development environments. These can be downloaded via the SoC Products Group Firmware Catalog. The new bitstream to be programmed into the FPGA can reside on the user's printed circuit board (PCB) in a separate SPI flash memory. Alternately, the user can modify the existing projects supplied by the SoC Products Group and, via custom handshaking software, throttle the download of the new image and program the FPGA a piece at a time in real time. A cost-effective and reliable approach would be to store the bitstream in an external SPI flash. Another option is storing a redundant bitstream image in an external SPI flash and loading the newest version into the FPGA only when receiving an IAP command. Since the FPGA I/Os are tristated or held at predefined or last known state during FPGA programming, the user must use MSS I/Os to interface to external memories. Since there are two SPI controllers in the MSS, the user can dedicate one to an SPI flash and the other to the particulars of an application. The amount of flash memory required to program the FPGA always exceeds the size of the eNVM block that is on-chip. The external memory controller (EMC) cannot be used as an interface to a memory device for storage of a bitstream because its I/O pads are FPGA I/Os; hence they are tristated when the FPGA is in a programming state.

## Re-Programming the eNVM Blocks Using the Cortex-M3

In this mode the Cortex-M3 is executing the eNVM programming algorithm from eSRAM. Since individual pages (132 bytes) of the eNVM can be write-protected, the programming algorithm software can be protected from inadvertent erasure. When reprogramming the eNVM, both MSS I/Os and FPGA I/Os are available as interfaces for sourcing the new eNVM image. The SoC Products Group provides working example projects for SoftConsole, IAR, and Keil development environments. These can be downloaded via the SoC Products Group Firmware Catalog.

Alternately, the eNVM can be reprogrammed by the Cortex-M3 via the IAP driver. This is necessary when using an encrypted image.

## Secure Programming

For background, refer to the "Security in Low Power Flash Devices" chapter of the *Fusion FPGA Fabric User's Guide* on the SoC Products Group website. SmartFusion ISP behaves identically to Fusion ISP. IAP of SmartFusion cSoCs is accomplished by using the IAP driver. Only the FPGA fabric and the eNVM can be reprogrammed with the protection of security measures by using the IAP driver.

## Typical Programming and Erase Times

Table 4-3 documents the typical programming and erase times for two components of SmartFusion cSoCs, FPGA fabric and eNVM, using the SoC Products Group's FlashPro hardware and software. These times will be different for other ISP and IAP methods. The **Program** action in FlashPro software includes erase, program, and verify to complete.

The typical programming (including erase) time per page of the eNVM is 8 ms.

**Table 4-3 • Typical Programming and Erase Times**

|         | FPGA Fabric (seconds) |        | eNVM (seconds) |        |
|---------|-----------------------|--------|----------------|--------|
|         | A2F200                | A2F500 | A2F200         | A2F500 |
| Erase   | 21                    | 21     | N/A            | N/A    |
| Program | 8                     | 15     | 18             | 26     |
| Verify  | 9                     | 16     | 26             | 42     |

## References

### User's Guides

*DirectC User's Guide*

[http://www.actel.com/documents/DirectC\\_UG.pdf](http://www.actel.com/documents/DirectC_UG.pdf)

*Fusion FGPA Fabric User's Guide*

[http://www.actel.com/documents/Fusion\\_UG.pdf](http://www.actel.com/documents/Fusion_UG.pdf)

#### Chapters:

"In-System Programming (ISP) of Actel's Low-Power Flash Devices Using FlashPro4/3/3X"

"Security in Low Power Flash Devices"

"Programming Flash Devices"

"Microprocessor Programming of Actel's Low-Power Flash Devices"



## 5 – Pin Descriptions

### Supply Pins

| Name        | Type   | Description                                                                                                                                                                                                                                                                                                                                                |
|-------------|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| GND         | Ground | Digital ground to the FPGA fabric, microcontroller subsystem and GPIOs                                                                                                                                                                                                                                                                                     |
| GND15ADC0   | Ground | Quiet analog ground to the 1.5 V circuitry of the first analog-to-digital converter (ADC)                                                                                                                                                                                                                                                                  |
| GND15ADC1   | Ground | Quiet analog ground to the 1.5 V circuitry of the second ADC                                                                                                                                                                                                                                                                                               |
| GND15ADC2   | Ground | Quiet analog ground to the 1.5 V circuitry of the third ADC                                                                                                                                                                                                                                                                                                |
| GND33ADC0   | Ground | Quiet analog ground to the 3.3 V circuitry of the first ADC                                                                                                                                                                                                                                                                                                |
| GND33ADC1   | Ground | Quiet analog ground to the 3.3 V circuitry of the second ADC                                                                                                                                                                                                                                                                                               |
| GND33ADC2   | Ground | Quiet analog ground to the 3.3 V circuitry of the third ADC                                                                                                                                                                                                                                                                                                |
| GND_A       | Ground | Quiet analog ground to the analog front-end                                                                                                                                                                                                                                                                                                                |
| GND_AQ      | Ground | Quiet analog ground to the analog I/O of SmartFusion cSoCs                                                                                                                                                                                                                                                                                                 |
| GNDENV_M    | Ground | Digital ground to the embedded nonvolatile memory (eNVM)                                                                                                                                                                                                                                                                                                   |
| GNDLPXTAL   | Ground | Analog ground to the low power 32 KHz crystal oscillator circuitry                                                                                                                                                                                                                                                                                         |
| GNDMAINXTAL | Ground | Analog ground to the main crystal oscillator circuitry                                                                                                                                                                                                                                                                                                     |
| GNDQ        | Ground | Quiet digital ground supply voltage to input buffers of I/O banks. Within the package, the GNDQ plane is decoupled from the simultaneous switching noise originated from the output buffer ground domain. This minimizes the noise transfer within the package and improves input signal integrity. GNDQ needs to always be connected on the board to GND. |
| GNDRCOSC    | Ground | Analog ground to the integrated RC oscillator circuit                                                                                                                                                                                                                                                                                                      |
| GNDSD0      | Ground | Analog ground to the first sigma-delta DAC                                                                                                                                                                                                                                                                                                                 |
| GNDSD1      | Ground | Common analog ground to the second and third sigma-delta DACs                                                                                                                                                                                                                                                                                              |
| GNDTM0      | Ground | Analog temperature monitor common ground for signal conditioning blocks SCB 0 and SCB 1 (see information for pins "TM0" and "TM1" in the <a href="#">"Analog Front-End (AFE)" section on page 5-12</a> ).                                                                                                                                                  |
| GNDTM1      | Ground | Analog temperature monitor common ground for signal conditioning block SCB 2 and SCB 3 (see information for pins "TM2" and "TM3" in the <a href="#">"Analog Front-End (AFE)" section on page 5-12</a> ).                                                                                                                                                   |
| GNDTM2      | Ground | Analog temperature monitor common ground for signal conditioning block SCB4                                                                                                                                                                                                                                                                                |
| GNDVAREF    | Ground | Analog ground reference used by the ADC. This pad should be connected to a quiet analog ground.                                                                                                                                                                                                                                                            |
| VCC         | Supply | Digital supply to the FPGA fabric and MSS, nominally 1.5 V. VCC is also required for powering the JTAG state machine, in addition to VJTAG. Even when a SmartFusion cSoC is in bypass mode in a JTAG chain of interconnected devices, both VCC and VJTAG must remain powered to allow JTAG signals to pass through the SmartFusion cSoC.                   |
| VCC15A      | Supply | Clean analog 1.5 V supply to the analog circuitry. Always power this pin.                                                                                                                                                                                                                                                                                  |

#### Notes:

1. The following 3.3 V supplies should be connected together while following proper noise filtering practices: VCC33A, VCC33ADCx, VCC33AP, VCC33SDDx, VCCMAINXTAL, and VCCLPXTAL.
2. The following 1.5 V supplies should be connected together while following proper noise filtering practices: VCC, VCC15A, and VCC15ADCx.

| Name        | Type   | Description                                                                                                                                                                                                                                                                                                                                                                  |
|-------------|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| VCC15ADC0   | Supply | Analog 1.5 V supply to the first ADC. Always power this pin.                                                                                                                                                                                                                                                                                                                 |
| VCC15ADC1   | Supply | Analog 1.5 V supply to the second ADC. Always power this pin.                                                                                                                                                                                                                                                                                                                |
| VCC15ADC2   | Supply | Analog 1.5 V supply to the third ADC. Always power this pin.                                                                                                                                                                                                                                                                                                                 |
| VCC33A      | Supply | Clean 3.3 V analog supply to the analog circuitry. VCC33A is also used to feed the 1.5 V voltage regulator for designs that do not provide an external supply to VCC. Refer to the Voltage Regulator (VR), Power Supply Monitor (PSM), and Power Modes section in the <a href="#">SmartFusion Microcontroller Subsystem User's Guide</a> for more information.               |
| VCC33ADC0   | Supply | Analog 3.3 V supply to the first ADC. Never ground this pin. Can be left floating if unused. <sup>1</sup>                                                                                                                                                                                                                                                                    |
| VCC33ADC1   | Supply | Analog 3.3 V supply to the second ADC. Never ground this pin. Can be left floating if unused. <sup>1</sup>                                                                                                                                                                                                                                                                   |
| VCC33ADC2   | Supply | Analog 3.3 V supply to the third ADC. Never ground this pin. Can be left floating if unused. <sup>1</sup>                                                                                                                                                                                                                                                                    |
| VCC33AP     | Supply | Analog clean 3.3 V supply to the charge pump. To avoid high current draw, VCC33AP should be powered up simultaneously with or after VCC33A. Can be pulled down if unused. <sup>1</sup>                                                                                                                                                                                       |
| VCC33N      | Supply | –3.3 V output from the voltage converter. A 2.2 $\mu$ F capacitor must be connected from this pin to GND. Analog charge pump capacitors are not needed if none of the analog SCB features are used and none of the SDDs are used. In that case it should be left unconnected.                                                                                                |
| VCC33SDD0   | Supply | Analog 3.3 V supply to the first sigma-delta DAC                                                                                                                                                                                                                                                                                                                             |
| VCC33SDD1   | Supply | Common analog 3.3 V supply to the second and third sigma-delta DACs                                                                                                                                                                                                                                                                                                          |
| VCCENVM     | Supply | Digital 1.5 V power supply to the embedded nonvolatile memory blocks. To avoid high current draw, VCC should be powered up before or simultaneously with VCCENVM.                                                                                                                                                                                                            |
| VCCESRAM    | Supply | Digital 1.5 V power supply to the embedded SRAM blocks. Available only on the 208PQFP package. It should be connected to VCC (in other packages, it is internally connected to VCC).                                                                                                                                                                                         |
| VCCFPGAIOB0 | Supply | Digital supply to the FPGA fabric I/O bank 0 (north FPGA I/O bank) for the output buffers and I/O logic.<br><br>Each bank can have a separate VCCFPGAIO connection. All I/Os in a bank will run off the same VCCFPGAIO supply. VCCFPGAIO can be 1.5 V, 1.8 V, 2.5 V, or 3.3 V, nominal voltage. Unused I/O banks should have their corresponding VCCFPGAIO pins tied to GND. |
| VCCFPGAIOB1 | Supply | Digital supply to the FPGA fabric I/O bank 1 (east FPGA I/O bank) for the output buffers and I/O logic.<br><br>Each bank can have a separate VCCFPGAIO connection. All I/Os in a bank will run off the same VCCFPGAIO supply. VCCFPGAIO can be 1.5 V, 1.8 V, 2.5 V, or 3.3 V, nominal voltage. Unused I/O banks should have their corresponding VCCFPGAIO pins tied to GND.  |
| VCCFPGAIOB5 | Supply | Digital supply to the FPGA fabric I/O bank 5 (west FPGA I/O bank) for the output buffers and I/O logic.<br><br>Each bank can have a separate VCCFPGAIO connection. All I/Os in a bank will run off the same VCCFPGAIO supply. VCCFPGAIO can be 1.5 V, 1.8 V, 2.5 V, or 3.3 V, nominal voltage. Unused I/O banks should have their corresponding VCCFPGAIO pins tied to GND.  |

**Notes:**

1. The following 3.3 V supplies should be connected together while following proper noise filtering practices: VCC33A, VCC33ADCx, VCC33AP, VCC33SDDx, VCCMAINXTAL, and VCCCLPXTAL.
2. The following 1.5 V supplies should be connected together while following proper noise filtering practices: VCC, VCC15A, and VCC15ADCx.



| Name       | Type   | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|------------|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| VCCLPXTAL  | Supply | Analog supply to the low power 32 KHz crystal oscillator. Always power this pin. <sup>1</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| VCCMAINTAL | Supply | Analog supply to the main crystal oscillator circuit. Always power this pin. <sup>1</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| VCCMSSIOB2 | Supply | Supply voltage to the microcontroller subsystem I/O bank 2 (east MSS I/O bank) for the output buffers and I/O logic.<br>Each bank can have a separate VCCMSSIO connection. All I/Os in a bank will run off the same VCCMSSIO supply. VCCMSSIO can be 1.5 V, 1.8 V, 2.5 V, or 3.3 V, nominal voltage. Unused I/O banks should have their corresponding VCCMSSIO pins tied to GND.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| VCCMSSIOB4 | Supply | Supply voltage to the microcontroller subsystem I/O bank 4 (west MSS I/O bank) for the output buffers and I/O logic.<br>Each bank can have a separate VCCMSSIO connection. All I/Os in a bank will run off the same VCCMSSIO supply. VCCMSSIO can be 1.5 V, 1.8 V, 2.5 V, or 3.3 V, nominal voltage. Unused I/O banks should have their corresponding VCCMSSIO pins tied to GND.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| VCCPLLx    | Supply | Analog 1.5 V supply to the PLL. Always power this pin.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| VCCRCOSC   | Supply | Analog supply to the integrated RC oscillator circuit. Always power this pin. <sup>1</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| VCOMPLAx   | Supply | Analog ground for the PLL                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| VDDBAT     | Supply | External battery connection to the low power 32 KHz crystal oscillator (along with VCCLPXTAL), RTC, and battery switchover circuit. Can be pulled down if unused.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| VJTAG      | Supply | Digital supply to the JTAG controller<br>SmartFusion cSoCs have a separate bank for the dedicated JTAG pins. The JTAG pins can be run at any voltage from 1.5 V to 3.3 V (nominal). Isolating the JTAG power supply in a separate I/O bank gives greater flexibility in supply selection and simplifies power supply and PCB design. If the JTAG interface is neither used nor planned to be used, the V <sub>JTAG</sub> pin together with the TRSTB pin could be tied to GND. Note that VCC is required to be powered for JTAG operation; VJTAG alone is insufficient. If a SmartFusion cSoC is in a JTAG chain of interconnected boards and it is desired to power down the board containing the device, this can be done provided both VJTAG and VCC to the device remain powered; otherwise, JTAG signals will not be able to transition the device, even in bypass mode. See "JTAG Pins" section on page 5-8. |
| VPP        | Supply | Digital programming circuitry supply<br>SmartFusion cSoCs support single-voltage in-system programming (ISP) of the configuration flash, embedded FlashROM (eFROM), and embedded nonvolatile memory (eNVM).<br>For programming, VPP should be in the 3.3 V ± 5% range. During normal device operation, VPP can be left floating or can be tied to any voltage between 0 V and 3.6 V. When the VPP pin is tied to ground, it shuts off the charge pump circuitry, resulting in no sources of oscillation from the charge pump circuitry. For proper programming, 0.01 µF and 0.33 µF capacitors (both rated at 16 V) are to be connected in parallel across VPP and GND, and positioned as close to the FPGA pins as possible.                                                                                                                                                                                      |

**Notes:**

1. The following 3.3 V supplies should be connected together while following proper noise filtering practices: VCC33A, VCC33ADCx, VCC33AP, VCC33SDDx, VCCMAINTAL, and VCCLPXTAL.
2. The following 1.5 V supplies should be connected together while following proper noise filtering practices: VCC, VCC15A, and VCC15ADCx.

## User-Defined Supply Pins

| Name     | Type  | Polarity/<br>Bus Size | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|----------|-------|-----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| VAREF0   | Input | 1                     | <p>Analog reference voltage for first ADC</p> <p>The SmartFusion cSoC can be configured to generate a 2.56 V internal reference that can be used by the ADC. While using the internal reference, the reference voltage is output on the VAREFOUT pin for use as a system reference. If a different reference voltage is required, it can be supplied by an external source and applied to this pin. The valid range of values that can be supplied to the ADC is 1.0 V to 3.3 V. When VAREF0 is internally generated, a bypass capacitor must be connected from this pin to ground. The value of the bypass capacitor should be between 3.3 <math>\mu</math>F and 22 <math>\mu</math>F, which is based on the needs of the individual designs. The choice of the capacitor value has an impact on the settling time it takes the VAREF0 signal to reach the required specification of 2.56 V to initiate valid conversions by the ADC. If the lower capacitor value is chosen, the settling time required for VAREF0 to achieve 2.56 V will be shorter than when selecting the larger capacitor value. The above range of capacitor values supports the accuracy specification of the ADC, which is detailed in the datasheet. Designers choosing the smaller capacitor value will not obtain as much margin in the accuracy as that achieved with a larger capacitor value. See the Analog-to-Digital Converter (ADC) section in the <a href="#">SmartFusion Programmable Analog User's Guide</a> for more information. The SoC Products Group recommends customers use 10 <math>\mu</math>F as the value of the bypass capacitor. Designers choosing to use an external VAREF0 need to ensure that a stable and clean VAREF0 source is supplied to the VAREF0 pin before initiating conversions by the ADC. To use the internal voltage reference, you must connect the VAREFOUT pin to the appropriate ADC VAREF<sub>x</sub> input—either the VAREF0 or VAREF1 pin—on the PCB.</p> |
| VAREF1   | Input | 1                     | <p>Analog reference voltage for second ADC</p> <p>See "VAREF0" above for more information.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| VAREF2   | Input | 1                     | <p>Analog reference voltage for third ADC</p> <p>See "VAREF0" above for more.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| VAREFOUT | Out   | 1                     | <p>Internal 2.56 V voltage reference output. Can be used to provide the two ADCs with a unique voltage reference externally by connecting VAREFOUT to both VAREF0 and VAREF1. To use the internal voltage reference, you must connect the VAREFOUT pin to the appropriate ADC VAREF<sub>x</sub> input—either the VAREF0 or VAREF1 pin—on the PCB.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |

## User Pins

| Name   | Type   | Polarity/<br>Bus Size | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|--------|--------|-----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| GPIO_x | In/out | 32                    | <p>Microcontroller Subsystem (MSS) General Purpose I/O (GPIO). The MSS GPIO pin functions as an input, output, tristate, or bidirectional buffer with configurable interrupt generation and Schmitt trigger support. Input and output signal levels are compatible with the I/O standard selected.</p> <p>Unused GPIO pins are tristated and do not include pull-up or pull-down resistors.</p> <p>During power-up, the used GPIO pins are tristated with no pull-up or pull-down resistors until Sys boot configures them.</p> <p>Some of these pins are also multiplexed with integrated peripherals in the MSS (SPI, I<sup>2</sup>C, and UART).</p> <p>GPIOs can be routed to dedicated I/O buffers (MSSIOBUF) or in some cases to the FPGA fabric interface through an IOMUX. This allows GPIO pins to be multiplexed as either I/Os for the FPGA fabric, the ARM<sup>®</sup> Cortex-M3 or for given integrated MSS peripherals. The MSS peripherals are not multiplexed with each other; they are multiplexed only with the GPIO block. For more information, see the General Purpose I/O Block (GPIO) section in the <a href="#">SmartFusion Microcontroller Subsystem User's Guide</a>.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IO     | In/out |                       | <p>FPGA user I/O. The naming convention used for each FPGA user I/O is <b>/IOuxwBVz</b>, where:</p> <p><b>u</b> = I/O pair number in bank, starting at 00 from the northwest I/O bank and proceeding in a clockwise direction.</p> <p><b>x</b> = P (positive) or N (negative) or S (single-ended) or R (regular, single-ended).</p> <p><b>w</b> = D (Differential Pair), P (Pair), or S (Single-Ended). D (Differential Pair) if both members of the pair are bonded out to adjacent pins or are separated only by one GND or NC pin; P (Pair) if both members of the pair are bonded out but do not meet the adjacency requirement; or S (Single-Ended) if the I/O pair is not bonded out. For Differential Pairs (D), adjacency for ball grid packages means only vertical or horizontal. Diagonal adjacency does not meet the requirements for a true differential pair.</p> <p><b>y</b> = Bank number starting at 0 from northwest I/O bank and incrementing clockwise.</p> <p><b>z</b> = VREF mini bank number.</p> <p>The FPGA user I/O pin functions as an input, output, tristate or bidirectional buffer. Input and output signal levels are compatible with the I/O standard selected. Unused I/O pins are disabled by Libero IDE software and include a weak pull-up resistor. During power-up, the used I/O pins are tristated with no pull-up or pull-down resistors until I/O enable (there is a delay after voltage stabilizes, and different I/O banks power up sequentially to avoid a surge of ICCI).</p> <p>Unused I/Os are configured as follows:</p> <ul style="list-style-type: none"> <li>• Output buffer is disabled (with tristate value of high impedance)</li> <li>• Input buffer is disabled (with tristate value of high impedance)</li> <li>• Weak pull-up is programmed</li> </ul> <p>Some of these pins are also multiplexed with integrated peripherals in the MSS (Ethernet MAC and external memory controller).</p> <p>Unused MSS I/Os are neither weakly pulled-up nor weakly pulled-down. The Schmitt trigger is disabled. Essentially, I/Os have the reset values as defined in Table 19-25 IOMUX_n_CR, in the <a href="#">SmartFusion Microcontroller Subsystem User's Guide</a>.</p> <p>During programming, I/Os become tristated and weakly pulled up to VCCI. With the VCCI and VCC supplies continuously powered up, when the device transitions from programming to operating mode, the I/Os are instantly configured to the desired user configuration. For more information, see the SmartFusion FPGA User I/Os section in the <a href="#">SmartFusion FPGA Fabric User's Guide</a>.</p> |

## Special Function Pins

| Name     | Type | Polarity/Bus Size | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|----------|------|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NC       |      |                   | No connect<br>This pin is not connected to circuitry within the device. These pins can be driven to any voltage or can be left floating with no effect on the operation of the device.                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| DC       |      |                   | Do not connect.<br>This pin should not be connected to any signals on the PCB. These pins should be left unconnected.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| LPXIN    | In   | 1                 | Low power 32 KHz crystal oscillator.<br>Input from the 32 KHz oscillator. Pin for connecting a low power 32 KHz watch crystal. If not used, the LPXIN pin can be left floating. For more information, see the PLLs, Clock Conditioning Circuitry, and On-Chip Crystal Oscillators section in the <a href="#">SmartFusion Microcontroller Subsystem User's Guide</a> .                                                                                                                                                                                                                                                                             |
| LPXOUT   | In   | 1                 | Low power 32 KHz crystal oscillator.<br>Output to the 32 KHz oscillator. Pin for connecting a low power 32 KHz watch crystal. If not used, the LPXOUT pin can be left floating. For more information, see the PLLs, Clock Conditioning Circuitry, and On-Chip Crystal Oscillators section in the <a href="#">SmartFusion Microcontroller Subsystem User's Guide</a> .                                                                                                                                                                                                                                                                             |
| MAINXIN  | In   | 1                 | Main crystal oscillator circuit.<br>Input to the crystal oscillator circuit. Pin for connecting an external crystal, ceramic resonator, or RC network. When using an external crystal or ceramic oscillator, external capacitors are also recommended. Refer to documentation from the crystal oscillator manufacturer for proper capacitor value.<br>If using an external RC network or clock input, MAINXIN should be used and MAINXOUT left unconnected. For more information, see the PLLs, Clock Conditioning Circuitry, and On-Chip Crystal Oscillators section in the <a href="#">SmartFusion Microcontroller Subsystem User's Guide</a> . |
| MAINXOUT | Out  | 1                 | Main crystal oscillator circuit.<br>Output from the crystal oscillator circuit. Pin for connecting external crystal or ceramic resonator. When using an external crystal or ceramic oscillator, external capacitors are also recommended. Refer to documentation from the crystal oscillator manufacturer for proper capacitor value.<br>If using external RC network or clock input, MAINXIN should be used and MAINXOUT left unconnected. For more information, see the PLLs, Clock Conditioning Circuitry, and On-Chip Crystal Oscillators section in the <a href="#">SmartFusion Microcontroller Subsystem User's Guide</a> .                 |
| NCAP     |      | 1                 | Negative capacitor connection.<br>This is the negative terminal of the charge pump. A capacitor, with a 2.2 $\mu$ F recommended value, is required to connect between PCAP and NCAP. Analog charge pump capacitors are not needed if none of the analog SCB features are used and none of the SDDs are used. In that case it should be left unconnected.                                                                                                                                                                                                                                                                                          |

| Name        | Type | Polarity/Bus Size | Description                                                                                                                                                                                                                                                                                                                                                                                                        |
|-------------|------|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| PCAP        |      | 1                 | Positive Capacitor connection.<br>This is the positive terminal of the charge pump. A capacitor, with a 2.2 $\mu$ F recommended value, is required to connect between PCAP and NCAP. If this pin is not used, it must be left unconnected/floating. In this case, no capacitor is needed. Analog charge pump capacitors are not needed if none of the analog SCB features are used, and none of the SDDs are used. |
| PTBASE      |      | 1                 | Pass transistor base connection<br>This is the control signal of the voltage regulator. This pin should be connected to the base of an external pass transistor used with the 1.5 V internal voltage regulator and can be floating if not used.                                                                                                                                                                    |
| PTEM        |      | 1                 | Pass transistor emitter connection.<br>This is the feedback input of the voltage regulator.<br>This pin should be connected to the emitter of an external pass transistor used with the 1.5 V internal voltage regulator and can be floating if not used.                                                                                                                                                          |
| MSS_RESET_N | In   | Low               | Reset signal for the microcontroller subsystem. Can be left floating because internal pull-up is there.                                                                                                                                                                                                                                                                                                            |
| PU_N        | In   | Low               | Push-button is the connection for the external momentary switch used to turn on the 1.5 V voltage regulator and can be floating if not used.                                                                                                                                                                                                                                                                       |

## JTAG Pins

SmartFusion cSoCs have a separate bank for the dedicated JTAG pins. The JTAG pins can be run at any voltage from 1.5 V to 3.3 V (nominal). VCC must also be powered for the JTAG state machine to operate, even if the device is in bypass mode; VJTAG alone is insufficient. Both VJTAG and VCC to the SmartFusion cSoC part must be supplied to allow JTAG signals to transition the SmartFusion cSoC. Isolating the JTAG power supply in a separate I/O bank gives greater flexibility with supply selection and simplifies power supply and PCB design. If the JTAG interface is neither used nor planned to be used, the VJTAG pin together with the TRSTB pin could be tied to GND.

| Name    | Type | Polarity/<br>Bus Size | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|---------|------|-----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| JTAGSEL | In   | 1                     | <p>JTAG controller selection</p> <p>Depending on the state of the JTAGSEL pin, an external JTAG controller will either see the FPGA fabric TAP/auxiliary TAP (High) or the Cortex-M3 JTAG debug interface (Low).</p> <p>The JTAGSEL pin should be connected to an external pull-up resistor such that the default configuration selects the FPGA fabric TAP.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| TCK     | In   | 1                     | <p>Test clock</p> <p>Serial input for JTAG boundary scan, ISP, and UJTAG. The TCK pin does not have an internal pull-up/-down resistor. If JTAG is not used, it is recommended to tie off TCK to GND or <math>V_{JTAG}</math> through a resistor placed close to the FPGA pin. This prevents JTAG operation in case TMS enters an undesired state.</p> <p>Note that to operate at all <math>V_{JTAG}</math> voltages, 500 <math>\Omega</math> to 1 k<math>\Omega</math> will satisfy the requirements. Refer to <a href="#">Table 5-1 on page 5-9</a> for more information.</p> <p>Can be left floating when unused.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| TDI     | In   | 1                     | <p>Test data</p> <p>Serial input for JTAG boundary scan, ISP, and UJTAG usage. There is an internal weak pull-up resistor on the TDI pin.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| TDO     | Out  | 1                     | <p>Test data</p> <p>Serial output for JTAG boundary scan, ISP, and UJTAG usage.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| TMS     | In   | HIGH                  | <p>Test mode select</p> <p>The TMS pin controls the use of the IEEE1532 boundary scan pins (TCK, TDI, TDO, TRST). There is an internal weak pull-up resistor on the TMS pin.</p> <p>Can be left floating when unused.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| TRSTB   | In   | HIGH                  | <p>Boundary scan reset pin</p> <p>The TRST pin functions as an active low input to asynchronously initialize (or reset) the boundary scan circuitry. There is an internal weak pull-up resistor on the TRST pin. If JTAG is not used, an external pull-down resistor could be included to ensure the TAP is held in reset mode. The resistor values must be chosen from <a href="#">Table 5-1 on page 5-9</a> and must satisfy the parallel resistance value requirement. The values in <a href="#">Table 5-1 on page 5-9</a> correspond to the resistor recommended when a single device is used. The values correspond to the equivalent parallel resistor when multiple devices are connected via a JTAG chain.</p> <p>In critical applications, an upset in the JTAG circuit could allow entering an undesired JTAG state. In such cases, it is recommended that you tie off TRST to GND through a resistor placed close to the FPGA pin.</p> <p>The TRSTB pin also resets the serial wire JTAG – debug port (SWJ-DP) circuitry within the Cortex-M3.</p> <p>Can be left floating when unused.</p> |

**Table 5-1 • Recommended Tie-Off Values for the TCK and TRST Pins**

| VJTAG          | Tie-Off Resistance <sup>1, 2</sup> |
|----------------|------------------------------------|
| VJTAG at 3.3 V | 200 $\Omega$ to 1 k $\Omega$       |
| VJTAG at 2.5 V | 200 $\Omega$ to 1 k $\Omega$       |
| VJTAG at 1.8 V | 500 $\Omega$ to 1 k $\Omega$       |
| VJTAG at 1.5 V | 500 $\Omega$ to 1 k $\Omega$       |

**Notes:**

1. The TCK pin can be pulled up/down.
2. The TRST pin can only be pulled down.
1. Equivalent parallel resistance if more than one device is on JTAG chain.

## Microcontroller Subsystem (MSS)

| Name                                                         | Type   | Polarity/<br>Bus Size | Description                                                                                                                            |
|--------------------------------------------------------------|--------|-----------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| <b>External Memory Controller</b>                            |        |                       |                                                                                                                                        |
| EMC_ABx                                                      | Out    | 26                    | External memory controller address bus<br>Can also be used as an FPGA user I/O (see "IO" on page 5-5).                                 |
| EMC_BYTENx                                                   | Out    | LOW/2                 | External memory controller byte enable<br>Can also be used as an FPGA user I/O (see "IO" on page 5-5).                                 |
| EMC_CLK                                                      | Out    | Rise                  | External memory controller clock<br>Can also be used as an FPGA user I/O (see "IO" on page 5-5).                                       |
| EMC_CSx_N                                                    | Out    | LOW/2                 | External memory controller chip selects<br>Can also be used as an FPGA User IO (see "IO" on page 5-5).                                 |
| EMC_DBx                                                      | In/out | 16                    | External memory controller data bus<br>Can also be used as an FPGA user I/O (see "IO" on page 5-5).                                    |
| EMC_OENx_N                                                   | Out    | LOW/2                 | External memory controller output enables<br>Can also be used as an FPGA User IO (see "IO" on page 5-5).                               |
| EMC_RW_N                                                     | Out    | Level                 | External memory controller read/write. Read = High, write = Low.<br>Can also be used as an FPGA user I/O (see "IO" on page 5-5).       |
| <b>Inter-Integrated Circuit (I<sup>2</sup>C) Peripherals</b> |        |                       |                                                                                                                                        |
| I2C_0_SCL                                                    | In/out | 1                     | I <sup>2</sup> C bus serial clock output. First I <sup>2</sup> C.<br>Can also be used as an MSS GPIO (see "GPIO_x" on page 5-5).       |
| I2C_0_SDA                                                    | In/out | 1                     | I <sup>2</sup> C bus serial data input/output. First I <sup>2</sup> C.<br>Can also be used as an MSS GPIO (see "GPIO_x" on page 5-5).  |
| I2C_1_SCL                                                    | In/out | 1                     | I <sup>2</sup> C bus serial clock output. Second I <sup>2</sup> C.<br>Can also be used as an MSS GPIO (see "GPIO_x" on page 5-5).      |
| I2C_1_SDA                                                    | In/out | 1                     | I <sup>2</sup> C bus serial data input/output. Second I <sup>2</sup> C.<br>Can also be used as an MSS GPIO (see "GPIO_x" on page 5-5). |
| <b>Serial Peripheral Interface (SPI) Controllers</b>         |        |                       |                                                                                                                                        |
| SPI_0_CLK                                                    | Out    | 1                     | Clock. First SPI.<br>Can also be used as an MSS GPIO (see "GPIO_x" on page 5-5).                                                       |
| SPI_0_DI                                                     | In     | 1                     | Data input. First SPI.<br>Can also be used as an MSS GPIO (see "GPIO_x" on page 5-5).                                                  |
| SPI_0_DO                                                     | Out    | 1                     | Data output. First SPI.<br>Can also be used as an MSS GPIO (see "GPIO_x" on page 5-5).                                                 |
| SPI_0_SS                                                     | Out    | 1                     | Slave select (chip select). First SPI.<br>Can also be used as an MSS GPIO (see "GPIO_x" on page 5-5).                                  |
| SPI_1_CLK                                                    | Out    | 1                     | Clock. Second SPI.<br>Can also be used as an MSS GPIO (see "GPIO_x" on page 5-5).                                                      |
| SPI_1_DI                                                     | In     | 1                     | Data input. Second SPI.<br>Can also be used as an MSS GPIO (see "GPIO_x" on page 5-5).                                                 |



| Name                                                                  | Type   | Polarity/<br>Bus Size | Description                                                                                                                                                                                                   |
|-----------------------------------------------------------------------|--------|-----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SPI_1_DO                                                              | Out    | 1                     | Data output. Second SPI.<br>Can also be used as an MSS GPIO (see "GPIO_x" on page 5-5).                                                                                                                       |
| SPI_1_SS                                                              | Out    | 1                     | Slave select (chip select). Second SPI.<br>Can also be used as an MSS GPIO (see "GPIO_x" on page 5-5).                                                                                                        |
| <b>Universal Asynchronous Receiver/Transmitter (UART) Peripherals</b> |        |                       |                                                                                                                                                                                                               |
| UART_0_RXD                                                            | In     | 1                     | Receive data. First UART.<br>Can also be used as an MSS GPIO (see "GPIO_x" on page 5-5).                                                                                                                      |
| UART_0_TXD                                                            | Out    | 1                     | Transmit data. First UART.<br>Can also be used as an MSS GPIO (see "GPIO_x" on page 5-5).                                                                                                                     |
| UART_1_RXD                                                            | In     | 1                     | Receive data. Second UART.<br>Can also be used as an MSS GPIO (see "GPIO_x" on page 5-5).                                                                                                                     |
| UART_1_TXD                                                            | Out    | 1                     | Transmit data. Second UART.<br>Can also be used as an MSS GPIO (see "GPIO_x" on page 5-5).                                                                                                                    |
| <b>Ethernet MAC</b>                                                   |        |                       |                                                                                                                                                                                                               |
| MAC_CLK                                                               | In     | Rise                  | Receive clock. 50 MHz $\pm$ 50 ppm clock source received from RMII PHY.<br>Can be left floating when unused.                                                                                                  |
| MAC_CRSDV                                                             | In     | High                  | Carrier sense/receive data valid for RMII PHY<br>Can also be used as an FPGA User IO (see "IO" on page 5-5).                                                                                                  |
| MAC_MDC                                                               | Out    | Rise                  | RMII management clock<br>Can also be used as an FPGA User IO (see "IO" on page 5-5).                                                                                                                          |
| MAC_MDIO                                                              | In/Out | 1                     | RMII management data input/output<br>Can also be used as an FPGA User IO (see "IO" on page 5-5).                                                                                                              |
| MAC_RXDx                                                              | In     | 2                     | Ethernet MAC receive data. Data recovered and decoded by PHY. The RXD[0] signal is the least significant bit.<br>Can also be used as an FPGA User I/O (see "IO" on page 5-5).                                 |
| MAC_RXER                                                              | In     | HIGH                  | Ethernet MAC receive error. If MACRX_ER is asserted during reception, the frame is received and status of the frame is updated with MACRX_ER.<br>Can also be used as an FPGA user I/O (see "IO" on page 5-5). |
| MAC_TXDx                                                              | Out    | 2                     | Ethernet MAC transmit data. The TXD[0] signal is the least significant bit.<br>Can also be used as an FPGA user I/O (see "IO" on page 5-5).                                                                   |
| MAC_TXEN                                                              | Out    | HIGH                  | Ethernet MAC transmit enable. When asserted, indicates valid data for the PHY on the TXD port.<br>Can also be used as an FPGA User I/O (see "IO" on page 5-5).                                                |

## Analog Front-End (AFE)

| Name  | Type | Description                                                                                                                                                                 | Associated With |      |
|-------|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|------|
|       |      |                                                                                                                                                                             | ADC/SDD         | SCB  |
| ABPS0 | In   | SCB 0 / active bipolar prescaler input 1.<br>See the Active Bipolar Prescaler (ABPS) section in the <a href="#">SmartFusion Programmable Analog User's Guide</a> .          | ADC0            | SCB0 |
| ABPS1 | In   | SCB 0 / active bipolar prescaler Input 2                                                                                                                                    | ADC0            | SCB0 |
| ABPS2 | In   | SCB 1 / active bipolar prescaler Input 1                                                                                                                                    | ADC0            | SCB1 |
| ABPS3 | In   | SCB 1 / active bipolar prescaler Input 2                                                                                                                                    | ADC0            | SCB1 |
| ABPS4 | In   | SCB 2 / active bipolar prescaler Input 1                                                                                                                                    | ADC1            | SCB2 |
| ABPS5 | In   | SCB 2 / active bipolar prescaler Input 2                                                                                                                                    | ADC1            | SCB2 |
| ABPS6 | In   | SCB 3 / active bipolar prescaler Input 1                                                                                                                                    | ADC1            | SCB3 |
| ABPS7 | In   | SCB 3 / active bipolar prescaler input 2                                                                                                                                    | ADC1            | SCB3 |
| ABPS8 | In   | SCB 4 / active bipolar prescaler input 1                                                                                                                                    | ADC2            | SCB4 |
| ABPS9 | In   | SCB 4 / active bipolar prescaler input 2                                                                                                                                    | ADC2            | SCB4 |
| ADC0  | In   | ADC 0 direct input 0 / FPGA Input.<br>See the "Sigma-Delta Digital-to-Analog Converter (DAC)" section in the <a href="#">SmartFusion Programmable Analog User's Guide</a> . | ADC0            | SCB0 |
| ADC1  | In   | ADC 0 direct input 1 / FPGA input                                                                                                                                           | ADC0            | SCB0 |
| ADC2  | In   | ADC 0 direct input 2 / FPGA input                                                                                                                                           | ADC0            | SCB1 |
| ADC3  | In   | ADC 0 direct input 3 / FPGA input                                                                                                                                           | ADC0            | SCB1 |
| ADC4  | In   | ADC 1 direct input 0 / FPGA input                                                                                                                                           | ADC1            | SCB2 |
| ADC5  | In   | ADC 1 direct input 1 / FPGA input                                                                                                                                           | ADC1            | SCB2 |
| ADC6  | In   | ADC 1 direct input 2 / FPGA input                                                                                                                                           | ADC1            | SCB3 |
| ADC7  | In   | ADC 1 direct input 3 / FPGA input                                                                                                                                           | ADC1            | SCB3 |
| ADC8  | In   | ADC 2 direct input 0 / FPGA input                                                                                                                                           | ADC2            | SCB4 |
| ADC9  | In   | ADC 2 direct input 1 / FPGA input                                                                                                                                           | ADC2            | SCB4 |
| ADC10 | In   | ADC 2 direct input 2 / FPGA input                                                                                                                                           | ADC2            | N/A  |
| ADC11 | In   | ADC 2 direct input 3 / FPGA input                                                                                                                                           | ADC2            | N/A  |
| CM0   | In   | SCB 0 / high side of current monitor / comparator<br>Positive input. See the Current Monitor section in the <a href="#">SmartFusion Programmable Analog User's Guide</a> .  | ADC0            | SCB0 |
| CM1   | In   | SCB 1 / high side of current monitor / comparator. Positive input.                                                                                                          | ADC0            | SCB1 |
| CM2   | In   | SCB 2 / high side of current monitor / comparator. Positive input.                                                                                                          | ADC1            | SCB2 |
| CM3   | In   | SCB 3 / high side of current monitor / comparator. Positive input.                                                                                                          | ADC1            | SCB3 |
| CM4   | In   | SCB 4 / high side of current monitor / comparator. Positive input.                                                                                                          | ADC2            | SCB4 |

**Note:** Unused analog inputs should be grounded. This aids in shielding and prevents an undesired coupling path.

| Name | Type | Description                                                                                                                                           | Associated With |      |
|------|------|-------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|------|
|      |      |                                                                                                                                                       | ADC/SDD         | SCB  |
| TM0  | In   | SCB 0 / low side of current monitor / comparator<br>Negative input / high side of temperature monitor. See the Temperature Monitor section.           | ADC0            | SCB0 |
| TM1  | In   | SCB 1 / low side of current monitor / comparator. Negative input / high side of temperature monitor.                                                  | ADC0            | SCB1 |
| TM2  | In   | SCB 2 / low side of current monitor / comparator. Negative input / high side of temperature monitor.                                                  | ADC1            | SCB2 |
| TM3  | In   | SCB 3 low side of current monitor / comparator. Negative input / high side of temperature monitor.                                                    | ADC1            | SCB3 |
| TM4  | In   | SCB 4 low side of current monitor / comparator. Negative input / high side of temperature monitor.                                                    | ADC2            | SCB4 |
| SDD0 | Out  | Output of SDD0<br>See the Sigma-Delta Digital-to-Analog Converter (DAC) section in the <a href="#">SmartFusion Programmable Analog User's Guide</a> . | SDD0            | N/A  |
| SDD1 | Out  | Output of SDD1                                                                                                                                        | SDD1            | N/A  |
| SDD2 | Out  | Output of SDD2                                                                                                                                        | SDD2            | N/A  |

*Note:* Unused analog inputs should be grounded. This aids in shielding and prevents an undesired coupling path.

## Analog Front-End Pin-Level Function Multiplexing

Table 5-2 describes the relationships between the various internal signals found in the analog front-end (AFE) and how they are multiplexed onto the external package pins. Note that, in general, only one function is available for those pads that have numerous functions listed. The exclusion to this rule is when a comparator is used; the ADC can still convert either input side of the comparator.

**Table 5-2 • Relationships Between Signals in the Analog Front-End**

| Pin   | ADC Channel | Dir.-In Option | Prescaler | Current Mon. | Temp. Mon. | Compar. | LVTTTL      | SDD MUX   | SDD      |
|-------|-------------|----------------|-----------|--------------|------------|---------|-------------|-----------|----------|
| ABPS0 | ADC0_CH1    |                | ABPS0_IN  |              |            |         |             |           |          |
| ABPS1 | ADC0_CH2    |                | ABPS1_IN  |              |            |         |             |           |          |
| ABPS2 | ADC0_CH5    |                | ABPS2_IN  |              |            |         |             |           |          |
| ABPS3 | ADC0_CH6    |                | ABPS3_IN  |              |            |         |             |           |          |
| ABPS4 | ADC1_CH1    |                | ABPS4_IN  |              |            |         |             |           |          |
| ABPS5 | ADC1_CH2    |                | ABPS5_IN  |              |            |         |             |           |          |
| ABPS6 | ADC1_CH5    |                | ABPS6_IN  |              |            |         |             |           |          |
| ABPS7 | ADC1_CH6    |                | ABPS7_IN  |              |            |         |             |           |          |
| ABPS8 | ADC2_CH1    |                | ABPS8_IN  |              |            |         |             |           |          |
| ABPS9 | ADC2_CH2    |                | ABPS9_IN  |              |            |         |             |           |          |
| ADC0  | ADC0_CH9    | Yes            |           |              |            | CMP1_P  | LVTTTL0_IN  |           |          |
| ADC1  | ADC0_CH10   | Yes            |           |              |            | CMP1_N  | LVTTTL1_IN  | SDDM0_OUT |          |
| ADC2  | ADC0_CH11   | Yes            |           |              |            | CMP3_P  | LVTTTL2_IN  |           |          |
| ADC3  | ADC0_CH12   | Yes            |           |              |            | CMP3_N  | LVTTTL3_IN  | SDDM1_OUT |          |
| ADC4  | ADC1_CH9    | Yes            |           |              |            | CMP5_P  | LVTTTL4_IN  |           |          |
| ADC5  | ADC1_CH10   | Yes            |           |              |            | CMP5_N  | LVTTTL5_IN  | SDDM2_OUT |          |
| ADC6  | ADC1_CH11   | Yes            |           |              |            | CMP7_P  | LVTTTL6_IN  |           |          |
| ADC7  | ADC1_CH12   | Yes            |           |              |            | CMP7_N  | LVTTTL7_IN  | SDDM3_OUT |          |
| ADC8  | ADC2_CH9    | Yes            |           |              |            | CMP9_P  | LVTTTL8_IN  |           |          |
| ADC9  | ADC2_CH10   | Yes            |           |              |            | CMP9_N  | LVTTTL9_IN  | SDDM4_OUT |          |
| ADC10 | ADC2_CH11   | Yes            |           |              |            |         | LVTTTL10_IN |           |          |
| ADC11 | ADC2_CH12   | Yes            |           |              |            |         | LVTTTL11_IN |           |          |
| CM0   | ADC0_CH3    | Yes            |           | CM0_H        |            | CMP0_P  |             |           |          |
| CM1   | ADC0_CH7    | Yes            |           | CM1_H        |            | CMP2_P  |             |           |          |
| CM2   | ADC1_CH3    | Yes            |           | CM2_H        |            | CMP4_P  |             |           |          |
| CM3   | ADC1_CH7    | Yes            |           | CM3_H        |            | CMP6_P  |             |           |          |
| CM4   | ADC2_CH3    | Yes            |           | CM4_H        |            | CMP8_P  |             |           |          |
| SDD0  | ADC0_CH15   |                |           |              |            |         |             |           | SDD0_OUT |
| SDD1  | ADC1_CH15   |                |           |              |            |         |             |           | SDD1_OUT |

**Notes:**

1. ABPSx\_IN: Input to active bipolar prescaler channel x.
2. CMx\_H/L: Current monitor channel x, high/low side.
3. TMx\_IO: Temperature monitor channel x.
4. CMPx\_P/N: Comparator channel x, positive/negative input.
5. LVTTTLx\_IN: LVTTTL I/O channel x.
6. SDDMx\_OUT: Output from sigma-delta DAC MUX channel x.
7. SDDx\_OUT: Direct output from sigma-delta DAC channel x.

**Table 5-2 • Relationships Between Signals in the Analog Front-End**

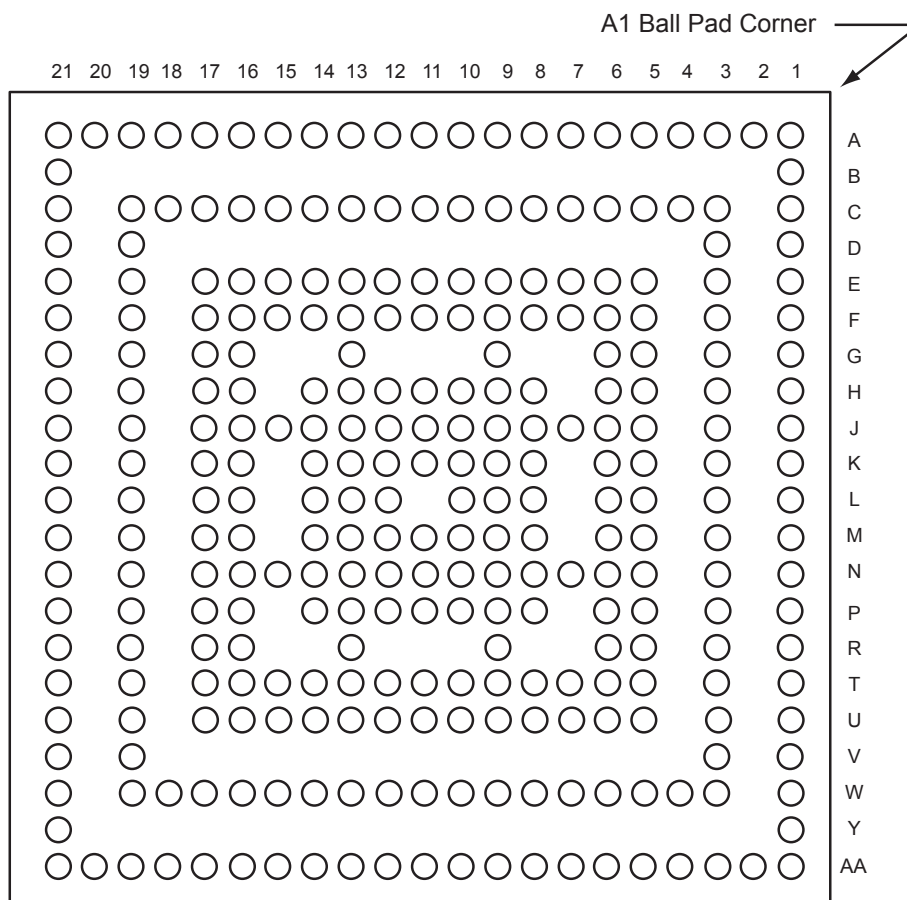
| Pin  | ADC Channel | Dir.-In Option | Prescaler | Current Mon. | Temp. Mon. | Compar. | LVTTTL | SDD MUX | SDD      |
|------|-------------|----------------|-----------|--------------|------------|---------|--------|---------|----------|
| SDD2 | ADC2_CH15   |                |           |              |            |         |        |         | SDD2_OUT |
| TM0  | ADC0_CH4    | Yes            |           | CM0_L        | TM0_IO     | CMP0_N  |        |         |          |
| TM1  | ADC0_CH8    | Yes            |           | CM1_L        | TM1_IO     | CMP2_N  |        |         |          |
| TM2  | ADC1_CH4    | Yes            |           | CM2_L        | TM2_IO     | CMP4_N  |        |         |          |
| TM3  | ADC1_CH8    | Yes            |           | CM3_L        | TM3_IO     | CMP6_N  |        |         |          |
| TM4  | ADC2_CH4    | Yes            |           | CM4_L        | TM4_IO     | CMP8_N  |        |         |          |

**Notes:**

1. *ABPSx\_IN*: Input to active bipolar prescaler channel *x*.
2. *CMx\_H/L*: Current monitor channel *x*, high/low side.
3. *TMx\_IO*: Temperature monitor channel *x*.
4. *CMPx\_P/N*: Comparator channel *x*, positive/negative input.
5. *LVTTTLx\_IN*: LVTTTL I/O channel *x*.
6. *SDDMx\_OUT*: Output from sigma-delta DAC MUX channel *x*.
7. *SDDx\_OUT*: Direct output from sigma-delta DAC channel *x*.

# Pin Assignment Tables

## CS288



*Note:* Bottom view

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

| Pin No. | CS288                 |                           |                           |
|---------|-----------------------|---------------------------|---------------------------|
|         | A2F060 Function       | A2F200 Function           | A2F500 Function           |
| A1      | VCCFPGAIOB0           | VCCFPGAIOB0               | VCCFPGAIOB0               |
| A2      | GNDQ                  | GNDQ                      | GNDQ                      |
| A3      | EMC_CLK/IO00NDB0V0    | EMC_CLK/GAA0/IO00NDB0V0   | EMC_CLK/GAA0/IO02NDB0V0   |
| A4      | EMC_RW_N/IO00PDB0V0   | EMC_RW_N/GAA1/IO00PDB0V0  | EMC_RW_N/GAA1/IO02PDB0V0  |
| A5      | GND                   | GND                       | GND                       |
| A6      | EMC_CS1_N/IO01PDB0V0  | EMC_CS1_N/GAB1/IO01PDB0V0 | EMC_CS1_N/GAB1/IO05PDB0V0 |
| A7      | EMC_CS0_N/IO01NDB0V0  | EMC_CS0_N/GAB0/IO01NDB0V0 | EMC_CS0_N/GAB0/IO05NDB0V0 |
| A8      | EMC_AB[0]/IO04NPB0V0  | EMC_AB[0]/IO04NPB0V0      | EMC_AB[0]/IO06NPB0V0      |
| A9      | VCCFPGAIOB0           | VCCFPGAIOB0               | VCCFPGAIOB0               |
| A10     | EMC_AB[4]/IO06NDB0V0  | EMC_AB[4]/IO06NDB0V0      | EMC_AB[4]/IO10NDB0V0      |
| A11     | EMC_AB[8]/IO08NPB0V0  | EMC_AB[8]/IO08NPB0V0      | EMC_AB[8]/IO13NPB0V0      |
| A12     | EMC_AB[14]/IO11NPB0V0 | EMC_AB[14]/IO11NPB0V0     | EMC_AB[14]/IO15NPB0V0     |
| A13     | GND                   | GND                       | GND                       |
| A14     | EMC_AB[18]/IO13NDB0V0 | EMC_AB[18]/IO13NDB0V0     | EMC_AB[18]/IO18NDB0V0     |
| A15     | EMC_AB[24]/IO16NDB0V0 | EMC_AB[24]/IO16NDB0V0     | EMC_AB[24]/IO20NDB0V0     |
| A16     | EMC_AB[25]/IO16PDB0V0 | EMC_AB[25]/IO16PDB0V0     | EMC_AB[25]/IO20PDB0V0     |
| A17     | VCCFPGAIOB0           | VCCFPGAIOB0               | VCCFPGAIOB0               |
| A18     | EMC_AB[20]/IO14NDB0V0 | EMC_AB[20]/IO14NDB0V0     | EMC_AB[20]/IO21NDB0V0     |
| A19     | EMC_AB[21]/IO14PDB0V0 | EMC_AB[21]/IO14PDB0V0     | EMC_AB[21]/IO21PDB0V0     |
| A20     | GNDQ                  | GNDQ                      | GNDQ                      |
| A21     | GND                   | GND                       | GND                       |
| AA1     | ADC1                  | ABPS1                     | ABPS1                     |
| AA2     | GNDQAQ                | GNDQAQ                    | GNDQAQ                    |
| AA3     | GNDA                  | GNDA                      | GNDA                      |
| AA4     | VCC33N                | VCC33N                    | VCC33N                    |
| AA5     | SDD0                  | SDD0                      | SDD0                      |
| AA6     | ADC0                  | ABPS0                     | ABPS0                     |
| AA7     | NC                    | GNDTM0                    | GNDTM0                    |
| AA8     | NC                    | ABPS2                     | ABPS2                     |
| AA9     | NC                    | VAREF0                    | VAREF0                    |
| AA10    | NC                    | GND15ADC0                 | GND15ADC0                 |
| AA11    | ADC9                  | ADC6                      | ADC6                      |
| AA12    | ABPS1                 | ABPS7                     | ABPS7                     |
| AA13    | ADC6                  | TM2                       | TM2                       |

*Note:* Shading denotes pins that do not have completely identical functions from density to density. For example, the bank assignment can be different for an I/O, or the function might be available only on a larger density device.

| Pin No. | CS288                 |                            |                            |
|---------|-----------------------|----------------------------|----------------------------|
|         | A2F060 Function       | A2F200 Function            | A2F500 Function            |
| AA14    | NC                    | ABPS4                      | ABPS4                      |
| AA15    | NC                    | SDD1                       | SDD1                       |
| AA16    | GNDVAREF              | GNDVAREF                   | GNDVAREF                   |
| AA17    | VAREFOUT              | VAREFOUT                   | VAREFOUT                   |
| AA18    | PU_N                  | PU_N                       | PU_N                       |
| AA19    | VCC33A                | VCC33A                     | VCC33A                     |
| AA20    | PTM                   | PTM                        | PTM                        |
| AA21    | GND                   | GND                        | GND                        |
| B1      | GND                   | GND                        | GND                        |
| B21     | IO17PDB0V0            | GBB2/IO20NDB1V0            | GBB2/IO27NDB1V0            |
| C1      | EMC_DB[15]/IO45PDB5V0 | EMC_DB[15]/GAA2/IO71PDB5V0 | EMC_DB[15]/GAA2/IO88PDB5V0 |
| C3      | VCOMPLA0              | VCOMPLA                    | VCOMPLA0                   |
| C4      | VCCPLL0               | VCCPLL                     | VCCPLL0                    |
| C5      | VCCFPGAIOB0           | VCCFPGAIOB0                | VCCFPGAIOB0                |
| C6      | EMC_AB[1]/IO04PPB0V0  | EMC_AB[1]/IO04PPB0V0       | EMC_AB[1]/IO06PPB0V0       |
| C7      | GND                   | GND                        | GND                        |
| C8      | EMC_OEN0_N/IO03NDB0V0 | EMC_OEN0_N/IO03NDB0V0      | EMC_OEN0_N/IO08NDB0V0      |
| C9      | EMC_AB[2]/IO05NDB0V0  | EMC_AB[2]/IO05NDB0V0       | EMC_AB[2]/IO09NDB0V0       |
| C10     | EMC_AB[5]/IO06PDB0V0  | EMC_AB[5]/IO06PDB0V0       | EMC_AB[5]/IO10PDB0V0       |
| C11     | VCCFPGAIOB0           | VCCFPGAIOB0                | VCCFPGAIOB0                |
| C12     | EMC_AB[9]/IO08PPB0V0  | EMC_AB[9]/IO08PPB0V0       | EMC_AB[9]/IO13PPB0V0       |
| C13     | EMC_AB[15]/IO11PPB0V0 | EMC_AB[15]/IO11PPB0V0      | EMC_AB[15]/IO15PPB0V0      |
| C14     | EMC_AB[19]/IO13PDB0V0 | EMC_AB[19]/IO13PDB0V0      | EMC_AB[19]/IO18PDB0V0      |
| C15     | GND                   | GND                        | GND                        |
| C16     | EMC_AB[22]/IO15NDB0V0 | EMC_AB[22]/IO15NDB0V0      | EMC_AB[22]/IO19NDB0V0      |
| C17     | EMC_AB[23]/IO15PDB0V0 | EMC_AB[23]/IO15PDB0V0      | EMC_AB[23]/IO19PDB0V0      |
| C18     | NC                    | NC                         | VCCPLL1                    |
| C19     | NC                    | NC                         | VCOMPLA1                   |
| C21     | IO17NDB0V0            | GBA2/IO20PDB1V0            | GBA2/IO27PDB1V0            |
| D1      | EMC_DB[14]/IO45NDB5V0 | EMC_DB[14]/GAB2/IO71NDB5V0 | EMC_DB[14]/GAB2/IO88NDB5V0 |
| D3      | VCCFPGAIOB5           | VCCFPGAIOB5                | VCCFPGAIOB5                |
| D19     | GND                   | GND                        | GND                        |
| D21     | VCCFPGAIOB1           | VCCFPGAIOB1                | VCCFPGAIOB1                |
| E1      | EMC_DB[13]/IO44PDB5V0 | EMC_DB[13]/GAC2/IO70PDB5V0 | EMC_DB[13]/GAC2/IO87PDB5V0 |

*Note:* Shading denotes pins that do not have completely identical functions from density to density. For example, the bank assignment can be different for an I/O, or the function might be available only on a larger density device.



| Pin No. | CS288                   |                              |                              |
|---------|-------------------------|------------------------------|------------------------------|
|         | A2F060 Function         | A2F200 Function              | A2F500 Function              |
| E3      | EMC_DB[12]/IO44NDB5V0   | EMC_DB[12]/IO70NDB5V0        | EMC_DB[12]/IO87NDB5V0        |
| E5      | GNDQ                    | GNDQ                         | GNDQ                         |
| E6      | EMC_BYTEN[0]/IO02NDB0V0 | EMC_BYTEN[0]/GAC0/IO02NDB0V0 | EMC_BYTEN[0]/GAC0/IO07NDB0V0 |
| E7      | EMC_BYTEN[1]/IO02PDB0V0 | EMC_BYTEN[1]/GAC1/IO02PDB0V0 | EMC_BYTEN[1]/GAC1/IO07PDB0V0 |
| E8      | EMC_OEN1_N/IO03PDB0V0   | EMC_OEN1_N/IO03PDB0V0        | EMC_OEN1_N/IO08PDB0V0        |
| E9      | EMC_AB[3]/IO05PDB0V0    | EMC_AB[3]/IO05PDB0V0         | EMC_AB[3]/IO09PDB0V0         |
| E10     | EMC_AB[10]/IO09NDB0V0   | EMC_AB[10]/IO09NDB0V0        | EMC_AB[10]/IO11NDB0V0        |
| E11     | EMC_AB[7]/IO07PDB0V0    | EMC_AB[7]/IO07PDB0V0         | EMC_AB[7]/IO12PDB0V0         |
| E12     | EMC_AB[13]/IO10PDB0V0   | EMC_AB[13]/IO10PDB0V0        | EMC_AB[13]/IO14PDB0V0        |
| E13     | EMC_AB[16]/IO12NDB0V0   | EMC_AB[16]/IO12NDB0V0        | EMC_AB[16]/IO17NDB0V0        |
| E14     | EMC_AB[17]/IO12PDB0V0   | EMC_AB[17]/IO12PDB0V0        | EMC_AB[17]/IO17PDB0V0        |
| E15     | GCC0/IO18NPB0V0         | GCB0/IO27NDB1V0              | GCB0/IO34NDB1V0              |
| E16     | GCA1/IO20PPB0V0         | GCB1/IO27PDB1V0              | GCB1/IO34PDB1V0              |
| E17     | GCC1/IO18PPB0V0         | GCB2/IO24PDB1V0              | GCB2/IO33PDB1V0              |
| E19     | GCB2/IO22PPB1V0         | GCA0/IO28NDB1V0              | GCA0/IO36NDB1V0              |
| E21     | IO21NDB1V0              | GCA1/IO28PDB1V0              | GCA1/IO36PDB1V0              |
| F1      | VCCFPGAIOB5             | VCCFPGAIOB5                  | VCCFPGAIOB5                  |
| F3      | GFB2/IO42NDB5V0         | GFB2/IO68NDB5V0              | GFB2/IO85NDB5V0              |
| F5      | GFA2/IO42PDB5V0         | GFA2/IO68PDB5V0              | GFA2/IO85PDB5V0              |
| F6      | EMC_DB[11]/IO43PDB5V0   | EMC_DB[11]/IO69PDB5V0        | EMC_DB[11]/IO86PDB5V0        |
| F7      | GND                     | GND                          | GND                          |
| F8      | NC                      | GFC1/IO66PPB5V0              | GFC1/IO83PPB5V0              |
| F9      | VCCFPGAIOB0             | VCCFPGAIOB0                  | VCCFPGAIOB0                  |
| F10     | EMC_AB[11]/IO09PDB0V0   | EMC_AB[11]/IO09PDB0V0        | EMC_AB[11]/IO11PDB0V0        |
| F11     | EMC_AB[6]/IO07NDB0V0    | EMC_AB[6]/IO07NDB0V0         | EMC_AB[6]/IO12NDB0V0         |
| F12     | EMC_AB[12]/IO10NDB0V0   | EMC_AB[12]/IO10NDB0V0        | EMC_AB[12]/IO14NDB0V0        |
| F13     | GND                     | GND                          | GND                          |
| F14     | GCB1/IO19PPB0V0         | GCC1/IO26PPB1V0              | GCC1/IO35PPB1V0              |
| F15     | GNDQ                    | GNDQ                         | GNDQ                         |
| F16     | VCCFPGAIOB1             | VCCFPGAIOB1                  | VCCFPGAIOB1                  |
| F17     | GCB0/IO19NPB0V0         | IO24NDB1V0                   | IO33NDB1V0                   |
| F19     | IO23NDB1V0              | GDB1/IO30PDB1V0              | GDB1/IO39PDB1V0              |
| F21     | GCA2/IO21PDB1V0         | GDB0/IO30NDB1V0              | GDB0/IO39NDB1V0              |
| G1      | IO41NDB5V0              | IO67NDB5V0                   | IO84NDB5V0                   |

*Note:* Shading denotes pins that do not have completely identical functions from density to density. For example, the bank assignment can be different for an I/O, or the function might be available only on a larger density device.

| Pin No. | CS288                 |                           |                           |
|---------|-----------------------|---------------------------|---------------------------|
|         | A2F060 Function       | A2F200 Function           | A2F500 Function           |
| G3      | GFC2/IO41PDB5V0       | GFC2/IO67PDB5V0           | GFC2/IO84PDB5V0           |
| G5      | NC                    | GFB1/IO65PDB5V0           | GFB1/IO82PDB5V0           |
| G6      | EMC_DB[10]/IO43NDB5V0 | EMC_DB[10]/IO69NDB5V0     | EMC_DB[10]/IO86NDB5V0     |
| G9      | NC                    | GFC0/IO66NPB5V0           | GFC0/IO83NPB5V0           |
| G13     | GCA0/IO20NPB0V0       | GCC0/IO26NPB1V0           | GCC0/IO35NPB1V0           |
| G16     | NC                    | GDA0/IO31NDB1V0           | GDA0/IO40NDB1V0           |
| G17     | IO22NPB1V0            | GDC1/IO29PDB1V0           | GDC1/IO38PDB1V0           |
| G19     | GCC2/IO23PDB1V0       | GDC0/IO29NDB1V0           | GDC0/IO38NDB1V0           |
| G21     | GND                   | GND                       | GND                       |
| H1      | EMC_DB[9]/IO40PPB5V0  | EMC_DB[9]/GEC1/IO63PPB5V0 | EMC_DB[9]/GEC1/IO80PPB5V0 |
| H3      | GND                   | GND                       | GND                       |
| H5      | NC                    | GFB0/IO65NDB5V0           | GFB0/IO82NDB5V0           |
| H6      | EMC_DB[7]/IO39PDB5V0  | EMC_DB[7]/GEB1/IO62PDB5V0 | EMC_DB[7]/GEB1/IO79PDB5V0 |
| H8      | GND                   | GND                       | GND                       |
| H9      | VCC                   | VCC                       | VCC                       |
| H10     | GND                   | GND                       | GND                       |
| H11     | VCC                   | VCC                       | VCC                       |
| H12     | GND                   | GND                       | GND                       |
| H13     | VCC                   | VCC                       | VCC                       |
| H14     | GND                   | GND                       | GND                       |
| H16     | NC                    | GDA1/IO31PDB1V0           | GDA1/IO40PDB1V0           |
| H17     | NC                    | GDC2/IO32PPB1V0           | GDC2/IO41PPB1V0           |
| H19     | VCCFPGAIOB1           | VCCFPGAIOB1               | VCCFPGAIOB1               |
| H21     | NC                    | GDB2/IO33PDB1V0           | GDB2/IO42PDB1V0           |
| J1      | EMC_DB[4]/IO38NPB5V0  | EMC_DB[4]/GEA0/IO61NPB5V0 | EMC_DB[4]/GEA0/IO78NPB5V0 |
| J3      | EMC_DB[8]/IO40NPB5V0  | EMC_DB[8]/GEC0/IO63NPB5V0 | EMC_DB[8]/GEC0/IO80NPB5V0 |
| J5      | EMC_DB[1]/IO36PDB5V0  | EMC_DB[1]/GEB2/IO59PDB5V0 | EMC_DB[1]/GEB2/IO76PDB5V0 |
| J6      | EMC_DB[6]/IO39NDB5V0  | EMC_DB[6]/GEB0/IO62NDB5V0 | EMC_DB[6]/GEB0/IO79NDB5V0 |
| J7      | VCCFPGAIOB5           | VCCFPGAIOB5               | VCCFPGAIOB5               |
| J8      | VCC                   | VCC                       | VCC                       |
| J9      | GND                   | GND                       | GND                       |
| J10     | VCC                   | VCC                       | VCC                       |
| J11     | GND                   | GND                       | GND                       |
| J12     | VCC                   | VCC                       | VCC                       |

*Note:* Shading denotes pins that do not have completely identical functions from density to density. For example, the bank assignment can be different for an I/O, or the function might be available only on a larger density device.

| Pin No. | CS288                |                           |                           |
|---------|----------------------|---------------------------|---------------------------|
|         | A2F060 Function      | A2F200 Function           | A2F500 Function           |
| J13     | GND                  | GND                       | GND                       |
| J14     | VCC                  | VCC                       | VCC                       |
| J15     | VPP                  | VPP                       | VPP                       |
| J16     | NC                   | IO32NPB1V0                | IO41NPB1V0                |
| J17     | NC                   | GNDQ                      | GNDQ                      |
| J19     | VCCMAINXTAL          | VCCMAINXTAL               | VCCMAINXTAL               |
| J21     | NC                   | GDA2/IO33NDB1V0           | GDA2/IO42NDB1V0           |
| K1      | GND                  | GND                       | GND                       |
| K3      | EMC_DB[5]/IO38PPB5V0 | EMC_DB[5]/GEA1/IO61PPB5V0 | EMC_DB[5]/GEA1/IO78PPB5V0 |
| K5      | EMC_DB[0]/IO36NDB5V0 | EMC_DB[0]/GEA2/IO59NDB5V0 | EMC_DB[0]/GEA2/IO76NDB5V0 |
| K6      | EMC_DB[3]/IO37PPB5V0 | EMC_DB[3]/GEC2/IO60PPB5V0 | EMC_DB[3]/GEC2/IO77PPB5V0 |
| K8      | GND                  | GND                       | GND                       |
| K9      | VCC                  | VCC                       | VCC                       |
| K10     | GND                  | GND                       | GND                       |
| K11     | VCC                  | VCC                       | VCC                       |
| K12     | GND                  | GND                       | GND                       |
| K13     | VCC                  | VCC                       | VCC                       |
| K14     | GND                  | GND                       | GND                       |
| K16     | LPXOUT               | LPXOUT                    | LPXOUT                    |
| K17     | GNDLPXTAL            | GNDLPXTAL                 | GNDLPXTAL                 |
| K19     | GNDMAINXTAL          | GNDMAINXTAL               | GNDMAINXTAL               |
| K21     | MAINXIN              | MAINXIN                   | MAINXIN                   |
| L1      | GNDRCOSC             | GNDRCOSC                  | GNDRCOSC                  |
| L3      | VCCFPGAIOB5          | VCCFPGAIOB5               | VCCFPGAIOB5               |
| L5      | EMC_DB[2]/IO37NPB5V0 | EMC_DB[2]/IO60NPB5V0      | EMC_DB[2]/IO77NPB5V0      |
| L6      | NC                   | GNDQ                      | GNDQ                      |
| L8      | VCC                  | VCC                       | VCC                       |
| L9      | GND                  | GND                       | GND                       |
| L10     | VCC                  | VCC                       | VCC                       |
| L12     | VCC                  | VCC                       | VCC                       |
| L13     | GND                  | GND                       | GND                       |
| L14     | VCC                  | VCC                       | VCC                       |
| L16     | VCCLPXTAL            | VCCLPXTAL                 | VCCLPXTAL                 |
| L17     | VDDBAT               | VDDBAT                    | VDDBAT                    |

**Note:** Shading denotes pins that do not have completely identical functions from density to density. For example, the bank assignment can be different for an I/O, or the function might be available only on a larger density device.

| Pin No. | CS288             |                   |                   |
|---------|-------------------|-------------------|-------------------|
|         | A2F060 Function   | A2F200 Function   | A2F500 Function   |
| L19     | LPXIN             | LPXIN             | LPXIN             |
| L21     | MAINXOUT          | MAINXOUT          | MAINXOUT          |
| M1      | VCCRCOSC          | VCCRCOSC          | VCCRCOSC          |
| M3      | MSS_RESET_N       | MSS_RESET_N       | MSS_RESET_N       |
| M5      | GPIO_5/IO28RSB4V0 | GPIO_5/IO42RSB4V0 | GPIO_5/IO51RSB4V0 |
| M6      | GND               | GND               | GND               |
| M8      | GND               | GND               | GND               |
| M9      | VCC               | VCC               | VCC               |
| M10     | GND               | GND               | GND               |
| M11     | VCC               | VCC               | VCC               |
| M12     | GND               | GND               | GND               |
| M13     | VCC               | VCC               | VCC               |
| M14     | GND               | GND               | GND               |
| M16     | TMS               | TMS               | TMS               |
| M17     | VJTAG             | VJTAG             | VJTAG             |
| M19     | TDO               | TDO               | TDO               |
| M21     | TRSTB             | TRSTB             | TRSTB             |
| N1      | VCCMSSIOB4        | VCCMSSIOB4        | VCCMSSIOB4        |
| N3      | GND               | GND               | GND               |
| N5      | GPIO_4/IO29RSB4V0 | GPIO_4/IO43RSB4V0 | GPIO_4/IO52RSB4V0 |
| N6      | GPIO_8/IO25RSB4V0 | GPIO_8/IO39RSB4V0 | GPIO_8/IO48RSB4V0 |
| N7      | GPIO_9/IO24RSB4V0 | GPIO_9/IO38RSB4V0 | GPIO_9/IO47RSB4V0 |
| N8      | VCC               | VCC               | VCC               |
| N9      | GND               | GND               | GND               |
| N10     | VCC               | VCC               | VCC               |
| N11     | GND               | GND               | GND               |
| N12     | VCC               | VCC               | VCC               |
| N13     | GND               | GND               | GND               |
| N14     | VCC               | VCC               | VCC               |
| N15     | GND               | GND               | GND               |
| N16     | TCK               | TCK               | TCK               |
| N17     | TDI               | TDI               | TDI               |
| N19     | GNDENVN           | GNDENVN           | GNDENVN           |
| N21     | VCCENVN           | VCCENVN           | VCCENVN           |

*Note:* Shading denotes pins that do not have completely identical functions from density to density. For example, the bank assignment can be different for an I/O, or the function might be available only on a larger density device.

| Pin No. | CS288              |                       |                       |
|---------|--------------------|-----------------------|-----------------------|
|         | A2F060 Function    | A2F200 Function       | A2F500 Function       |
| P1      | GPIO_0/IO33RSB4V0  | MAC_MDC/IO48RSB4V0    | MAC_MDC/IO57RSB4V0    |
| P3      | GPIO_7/IO26RSB4V0  | GPIO_7/IO40RSB4V0     | GPIO_7/IO49RSB4V0     |
| P5      | GPIO_6/IO27RSB4V0  | GPIO_6/IO41RSB4V0     | GPIO_6/IO50RSB4V0     |
| P6      | VCCMSSIOB4         | VCCMSSIOB4            | VCCMSSIOB4            |
| P8      | GND                | GND                   | GND                   |
| P9      | VCC                | VCC                   | VCC                   |
| P10     | GND                | GND                   | GND                   |
| P11     | VCC                | VCC                   | VCC                   |
| P12     | GND                | GND                   | GND                   |
| P13     | VCC                | VCC                   | VCC                   |
| P14     | GND                | GND                   | GND                   |
| P16     | JTAGSEL            | JTAGSEL               | JTAGSEL               |
| P17     | I2C_0_SCL/GPIO_23  | I2C_0_SCL/GPIO_23     | I2C_0_SCL/GPIO_23     |
| P19     | VCCMSSIOB2         | VCCMSSIOB2            | VCCMSSIOB2            |
| P21     | GND                | GND                   | GND                   |
| R1      | GPIO_2/IO31RSB4V0  | MAC_MDIO/IO49RSB4V0   | MAC_MDIO/IO58RSB4V0   |
| R3      | GPIO_1/IO32RSB4V0  | MAC_TXEN/IO52RSB4V0   | MAC_TXEN/IO61RSB4V0   |
| R5      | GPIO_3/IO30RSB4V0  | MAC_TXD[0]/IO56RSB4V0 | MAC_TXD[0]/IO65RSB4V0 |
| R6      | GPIO_10/IO35RSB4V0 | MAC_CRSDV/IO51RSB4V0  | MAC_CRSDV/IO60RSB4V0  |
| R9      | GNDA               | GNDA                  | GNDA                  |
| R13     | GNDA               | GNDA                  | GNDA                  |
| R16     | UART_1_RXD/GPIO_29 | UART_1_RXD/GPIO_29    | UART_1_RXD/GPIO_29    |
| R17     | UART_1_TXD/GPIO_28 | UART_1_TXD/GPIO_28    | UART_1_TXD/GPIO_28    |
| R19     | I2C_0_SDA/GPIO_22  | I2C_0_SDA/GPIO_22     | I2C_0_SDA/GPIO_22     |
| R21     | I2C_1_SDA/GPIO_30  | I2C_1_SDA/GPIO_30     | I2C_1_SDA/GPIO_30     |
| T1      | GND                | GND                   | GND                   |
| T3      | NC                 | MAC_TXD[1]/IO55RSB4V0 | MAC_TXD[1]/IO64RSB4V0 |
| T5      | NC                 | MAC_RXD[1]/IO53RSB4V0 | MAC_RXD[1]/IO62RSB4V0 |
| T6      | GPIO_11/IO34RSB4V0 | MAC_RXER/IO50RSB4V0   | MAC_RXER/IO59RSB4V0   |
| T7      | NC                 | CM1                   | CM1                   |
| T8      | NC                 | ADC1                  | ADC1                  |
| T9      | NC                 | GND33ADC0             | GND33ADC0             |
| T10     | NC                 | VCC15ADC0             | VCC15ADC0             |
| T11     | GND33ADC0          | GND33ADC1             | GND33ADC1             |

**Note:** Shading denotes pins that do not have completely identical functions from density to density. For example, the bank assignment can be different for an I/O, or the function might be available only on a larger density device.

| Pin No. | CS288              |                       |                       |
|---------|--------------------|-----------------------|-----------------------|
|         | A2F060 Function    | A2F200 Function       | A2F500 Function       |
| T12     | VAREF0             | VAREF1                | VAREF1                |
| T13     | ADC7               | ADC4                  | ADC4                  |
| T14     | TM0                | TM3                   | TM3                   |
| T15     | SPI_1_SS/GPIO_27   | SPI_1_SS/GPIO_27      | SPI_1_SS/GPIO_27      |
| T16     | VCCMSSIOB2         | VCCMSSIOB2            | VCCMSSIOB2            |
| T17     | UART_0_RXD/GPIO_21 | UART_0_RXD/GPIO_21    | UART_0_RXD/GPIO_21    |
| T19     | UART_0_TXD/GPIO_20 | UART_0_TXD/GPIO_20    | UART_0_TXD/GPIO_20    |
| T21     | I2C_1_SCL/GPIO_31  | I2C_1_SCL/GPIO_31     | I2C_1_SCL/GPIO_31     |
| U1      | NC                 | MAC_RXD[0]/IO54RSB4V0 | MAC_RXD[0]/IO63RSB4V0 |
| U3      | VCCMSSIOB4         | VCCMSSIOB4            | VCCMSSIOB4            |
| U5      | VCC33SDD0          | VCC33SDD0             | VCC33SDD0             |
| U6      | VCC15A             | VCC15A                | VCC15A                |
| U7      | NC                 | ABPS3                 | ABPS3                 |
| U8      | NC                 | ADC2                  | ADC2                  |
| U9      | NC                 | VCC33ADC0             | VCC33ADC0             |
| U10     | GND15ADC0          | GND15ADC1             | GND15ADC1             |
| U11     | VCC33ADC0          | VCC33ADC1             | VCC33ADC1             |
| U12     | ADC10              | ADC7                  | ADC7                  |
| U13     | ABPS0              | ABPS6                 | ABPS6                 |
| U14     | GNDTM0             | GNDTM1                | GNDTM1                |
| U15     | SPI_1_CLK/GPIO_26  | SPI_1_CLK/GPIO_26     | SPI_1_CLK/GPIO_26     |
| U16     | SPI_0_CLK/GPIO_18  | SPI_0_CLK/GPIO_18     | SPI_0_CLK/GPIO_18     |
| U17     | SPI_0_SS/GPIO_19   | SPI_0_SS/GPIO_19      | SPI_0_SS/GPIO_19      |
| U19     | GND                | GND                   | GND                   |
| U21     | SPI_1_DO/GPIO_24   | SPI_1_DO/GPIO_24      | SPI_1_DO/GPIO_24      |
| V1      | NC                 | MAC_CLK               | MAC_CLK               |
| V3      | GNDSDDD0           | GNDSDDD0              | GNDSDDD0              |
| V19     | SPI_1_DI/GPIO_25   | SPI_1_DI/GPIO_25      | SPI_1_DI/GPIO_25      |
| V21     | VCCMSSIOB2         | VCCMSSIOB2            | VCCMSSIOB2            |
| W1      | PCAP               | PCAP                  | PCAP                  |
| W3      | NCAP               | NCAP                  | NCAP                  |
| W4      | ADC2               | CM0                   | CM0                   |
| W5      | ADC3               | TM0                   | TM0                   |
| W6      | ADC4               | TM1                   | TM1                   |

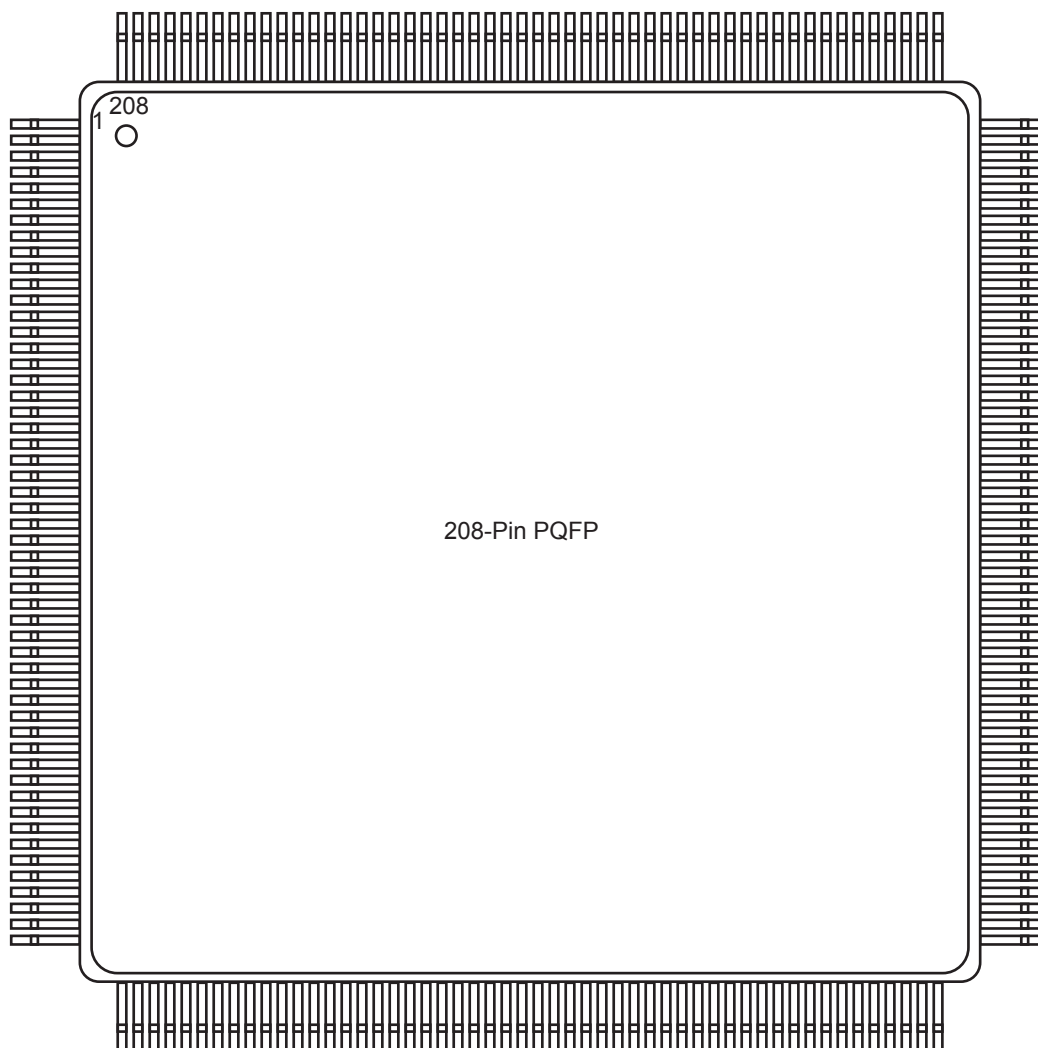
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| Pin No. | CS288            |                  |                  |
|---------|------------------|------------------|------------------|
|         | A2F060 Function  | A2F200 Function  | A2F500 Function  |
| W7      | NC               | ADC0             | ADC0             |
| W8      | NC               | ADC3             | ADC3             |
| W9      | NC               | GND33ADC0        | GND33ADC0        |
| W10     | VCC15ADC0        | VCC15ADC1        | VCC15ADC1        |
| W11     | GND33ADC0        | GND33ADC1        | GND33ADC1        |
| W12     | ADC8             | ADC5             | ADC5             |
| W13     | CM0              | CM3              | CM3              |
| W14     | ADC5             | CM2              | CM2              |
| W15     | NC               | ABPS5            | ABPS5            |
| W16     | GND AQ           | GND AQ           | GND AQ           |
| W17     | NC               | VCC33SDD1        | VCC33SDD1        |
| W18     | NC               | GND SDD1         | GND SDD1         |
| W19     | PTBASE           | PTBASE           | PTBASE           |
| W21     | SPI_0_DI/GPIO_17 | SPI_0_DI/GPIO_17 | SPI_0_DI/GPIO_17 |
| Y1      | VCC33AP          | VCC33AP          | VCC33AP          |
| Y21     | SPI_0_DO/GPIO_16 | SPI_0_DO/GPIO_16 | SPI_0_DO/GPIO_16 |

*Note:* Shading denotes pins that do not have completely identical functions from density to density. For example, the bank assignment can be different for an I/O, or the function might be available only on a larger density device.

## PQ208

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### **Note**

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



| Pin Number | PQ208                      |                     |
|------------|----------------------------|---------------------|
|            | A2F200                     | A2F500              |
| 1          | VCCPLL                     | VCCPLL0             |
| 2          | VCOMPLA                    | VCOMPLA0            |
| 3          | GNDQ                       | GNDQ                |
| 4          | EMC_DB[15]/GAA2/IO71PDB5V0 | GAA2/IO88PDB5V0     |
| 5          | EMC_DB[14]/GAB2/IO71NDB5V0 | GAB2/IO88NDB5V0     |
| 6          | EMC_DB[13]/GAC2/IO70PDB5V0 | GAC2/IO87PDB5V0     |
| 7          | EMC_DB[12]/IO70NDB5V0      | IO87NDB5V0          |
| 8          | VCC                        | VCC                 |
| 9          | GND                        | GND                 |
| 10         | VCCFPGAIOB5                | VCCFPGAIOB5         |
| 11         | EMC_DB[11]/IO69PDB5V0      | IO86PDB5V0          |
| 12         | EMC_DB[10]/IO69NDB5V0      | IO86NDB5V0          |
| 13         | GFA2/IO68PSB5V0            | GFA2/IO85PSB5V0     |
| 14         | GFA1/IO64PDB5V0            | GFA1/IO81PDB5V0     |
| 15         | GFA0/IO64NDB5V0            | GFA0/IO81NDB5V0     |
| 16         | EMC_DB[9]/GEC1/IO63PDB5V0  | GEC1/IO80PDB5V0     |
| 17         | EMC_DB[8]/GEC0/IO63NDB5V0  | GEC0/IO80NDB5V0     |
| 18         | EMC_DB[7]/GEB1/IO62PDB5V0  | GEB1/IO79PDB5V0     |
| 19         | EMC_DB[6]/GEB0/IO62NDB5V0  | GEB0/IO79NDB5V0     |
| 20         | EMC_DB[5]/GEA1/IO61PDB5V0  | GEA1/IO78PDB5V0     |
| 21         | EMC_DB[4]/GEA0/IO61NDB5V0  | GEA0/IO78NDB5V0     |
| 22         | VCC                        | VCC                 |
| 23         | GND                        | GND                 |
| 24         | VCCFPGAIOB5                | VCCFPGAIOB5         |
| 25         | EMC_DB[3]/GEC2/IO60PDB5V0  | GEC2/IO77PDB5V0     |
| 26         | EMC_DB[2]/IO60NDB5V0       | IO77NDB5V0          |
| 27         | EMC_DB[1]/GEB2/IO59PDB5V0  | GEB2/IO76PDB5V0     |
| 28         | EMC_DB[0]/GEA2/IO59NDB5V0  | GEA2/IO76NDB5V0     |
| 29         | VCC                        | VCC                 |
| 30         | GND                        | GND                 |
| 31         | GNDRCOSC                   | GNDRCOSC            |
| 32         | VCCRCOSC                   | VCCRCOSC            |
| 33         | MSS_RESET_N                | MSS_RESET_N         |
| 34         | VCCESRAM                   | VCCESRAM            |
| 35         | MAC_MDC/IO48RSB4V0         | MAC_MDC/IO57RSB4V0  |
| 36         | MAC_MDIO/IO49RSB4V0        | MAC_MDIO/IO58RSB4V0 |

| Pin Number | PQ208                 |                       |
|------------|-----------------------|-----------------------|
|            | A2F200                | A2F500                |
| 37         | MAC_TXEN/IO52RSB4V0   | MAC_TXEN/IO61RSB4V0   |
| 38         | MAC_CRSDV/IO51RSB4V0  | MAC_CRSDV/IO60RSB4V0  |
| 39         | MAC_RXER/IO50RSB4V0   | MAC_RXER/IO59RSB4V0   |
| 40         | GND                   | GND                   |
| 41         | VCCMSSIOB4            | VCCMSSIOB4            |
| 42         | VCC                   | VCC                   |
| 43         | MAC_TXD[0]/IO56RSB4V0 | MAC_TXD[0]/IO65RSB4V0 |
| 44         | MAC_TXD[1]/IO55RSB4V0 | MAC_TXD[1]/IO64RSB4V0 |
| 45         | MAC_RXD[0]/IO54RSB4V0 | MAC_RXD[0]/IO63RSB4V0 |
| 46         | MAC_RXD[1]/IO53RSB4V0 | MAC_RXD[1]/IO62RSB4V0 |
| 47         | MAC_CLK               | MAC_CLK               |
| 48         | GNDSDD0               | GNDSDD0               |
| 49         | VCC33SDD0             | VCC33SDD0             |
| 50         | VCC15A                | VCC15A                |
| 51         | PCAP                  | PCAP                  |
| 52         | NCAP                  | NCAP                  |
| 53         | VCC33AP               | VCC33AP               |
| 54         | VCC33N                | VCC33N                |
| 55         | SDD0                  | SDD0                  |
| 56         | GNDA                  | GNDA                  |
| 57         | GNDAQ                 | GNDAQ                 |
| 58         | ABPS0                 | ABPS0                 |
| 59         | ABPS1                 | ABPS1                 |
| 60         | CM0                   | CM0                   |
| 61         | TM0                   | TM0                   |
| 62         | GNDTM0                | GNDTM0                |
| 63         | TM1                   | TM1                   |
| 64         | CM1                   | CM1                   |
| 65         | ABPS3                 | ABPS3                 |
| 66         | ABPS2                 | ABPS2                 |
| 67         | ADC0                  | ADC0                  |
| 68         | ADC1                  | ADC1                  |
| 69         | ADC2                  | ADC2                  |
| 70         | ADC3                  | ADC3                  |
| 71         | VAREF0                | VAREF0                |
| 72         | GND33ADC0             | GND33ADC0             |

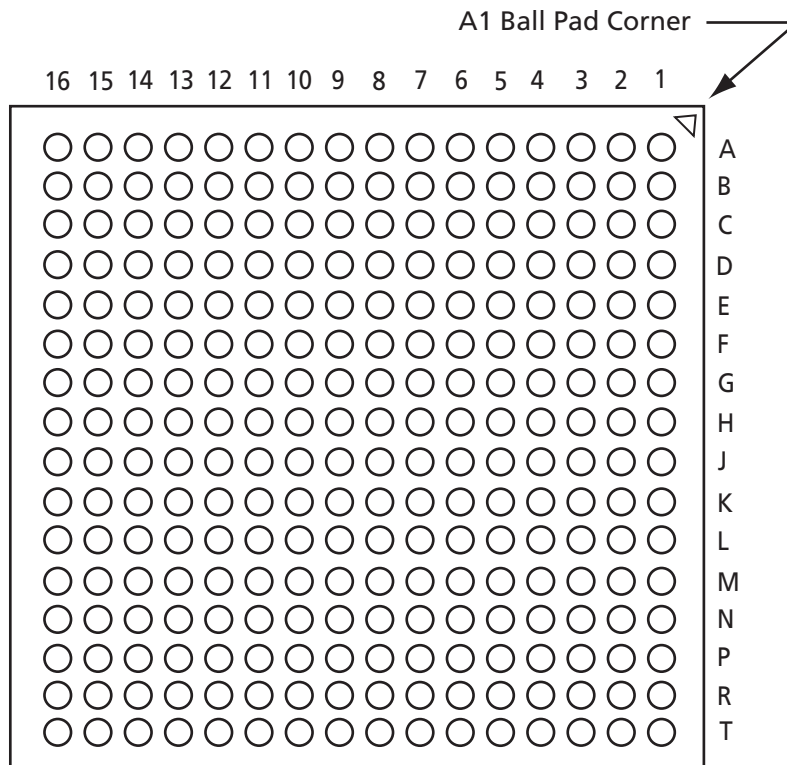
| Pin Number | PQ208             |                   |
|------------|-------------------|-------------------|
|            | A2F200            | A2F500            |
| 73         | VCC33ADC0         | VCC33ADC0         |
| 74         | GND33ADC0         | GND33ADC0         |
| 75         | VCC15ADC0         | VCC15ADC0         |
| 76         | GND15ADC0         | GND15ADC0         |
| 77         | GND15ADC1         | GND15ADC1         |
| 78         | VCC15ADC1         | VCC15ADC1         |
| 79         | GND33ADC1         | GND33ADC1         |
| 80         | VCC33ADC1         | VCC33ADC1         |
| 81         | GND33ADC1         | GND33ADC1         |
| 82         | VAREF1            | VAREF1            |
| 83         | ADC7              | ADC7              |
| 84         | ADC6              | ADC6              |
| 85         | ADC5              | ADC5              |
| 86         | ADC4              | ADC4              |
| 87         | ABPS6             | ABPS6             |
| 88         | ABPS7             | ABPS7             |
| 89         | CM3               | CM3               |
| 90         | TM3               | TM3               |
| 91         | GNDTM1            | GNDTM1            |
| 92         | TM2               | TM2               |
| 93         | CM2               | CM2               |
| 94         | ABPS5             | ABPS5             |
| 95         | ABPS4             | ABPS4             |
| 96         | GNDQAQ            | GNDQAQ            |
| 97         | GNDQA             | GNDQA             |
| 98         | NC                | NC                |
| 99         | GNDVAREF          | GNDVAREF          |
| 100        | VAREFOUT          | VAREFOUT          |
| 101        | PU_N              | PU_N              |
| 102        | VCC33A            | VCC33A            |
| 103        | PTEM              | PTEM              |
| 104        | PTBASE            | PTBASE            |
| 105        | SPI_0_DO/GPIO_16  | SPI_0_DO/GPIO_16  |
| 106        | SPI_0_DI/GPIO_17  | SPI_0_DI/GPIO_17  |
| 107        | SPI_0_CLK/GPIO_18 | SPI_0_CLK/GPIO_18 |
| 108        | SPI_0_SS/GPIO_19  | SPI_0_SS/GPIO_19  |

| Pin Number | PQ208              |                    |
|------------|--------------------|--------------------|
|            | A2F200             | A2F500             |
| 109        | UART_0_RXD/GPIO_21 | UART_0_RXD/GPIO_21 |
| 110        | UART_0_TXD/GPIO_20 | UART_0_TXD/GPIO_20 |
| 111        | UART_1_RXD/GPIO_29 | UART_1_RXD/GPIO_29 |
| 112        | UART_1_TXD/GPIO_28 | UART_1_TXD/GPIO_28 |
| 113        | VCC                | VCC                |
| 114        | VCCMSSIOB2         | VCCMSSIOB2         |
| 115        | GND                | GND                |
| 116        | I2C_1_SDA/GPIO_30  | I2C_1_SDA/GPIO_30  |
| 117        | I2C_1_SCL/GPIO_31  | I2C_1_SCL/GPIO_31  |
| 118        | I2C_0_SDA/GPIO_22  | I2C_0_SDA/GPIO_22  |
| 119        | I2C_0_SCL/GPIO_23  | I2C_0_SCL/GPIO_23  |
| 120        | GNDENV             | GNDENV             |
| 121        | VCCENV             | VCCENV             |
| 122        | JTAGSEL            | JTAGSEL            |
| 123        | TCK                | TCK                |
| 124        | TDI                | TDI                |
| 125        | TMS                | TMS                |
| 126        | TDO                | TDO                |
| 127        | TRSTB              | TRSTB              |
| 128        | VJTAG              | VJTAG              |
| 129        | VDDBAT             | VDDBAT             |
| 130        | VCCLPXTAL          | VCCLPXTAL          |
| 131        | LPXOUT             | LPXOUT             |
| 132        | LPXIN              | LPXIN              |
| 133        | GNDLPXTAL          | GNDLPXTAL          |
| 134        | GNDMAINXTAL        | GNDMAINXTAL        |
| 135        | MAINXOUT           | MAINXOUT           |
| 136        | MAINXIN            | MAINXIN            |
| 137        | VCCMAINXTAL        | VCCMAINXTAL        |
| 138        | GND                | GND                |
| 139        | VCC                | VCC                |
| 140        | VPP                | VPP                |
| 141        | VCCFPGAIOB1        | VCCFPGAIOB1        |
| 142        | GDA0/IO31NDB1V0    | GDA0/IO40NDB1V0    |
| 143        | GDA1/IO31PDB1V0    | GDA1/IO40PDB1V0    |
| 144        | GDC0/IO29NSB1V0    | GDC0/IO38NSB1V0    |

| Pin Number | PQ208                 |                 |
|------------|-----------------------|-----------------|
|            | A2F200                | A2F500          |
| 145        | GCA0/IO28NDB1V0       | GCA0/IO36NDB1V0 |
| 146        | GCA1/IO28PDB1V0       | GCA1/IO36PDB1V0 |
| 147        | VCCFPGAIOB1           | VCCFPGAIOB1     |
| 148        | GND                   | GND             |
| 149        | VCC                   | VCC             |
| 150        | IO25NDB1V0            | IO30NDB1V0      |
| 151        | GCC2/IO25PDB1V0       | GBC2/IO30PDB1V0 |
| 152        | IO23NDB1V0            | IO28NDB1V0      |
| 153        | GCA2/IO23PDB1V0       | GCA2/IO28PDB1V0 |
| 154        | GBC2/IO21PSB1V0       | GBB2/IO27NDB1V0 |
| 155        | GBA2/IO20PSB1V0       | GBA2/IO27PDB1V0 |
| 156        | GNDQ                  | GNDQ            |
| 157        | GNDQ                  | GNDQ            |
| 158        | VCCFPGAIOB0           | VCCFPGAIOB0     |
| 159        | GBA1/IO19PDB0V0       | GBA1/IO23PDB0V0 |
| 160        | GBA0/IO19NDB0V0       | GBA0/IO23NDB0V0 |
| 161        | VCCFPGAIOB0           | VCCFPGAIOB0     |
| 162        | GND                   | GND             |
| 163        | VCC                   | VCC             |
| 164        | EMC_AB[25]/IO16PDB0V0 | IO21PDB0V0      |
| 165        | EMC_AB[24]/IO16NDB0V0 | IO21NDB0V0      |
| 166        | EMC_AB[23]/IO15PDB0V0 | IO20PDB0V0      |
| 167        | EMC_AB[22]/IO15NDB0V0 | IO20NDB0V0      |
| 168        | EMC_AB[21]/IO14PDB0V0 | IO19PDB0V0      |
| 169        | EMC_AB[20]/IO14NDB0V0 | IO19NDB0V0      |
| 170        | EMC_AB[19]/IO13PDB0V0 | IO18PDB0V0      |
| 171        | EMC_AB[18]/IO13NDB0V0 | IO18NDB0V0      |
| 172        | EMC_AB[17]/IO12PDB0V0 | IO17PDB0V0      |
| 173        | EMC_AB[16]/IO12NDB0V0 | IO17NDB0V0      |
| 174        | VCCFPGAIOB0           | VCCFPGAIOB0     |
| 175        | GND                   | GND             |
| 176        | VCC                   | VCC             |
| 177        | EMC_AB[15]/IO11PDB0V0 | IO14PDB0V0      |
| 178        | EMC_AB[14]/IO11NDB0V0 | IO14NDB0V0      |
| 179        | EMC_AB[13]/IO10PDB0V0 | IO13PDB0V0      |
| 180        | EMC_AB[12]/IO10NDB0V0 | IO13NDB0V0      |

| Pin Number | PQ208                        |                 |
|------------|------------------------------|-----------------|
|            | A2F200                       | A2F500          |
| 181        | EMC_AB[11]/IO09PDB0V0        | IO12PDB0V0      |
| 182        | EMC_AB[10]/IO09NDB0V0        | IO12NDB0V0      |
| 183        | EMC_AB[9]/IO08PDB0V0         | IO11PDB0V0      |
| 184        | EMC_AB[8]/IO08NDB0V0         | IO11NDB0V0      |
| 185        | EMC_AB[7]/IO07PDB0V0         | IO10PDB0V0      |
| 186        | EMC_AB[6]/IO07NDB0V0         | IO10NDB0V0      |
| 187        | VCCFPGAIOB0                  | VCCFPGAIOB0     |
| 188        | GND                          | GND             |
| 189        | VCC                          | VCC             |
| 190        | EMC_AB[5]/IO06PDB0V0         | IO08PDB0V0      |
| 191        | EMC_AB[4]/IO06NDB0V0         | IO08NDB0V0      |
| 192        | EMC_AB[3]/IO05PDB0V0         | GAC1/IO07PDB0V0 |
| 193        | EMC_AB[2]/IO05NDB0V0         | GAC0/IO07NDB0V0 |
| 194        | EMC_AB[1]/IO04PDB0V0         | IO04PDB0V0      |
| 195        | EMC_AB[0]/IO04NDB0V0         | IO04NDB0V0      |
| 196        | EMC_OEN1_N/IO03PDB0V0        | IO03PDB0V0      |
| 197        | EMC_OEN0_N/IO03NDB0V0        | IO03NDB0V0      |
| 198        | EMC_BYTEN[1]/GAC1/IO02PDB0V0 | GAA1/IO02PDB0V0 |
| 199        | EMC_BYTEN[0]/GAC0/IO02NDB0V0 | GAA0/IO02NDB0V0 |
| 200        | VCCFPGAIOB0                  | VCCFPGAIOB0     |
| 201        | GND                          | GND             |
| 202        | VCC                          | VCC             |
| 203        | EMC_CS1_N/GAB1/IO01PDB0V0    | IO01PDB0V0      |
| 204        | EMC_CS0_N/GAB0/IO01NDB0V0    | IO01NDB0V0      |
| 205        | EMC_RW_N/GAA1/IO00PDB0V0     | IO00PDB0V0      |
| 206        | EMC_CLK/GAA0/IO00NDB0V0      | IO00NDB0V0      |
| 207        | VCCFPGAIOB0                  | VCCFPGAIOB0     |
| 208        | GNDQ                         | GNDQ            |

## FG256



### Note

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

| Pin No. | FG256                   |                              |                              |
|---------|-------------------------|------------------------------|------------------------------|
|         | A2F060 Function         | A2F200 Function              | A2F500 Function              |
| A1      | GND                     | GND                          | GND                          |
| A2      | VCCFPGAIOB0             | VCCFPGAIOB0                  | VCCFPGAIOB0                  |
| A3      | EMC_AB[0]/IO04NDB0V0    | EMC_AB[0]/IO04NDB0V0         | EMC_AB[0]/IO06NDB0V0         |
| A4      | EMC_AB[1]/IO04PDB0V0    | EMC_AB[1]/IO04PDB0V0         | EMC_AB[1]/IO06PDB0V0         |
| A5      | GND                     | GND                          | GND                          |
| A6      | EMC_AB[3]/IO05PDB0V0    | EMC_AB[3]/IO05PDB0V0         | EMC_AB[3]/IO09PDB0V0         |
| A7      | EMC_AB[5]/IO06PDB0V0    | EMC_AB[5]/IO06PDB0V0         | EMC_AB[5]/IO10PDB0V0         |
| A8      | VCCFPGAIOB0             | VCCFPGAIOB0                  | VCCFPGAIOB0                  |
| A9      | GND                     | GND                          | GND                          |
| A10     | EMC_AB[14]/IO11NDB0V0   | EMC_AB[14]/IO11NDB0V0        | EMC_AB[14]/IO15NDB0V0        |
| A11     | EMC_AB[15]/IO11PDB0V0   | EMC_AB[15]/IO11PDB0V0        | EMC_AB[15]/IO15PDB0V0        |
| A12     | GND                     | GND                          | GND                          |
| A13     | EMC_AB[20]/IO14NDB0V0   | EMC_AB[20]/IO14NDB0V0        | EMC_AB[20]/IO21NDB0V0        |
| A14     | EMC_AB[24]/IO16NDB0V0   | EMC_AB[24]/IO16NDB0V0        | EMC_AB[24]/IO20NDB0V0        |
| A15     | VCCFPGAIOB0             | VCCFPGAIOB0                  | VCCFPGAIOB0                  |
| A16     | GND                     | GND                          | GND                          |
| B1      | EMC_DB[15]/IO45PDB5V0   | EMC_DB[15]/GAA2/IO71PDB5V0   | EMC_DB[15]/GAA2/IO88PDB5V0   |
| B2      | GND                     | GND                          | GND                          |
| B3      | EMC_BYTEN[1]/IO02PDB0V0 | EMC_BYTEN[1]/GAC1/IO02PDB0V0 | EMC_BYTEN[1]/GAC1/IO07PDB0V0 |
| B4      | EMC_OEN0_N/IO03NDB0V0   | EMC_OEN0_N/IO03NDB0V0        | EMC_OEN0_N/IO08NDB0V0        |
| B5      | EMC_OEN1_N/IO03PDB0V0   | EMC_OEN1_N/IO03PDB0V0        | EMC_OEN1_N/IO08PDB0V0        |
| B6      | EMC_AB[2]/IO05NDB0V0    | EMC_AB[2]/IO05NDB0V0         | EMC_AB[2]/IO09NDB0V0         |
| B7      | EMC_AB[4]/IO06NDB0V0    | EMC_AB[4]/IO06NDB0V0         | EMC_AB[4]/IO10NDB0V0         |
| B8      | EMC_AB[9]/IO08PDB0V0    | EMC_AB[9]/IO08PDB0V0         | EMC_AB[9]/IO13PDB0V0         |
| B9      | EMC_AB[12]/IO10NDB0V0   | EMC_AB[12]/IO10NDB0V0        | EMC_AB[12]/IO14NDB0V0        |
| B10     | EMC_AB[13]/IO10PDB0V0   | EMC_AB[13]/IO10PDB0V0        | EMC_AB[13]/IO14PDB0V0        |
| B11     | EMC_AB[16]/IO12NDB0V0   | EMC_AB[16]/IO12NDB0V0        | EMC_AB[16]/IO17NDB0V0        |
| B12     | EMC_AB[18]/IO13NDB0V0   | EMC_AB[18]/IO13NDB0V0        | EMC_AB[18]/IO18NDB0V0        |
| B13     | EMC_AB[21]/IO14PDB0V0   | EMC_AB[21]/IO14PDB0V0        | EMC_AB[21]/IO21PDB0V0        |
| B14     | EMC_AB[25]/IO16PDB0V0   | EMC_AB[25]/IO16PDB0V0        | EMC_AB[25]/IO20PDB0V0        |
| B15     | GND                     | GND                          | GND                          |
| B16     | GNDQ                    | GNDQ                         | GNDQ                         |
| C1      | EMC_DB[14]/IO45NDB5V0   | EMC_DB[14]/GAB2/IO71NDB5V0   | EMC_DB[14]/GAB2/IO88NDB5V0   |
| C2      | VCCPLL0                 | VCCPLL                       | VCCPLL0                      |

*Note:* Shading denotes pins that do not have completely identical functions from density to density. For example, the bank assignment can be different for an I/O, or the function might be available only on a larger density device.



| Pin No. | FG256                   |                              |                              |
|---------|-------------------------|------------------------------|------------------------------|
|         | A2F060 Function         | A2F200 Function              | A2F500 Function              |
| C3      | EMC_BYTEN[0]/IO02NDB0V0 | EMC_BYTEN[0]/GAC0/IO02NDB0V0 | EMC_BYTEN[0]/GAC0/IO07NDB0V0 |
| C4      | VCCFPGAIOB0             | VCCFPGAIOB0                  | VCCFPGAIOB0                  |
| C5      | EMC_CS0_N/IO01NDB0V0    | EMC_CS0_N/GAB0/IO01NDB0V0    | EMC_CS0_N/GAB0/IO05NDB0V0    |
| C6      | EMC_CS1_N/IO01PDB0V0    | EMC_CS1_N/GAB1/IO01PDB0V0    | EMC_CS1_N/GAB1/IO05PDB0V0    |
| C7      | GND                     | GND                          | GND                          |
| C8      | EMC_AB[8]/IO08NDB0V0    | EMC_AB[8]/IO08NDB0V0         | EMC_AB[8]/IO13NDB0V0         |
| C9      | EMC_AB[11]/IO09PDB0V0   | EMC_AB[11]/IO09PDB0V0        | EMC_AB[11]/IO11PDB0V0        |
| C10     | VCCFPGAIOB0             | VCCFPGAIOB0                  | VCCFPGAIOB0                  |
| C11     | EMC_AB[17]/IO12PDB0V0   | EMC_AB[17]/IO12PDB0V0        | EMC_AB[17]/IO17PDB0V0        |
| C12     | EMC_AB[19]/IO13PDB0V0   | EMC_AB[19]/IO13PDB0V0        | EMC_AB[19]/IO18PDB0V0        |
| C13     | GND                     | GND                          | GND                          |
| C14     | GCC0/IO18NPB0V0         | GBA2/IO20PPB1V0              | GBA2/IO27PPB1V0              |
| C15     | GCB0/IO19NDB0V0         | GCA2/IO23PDB1V0              | GCA2/IO28PDB1V0              |
| C16     | GCB1/IO19PDB0V0         | IO23NDB1V0                   | IO28NDB1V0                   |
| D1      | VCCFPGAIOB5             | VCCFPGAIOB5                  | VCCFPGAIOB5                  |
| D2      | VCOMPLA0                | VCOMPLA                      | VCOMPLA0                     |
| D3      | GND                     | GND                          | GND                          |
| D4      | GNDQ                    | GNDQ                         | GNDQ                         |
| D5      | EMC_CLK/IO00NDB0V0      | EMC_CLK/GAA0/IO00NDB0V0      | EMC_CLK/GAA0/IO02NDB0V0      |
| D6      | EMC_RW_N/IO00PDB0V0     | EMC_RW_N/GAA1/IO00PDB0V0     | EMC_RW_N/GAA1/IO02PDB0V0     |
| D7      | EMC_AB[6]/IO07NDB0V0    | EMC_AB[6]/IO07NDB0V0         | EMC_AB[6]/IO12NDB0V0         |
| D8      | EMC_AB[7]/IO07PDB0V0    | EMC_AB[7]/IO07PDB0V0         | EMC_AB[7]/IO12PDB0V0         |
| D9      | EMC_AB[10]/IO09NDB0V0   | EMC_AB[10]/IO09NDB0V0        | EMC_AB[10]/IO11NDB0V0        |
| D10     | EMC_AB[22]/IO15NDB0V0   | EMC_AB[22]/IO15NDB0V0        | EMC_AB[22]/IO19NDB0V0        |
| D11     | EMC_AB[23]/IO15PDB0V0   | EMC_AB[23]/IO15PDB0V0        | EMC_AB[23]/IO19PDB0V0        |
| D12     | GNDQ                    | GNDQ                         | GNDQ                         |
| D13     | GCC1/IO18PPB0V0         | GBB2/IO20NPB1V0              | GBB2/IO27NPB1V0              |
| D14     | GCA0/IO20NDB0V0         | GCB2/IO24PDB1V0              | GCB2/IO33PDB1V0              |
| D15     | GCA1/IO20PDB0V0         | IO24NDB1V0                   | IO33NDB1V0                   |
| D16     | VCCFPGAIOB1             | VCCFPGAIOB1                  | VCCFPGAIOB1                  |
| E1      | EMC_DB[13]/IO44PDB5V0   | EMC_DB[13]/GAC2/IO70PDB5V0   | EMC_DB[13]/GAC2/IO87PDB5V0   |
| E2      | EMC_DB[12]/IO44NDB5V0   | EMC_DB[12]/IO70NDB5V0        | EMC_DB[12]/IO87NDB5V0        |
| E3      | GFA2/IO42PDB5V0         | GFA2/IO68PDB5V0              | GFA2/IO85PDB5V0              |
| E4      | EMC_DB[10]/IO43NPB5V0   | EMC_DB[10]/IO69NPB5V0        | EMC_DB[10]/IO86NPB5V0        |

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| Pin No. | FG256                 |                           |                           |
|---------|-----------------------|---------------------------|---------------------------|
|         | A2F060 Function       | A2F200 Function           | A2F500 Function           |
| E5      | GNDQ                  | GNDQ                      | GNDQ                      |
| E6      | GND                   | GND                       | GND                       |
| E7      | VCCFPGAIOB0           | VCCFPGAIOB0               | VCCFPGAIOB0               |
| E8      | GND                   | GND                       | GND                       |
| E9      | VCCFPGAIOB0           | VCCFPGAIOB0               | VCCFPGAIOB0               |
| E10     | GND                   | GND                       | GND                       |
| E11     | VCCFPGAIOB0           | VCCFPGAIOB0               | VCCFPGAIOB0               |
| E12     | GCB2/IO22PDB1V0       | GCA1/IO28PDB1V0           | GCA1/IO36PDB1V0           |
| E13     | VCCFPGAIOB1           | VCCFPGAIOB1               | VCCFPGAIOB1               |
| E14     | GCA2/IO21PDB1V0       | GCB1/IO27PDB1V0           | GCB1/IO34PDB1V0           |
| E15     | GCC2/IO23PDB1V0       | GDC1/IO29PDB1V0           | GDC1/IO38PDB1V0           |
| E16     | IO23NDB1V0            | GDC0/IO29NDB1V0           | GDC0/IO38NDB1V0           |
| F1      | EMC_DB[9]/IO40PDB5V0  | EMC_DB[9]/GEC1/IO63PDB5V0 | EMC_DB[9]/GEC1/IO80PDB5V0 |
| F2      | GND                   | GND                       | GND                       |
| F3      | GFB2/IO42NDB5V0       | GFB2/IO68NDB5V0           | GFB2/IO85NDB5V0           |
| F4      | VCCFPGAIOB5           | VCCFPGAIOB5               | VCCFPGAIOB5               |
| F5      | EMC_DB[11]/IO43PPB5V0 | EMC_DB[11]/IO69PPB5V0     | EMC_DB[11]/IO86PPB5V0     |
| F6      | VCCFPGAIOB5           | VCCFPGAIOB5               | VCCFPGAIOB5               |
| F7      | GND                   | GND                       | GND                       |
| F8      | VCC                   | VCC                       | VCC                       |
| F9      | GND                   | GND                       | GND                       |
| F10     | VCC                   | VCC                       | VCC                       |
| F11     | GND                   | GND                       | GND                       |
| F12     | IO22NDB1V0            | GCA0/IO28NDB1V0           | GCA0/IO36NDB1V0           |
| F13     | NC                    | GNDQ                      | GNDQ                      |
| F14     | IO21NDB1V0            | GCB0/IO27NDB1V0           | GCB0/IO34NDB1V0           |
| F15     | GND                   | GND                       | GND                       |
| F16     | VCCENVM               | VCCENVM                   | VCCENVM                   |
| G1      | EMC_DB[8]/IO40NDB5V0  | EMC_DB[8]/GEC0/IO63NDB5V0 | EMC_DB[8]/GEC0/IO80NDB5V0 |
| G2      | EMC_DB[7]/IO39PDB5V0  | EMC_DB[7]/GEB1/IO62PDB5V0 | EMC_DB[7]/GEB1/IO79PDB5V0 |
| G3      | EMC_DB[6]/IO39NDB5V0  | EMC_DB[6]/GEB0/IO62NDB5V0 | EMC_DB[6]/GEB0/IO79NDB5V0 |
| G4      | GFC2/IO41PDB5V0       | GFC2/IO67PDB5V0           | GFC2/IO84PDB5V0           |
| G5      | IO41NDB5V0            | IO67NDB5V0                | IO84NDB5V0                |
| G6      | GND                   | GND                       | GND                       |

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| Pin No. | FG256                |                           |                           |
|---------|----------------------|---------------------------|---------------------------|
|         | A2F060 Function      | A2F200 Function           | A2F500 Function           |
| G7      | VCC                  | VCC                       | VCC                       |
| G8      | GND                  | GND                       | GND                       |
| G9      | VCC                  | VCC                       | VCC                       |
| G10     | GND                  | GND                       | GND                       |
| G11     | VCCFPGAIOB1          | VCCFPGAIOB1               | VCCFPGAIOB1               |
| G12     | VPP                  | VPP                       | VPP                       |
| G13     | TRSTB                | TRSTB                     | TRSTB                     |
| G14     | TMS                  | TMS                       | TMS                       |
| G15     | TCK                  | TCK                       | TCK                       |
| G16     | GNDENVN              | GNDENVN                   | GNDENVN                   |
| H1      | GND                  | GND                       | GND                       |
| H2      | EMC_DB[5]/IO38PPB5V0 | EMC_DB[5]/GEA1/IO61PPB5V0 | EMC_DB[5]/GEA1/IO78PPB5V0 |
| H3      | VCCFPGAIOB5          | VCCFPGAIOB5               | VCCFPGAIOB5               |
| H4      | EMC_DB[1]/IO36PDB5V0 | EMC_DB[1]/GEB2/IO59PDB5V0 | EMC_DB[1]/GEB2/IO76PDB5V0 |
| H5      | EMC_DB[0]/IO36NDB5V0 | EMC_DB[0]/GEA2/IO59NDB5V0 | EMC_DB[0]/GEA2/IO76NDB5V0 |
| H6      | VCCFPGAIOB5          | VCCFPGAIOB5               | VCCFPGAIOB5               |
| H7      | GND                  | GND                       | GND                       |
| H8      | VCC                  | VCC                       | VCC                       |
| H9      | GND                  | GND                       | GND                       |
| H10     | VCC                  | VCC                       | VCC                       |
| H11     | GND                  | GND                       | GND                       |
| H12     | VJTAG                | VJTAG                     | VJTAG                     |
| H13     | TDO                  | TDO                       | TDO                       |
| H14     | TDI                  | TDI                       | TDI                       |
| H15     | JTAGSEL              | JTAGSEL                   | JTAGSEL                   |
| H16     | GND                  | GND                       | GND                       |
| J1      | EMC_DB[4]/IO38NPB5V0 | EMC_DB[4]/GEA0/IO61NPB5V0 | EMC_DB[4]/GEA0/IO78NPB5V0 |
| J2      | EMC_DB[3]/IO37PDB5V0 | EMC_DB[3]/GEC2/IO60PDB5V0 | EMC_DB[3]/GEC2/IO77PDB5V0 |
| J3      | EMC_DB[2]/IO37NDB5V0 | EMC_DB[2]/IO60NDB5V0      | EMC_DB[2]/IO77NDB5V0      |
| J4      | GNDRCOSC             | GNDRCOSC                  | GNDRCOSC                  |
| J5      | NC                   | GNDQ                      | GNDQ                      |
| J6      | GND                  | GND                       | GND                       |
| J7      | VCC                  | VCC                       | VCC                       |
| J8      | GND                  | GND                       | GND                       |

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| Pin No. | FG256              |                      |                      |
|---------|--------------------|----------------------|----------------------|
|         | A2F060 Function    | A2F200 Function      | A2F500 Function      |
| J9      | VCC                | VCC                  | VCC                  |
| J10     | GND                | GND                  | GND                  |
| J11     | VCCMSSIOB2         | VCCMSSIOB2           | VCCMSSIOB2           |
| J12     | I2C_0_SCL/GPIO_23  | I2C_0_SCL/GPIO_23    | I2C_0_SCL/GPIO_23    |
| J13     | I2C_0_SDA/GPIO_22  | I2C_0_SDA/GPIO_22    | I2C_0_SDA/GPIO_22    |
| J14     | I2C_1_SCL/GPIO_31  | I2C_1_SCL/GPIO_31    | I2C_1_SCL/GPIO_31    |
| J15     | VCCMSSIOB2         | VCCMSSIOB2           | VCCMSSIOB2           |
| J16     | I2C_1_SDA/GPIO_30  | I2C_1_SDA/GPIO_30    | I2C_1_SDA/GPIO_30    |
| K1      | GPIO_1/IO32RSB4V0  | MAC_MDIO/IO49RSB4V0  | MAC_MDIO/IO58RSB4V0  |
| K2      | GPIO_0/IO33RSB4V0  | MAC_MDC/IO48RSB4V0   | MAC_MDC/IO57RSB4V0   |
| K3      | VCCMSSIOB4         | VCCMSSIOB4           | VCCMSSIOB4           |
| K4      | MSS_RESET_N        | MSS_RESET_N          | MSS_RESET_N          |
| K5      | VCCRCOSC           | VCCRCOSC             | VCCRCOSC             |
| K6      | VCCMSSIOB4         | VCCMSSIOB4           | VCCMSSIOB4           |
| K7      | GND                | GND                  | GND                  |
| K8      | VCC                | VCC                  | VCC                  |
| K9      | GND                | GND                  | GND                  |
| K10     | VCC                | VCC                  | VCC                  |
| K11     | GND                | GND                  | GND                  |
| K12     | UART_0_RXD/GPIO_21 | UART_0_RXD/GPIO_21   | UART_0_RXD/GPIO_21   |
| K13     | GND                | GND                  | GND                  |
| K14     | UART_1_TXD/GPIO_28 | UART_1_TXD/GPIO_28   | UART_1_TXD/GPIO_28   |
| K15     | UART_1_RXD/GPIO_29 | UART_1_RXD/GPIO_29   | UART_1_RXD/GPIO_29   |
| K16     | UART_0_TXD/GPIO_20 | UART_0_TXD/GPIO_20   | UART_0_TXD/GPIO_20   |
| L1      | GND                | GND                  | GND                  |
| L2      | GPIO_2/IO31RSB4V0  | MAC_TXEN/IO52RSB4V0  | MAC_TXEN/IO61RSB4V0  |
| L3      | GPIO_3/IO30RSB4V0  | MAC_CRSDV/IO51RSB4V0 | MAC_CRSDV/IO60RSB4V0 |
| L4      | GPIO_4/IO29RSB4V0  | MAC_RXER/IO50RSB4V0  | MAC_RXER/IO59RSB4V0  |
| L5      | GPIO_9/IO24RSB4V0  | MAC_CLK              | MAC_CLK              |
| L6      | GND                | GND                  | GND                  |
| L7      | VCC                | VCC                  | VCC                  |
| L8      | GND                | GND                  | GND                  |
| L9      | VCC                | VCC                  | VCC                  |
| L10     | GND                | GND                  | GND                  |

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| Pin No. | FG256             |                       |                       |
|---------|-------------------|-----------------------|-----------------------|
|         | A2F060 Function   | A2F200 Function       | A2F500 Function       |
| L11     | VCCMSSIOB2        | VCCMSSIOB2            | VCCMSSIOB2            |
| L12     | SPI_1_DO/GPIO_24  | SPI_1_DO/GPIO_24      | SPI_1_DO/GPIO_24      |
| L13     | SPI_1_SS/GPIO_27  | SPI_1_SS/GPIO_27      | SPI_1_SS/GPIO_27      |
| L14     | SPI_1_CLK/GPIO_26 | SPI_1_CLK/GPIO_26     | SPI_1_CLK/GPIO_26     |
| L15     | SPI_1_DI/GPIO_25  | SPI_1_DI/GPIO_25      | SPI_1_DI/GPIO_25      |
| L16     | GND               | GND                   | GND                   |
| M1      | GPIO_5/IO28RSB4V0 | MAC_TXD[0]/IO56RSB4V0 | MAC_TXD[0]/IO65RSB4V0 |
| M2      | GPIO_6/IO27RSB4V0 | MAC_TXD[1]/IO55RSB4V0 | MAC_TXD[1]/IO64RSB4V0 |
| M3      | GPIO_7/IO26RSB4V0 | MAC_RXD[0]/IO54RSB4V0 | MAC_RXD[0]/IO63RSB4V0 |
| M4      | GND               | GND                   | GND                   |
| M5      | NC                | ADC3                  | ADC3                  |
| M6      | NC                | GND15ADC0             | GND15ADC0             |
| M7      | GND33ADC0         | GND33ADC1             | GND33ADC1             |
| M8      | GND33ADC0         | GND33ADC1             | GND33ADC1             |
| M9      | ADC7              | ADC4                  | ADC4                  |
| M10     | GNDTM0            | GNDTM1                | GNDTM1                |
| M11     | ADC6              | TM2                   | TM2                   |
| M12     | ADC5              | CM2                   | CM2                   |
| M13     | SPI_0_SS/GPIO_19  | SPI_0_SS/GPIO_19      | SPI_0_SS/GPIO_19      |
| M14     | VCCMSSIOB2        | VCCMSSIOB2            | VCCMSSIOB2            |
| M15     | SPI_0_CLK/GPIO_18 | SPI_0_CLK/GPIO_18     | SPI_0_CLK/GPIO_18     |
| M16     | SPI_0_DI/GPIO_17  | SPI_0_DI/GPIO_17      | SPI_0_DI/GPIO_17      |
| N1      | GPIO_8/IO25RSB4V0 | MAC_RXD[1]/IO53RSB4V0 | MAC_RXD[1]/IO62RSB4V0 |
| N2      | VCCMSSIOB4        | VCCMSSIOB4            | VCCMSSIOB4            |
| N3      | VCC15A            | VCC15A                | VCC15A                |
| N4      | VCC33AP           | VCC33AP               | VCC33AP               |
| N5      | NC                | ABPS3                 | ABPS3                 |
| N6      | ADC4              | TM1                   | TM1                   |
| N7      | NC                | GND33ADC0             | GND33ADC0             |
| N8      | VCC33ADC0         | VCC33ADC1             | VCC33ADC1             |
| N9      | ADC8              | ADC5                  | ADC5                  |
| N10     | CM0               | CM3                   | CM3                   |
| N11     | GNDQAQ            | GNDQAQ                | GNDQAQ                |
| N12     | VAREFOUT          | VAREFOUT              | VAREFOUT              |

**Note:** Shading denotes pins that do not have completely identical functions from density to density. For example, the bank assignment can be different for an I/O, or the function might be available only on a larger density device.

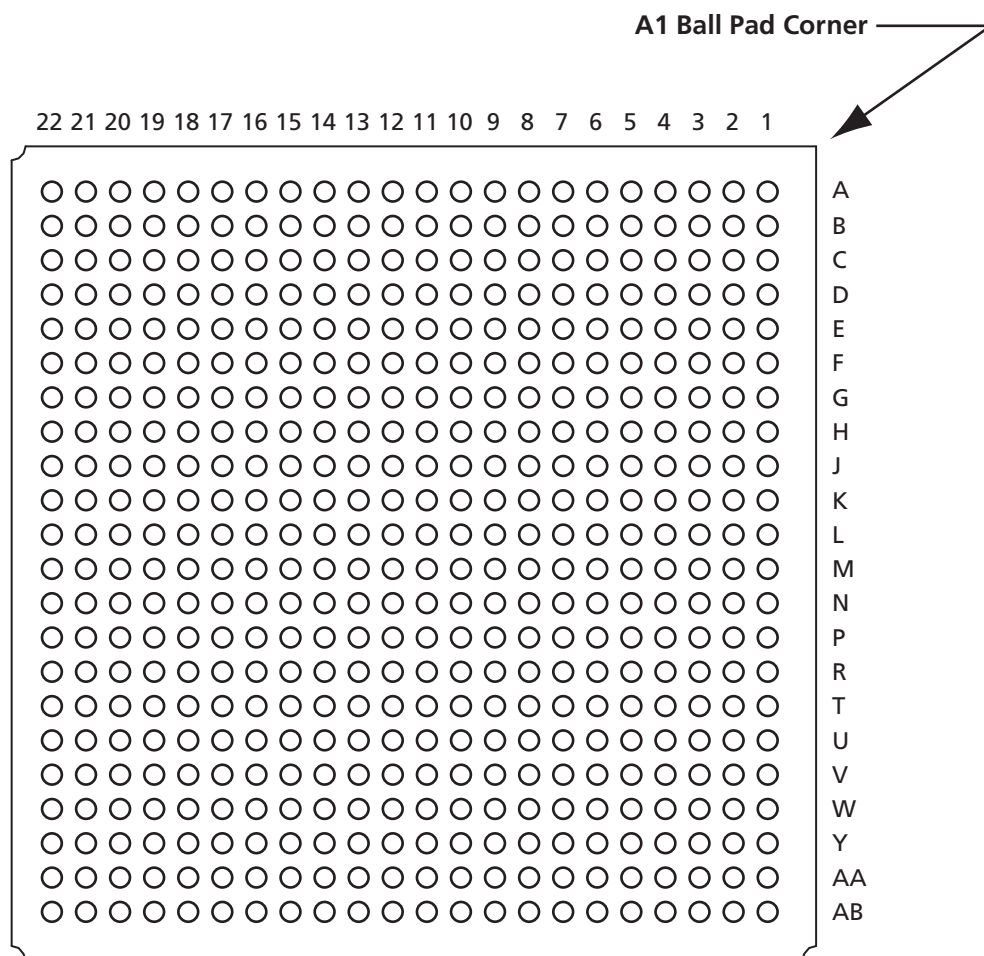
| Pin No. | FG256            |                  |                  |
|---------|------------------|------------------|------------------|
|         | A2F060 Function  | A2F200 Function  | A2F500 Function  |
| N13     | NC               | GNDSDD1          | GNDSDD1          |
| N14     | NC               | VCC33SDD1        | VCC33SDD1        |
| N15     | GND              | GND              | GND              |
| N16     | SPI_0_DO/GPIO_16 | SPI_0_DO/GPIO_16 | SPI_0_DO/GPIO_16 |
| P1      | GNDSDD0          | GNDSDD0          | GNDSDD0          |
| P2      | VCC33SDD0        | VCC33SDD0        | VCC33SDD0        |
| P3      | VCC33N           | VCC33N           | VCC33N           |
| P4      | GNDA             | GNDA             | GNDA             |
| P5      | GNDAQ            | GNDAQ            | GNDAQ            |
| P6      | NC               | CM1              | CM1              |
| P7      | NC               | ADC2             | ADC2             |
| P8      | NC               | VCC15ADC0        | VCC15ADC0        |
| P9      | ADC9             | ADC6             | ADC6             |
| P10     | TM0              | TM3              | TM3              |
| P11     | GNDA             | GNDA             | GNDA             |
| P12     | VCCMAINXTAL      | VCCMAINXTAL      | VCCMAINXTAL      |
| P13     | GNDLPXTAL        | GNDLPXTAL        | GNDLPXTAL        |
| P14     | VDDBAT           | VDDBAT           | VDDBAT           |
| P15     | PTM              | PTM              | PTM              |
| P16     | PTBASE           | PTBASE           | PTBASE           |
| R1      | PCAP             | PCAP             | PCAP             |
| R2      | SDD0             | SDD0             | SDD0             |
| R3      | ADC0             | ABPS0            | ABPS0            |
| R4      | ADC3             | TM0              | TM0              |
| R5      | NC               | ABPS2            | ABPS2            |
| R6      | NC               | ADC1             | ADC1             |
| R7      | NC               | VCC33ADC0        | VCC33ADC0        |
| R8      | VCC15ADC0        | VCC15ADC1        | VCC15ADC1        |
| R9      | ADC10            | ADC7             | ADC7             |
| R10     | ABPS1            | ABPS7            | ABPS7            |
| R11     | NC               | ABPS4            | ABPS4            |
| R12     | MAINXIN          | MAINXIN          | MAINXIN          |
| R13     | MAINXOUT         | MAINXOUT         | MAINXOUT         |
| R14     | LPXIN            | LPXIN            | LPXIN            |

*Note:* Shading denotes pins that do not have completely identical functions from density to density. For example, the bank assignment can be different for an I/O, or the function might be available only on a larger density device.

| Pin No. | FG256           |                 |                 |
|---------|-----------------|-----------------|-----------------|
|         | A2F060 Function | A2F200 Function | A2F500 Function |
| R15     | LPXOUT          | LPXOUT          | LPXOUT          |
| R16     | VCC33A          | VCC33A          | VCC33A          |
| T1      | NCAP            | NCAP            | NCAP            |
| T2      | ADC1            | ABPS1           | ABPS1           |
| T3      | ADC2            | CM0             | CM0             |
| T4      | NC              | GNDTM0          | GNDTM0          |
| T5      | NC              | ADC0            | ADC0            |
| T6      | NC              | VAREF0          | VAREF0          |
| T7      | NC              | GND33ADC0       | GND33ADC0       |
| T8      | GND15ADC0       | GND15ADC1       | GND15ADC1       |
| T9      | VAREF0          | VAREF1          | VAREF1          |
| T10     | ABPS0           | ABPS6           | ABPS6           |
| T11     | NC              | ABPS5           | ABPS5           |
| T12     | NC              | SDD1            | SDD1            |
| T13     | GNDVAREF        | GNDVAREF        | GNDVAREF        |
| T14     | GNDMAINXTAL     | GNDMAINXTAL     | GNDMAINXTAL     |
| T15     | VCCLPXTAL       | VCCLPXTAL       | VCCLPXTAL       |
| T16     | PU_N            | PU_N            | PU_N            |

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## FG484



### Note

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



| Pin Number | FG484                     |                           |
|------------|---------------------------|---------------------------|
|            | A2F200 Function           | A2F500 Function           |
| A1         | GND                       | GND                       |
| A2         | NC                        | NC                        |
| A3         | NC                        | NC                        |
| A4         | GND                       | GND                       |
| A5         | EMC_CS0_N/GAB0/IO01NDB0V0 | EMC_CS0_N/GAB0/IO05NDB0V0 |
| A6         | EMC_CS1_N/GAB1/IO01PDB0V0 | EMC_CS1_N/GAB1/IO05PDB0V0 |
| A7         | GND                       | GND                       |
| A8         | EMC_AB[0]/IO04NDB0V0      | EMC_AB[0]/IO06NDB0V0      |
| A9         | EMC_AB[1]/IO04PDB0V0      | EMC_AB[1]/IO06PDB0V0      |
| A10        | GND                       | GND                       |
| A11        | NC                        | NC                        |
| A12        | EMC_AB[7]/IO07PDB0V0      | EMC_AB[7]/IO12PDB0V0      |
| A13        | GND                       | GND                       |
| A14        | EMC_AB[12]/IO10NDB0V0     | EMC_AB[12]/IO14NDB0V0     |
| A15        | EMC_AB[13]/IO10PDB0V0     | EMC_AB[13]/IO14PDB0V0     |
| A16        | GND                       | GND                       |
| A17        | NC                        | IO16NDB0V0                |
| A18        | NC                        | IO16PDB0V0                |
| A19        | GND                       | GND                       |
| A20        | NC                        | NC                        |
| A21        | NC                        | NC                        |
| A22        | GND                       | GND                       |
| AA1        | GPIO_4/IO43RSB4V0         | GPIO_4/IO52RSB4V0         |
| AA2        | GPIO_12/IO37RSB4V0        | GPIO_12/IO46RSB4V0        |
| AA3        | MAC_MDC/IO48RSB4V0        | MAC_MDC/IO57RSB4V0        |
| AA4        | MAC_RXER/IO50RSB4V0       | MAC_RXER/IO59RSB4V0       |
| AA5        | MAC_TXD[0]/IO56RSB4V0     | MAC_TXD[0]/IO65RSB4V0     |
| AA6        | ABPS0                     | ABPS0                     |
| AA7        | TM1                       | TM1                       |
| AA8        | ADC1                      | ADC1                      |
| AA9        | GND15ADC1                 | GND15ADC1                 |
| AA10       | GND33ADC1                 | GND33ADC1                 |
| AA11       | CM3                       | CM3                       |
| AA12       | GNDTM1                    | GNDTM1                    |
| AA13       | NC                        | ADC10                     |
| AA14       | NC                        | ADC9                      |

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| Pin Number | FG484                      |                            |
|------------|----------------------------|----------------------------|
|            | A2F200 Function            | A2F500 Function            |
| AA15       | NC                         | GND15ADC2                  |
| AA16       | MAINXIN                    | MAINXIN                    |
| AA17       | MAINXOUT                   | MAINXOUT                   |
| AA18       | LPXIN                      | LPXIN                      |
| AA19       | LPXOUT                     | LPXOUT                     |
| AA20       | NC                         | NC                         |
| AA21       | NC                         | NC                         |
| AA22       | SPI_1_CLK/GPIO_26          | SPI_1_CLK/GPIO_26          |
| AB1        | GND                        | GND                        |
| AB2        | GPIO_13/IO36RSB4V0         | GPIO_13/IO45RSB4V0         |
| AB3        | GPIO_14/IO35RSB4V0         | GPIO_14/IO44RSB4V0         |
| AB4        | GND                        | GND                        |
| AB5        | PCAP                       | PCAP                       |
| AB6        | NCAP                       | NCAP                       |
| AB7        | ABPS3                      | ABPS3                      |
| AB8        | ADC3                       | ADC3                       |
| AB9        | GND15ADC0                  | GND15ADC0                  |
| AB10       | VCC33ADC1                  | VCC33ADC1                  |
| AB11       | VAREF1                     | VAREF1                     |
| AB12       | TM2                        | TM2                        |
| AB13       | CM2                        | CM2                        |
| AB14       | ABPS4                      | ABPS4                      |
| AB15       | GND4Q                      | GND4Q                      |
| AB16       | GNDMAINXTAL                | GNDMAINXTAL                |
| AB17       | GNDLPXTAL                  | GNDLPXTAL                  |
| AB18       | VCCLPXTAL                  | VCCLPXTAL                  |
| AB19       | VDDBAT                     | VDDBAT                     |
| AB20       | PTBASE                     | PTBASE                     |
| AB21       | NC                         | NC                         |
| AB22       | GND                        | GND                        |
| B1         | EMC_DB[15]/GAA2/IO71PDB5V0 | EMC_DB[15]/GAA2/IO88PDB5V0 |
| B2         | GND                        | GND                        |
| B3         | NC                         | NC                         |
| B4         | NC                         | NC                         |
| B5         | VCCFPGAIOB0                | VCCFPGAIOB0                |
| B6         | EMC_RW_N/GAA1/IO00PDB0V0   | EMC_RW_N/GAA1/IO02PDB0V0   |

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| Pin Number | FG484                        |                              |
|------------|------------------------------|------------------------------|
|            | A2F200 Function              | A2F500 Function              |
| B7         | NC                           | IO04PPB0V0                   |
| B8         | VCCFPGAIOB0                  | VCCFPGAIOB0                  |
| B9         | EMC_BYTEN[0]/GAC0/IO02NDB0V0 | EMC_BYTEN[0]/GAC0/IO07NDB0V0 |
| B10        | EMC_AB[2]/IO05NDB0V0         | EMC_AB[2]/IO09NDB0V0         |
| B11        | EMC_AB[3]/IO05PDB0V0         | EMC_AB[3]/IO09PDB0V0         |
| B12        | EMC_AB[6]/IO07NDB0V0         | EMC_AB[6]/IO12NDB0V0         |
| B13        | EMC_AB[14]/IO11NDB0V0        | EMC_AB[14]/IO15NDB0V0        |
| B14        | EMC_AB[15]/IO11PDB0V0        | EMC_AB[15]/IO15PDB0V0        |
| B15        | VCCFPGAIOB0                  | VCCFPGAIOB0                  |
| B16        | EMC_AB[18]/IO13NDB0V0        | EMC_AB[18]/IO18NDB0V0        |
| B17        | EMC_AB[19]/IO13PDB0V0        | EMC_AB[19]/IO18PDB0V0        |
| B18        | VCCFPGAIOB0                  | VCCFPGAIOB0                  |
| B19        | GBB0/IO18NDB0V0              | GBB0/IO24NDB0V0              |
| B20        | GBB1/IO18PDB0V0              | GBB1/IO24PDB0V0              |
| B21        | GND                          | GND                          |
| B22        | GBA2/IO20PDB1V0              | GBA2/IO27PDB1V0              |
| C1         | EMC_DB[14]/GAB2/IO71NDB5V0   | EMC_DB[14]/GAB2/IO88NDB5V0   |
| C2         | NC                           | NC                           |
| C3         | NC                           | NC                           |
| C4         | NC                           | IO01NDB0V0                   |
| C5         | NC                           | IO01PDB0V0                   |
| C6         | EMC_CLK/GAA0/IO00NDB0V0      | EMC_CLK/GAA0/IO02NDB0V0      |
| C7         | NC                           | IO03PPB0V0                   |
| C8         | NC                           | IO04NPB0V0                   |
| C9         | EMC_BYTEN[1]/GAC1/IO02PDB0V0 | EMC_BYTEN[1]/GAC1/IO07PDB0V0 |
| C10        | EMC_OEN1_N/IO03PDB0V0        | EMC_OEN1_N/IO08PDB0V0        |
| C11        | GND                          | GND                          |
| C12        | VCCFPGAIOB0                  | VCCFPGAIOB0                  |
| C13        | EMC_AB[8]/IO08NDB0V0         | EMC_AB[8]/IO13NDB0V0         |
| C14        | EMC_AB[16]/IO12NDB0V0        | EMC_AB[16]/IO17NDB0V0        |
| C15        | EMC_AB[17]/IO12PDB0V0        | EMC_AB[17]/IO17PDB0V0        |
| C16        | EMC_AB[24]/IO16NDB0V0        | EMC_AB[24]/IO20NDB0V0        |
| C17        | EMC_AB[22]/IO15NDB0V0        | EMC_AB[22]/IO19NDB0V0        |
| C18        | EMC_AB[23]/IO15PDB0V0        | EMC_AB[23]/IO19PDB0V0        |
| C19        | GBA0/IO19NPB0V0              | GBA0/IO23NPB0V0              |
| C20        | NC                           | NC                           |

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| Pin Number | FG484                      |                            |
|------------|----------------------------|----------------------------|
|            | A2F200 Function            | A2F500 Function            |
| C21        | GBC2/IO21PDB1V0            | GBC2/IO30PDB1V0            |
| C22        | GBB2/IO20NDB1V0            | GBB2/IO27NDB1V0            |
| D1         | GND                        | GND                        |
| D2         | EMC_DB[12]/IO70NDB5V0      | EMC_DB[12]/IO87NDB5V0      |
| D3         | EMC_DB[13]/GAC2/IO70PDB5V0 | EMC_DB[13]/GAC2/IO87PDB5V0 |
| D4         | NC                         | NC                         |
| D5         | NC                         | NC                         |
| D6         | GND                        | GND                        |
| D7         | NC                         | IO00NPB0V0                 |
| D8         | NC                         | IO03NPB0V0                 |
| D9         | GND                        | GND                        |
| D10        | EMC_OEN0_N/IO03NDB0V0      | EMC_OEN0_N/IO08NDB0V0      |
| D11        | EMC_AB[10]/IO09NDB0V0      | EMC_AB[10]/IO11NDB0V0      |
| D12        | EMC_AB[11]/IO09PDB0V0      | EMC_AB[11]/IO11PDB0V0      |
| D13        | EMC_AB[9]/IO08PDB0V0       | EMC_AB[9]/IO13PDB0V0       |
| D14        | GND                        | GND                        |
| D15        | GBC1/IO17PPB0V0            | GBC1/IO22PPB0V0            |
| D16        | EMC_AB[25]/IO16PDB0V0      | EMC_AB[25]/IO20PDB0V0      |
| D17        | GND                        | GND                        |
| D18        | GBA1/IO19PPB0V0            | GBA1/IO23PPB0V0            |
| D19        | NC                         | NC                         |
| D20        | NC                         | NC                         |
| D21        | IO21NDB1V0                 | IO30NDB1V0                 |
| D22        | GND                        | GND                        |
| E1         | GFC2/IO67PPB5V0            | GFC2/IO84PPB5V0            |
| E2         | VCCFPGAIOB5                | VCCFPGAIOB5                |
| E3         | GFA2/IO68PDB5V0            | GFA2/IO85PDB5V0            |
| E4         | GND                        | GND                        |
| E5         | NC                         | NC                         |
| E6         | GNDQ                       | GNDQ                       |
| E7         | VCCFPGAIOB0                | VCCFPGAIOB0                |
| E8         | NC                         | IO00PPB0V0                 |
| E9         | NC                         | NC                         |
| E10        | VCCFPGAIOB0                | VCCFPGAIOB0                |
| E11        | EMC_AB[4]/IO06NDB0V0       | EMC_AB[4]/IO10NDB0V0       |
| E12        | EMC_AB[5]/IO06PDB0V0       | EMC_AB[5]/IO10PDB0V0       |

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| Pin Number | FG484                     |                           |
|------------|---------------------------|---------------------------|
|            | A2F200 Function           | A2F500 Function           |
| E13        | VCCFPGAIOB0               | VCCFPGAIOB0               |
| E14        | GBC0/IO17NPB0V0           | GBC0/IO22NPB0V0           |
| E15        | NC                        | NC                        |
| E16        | VCCFPGAIOB0               | VCCFPGAIOB0               |
| E17        | NC                        | VCOMPLA1                  |
| E18        | NC                        | IO25NPB1V0                |
| E19        | GND                       | GND                       |
| E20        | NC                        | NC                        |
| E21        | VCCFPGAIOB1               | VCCFPGAIOB1               |
| E22        | IO22NDB1V0                | IO32NDB1V0                |
| F1         | GFB1/IO65PPB5V0           | GFB1/IO82PPB5V0           |
| F2         | IO67NPB5V0                | IO84NPB5V0                |
| F3         | GFB2/IO68NDB5V0           | GFB2/IO85NDB5V0           |
| F4         | EMC_DB[10]/IO69NPB5V0     | EMC_DB[10]/IO86NPB5V0     |
| F5         | VCCFPGAIOB5               | VCCFPGAIOB5               |
| F6         | VCCPLL                    | VCCPLL0                   |
| F7         | VCOMPLA                   | VCOMPLA0                  |
| F8         | NC                        | NC                        |
| F9         | NC                        | NC                        |
| F10        | NC                        | NC                        |
| F11        | NC                        | NC                        |
| F12        | NC                        | NC                        |
| F13        | EMC_AB[20]/IO14NDB0V0     | EMC_AB[20]/IO21NDB0V0     |
| F14        | EMC_AB[21]/IO14PDB0V0     | EMC_AB[21]/IO21PDB0V0     |
| F15        | GNDQ                      | GNDQ                      |
| F16        | NC                        | VCCPLL1                   |
| F17        | NC                        | IO25PPB1V0                |
| F18        | VCCFPGAIOB1               | VCCFPGAIOB1               |
| F19        | IO23NDB1V0                | IO28NDB1V0                |
| F20        | NC                        | IO31PDB1V0                |
| F21        | NC                        | IO31NDB1V0                |
| F22        | IO22PDB1V0                | IO32PDB1V0                |
| G1         | GND                       | GND                       |
| G2         | GFB0/IO65NPB5V0           | GFB0/IO82NPB5V0           |
| G3         | EMC_DB[9]/GEC1/IO63PDB5V0 | EMC_DB[9]/GEC1/IO80PDB5V0 |
| G4         | GFC1/IO66PPB5V0           | GFC1/IO83PPB5V0           |

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| Pin Number | FG484                     |                           |
|------------|---------------------------|---------------------------|
|            | A2F200 Function           | A2F500 Function           |
| G5         | EMC_DB[11]/IO69PPB5V0     | EMC_DB[11]/IO86PPB5V0     |
| G6         | GNDQ                      | GNDQ                      |
| G7         | NC                        | NC                        |
| G8         | GND                       | GND                       |
| G9         | VCCFPGAIOB0               | VCCFPGAIOB0               |
| G10        | GND                       | GND                       |
| G11        | VCCFPGAIOB0               | VCCFPGAIOB0               |
| G12        | GND                       | GND                       |
| G13        | VCCFPGAIOB0               | VCCFPGAIOB0               |
| G14        | GND                       | GND                       |
| G15        | VCCFPGAIOB0               | VCCFPGAIOB0               |
| G16        | GNDQ                      | GNDQ                      |
| G17        | NC                        | IO26PDB1V0                |
| G18        | NC                        | IO26NDB1V0                |
| G19        | GCA2/IO23PDB1V0           | GCA2/IO28PDB1V0           |
| G20        | IO24NDB1V0                | IO33NDB1V0                |
| G21        | GCB2/IO24PDB1V0           | GCB2/IO33PDB1V0           |
| G22        | GND                       | GND                       |
| H1         | EMC_DB[7]/GEB1/IO62PDB5V0 | EMC_DB[7]/GEB1/IO79PDB5V0 |
| H2         | VCCFPGAIOB5               | VCCFPGAIOB5               |
| H3         | EMC_DB[8]/GEC0/IO63NDB5V0 | EMC_DB[8]/GEC0/IO80NDB5V0 |
| H4         | GND                       | GND                       |
| H5         | GFC0/IO66NPB5V0           | GFC0/IO83NPB5V0           |
| H6         | GFA1/IO64PDB5V0           | GFA1/IO81PDB5V0           |
| H7         | GND                       | GND                       |
| H8         | VCC                       | VCC                       |
| H9         | GND                       | GND                       |
| H10        | VCC                       | VCC                       |
| H11        | GND                       | GND                       |
| H12        | VCC                       | VCC                       |
| H13        | GND                       | GND                       |
| H14        | VCC                       | VCC                       |
| H15        | GND                       | GND                       |
| H16        | VCCFPGAIOB1               | VCCFPGAIOB1               |
| H17        | IO25NDB1V0                | IO29NDB1V0                |
| H18        | GCC2/IO25PDB1V0           | GCC2/IO29PDB1V0           |

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| Pin Number | FG484                     |                           |
|------------|---------------------------|---------------------------|
|            | A2F200 Function           | A2F500 Function           |
| H19        | GND                       | GND                       |
| H20        | GCC0/IO26NPB1V0           | GCC0/IO35NPB1V0           |
| H21        | VCCFPGAIOB1               | VCCFPGAIOB1               |
| H22        | GCB0/IO27NDB1V0           | GCB0/IO34NDB1V0           |
| J1         | EMC_DB[6]/GEB0/IO62NDB5V0 | EMC_DB[6]/GEB0/IO79NDB5V0 |
| J2         | EMC_DB[5]/GEA1/IO61PDB5V0 | EMC_DB[5]/GEA1/IO78PDB5V0 |
| J3         | EMC_DB[4]/GEA0/IO61NDB5V0 | EMC_DB[4]/GEA0/IO78NDB5V0 |
| J4         | EMC_DB[3]/GEC2/IO60PPB5V0 | EMC_DB[3]/GEC2/IO77PPB5V0 |
| J5         | VCCFPGAIOB5               | VCCFPGAIOB5               |
| J6         | GFA0/IO64NDB5V0           | GFA0/IO81NDB5V0           |
| J7         | VCCFPGAIOB5               | VCCFPGAIOB5               |
| J8         | GND                       | GND                       |
| J9         | VCC                       | VCC                       |
| J10        | GND                       | GND                       |
| J11        | VCC                       | VCC                       |
| J12        | GND                       | GND                       |
| J13        | VCC                       | VCC                       |
| J14        | GND                       | GND                       |
| J15        | VCC                       | VCC                       |
| J16        | GND                       | GND                       |
| J17        | NC                        | IO37PDB1V0                |
| J18        | VCCFPGAIOB1               | VCCFPGAIOB1               |
| J19        | GCA0/IO28NDB1V0           | GCA0/IO36NDB1V0           |
| J20        | GCA1/IO28PDB1V0           | GCA1/IO36PDB1V0           |
| J21        | GCC1/IO26PPB1V0           | GCC1/IO35PPB1V0           |
| J22        | GCB1/IO27PDB1V0           | GCB1/IO34PDB1V0           |
| K1         | GND                       | GND                       |
| K2         | EMC_DB[0]/GEA2/IO59NDB5V0 | EMC_DB[0]/GEA2/IO76NDB5V0 |
| K3         | EMC_DB[1]/GEB2/IO59PDB5V0 | EMC_DB[1]/GEB2/IO76PDB5V0 |
| K4         | NC                        | IO74PPB5V0                |
| K5         | EMC_DB[2]/IO60NPB5V0      | EMC_DB[2]/IO77NPB5V0      |
| K6         | NC                        | IO75PDB5V0                |
| K7         | GND                       | GND                       |
| K8         | VCC                       | VCC                       |
| K9         | GND                       | GND                       |
| K10        | VCC                       | VCC                       |

**Note:** Shading denotes pins that do not have completely identical functions from density to density. For example, the bank assignment can be different for an I/O, or the function might be available only on a larger density device.

| Pin Number | FG484           |                 |
|------------|-----------------|-----------------|
|            | A2F200 Function | A2F500 Function |
| K11        | GND             | GND             |
| K12        | VCC             | VCC             |
| K13        | GND             | GND             |
| K14        | VCC             | VCC             |
| K15        | GND             | GND             |
| K16        | VCCFPGAIOB1     | VCCFPGAIOB1     |
| K17        | NC              | IO37NDB1V0      |
| K18        | GDA1/IO31PDB1V0 | GDA1/IO40PDB1V0 |
| K19        | GDA0/IO31NDB1V0 | GDA0/IO40NDB1V0 |
| K20        | GDC1/IO29PDB1V0 | GDC1/IO38PDB1V0 |
| K21        | GDC0/IO29NDB1V0 | GDC0/IO38NDB1V0 |
| K22        | GND             | GND             |
| L1         | NC              | IO73PDB5V0      |
| L2         | NC              | IO73NDB5V0      |
| L3         | NC              | IO72PPB5V0      |
| L4         | GND             | GND             |
| L5         | NC              | IO74NPB5V0      |
| L6         | NC              | IO75NDB5V0      |
| L7         | VCCFPGAIOB5     | VCCFPGAIOB5     |
| L8         | GND             | GND             |
| L9         | VCC             | VCC             |
| L10        | GND             | GND             |
| L11        | VCC             | VCC             |
| L12        | GND             | GND             |
| L13        | VCC             | VCC             |
| L14        | GND             | GND             |
| L15        | VCC             | VCC             |
| L16        | GND             | GND             |
| L17        | GNDQ            | GNDQ            |
| L18        | GDA2/IO33NDB1V0 | GDA2/IO42NDB1V0 |
| L19        | VCCFPGAIOB1     | VCCFPGAIOB1     |
| L20        | GDB1/IO30PDB1V0 | GDB1/IO39PDB1V0 |
| L21        | GDB0/IO30NDB1V0 | GDB0/IO39NDB1V0 |
| L22        | GDC2/IO32PDB1V0 | GDC2/IO41PDB1V0 |
| M1         | NC              | IO71PDB5V0      |
| M2         | NC              | IO71NDB5V0      |

**Note:** Shading denotes pins that do not have completely identical functions from density to density. For example, the bank assignment can be different for an I/O, or the function might be available only on a larger density device.



| Pin Number | FG484           |                 |
|------------|-----------------|-----------------|
|            | A2F200 Function | A2F500 Function |
| M3         | VCCFPGAIOB5     | VCCFPGAIOB5     |
| M4         | NC              | IO72NPB5V0      |
| M5         | GNDQ            | GNDQ            |
| M6         | NC              | IO68PDB5V0      |
| M7         | GND             | GND             |
| M8         | VCC             | VCC             |
| M9         | GND             | GND             |
| M10        | VCC             | VCC             |
| M11        | GND             | GND             |
| M12        | VCC             | VCC             |
| M13        | GND             | GND             |
| M14        | VCC             | VCC             |
| M15        | GND             | GND             |
| M16        | VCCFPGAIOB1     | VCCFPGAIOB1     |
| M17        | NC              | NC              |
| M18        | GDB2/IO33PDB1V0 | GDB2/IO42PDB1V0 |
| M19        | VJTAG           | VJTAG           |
| M20        | GND             | GND             |
| M21        | VPP             | VPP             |
| M22        | IO32NDB1V0      | IO41NDB1V0      |
| N1         | GND             | GND             |
| N2         | NC              | IO70PDB5V0      |
| N3         | NC              | IO70NDB5V0      |
| N4         | VCCRCOSC        | VCCRCOSC        |
| N5         | VCCFPGAIOB5     | VCCFPGAIOB5     |
| N6         | NC              | IO68NDB5V0      |
| N7         | VCCFPGAIOB5     | VCCFPGAIOB5     |
| N8         | GND             | GND             |
| N9         | VCC             | VCC             |
| N10        | GND             | GND             |
| N11        | VCC             | VCC             |
| N12        | GND             | GND             |
| N13        | VCC             | VCC             |
| N14        | GND             | GND             |
| N15        | VCC             | VCC             |
| N16        | NC              | GND             |

**Note:** Shading denotes pins that do not have completely identical functions from density to density. For example, the bank assignment can be different for an I/O, or the function might be available only on a larger density device.

| Pin Number | FG484             |                   |
|------------|-------------------|-------------------|
|            | A2F200 Function   | A2F500 Function   |
| N17        | NC                | NC                |
| N18        | VCCFPGAIOB1       | VCCFPGAIOB1       |
| N19        | VCCENVM           | VCCENVM           |
| N20        | GNDENVM           | GNDENVM           |
| N21        | NC                | NC                |
| N22        | GND               | GND               |
| P1         | NC                | IO69NDB5V0        |
| P2         | NC                | IO69PDB5V0        |
| P3         | GNDRCOSC          | GNDRCOSC          |
| P4         | GND               | GND               |
| P5         | NC                | NC                |
| P6         | NC                | NC                |
| P7         | GND               | GND               |
| P8         | VCC               | VCC               |
| P9         | GND               | GND               |
| P10        | VCC               | VCC               |
| P11        | GND               | GND               |
| P12        | VCC               | VCC               |
| P13        | GND               | GND               |
| P14        | VCC               | VCC               |
| P15        | GND               | GND               |
| P16        | VCCFPGAIOB1       | VCCFPGAIOB1       |
| P17        | TDI               | TDI               |
| P18        | TCK               | TCK               |
| P19        | GND               | GND               |
| P20        | TMS               | TMS               |
| P21        | TDO               | TDO               |
| P22        | TRSTB             | TRSTB             |
| R1         | MSS_RESET_N       | MSS_RESET_N       |
| R2         | VCCFPGAIOB5       | VCCFPGAIOB5       |
| R3         | GPIO_1/IO46RSB4V0 | GPIO_1/IO55RSB4V0 |
| R4         | NC                | NC                |
| R5         | NC                | NC                |
| R6         | NC                | NC                |
| R7         | NC                | NC                |
| R8         | GND               | GND               |

**Note:** Shading denotes pins that do not have completely identical functions from density to density. For example, the bank assignment can be different for an I/O, or the function might be available only on a larger density device.

| Pin Number | FG484              |                    |
|------------|--------------------|--------------------|
|            | A2F200 Function    | A2F500 Function    |
| R9         | VCC                | VCC                |
| R10        | GND                | GND                |
| R11        | VCC                | VCC                |
| R12        | GND                | GND                |
| R13        | VCC                | VCC                |
| R14        | GND                | GND                |
| R15        | VCC                | VCC                |
| R16        | JTAGSEL            | JTAGSEL            |
| R17        | NC                 | NC                 |
| R18        | NC                 | NC                 |
| R19        | NC                 | NC                 |
| R20        | NC                 | NC                 |
| R21        | VCCFPGAIOB1        | VCCFPGAIOB1        |
| R22        | NC                 | NC                 |
| T1         | GND                | GND                |
| T2         | VCCMSSIOB4         | VCCMSSIOB4         |
| T3         | GPIO_8/IO39RSB4V0  | GPIO_8/IO48RSB4V0  |
| T4         | GPIO_11/IO57RSB4V0 | GPIO_11/IO66RSB4V0 |
| T5         | GND                | GND                |
| T6         | MAC_CLK            | MAC_CLK            |
| T7         | VCCMSSIOB4         | VCCMSSIOB4         |
| T8         | VCC33SDD0          | VCC33SDD0          |
| T9         | VCC15A             | VCC15A             |
| T10        | GNDAC              | GNDAC              |
| T11        | GND33ADC0          | GND33ADC0          |
| T12        | ADC7               | ADC7               |
| T13        | NC                 | TM4                |
| T14        | NC                 | VAREF2             |
| T15        | VAREFOUT           | VAREFOUT           |
| T16        | VCCMSSIOB2         | VCCMSSIOB2         |
| T17        | SPI_1_DO/GPIO_24   | SPI_1_DO/GPIO_24   |
| T18        | GND                | GND                |
| T19        | NC                 | NC                 |
| T20        | NC                 | NC                 |
| T21        | VCCMSSIOB2         | VCCMSSIOB2         |
| T22        | GND                | GND                |

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| Pin Number | FG484                 |                       |
|------------|-----------------------|-----------------------|
|            | A2F200 Function       | A2F500 Function       |
| U1         | GND                   | GND                   |
| U2         | GPIO_5/IO42RSB4V0     | GPIO_5/IO51RSB4V0     |
| U3         | GPIO_10/IO58RSB4V0    | GPIO_10/IO67RSB4V0    |
| U4         | VCCMSSIOB4            | VCCMSSIOB4            |
| U5         | MAC_RXD[1]/IO53RSB4V0 | MAC_RXD[1]/IO62RSB4V0 |
| U6         | NC                    | NC                    |
| U7         | VCC33AP               | VCC33AP               |
| U8         | VCC33N                | VCC33N                |
| U9         | CM1                   | CM1                   |
| U10        | VAREF0                | VAREF0                |
| U11        | GND33ADC1             | GND33ADC1             |
| U12        | ADC4                  | ADC4                  |
| U13        | NC                    | GNDTM2                |
| U14        | NC                    | ADC11                 |
| U15        | GNDVAREF              | GNDVAREF              |
| U16        | VCC33SDD1             | VCC33SDD1             |
| U17        | SPI_0_DO/GPIO_16      | SPI_0_DO/GPIO_16      |
| U18        | UART_0_RXD/GPIO_21    | UART_0_RXD/GPIO_21    |
| U19        | VCCMSSIOB2            | VCCMSSIOB2            |
| U20        | I2C_1_SCL/GPIO_31     | I2C_1_SCL/GPIO_31     |
| U21        | I2C_0_SCL/GPIO_23     | I2C_0_SCL/GPIO_23     |
| U22        | GND                   | GND                   |
| V1         | GPIO_0/IO47RSB4V0     | GPIO_0/IO56RSB4V0     |
| V2         | GPIO_6/IO41RSB4V0     | GPIO_6/IO50RSB4V0     |
| V3         | GPIO_9/IO38RSB4V0     | GPIO_9/IO47RSB4V0     |
| V4         | MAC_MDIO/IO49RSB4V0   | MAC_MDIO/IO58RSB4V0   |
| V5         | MAC_RXD[0]/IO54RSB4V0 | MAC_RXD[0]/IO63RSB4V0 |
| V6         | GND                   | GND                   |
| V7         | SDD0                  | SDD0                  |
| V8         | ABPS1                 | ABPS1                 |
| V9         | ADC2                  | ADC2                  |
| V10        | VCC33ADC0             | VCC33ADC0             |
| V11        | ADC6                  | ADC6                  |
| V12        | ADC5                  | ADC5                  |
| V13        | ABPS5                 | ABPS5                 |
| V14        | NC                    | ADC8                  |

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| Pin Number | FG484                 |                       |
|------------|-----------------------|-----------------------|
|            | A2F200 Function       | A2F500 Function       |
| V15        | NC                    | GND33ADC2             |
| V16        | NC                    | NC                    |
| V17        | GND                   | GND                   |
| V18        | SPI_0_DI/GPIO_17      | SPI_0_DI/GPIO_17      |
| V19        | SPI_1_DI/GPIO_25      | SPI_1_DI/GPIO_25      |
| V20        | UART_1_TXD/GPIO_28    | UART_1_TXD/GPIO_28    |
| V21        | I2C_0_SDA/GPIO_22     | I2C_0_SDA/GPIO_22     |
| V22        | I2C_1_SDA/GPIO_30     | I2C_1_SDA/GPIO_30     |
| W1         | GPIO_2/IO45RSB4V0     | GPIO_2/IO54RSB4V0     |
| W2         | GPIO_7/IO40RSB4V0     | GPIO_7/IO49RSB4V0     |
| W3         | GND                   | GND                   |
| W4         | MAC_CRSDV/IO51RSB4V0  | MAC_CRSDV/IO60RSB4V0  |
| W5         | MAC_TXD[1]/IO55RSB4V0 | MAC_TXD[1]/IO64RSB4V0 |
| W6         | NC                    | SDD2                  |
| W7         | GND                   | GND                   |
| W8         | TM0                   | TM0                   |
| W9         | ABPS2                 | ABPS2                 |
| W10        | GND33ADC0             | GND33ADC0             |
| W11        | VCC15ADC1             | VCC15ADC1             |
| W12        | ABPS6                 | ABPS6                 |
| W13        | NC                    | CM4                   |
| W14        | NC                    | ABPS9                 |
| W15        | NC                    | VCC33ADC2             |
| W16        | GND                   | GND                   |
| W17        | PU_N                  | PU_N                  |
| W18        | GNDSD1                | GNDSD1                |
| W19        | SPI_0_CLK/GPIO_18     | SPI_0_CLK/GPIO_18     |
| W20        | GND                   | GND                   |
| W21        | SPI_1_SS/GPIO_27      | SPI_1_SS/GPIO_27      |
| W22        | UART_1_RXD/GPIO_29    | UART_1_RXD/GPIO_29    |
| Y1         | GPIO_3/IO44RSB4V0     | GPIO_3/IO53RSB4V0     |
| Y2         | VCCMSSIOB4            | VCCMSSIOB4            |
| Y3         | GPIO_15/IO34RSB4V0    | GPIO_15/IO43RSB4V0    |
| Y4         | MAC_TXEN/IO52RSB4V0   | MAC_TXEN/IO61RSB4V0   |
| Y5         | VCCMSSIOB4            | VCCMSSIOB4            |
| Y6         | GNDSD0                | GNDSD0                |

**Note:** Shading denotes pins that do not have completely identical functions from density to density. For example, the bank assignment can be different for an I/O, or the function might be available only on a larger density device.

| Pin Number | FG484              |                    |
|------------|--------------------|--------------------|
|            | A2F200 Function    | A2F500 Function    |
| Y7         | CM0                | CM0                |
| Y8         | GNDTM0             | GNDTM0             |
| Y9         | ADC0               | ADC0               |
| Y10        | VCC15ADC0          | VCC15ADC0          |
| Y11        | ABPS7              | ABPS7              |
| Y12        | TM3                | TM3                |
| Y13        | NC                 | ABPS8              |
| Y14        | NC                 | GND33ADC2          |
| Y15        | NC                 | VCC15ADC2          |
| Y16        | VCCMAINXTAL        | VCCMAINXTAL        |
| Y17        | SDD1               | SDD1               |
| Y18        | PTEM               | PTEM               |
| Y19        | VCC33A             | VCC33A             |
| Y20        | SPI_0_SS/GPIO_19   | SPI_0_SS/GPIO_19   |
| Y21        | VCCMSSIOB2         | VCCMSSIOB2         |
| Y22        | UART_0_TXD/GPIO_20 | UART_0_TXD/GPIO_20 |

**Note:** Shading denotes pins that do not have completely identical functions from density to density. For example, the bank assignment can be different for an I/O, or the function might be available only on a larger density device.

## 6 – Datasheet Information

### List of Changes

The following table lists critical changes that were made in each revision of the SmartFusion datasheet.

| Revision                    | Changes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Page                                 |
|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|
| Revision 7<br>(August 2011) | The title of the datasheet was changed from SmartFusion Intelligent Mixed Signal FPGAs to SmartFusion Customizable System-on-Chip (cSoC). Terminology throughout was changed accordingly. The term cSoC defines a category of devices that include at least FPGA fabric and a processor subsystem of some sort. It can also include any of the following: analog, SerDes, ASIC blocks, customer specific IP, or application-specific IP. SmartFusion is Microsemi's first cSoC (SAR 33071).                                                                                  | N/A                                  |
|                             | The "SmartFusion cSoC Family Product Table" was revised to remove the note stating that the A2F060 device is under definition and subject to change (SAR 33070). A note was added for EMC, stating that it is not available on A2F500 for the PQ208 package (SAR 33041).                                                                                                                                                                                                                                                                                                     | II                                   |
|                             | The "SmartFusion cSoC Device Status" table was revised. The status for A2F060 CS288 and FG256 moved from Advance to Preliminary. A2F200 PQ208 and A2F500 PQ208 moved from Advance to Production (SAR 33069).                                                                                                                                                                                                                                                                                                                                                                 | III                                  |
|                             | The "Package I/Os: MSS + FPGA I/Os" table was revised. The number of direct analog inputs for A2F060 packages increased from 6 to 11. The number of MSS I/Os for the A2F060 FG256 package increased from 25 to 26 (SAR 33070). A note was added stating that EMC is not available for the A2F500 PQ208 package (SAR 33041).                                                                                                                                                                                                                                                  | III                                  |
|                             | The note associated with the "SmartFusion cSoC System Architecture" diagram was corrected from "Architecture for A2F500" to "Architecture for A2F200" (SAR 32578).                                                                                                                                                                                                                                                                                                                                                                                                           | V                                    |
|                             | The Licensed DPA Logo was added to the "Product Ordering Codes" section. The trademarked Licensed DPA Logo identifies that a product is covered by a DPA counter-measures license from Cryptography Research (SAR 32151).                                                                                                                                                                                                                                                                                                                                                    | VI                                   |
|                             | The "Security" section and "Secure Programming" section were updated to clarify that although no existing security measures can give an absolute guarantee, SmartFusion cSoCs implement the best security available in the industry (SAR 32865).                                                                                                                                                                                                                                                                                                                             | 1-2, 4-9                             |
|                             | Storage temperature, $T_{STG}$ , and junction temperature, $T_J$ , were added to Table 2-1 • Absolute Maximum Ratings (SAR 30863).                                                                                                                                                                                                                                                                                                                                                                                                                                           | 2-1                                  |
|                             | AC/DC characteristics for A2F060 were added to the "SmartFusion DC and Switching Characteristics" chapter (SAR 33132). The following tables were updated:<br>Table 2-14 • Different Components Contributing to Dynamic Power Consumption in SmartFusion cSoCs<br>Table 2-15 • Different Components Contributing to the Static Power Consumption in SmartFusion cSoCs<br>Table 2-90 • eNVM Block Timing, Worst Commercial Case Conditions: $T_J = 85^{\circ}\text{C}$ , $V_{CC} = 1.425\text{ V}$<br>Table 2-99 • Analog Sigma-Delta DAC<br>Table 2-101 • SPI Characteristics | 2-12<br>2-13<br>2-74<br>2-84<br>2-88 |

| Revision                  | Changes                                                                                                                                                                                                                                                                                                                                                                                                           | Page            |
|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| Revision 7<br>(continued) | The following sentence was removed from the "I/O Power-Up and Supply Voltage Thresholds for Power-On Reset (Commercial and Industrial)" section because it is incorrect (SAR 31047):<br>"The many different supplies can power up in any sequence with minimized current spikes or surges."                                                                                                                       | 2-4             |
|                           | Table 2-8 • Quiescent Supply Current Characteristics was divided into two tables: one for power supplies configurations and one for quiescent supply current. SoC mode was added to both tables (SAR 26378) and VCOMPLAx was removed from Table 2-8 • Power Supplies Configuration (SAR 29591). Quiescent supply current values were updated in Table 2-9 • Quiescent Supply Current Characteristics (SAR 33067). | 2-10            |
|                           | The "Total Static Power Consumption— $P_{STAT}$ " section was revised: " $N_{eNVM-BLOCKS} * P_{DC4}$ " was removed from the equation for $P_{STAT}$ (SAR 33067).                                                                                                                                                                                                                                                  | 2-14            |
|                           | Table 2-14 • Different Components Contributing to Dynamic Power Consumption in SmartFusion cSoCs and Table 2-15 • Different Components Contributing to the Static Power Consumption in SmartFusion cSoCs were revised to reflect updates in the SmartFusion power calculator (SARs 26405, 33067).                                                                                                                 | 2-12,<br>2-13   |
|                           | Table 2-82 • A2F060 Global Resource is new (SAR 33132).                                                                                                                                                                                                                                                                                                                                                           | 2-61            |
|                           | Output duty cycle was corrected to 50% in Table 2-83 • Electrical Characteristics of the RC Oscillator. It was incorrectly noted as 1% previously. Operating current for 3.3 domain was added (SAR 32940).                                                                                                                                                                                                        | 2-61            |
|                           | Table 2-86 • SmartFusion CCC/PLL Specification was revised to add information and measurements regarding CCC output peak-to-peak period jitter (SAR 32996).                                                                                                                                                                                                                                                       | 2-63            |
|                           | The port names in the SRAM "Timing Waveforms", SRAM "Timing Characteristics" tables, Figure 2-36 • FIFO Reset, and the FIFO "Timing Waveforms" tables were revised to ensure consistency with the software names (SAR 29991).                                                                                                                                                                                     | 2-66 to<br>2-74 |
|                           | Table 2-90 • eNVM Block Timing, Worst Commercial Case Conditions: $T_J = 85^{\circ}\text{C}$ , $V_{CC} = 1.425\text{ V}$ was revised to correct the maximum frequencies (SAR 32410).                                                                                                                                                                                                                              | 2-74            |
|                           | Table 2-96 • VAREF Stabilization Time was moved to the "SmartFusion DC and Switching Characteristics" section from the SmartFusion Programmable Analog User's Guide because the information is extracted from characterization (SAR 24298).                                                                                                                                                                       | 2-80            |
|                           | The hysteresis section in Table 2-98 • Comparator Performance Specifications was revised (SAR 33158).                                                                                                                                                                                                                                                                                                             | 2-83            |
|                           | The "SmartFusion Development Tools" was extensively updated (SAR 33216).                                                                                                                                                                                                                                                                                                                                          | 3-1             |
|                           | The text following Table 4-2 • JTAG Pin Descriptions was updated to add information on control of the JTAGSEL pin. Manual jumpers on the evaluation and development kits allow manual selection of this function for J-Link and ULINK debuggers (SAR 25592).                                                                                                                                                      | 4-7             |



| Revision                   | Changes                                                                                                                                                                                                                                                                                                                                                                                                                  | Page                   |
|----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| Revision 7<br>(continued)  | Usage instructions, such as how to handle the pin when unused, were added for the following supply pins (SAR 29769):<br>"VCC15A"<br>"VCC15ADC0" through "VCC15ADC2"<br>"VCC33ADC0" through "VCC33ADC2"<br>"VCC33AP"<br>"VCC33ADC2"<br>"VCCLPXTAL"<br>"VCCMAINXTAL"<br>"VCCMSSIOB2"<br>"VCCPLLx"<br>"VCCRCOSC"<br>"VDDBAT"                                                                                                | 5-1<br>through<br>5-3  |
|                            | The "IO" description was revised to clarify the definitions of u, I/O pair, and w, differential pair (SAR 31147). Information on configuration of unused I/Os (including unused MSS I/Os, SAR 26891) was added (SAR 32643).                                                                                                                                                                                              | 5-5                    |
|                            | Usage instructions were added for the following pins (SAR 29769):<br>"MSS_RESET_N"<br>"TCK"<br>"TMS"<br>"TRSTB"<br>"MAC_CLK"                                                                                                                                                                                                                                                                                             | 5-7<br>through<br>5-11 |
|                            | Package names used in the "Pin Assignment Tables" section were revised to match standards given in <i>Package Mechanical Drawings</i> (SAR 27395).                                                                                                                                                                                                                                                                       | 5-16                   |
|                            | The pin assignments for A2F060 for "CS288" and "FG256" have been revised due to the device status change from advance to preliminary (SAR 33068).<br>The "CS288" and "FG256" pin assignment sections previously compared functions between A2F060/A2F200 devices in one table and A2F200/A2F500 in a separate table. Functions for all three devices have now been combined into one table for each package (SAR 33072). | 5-16,<br>5-33          |
|                            | The "PQ208" pin table was revised for A2F500 to remove EMC functions, which are not available for this device/package combination (SAR 33041).                                                                                                                                                                                                                                                                           | 5-26                   |
| Revision 6<br>(March 2011) | The "PQ208" package was added to product tables and "Product Ordering Codes" for A2F200 and A2F500 (SAR 31005).                                                                                                                                                                                                                                                                                                          | III                    |
|                            | The "Package I/Os: MSS + FPGA I/Os" table was revised to add the CS288 package for A2F060 and the PQ208 package for A2F200 and A2F500. A row was added for shared analog inputs (SAR 31034).                                                                                                                                                                                                                             | III                    |
|                            | The "SmartFusion cSoC Device Status" table was updated (SAR 31084).                                                                                                                                                                                                                                                                                                                                                      | III                    |
|                            | VCCEsRAM was added to Table 2-1 • Absolute Maximum Ratings, Table 2-3 • Recommended Operating Conditions, Table 2-8 • Power Supplies Configuration, and the "Supply Pins" table (SAR 31035).                                                                                                                                                                                                                             | 2-1, 2-3,<br>2-10, 5-1 |
|                            | The following note was removed from Table 2-8 • Power Supplies Configuration (SAR 30984):<br>"Current monitors and temperature monitors should not be used when Power-Down and/or Sleep mode are required by the application."                                                                                                                                                                                           | 2-10                   |

| Revision                      | Changes                                                                                                                                                                                                                                                                                                                                                                                                | Page          |
|-------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| Revision 6<br>(continued)     | Dynamic power values were updated in the following tables. The table subtitles changed where FPGA I/O banks were involved to note "I/O assigned to EMC I/O pins" (SAR 30987).                                                                                                                                                                                                                          | 2-10          |
|                               | Table 2-10 • Summary of I/O Input Buffer Power (per pin) – Default I/O Software Settings                                                                                                                                                                                                                                                                                                               | 2-11          |
|                               | Table 2-13 • Summary of I/O Output Buffer Power (per pin) – Default I/O Software Settings.                                                                                                                                                                                                                                                                                                             |               |
|                               | The "Timing Model" was updated (SAR 30986).                                                                                                                                                                                                                                                                                                                                                            | 2-19          |
|                               | Values in the timing tables for the following sections were updated. Table subtitles were updated for FPGA I/O banks to note "I/O assigned to EMC I/O pins" (SAR 30986).                                                                                                                                                                                                                               |               |
|                               | "Overview of I/O Performance" section: Table 2-24, Table 2-25                                                                                                                                                                                                                                                                                                                                          | 2-23          |
|                               | "Detailed I/O DC Characteristics" section: Table 2-38, Table 2-39, Table 2-40, Table 2-44, Table 2-45, Table 2-46, Table 2-50, Table 2-51, Table 2-52, Table 2-56, Table 2-57, Table 2-58, Table 2-61, Table 2-62                                                                                                                                                                                      | 2-26          |
|                               | "LVDS" section: Table 2-65                                                                                                                                                                                                                                                                                                                                                                             | 2-40          |
| Revision 5<br>(December 2010) | "LVPECL" section: Table 2-68                                                                                                                                                                                                                                                                                                                                                                           | 2-43          |
|                               | "Global Tree Timing Characteristics" section: Table 2-80, Table 2-81                                                                                                                                                                                                                                                                                                                                   | 2-59          |
|                               | The "PQ208" section and pin tables are new (SAR 31005).                                                                                                                                                                                                                                                                                                                                                | 5-26          |
|                               | Global clocks were removed from the A2F060 pin table for the "CS288" and "FG256" packages, resulting in changed function names for affected pins (SAR 31033).                                                                                                                                                                                                                                          | 5-34          |
|                               | Table 2-2 • Analog Maximum Ratings was revised. The recommended CM[n] pad voltage (relative to ground) was changed from –11 to –0.3 (SAR 28219).                                                                                                                                                                                                                                                       | 2-2           |
|                               | Table 2-7 • Temperature and Voltage Derating Factors for Timing Delays was revised to change the values for 100°C.                                                                                                                                                                                                                                                                                     | 2-9           |
|                               | Power-down and Sleep modes, and all associated notes, were removed from Table 2-8 • Power Supplies Configuration (SAR 29479). IDC3 and IDC4 were renamed to IDC1 and IDC2 (SAR 29478). These modes are no longer supported. A note was added to the table stating that current monitors and temperature monitors should not be used when Power-down and/or Sleep mode are required by the application. | 2-10          |
|                               | The "Power-Down and Sleep Mode Implementation" section was deleted (SAR 29479).                                                                                                                                                                                                                                                                                                                        | N/A           |
|                               | Values for PAC9 and PAC10 for LVDS and LVPECL were revised in Table 2-10 • Summary of I/O Input Buffer Power (per pin) – Default I/O Software Settings and Table 2-12 • Summary of I/O Output Buffer Power (per pin) – Default I/O Software Settings*.                                                                                                                                                 | 2-10,<br>2-11 |
|                               | Values for PAC1 through PAC4, PDC1, and PDC2 were added for A2F500 in Table 2-14 • Different Components Contributing to Dynamic Power Consumption in SmartFusion cSoCs and Table 2-15 • Different Components Contributing to the Static Power Consumption in SmartFusion cSoCs                                                                                                                         | 2-12,<br>2-13 |
|                               | The equation for "Total Dynamic Power Consumption— $P_{DYN}$ " in "SoC Mode" was revised to add $P_{MSS}$ . The "Microcontroller Subsystem Dynamic Contribution— $P_{MSS}$ " section is new (SAR 29462).                                                                                                                                                                                               | 2-14,<br>2-18 |
|                               | Information in Table 2-24 • Summary of I/O Timing Characteristics—Software Default Settings (applicable to FPGA I/O banks) and Table 2-25 • Summary of I/O Timing Characteristics—Software Default Settings (applicable to MSS I/O banks) was updated.                                                                                                                                                 | 2-25          |

| Revision                       | Changes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Page         |
|--------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| Revision 5<br>(continued)      | Available values for the Std. speed were added to the timing tables from <a href="#">Table 2-38 • 3.3 V LVTTTL / 3.3 V LVCMOS High Slew</a> to <a href="#">Table 2-92 • JTAG 1532</a> (SAR 29331).<br>One or more values changed for the –1 speed in tables covering 3.3 V LVCMOS, 2.5 V LVCMOS, 1.8 V LVCMOS, 1.5 V LVCMOS, Combinatorial Cell Propagation Delays, and A2F200 Global Resources.                                                                                                                              | 2-31 to 2-75 |
|                                | <a href="#">Table 2-80 • A2F500 Global Resource</a> is new.                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 2-60         |
|                                | <a href="#">Table 2-90 • eNVM Block Timing, Worst Commercial Case Conditions: T<sub>J</sub> = 85°C, VCC = 1.425 V</a> was revised (SAR 27585).                                                                                                                                                                                                                                                                                                                                                                                | 2-74         |
|                                | The programmable analog specifications tables were revised with updated information.                                                                                                                                                                                                                                                                                                                                                                                                                                          | 2-76 to 2-86 |
|                                | <a href="#">Table 4-1 • Supported JTAG Programming Hardware</a> was revised by adding a note to indicate "planned support" for several of the items in the table.                                                                                                                                                                                                                                                                                                                                                             | 4-7          |
|                                | The note on JTAGSEL in the <a href="#">"In-System Programming" section</a> was revised to state that SoftConsole selects the appropriate TAP controller using the CTXSELECT JTAG command. When using SoftConsole, the state of JTAGSEL is a "don't care" (SAR 29261).                                                                                                                                                                                                                                                         | 4-7          |
|                                | The <a href="#">"CS288"</a> and <a href="#">"FG256"</a> pin tables for A2F060 are new, comparing the A2F060 function with the A2F200 function (SAR 29353).                                                                                                                                                                                                                                                                                                                                                                    | 5-17         |
|                                | The <a href="#">"Handling When Unused"</a> column was removed from the <a href="#">"FG256"</a> pin table for A2F200 and A2F500 (SAR 29691).                                                                                                                                                                                                                                                                                                                                                                                   | 5-33         |
| Revision 4<br>(September 2010) | <a href="#">Table 2-8 • Power Supplies Configuration</a> was revised. VCCRCOSC was moved to a column of its own with new values. VCCENVM was added to the table. Standby mode for VJTAG and VPP was changed from 0 V to N/A. "Disable" was changed to "Off" in the eNVM column. The column for RCOSC was deleted.                                                                                                                                                                                                             | 2-10         |
|                                | The <a href="#">"Power-Down and Sleep Mode Implementation" section</a> was revised to include VCCROSC.                                                                                                                                                                                                                                                                                                                                                                                                                        | 2-11         |
| Revision 3<br>(September 2010) | The <a href="#">"I/Os and Operating Voltage" section</a> was revised to list "single 3.3 V power supply with on-chip 1.5 V regulator" and "external 1.5 V is allowed" (SAR 27663).                                                                                                                                                                                                                                                                                                                                            | I            |
|                                | The CS288 package was added to the <a href="#">"Package I/Os: MSS + FPGA I/Os" table</a> (SAR 27101), <a href="#">"Product Ordering Codes" table</a> , and <a href="#">"Temperature Grade Offerings" table</a> (SAR 27044). The number of direct analog inputs for the FG256 package in A2F060 was changed from 8 to 6.                                                                                                                                                                                                       | III, VI, VI  |
|                                | Two notes were added to the <a href="#">"SmartFusion cSoC Family Product Table"</a> indicating limitations for features of the A2F500 device:<br><i>Two PLLs are available in CS288 and FG484 (one PLL in FG256).<br/>[ADCs, DACs, SCBs, comparators, current monitors, and bipolar high voltage monitors are] Available on FG484 only. FG256 and CS288 packages offer the same programmable analog capabilities as A2F200.</i><br>Table cells were merged in rows containing the same values for easier reading (SAR 24748). | II           |

| Revision                  | Changes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Page |
|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| Revision 3<br>(continued) | The security feature option was added to the "Product Ordering Codes" table.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | VI   |
|                           | In <a href="#">Table 2-3 • Recommended Operating Conditions</a> , the VDDBAT recommended operating range was changed from "2.97 to 3.63" to "2.7 to 3.63" (SAR 25246). Recommended operating range was changed to "3.15 to 3.45" for the following voltages:<br>VCC33A<br>VCC33ADCx<br>VCC33AP<br>VCC33SDDx<br>VCCMAINXTAL<br>VCCLPXTAL<br>Two notes were added to the table (SAR 27109):<br>1. The following 3.3 V supplies should be connected together while following proper noise filtering practices: VCC33A, VCC33ADCx, VCC33AP, VCC33SDDx, VCCMAINXTAL, and VCCLPXTAL.<br>2. The following 1.5 V supplies should be connected together while following proper noise filtering practices: VCC, VCC15A, and VCC15ADCx. | 2-3  |
|                           | In <a href="#">Table 2-3 • Recommended Operating Conditions</a> , the description for VCCLPXTAL was corrected to change "32 Hz" to "32 KHz" (SAR 27110).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 2-3  |
|                           | The "Power Supply Sequencing Requirement" section is new (SAR 27178).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 2-4  |
|                           | <a href="#">Table 2-8 • Power Supplies Configuration</a> was revised to change most on/off entries to voltages. Note 5 was added, stating that "on" means proper voltage is applied. The values of 6 $\mu$ A and 16 $\mu$ A were removed for IDC1 and IDC2 for 3.3 V. A note was added for IDC1 and IDC2: "Power mode and Sleep mode are consuming higher current than expected in the current version of silicon. These specifications will be updated when new version of the silicon is available" (SAR 27926).                                                                                                                                                                                                           | 2-10 |
|                           | The "Power-Down and Sleep Mode Implementation" section is new (SAR 27178).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 2-11 |
|                           | A note was added to <a href="#">Table 2-86 • SmartFusion CCC/PLL Specification</a> , pertaining to $f_{out\_CCC}$ , stating that "one of the CCC outputs (GLA0) is used as an MSS clock and is limited to 100 MHz (maximum) by software" (SAR 26388).                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 2-63 |
|                           | <a href="#">Table 2-90 • eNVM Block Timing, Worst Commercial Case Conditions: <math>T_J = 85^{\circ}\text{C}</math>, <math>V_{CC} = 1.425\text{ V}</math></a> was revised. Values were included for A2F200 and A2F500, for –1 and Std. speed grades. A note was added to define 6:1:1:1 and 5:1:1:1 (SAR 26166).                                                                                                                                                                                                                                                                                                                                                                                                             | 2-74 |
|                           | The units were corrected (mV instead of V) for input referred offset voltage, GDEC[1:0] = 00 in <a href="#">Table 2-97 • ABPS Performance Specifications</a> (SAR 25381).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 2-81 |
|                           | The test condition values for operating current (ICC33A, typical) were changed in <a href="#">Table 2-100 • Voltage Regulator</a> (SAR 26465).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 2-86 |
|                           | <a href="#">Figure 2-44 • Typical Output Voltage</a> was revised to add legends for the three curves, stating the load represented by each (SAR 25247).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 2-87 |
|                           | The "SmartFusion Programming" chapter was moved to this document from the SmartFusion Subsystem Microcontroller User's Guide (SAR 26542). The "Typical Programming and Erase Times" section was added to this chapter.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 4-7  |
|                           | <a href="#">Figure 4-1 • TRSTB Logic</a> was revised to change 1.5 V to "VJTAG (1.5 V to 3.3 V nominal)" (SAR 24694).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 4-8  |

| Revision                   | Changes                                                                                                                                                                                                                                                                                                                                                                                   | Page             |
|----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|
| Revision 3<br>(continued)  | Two notes were added to the "Supply Pins" table (SAR 27109):<br>1. The following supplies should be connected together while following proper noise filtering practices: VCC33A, VCC33ADCx, VCC33AP, VCC33SDDx, VCCMAINXTAL, and VCCLPXTAL.<br>2. The following 1.5 V supplies should be connected together while following proper noise filtering practices: VCC, VCC15A, and VCC15ADCx. | 5-1              |
|                            | The descriptions for the "VCC33N", "NCAP", and "PCAP" pins were revised to include information on what to do if analog SCB features and SDDs are not used (SAR 26744).                                                                                                                                                                                                                    | 5-2, 5-6,<br>5-7 |
|                            | Information was added to the "User Pins" table regarding tristating of used and unused GPIO pins. The IO portion of the table was revised to state that unused I/O pins are disabled by Libero IDE software and include a weak pull-up resistor (SAR 26890). Information was added regarding behavior of used I/O pins during power-up.                                                   | 5-5              |
|                            | The type for "EMC_RW_N" was changed from In/out to Out (SAR 25113).                                                                                                                                                                                                                                                                                                                       | 5-10             |
|                            | A note was added to the "Analog Front-End (AFE)" table stating that unused analog inputs should be grounded (SAR 26744).                                                                                                                                                                                                                                                                  | 5-12             |
|                            | The "CS288" section is new, with pin tables for A2F200 and A2F500 (SAR 27044).                                                                                                                                                                                                                                                                                                            | 5-16             |
|                            | The "FG256" pin table was replaced and now includes "Handling When Unused" information (SAR 27709).                                                                                                                                                                                                                                                                                       | 5-33             |
|                            |                                                                                                                                                                                                                                                                                                                                                                                           |                  |
| Revision 2<br>(May 2010)   | Embedded nonvolatile flash memory (eNVM) was changed from "64 to 512 Kbytes" to "128 to 512 Kbytes" in the "Microcontroller Subsystem (MSS)" section and "SmartFusion cSoC Family Product Table" (SAR 26005).                                                                                                                                                                             | I, II            |
|                            | The main oscillator range of values was changed to "32 KHz to 20 MHz" in the "Microcontroller Subsystem (MSS)" section and the "SmartFusion cSoC Family Product Table" (SAR 24906).                                                                                                                                                                                                       | I, II            |
|                            | The value for t <sub>PD</sub> was changed from 50 ns to 15 ns for the high-speed voltage comparators listed in the "Analog Front-End (AFE)" section (SAR 26005).                                                                                                                                                                                                                          | I                |
|                            | The number of PLLs for A2F200 was changed from 2 to 1 in the "SmartFusion cSoC Family Product Table" (SAR 25093).                                                                                                                                                                                                                                                                         | II               |
|                            | Values for direct analog input, total analog input, and total I/Os were updated for the FG256 package, A2F060, in the "Package I/Os: MSS + FPGA I/Os" table. The Max. column was removed from the table (SAR 26005).                                                                                                                                                                      | III              |
|                            | The Speed Grade section of the "Product Ordering Codes" table was revised (SAR 25257).                                                                                                                                                                                                                                                                                                    | VI               |
| Revision 1<br>(March 2010) | The "Product Ordering Codes" table was revised to add "blank" as an option for lead-free packaging and application (junction temperature range).                                                                                                                                                                                                                                          | VI               |
|                            | Table 2-3 • Recommended Operating Conditions was revised. Ta (ambient temperature) was replaced with T <sub>J</sub> (junction temperature).                                                                                                                                                                                                                                               | 2-3              |
|                            | PDC5 was deleted from Table 2-15 • Different Components Contributing to the Static Power Consumption in SmartFusion cSoCs.                                                                                                                                                                                                                                                                | 2-13             |
|                            | The formulas in the footnotes for Table 2-29 • I/O Weak Pull-Up/Pull-Down Resistances were revised.                                                                                                                                                                                                                                                                                       | 2-27             |
|                            | The values for input biased current were revised in Table 2-93 • Current Monitor Performance Specification.                                                                                                                                                                                                                                                                               | 2-76             |

| Revision                   | Changes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Page            |
|----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| Revision 0<br>(March 2010) | The "Analog Front-End (AFE)" section was updated to change the throughput for 10-bit mode from 600 Ksps to 550 Ksps.                                                                                                                                                                                                                                                                                                                                                                                                                | I               |
|                            | The A2F060 device was added to product information tables.                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | N/A             |
|                            | The "Product Ordering Codes" table was updated to removed Std. speed and add speed grade 1. Pre-production was removed from the application ordering code category.                                                                                                                                                                                                                                                                                                                                                                 | VI              |
|                            | The "SmartFusion cSoC Block Diagram" was revised.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | IV              |
|                            | The "Datasheet Categories" section was updated, referencing the "SmartFusion cSoC Block Diagram" table, which is new.                                                                                                                                                                                                                                                                                                                                                                                                               | 1-4, IV         |
|                            | The "VCCI" parameter was renamed to "VCCxxxIOBx."<br>"Advanced I/Os" were renamed to "FPGA I/Os."<br>Generic pin names that represent multiple pins were standardized with a lower case x as a placeholder. For example, VAREFx designates VAREF0, VAREF1, and VAREF2.<br>Modes were renamed as follows:<br>Operating mode was renamed to SoC mode.<br>32KHz Active mode was renamed to Standby mode.<br>Battery mode was renamed to Time Keeping mode.<br>Table entries have been filled with values as data has become available. | N/A             |
|                            | Table 2-1 • Absolute Maximum Ratings, Table 2-2 • Analog Maximum Ratings, and Table 2-3 • Recommended Operating Conditions were revised extensively.                                                                                                                                                                                                                                                                                                                                                                                | 2-1 through 2-3 |
|                            | Device names were updated in Table 2-6 • Package Thermal Resistance.                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 2-7             |
|                            | Table 2-8 • Power Supplies Configuration was revised extensively.                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 2-10            |
|                            | Table 2-11 • Summary of I/O Input Buffer Power (per pin) – Default I/O Software Settings was revised extensively.                                                                                                                                                                                                                                                                                                                                                                                                                   | 2-11            |
|                            | Removed "Example of Power Calculation."                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | N/A             |
|                            | Table 2-14 • Different Components Contributing to Dynamic Power Consumption in SmartFusion cSoCs was revised extensively.                                                                                                                                                                                                                                                                                                                                                                                                           | 2-12            |
|                            | Table 2-15 • Different Components Contributing to the Static Power Consumption in SmartFusion cSoCs was revised extensively.                                                                                                                                                                                                                                                                                                                                                                                                        | 2-13            |
|                            | The "Power Calculation Methodology" section was revised.                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 2-14            |
|                            | Table 2-83 • Electrical Characteristics of the RC Oscillator was revised extensively.                                                                                                                                                                                                                                                                                                                                                                                                                                               | 2-61            |
|                            | Table 2-85 • Electrical Characteristics of the Low Power Oscillator was revised extensively.                                                                                                                                                                                                                                                                                                                                                                                                                                        | 2-62            |
|                            | The parameter $t_{RSTBQ}$ was changed to $T_{C2CWRH}$ in Table 2-87 • RAM4K9.                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 2-69            |
|                            | The 12-bit mode row for integral non-linearity was removed from Table 2-95 • ADC Specifications. The typical value for 10-bit mode was revised. The table note was punctuated correctly to make it clear.                                                                                                                                                                                                                                                                                                                           | 2-79            |
|                            | Figure 37-34 • Write Access after Write onto Same Address, Figure 37-34 • Read Access after Write onto Same Address, and Figure 37-34 • Write Access after Read onto Same Address were deleted.                                                                                                                                                                                                                                                                                                                                     | N/A             |
|                            | Table 2-100 • Voltage Regulator was revised extensively.                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 2-86            |
|                            | The "Serial Peripheral Interface (SPI) Characteristics" section and "Inter-Integrated Circuit (I <sup>2</sup> C) Characteristics" section are new.                                                                                                                                                                                                                                                                                                                                                                                  | 2-88, 2-90      |



| Revision                   | Changes                                                                                                                                                                                                                                  | Page                   |
|----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| Revision 0<br>(continued)  | "SmartFusion Development Tools" section was replaced with new content.                                                                                                                                                                   | 3-1                    |
|                            | The pin description tables were revised by adding additional pins to reflect the pinout for A2F500.                                                                                                                                      | 5-1<br>through<br>5-14 |
|                            | The descriptions for "GNDSDDD1" and "VCC33SDDD1" were revised.                                                                                                                                                                           | 5-1, 5-2               |
|                            | The description for "VCC33A" was revised.                                                                                                                                                                                                | 5-2                    |
|                            | The pin tables for the "FG256" and "FG484" were replaced with tables that compare pin functions across densities for each package.                                                                                                       | 5-33                   |
| Draft B<br>(December 2009) | The "Digital I/Os" section was renamed to the "I/Os and Operating Voltage" section and information was added regarding digital and analog VCC.                                                                                           | I                      |
|                            | The "SmartFusion cSoC Family Product Table" and "Package I/Os: MSS + FPGA I/Os" section were revised.                                                                                                                                    | II                     |
|                            | The terminology for the analog blocks was changed to "programmable analog," consisting of two blocks: the analog front-end and analog compute engine. This is reflected throughout the text and in the "SmartFusion cSoC Block Diagram". | IV                     |
|                            | The "Product Ordering Codes" table was revised to add G as an ordering code for eNVM size.                                                                                                                                               | VI                     |
|                            | Timing tables were populated with information that has become available for speed grade –1.                                                                                                                                              | N/A                    |
|                            | All occurrences of the VMV parameter were removed.                                                                                                                                                                                       | N/A                    |
|                            | The SDD[n] voltage parameter was removed from Table 2-2 • Analog Maximum Ratings.                                                                                                                                                        | 2-2                    |
|                            | Table 36-4 • Flash Programming Limits – Retention, Storage and Operating Temperature was replaced with Table 2-4 • FPGA and Embedded Flash Programming, Storage and Operating Limits.                                                    | 2-4                    |
|                            | The "Thermal Characteristics" section was revised extensively.                                                                                                                                                                           | 2-7                    |
|                            | Table 2-8 • Power Supplies Configuration was revised significantly.                                                                                                                                                                      | 2-10                   |
|                            | Table 2-14 • Different Components Contributing to Dynamic Power Consumption in SmartFusion cSoCs and Table 2-15 • Different Components Contributing to the Static Power Consumption in SmartFusion cSoCs were updated.                   | 2-12                   |
|                            | Figure 2-2 • Timing Model was updated.                                                                                                                                                                                                   | 2-19                   |
|                            | The temperature associated with the reliability for LVTTTL/LVCMOS in Table 2-34 • I/O Input Rise Time, Fall Time, and Related I/O Reliability was changed from 110° to 100°.                                                             | 2-29                   |
|                            | The values in Table 2-78 • Combinatorial Cell Propagation Delays were updated.                                                                                                                                                           | 2-57                   |
|                            | Table 2-85 • Electrical Characteristics of the Low Power Oscillator is new. Table 2-84 • Electrical Characteristics of the Main Crystal Oscillator was revised.                                                                          | 2-62                   |
|                            | Table 2-90 • eNVM Block Timing, Worst Commercial Case Conditions: T <sub>J</sub> = 85°C, VCC = 1.425 V and Table 2-91 • FlashROM Access Time, Worst Commercial Case Conditions: T <sub>J</sub> = 85°C, VCC = 1.425 V are new.            | 2-74                   |
|                            | The performance tables in the "Programmable Analog Specifications" section were revised, including new data available. Table 2-99 • Analog Sigma-Delta DAC is new.                                                                       | 2-76                   |
|                            | The "256-Pin FBGA" table for A2F200 is new.                                                                                                                                                                                              | 4-15                   |

## Datasheet Categories

### **Categories**

In order to provide the latest information to designers, some datasheet parameters are published before data has been fully characterized from silicon devices. The data provided for a given device, as highlighted in the "SmartFusion cSoC Device Status" table on page III, is designated as either "Product Brief," "Advance," "Preliminary," or "Production." The definitions 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.

#### **Production**

This version contains information that is considered to be final.

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