

**Module 1:  
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## Introduction

The Spartan®-3E family of Field-Programmable Gate Arrays (FPGAs) is specifically designed to meet the needs of high volume, cost-sensitive consumer electronic applications. The five-member family offers densities ranging from 100,000 to 1.6 million system gates, as shown in [Table 1](#).

The Spartan-3E family builds on the success of the earlier Spartan-3 family by increasing the amount of logic per I/O, significantly reducing the cost per logic cell. New features improve system performance and reduce the cost of configuration. These Spartan-3E FPGA enhancements, combined with advanced 90 nm process technology, deliver more functionality and bandwidth per dollar than was previously possible, setting new standards in the programmable logic industry.

Because of their exceptionally low cost, Spartan-3E FPGAs are ideally suited to a wide range of consumer electronics applications, including broadband access, home networking, display/projection, and digital television equipment.

The Spartan-3E family is a superior alternative to mask programmed ASICs. FPGAs avoid the high initial cost, the lengthy development cycles, and the inherent inflexibility of conventional ASICs. Also, FPGA programmability permits design upgrades in the field with no hardware replacement necessary, an impossibility with ASICs.

## Features

- Very low cost, high-performance logic solution for high-volume, consumer-oriented applications
- Proven advanced 90-nanometer process technology
- Multi-voltage, multi-standard SelectIO™ interface pins
  - Up to 376 I/O pins or 156 differential signal pairs

- LVCMS, LVTTL, HSTL, and SSTL single-ended signal standards
- 3.3V, 2.5V, 1.8V, 1.5V, and 1.2V signaling
- 622+ Mb/s data transfer rate per I/O
- True LVDS, RSDS, mini-LVDS, differential HSTL/SSTL differential I/O
- Enhanced Double Data Rate (DDR) support
- DDR SDRAM support up to 333 Mb/s
- Abundant, flexible logic resources
  - Densities up to 33,192 logic cells, including optional shift register or distributed RAM support
  - Efficient wide multiplexers, wide logic
  - Fast look-ahead carry logic
  - Enhanced 18 x 18 multipliers with optional pipeline
  - IEEE 1149.1/1532 JTAG programming/debug port
- Hierarchical SelectRAM™ memory architecture
  - Up to 648 Kbits of fast block RAM
  - Up to 231 Kbits of efficient distributed RAM
- Up to eight Digital Clock Managers (DCMs)
  - Clock skew elimination (delay locked loop)
  - Frequency synthesis, multiplication, division
  - High-resolution phase shifting
  - Wide frequency range (5 MHz to over 300 MHz)
- Eight global clocks plus eight additional clocks per each half of device, plus abundant low-skew routing
- Configuration interface to industry-standard PROMs
  - Low-cost, space-saving SPI serial Flash PROM
  - x8 or x8/x16 parallel NOR Flash PROM
  - Low-cost Xilinx® [Platform Flash](#) with JTAG
- Complete Xilinx [ISE](#)® and [WebPACK](#)™ software
- [MicroBlaze](#)™ and [PicoBlaze](#)™ embedded processor cores
- Fully compliant 32-/64-bit 33 [MHz PCI support](#) (66 MHz in some devices)
- Low-cost QFP and BGA packaging options
- Common footprints support easy density migration
- Pb-free packaging options
- [XA Automotive version](#) available

**Table 1: Summary of Spartan-3E FPGA Attributes**

| Device    | System Gates | Equivalent Logic Cells | CLB Array<br>(One CLB = Four Slices) |         |            |              | Distributed RAM bits <sup>(1)</sup> | Block RAM bits <sup>(1)</sup> | Dedicated Multipliers | DCMs | Maximum User I/O | Maximum Differential I/O Pairs |
|-----------|--------------|------------------------|--------------------------------------|---------|------------|--------------|-------------------------------------|-------------------------------|-----------------------|------|------------------|--------------------------------|
|           |              |                        | Rows                                 | Columns | Total CLBs | Total Slices |                                     |                               |                       |      |                  |                                |
| XC3S100E  | 100K         | 2,160                  | 22                                   | 16      | 240        | 960          | 15K                                 | 72K                           | 4                     | 2    | 108              | 40                             |
| XC3S250E  | 250K         | 5,508                  | 34                                   | 26      | 612        | 2,448        | 38K                                 | 216K                          | 12                    | 4    | 172              | 68                             |
| XC3S500E  | 500K         | 10,476                 | 46                                   | 34      | 1,164      | 4,656        | 73K                                 | 360K                          | 20                    | 4    | 232              | 92                             |
| XC3S1200E | 1200K        | 19,512                 | 60                                   | 46      | 2,168      | 8,672        | 136K                                | 504K                          | 28                    | 8    | 304              | 124                            |
| XC3S1600E | 1600K        | 33,192                 | 76                                   | 58      | 3,688      | 14,752       | 231K                                | 648K                          | 36                    | 8    | 376              | 156                            |

**Notes:**

- By convention, one Kb is equivalent to 1,024 bits.

## Architectural Overview

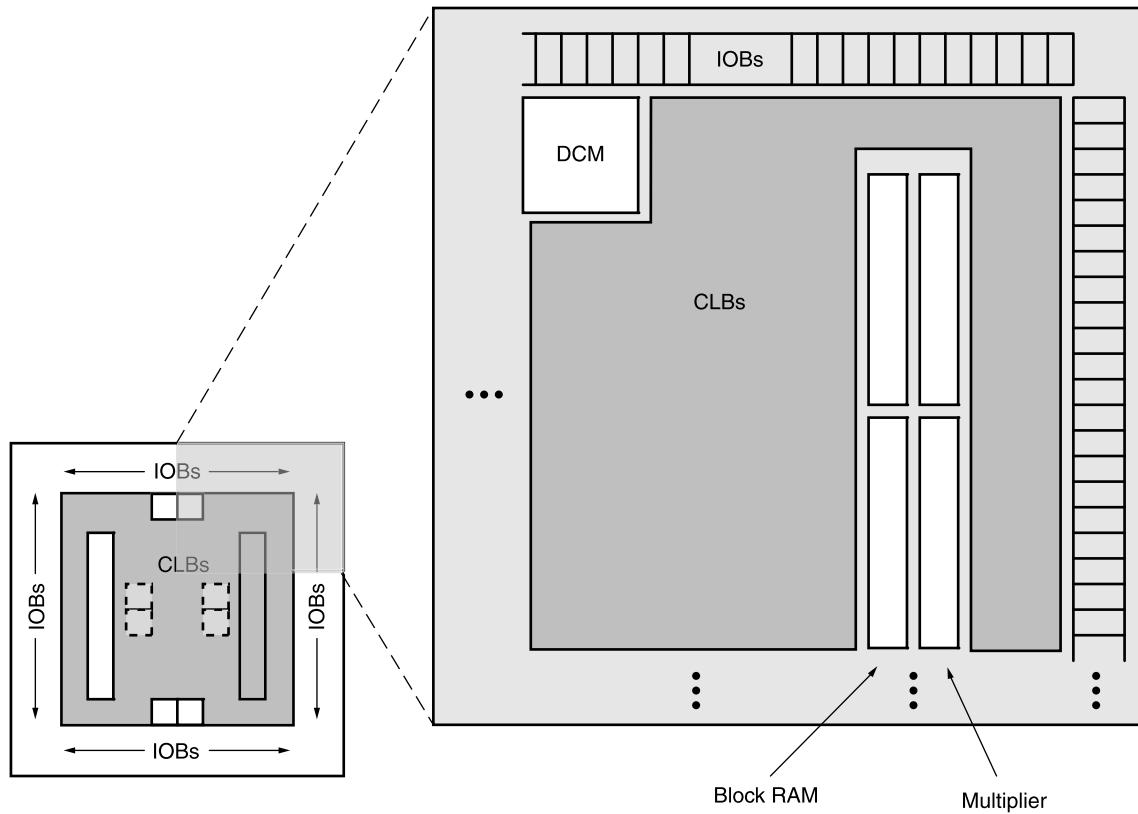
The Spartan-3E family architecture consists of five fundamental programmable functional elements:

- **Configurable Logic Blocks (CLBs)** contain flexible Look-Up Tables (LUTs) that implement logic plus storage elements used as flip-flops or latches. CLBs perform a wide variety of logical functions as well as store data.
- **Input/Output Blocks (IOBs)** control the flow of data between the I/O pins and the internal logic of the device. Each IOB supports bidirectional data flow plus 3-state operation. Supports a variety of signal standards, including four high-performance differential standards. Double Data-Rate (DDR) registers are included.
- **Block RAM** provides data storage in the form of 18-Kbit dual-port blocks.
- **Multiplier Blocks** accept two 18-bit binary numbers as inputs and calculate the product.

- **Digital Clock Manager (DCM) Blocks** provide self-calibrating, fully digital solutions for distributing, delaying, multiplying, dividing, and phase-shifting clock signals.

These elements are organized as shown in [Figure 1](#). A ring of IOBs surrounds a regular array of CLBs. Each device has two columns of block RAM except for the XC3S100E, which has one column. Each RAM column consists of several 18-Kbit RAM blocks. Each block RAM is associated with a dedicated multiplier. The DCMS are positioned in the center with two at the top and two at the bottom of the device. The XC3S100E has only one DCM at the top and bottom, while the XC3S1200E and XC3S1600E add two DCMs in the middle of the left and right sides.

The Spartan-3E family features a rich network of traces that interconnect all five functional elements, transmitting signals among them. Each functional element has an associated switch matrix that permits multiple connections to the routing.



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Figure 1: Spartan-3E Family Architecture

## Configuration

Spartan-3E FPGAs are programmed by loading configuration data into robust, reprogrammable, static CMOS configuration latches (CCLs) that collectively control all functional elements and routing resources. The FPGA's configuration data is stored externally in a PROM or some other non-volatile medium, either on or off the board. After applying power, the configuration data is written to the FPGA using any of seven different modes:

- Master Serial from a Xilinx Platform Flash PROM
- Serial Peripheral Interface (SPI) from an industry-standard SPI serial Flash
- Byte Peripheral Interface (BPI) Up or Down from an industry-standard x8 or x8/x16 parallel NOR Flash
- Slave Serial, typically downloaded from a processor
- Slave Parallel, typically downloaded from a processor
- Boundary Scan (JTAG), typically downloaded from a processor or system tester.

Furthermore, Spartan-3E FPGAs support MultiBoot configuration, allowing two or more FPGA configuration bitstreams to be stored in a single parallel NOR Flash. The FPGA application controls which configuration to load next and when to load it.

## I/O Capabilities

The Spartan-3E FPGA SelectIO interface supports many popular single-ended and differential standards. [Table 2](#) shows the number of user I/Os as well as the number of differential I/O pairs available for each device/package combination.

Spartan-3E FPGAs support the following single-ended standards:

- 3.3V low-voltage TTL (LVTTL)
- Low-voltage CMOS (LVC MOS) at 3.3V, 2.5V, 1.8V, 1.5V, or 1.2V
- 3V PCI at 33 MHz, and in some devices, [66 MHz](#)
- HSTL I and III at 1.8V, commonly used in memory applications
- SSTL I at 1.8V and 2.5V, commonly used for memory applications

Spartan-3E FPGAs support the following differential standards:

- LVDS
- Bus LVDS
- mini-LVDS
- RSDS
- Differential HSTL (1.8V, Types I and III)
- Differential SSTL (2.5V and 1.8V, Type I)
- 2.5V LVPECL inputs

**Table 2: Available User I/Os and Differential (Diff) I/O Pairs**

| Package                | VQ100<br>VQG100           |           | CP132<br>CPG132 |           | TQ144<br>TQG144 |           | PQ208<br>PQG208 |           | FT256<br>FTG256 |           | FG320<br>FGG320 |            | FG400<br>FGG400 |             | FG484<br>FGG484 |             |
|------------------------|---------------------------|-----------|-----------------|-----------|-----------------|-----------|-----------------|-----------|-----------------|-----------|-----------------|------------|-----------------|-------------|-----------------|-------------|
| Footprint<br>Size (mm) | 16 x 16                   |           | 8 x 8           |           | 22 x 22         |           | 30.5 x 30.5     |           | 17 x 17         |           | 19 x 19         |            | 21 x 21         |             | 23 x 23         |             |
| Device                 | User                      | Diff      | User            | Diff      | User            | Diff      | User            | Diff      | User            | Diff      | User            | Diff       | User            | Diff        | User            | Diff        |
| XC3S100E               | 66 <sup>(2)</sup><br>9(7) | 30<br>(2) | 83<br>(11)      | 35<br>(2) | 108<br>(28)     | 40<br>(4) | -               | -         | -               | -         | -               | -          | -               | -           | -               | -           |
| XC3S250E               | 66<br>(7)                 | 30<br>(2) | 92<br>(7)       | 41<br>(2) | 108<br>(28)     | 40<br>(4) | 158<br>(32)     | 65<br>(5) | 172<br>(40)     | 68<br>(8) | -               | -          | -               | -           | -               | -           |
| XC3S500E               | 66 <sup>(3)</sup><br>(7)  | 30<br>(2) | 92<br>(7)       | 41<br>(2) | -               | -         | 158<br>(32)     | 65<br>(5) | 190<br>(41)     | 77<br>(8) | 232<br>(56)     | 92<br>(12) | -               | -           | -               | -           |
| XC3S1200E              | -                         | -         | -               | -         | -               | -         | -               | -         | 190<br>(40)     | 77<br>(8) | 250<br>(56)     | 99<br>(12) | 304<br>(72)     | 124<br>(20) | -               | -           |
| XC3S1600E              | -                         | -         | -               | -         | -               | -         | -               | -         | -               | -         | 250<br>(56)     | 99<br>(12) | 304<br>(72)     | 124<br>(20) | 376<br>(82)     | 156<br>(21) |

### Notes:

1. All Spartan-3E devices provided in the same package are pin-compatible as further described in Module 4, [Pinout Descriptions](#).
2. The number shown in **bold** indicates the maximum number of I/O and input-only pins. The number shown in *(italics)* indicates the number of input-only pins.
3. The XC3S500E is available in the VQG100 Pb-free package and not the standard VQ100. The VQG100 and VQ100 pin-outs are identical and general references to the VQ100 will apply to the XC3S500E.

## Package Marking

Figure 2 provides a top marking example for Spartan-3E FPGAs in the quad-flat packages. Figure 3 shows the top marking for Spartan-3E FPGAs in BGA packages except the 132-ball chip-scale package (CP132 and CPG132). The markings for the BGA packages are nearly identical to those for the quad-flat packages, except that the marking is rotated with respect to the ball A1 indicator. Figure 4 shows the top marking for Spartan-3E FPGAs in the CP132 and CPG132 packages.

On the QFP and BGA packages, the optional numerical Stepping Code follows the Lot Code.

The “5C” and “4I” part combinations can have a dual mark of “5C/4I”. Devices with a single mark are only guaranteed for the marked speed grade and temperature range. All “5C” and “4I” part combinations use the Stepping 1 production silicon.

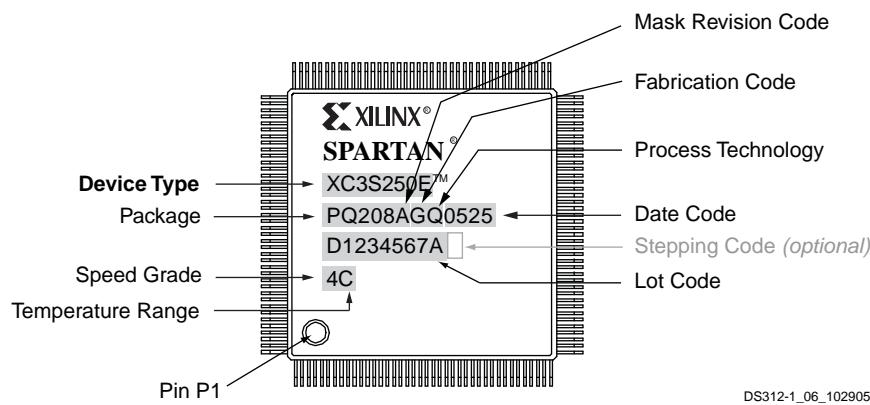


Figure 2: Spartan-3E QFP Package Marking Example

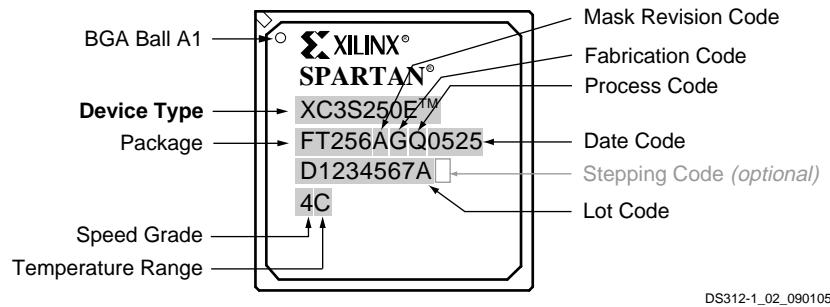


Figure 3: Spartan-3E BGA Package Marking Example

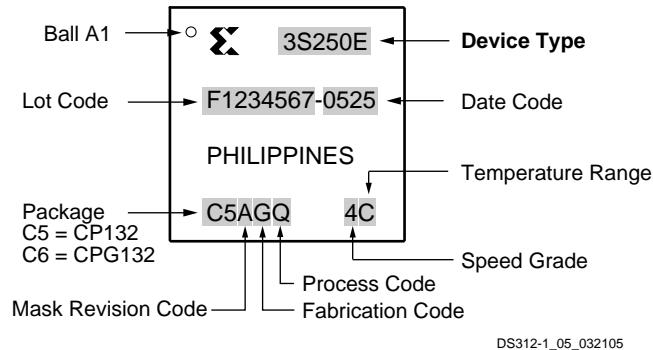
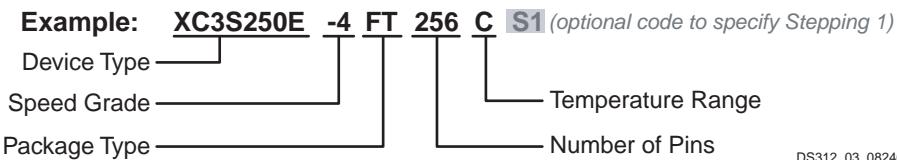


Figure 4: Spartan-3E CP132 and CPG132 Package Marking Example

## Ordering Information

Spartan-3E FPGAs are available in both standard and Pb-free packaging options for all device/package combinations. All devices are available in Pb-free packages, which adds a 'G' character to the ordering code. All devices are available in either Commercial (C) or Industrial (I)

temperature ranges. Both the standard -4 and faster -5 speed grades are available for the Commercial temperature range. However, only the -4 speed grade is available for the Industrial temperature range. See [Table 2](#) for valid device/package combinations.



DS312\_03\_082409

| Device                  | Speed Grade                        | Package Type / Number of Pins |  | Temperature Range (T <sub>J</sub> ) |
|-------------------------|------------------------------------|-------------------------------|--|-------------------------------------|
| XC3S100E                | -4 Standard Performance            | VQ100<br>VQG100               | 100-pin Very Thin Quad Flat Pack (VQFP)          | C Commercial (0°C to 85°C)          |
| XC3S250E                | -5 High Performance <sup>(1)</sup> | CP132<br>CPG132               | 132-ball Chip-Scale Package (CSP)                | I Industrial (-40°C to 100°C)       |
| XC3S500E <sup>(2)</sup> |                                    | TQ144<br>TQG144               | 144-pin Thin Quad Flat Pack (TQFP)               |                                     |
| XC3S1200E               |                                    | PQ208<br>PQG208               | 208-pin Plastic Quad Flat Pack (PQFP)            |                                     |
| XC3S1600E               |                                    | FT256<br>FTG256               | 256-ball Fine-Pitch Thin Ball Grid Array (FTBGA) |                                     |
|                         |                                    | FG320<br>FGG320               | 320-ball Fine-Pitch Ball Grid Array (FBGA)       |                                     |
|                         |                                    | FG400<br>FGG400               | 400-ball Fine-Pitch Ball Grid Array (FBGA)       |                                     |
|                         |                                    | FG484<br>FGG484               | 484-ball Fine-Pitch Ball Grid Array (FBGA)       |                                     |

### Notes:

1. The -5 speed grade is exclusively available in the Commercial temperature range.
2. The XC3S500E VQG100 is available only in the -4 Speed Grade.
3. See [DS635](#) for the XA Automotive Spartan-3E FPGAs.

### Production Stepping

The Spartan-3E FPGA family uses production stepping to indicate improved capabilities or enhanced features.

Stepping 1 is, by definition, a functional superset of Stepping 0. Furthermore, configuration bitstreams generated for any stepping are forward compatible. See [Table 72](#) for additional details.

Xilinx has shipped both Stepping 0 and Stepping 1. Designs operating on the Stepping 0 devices perform similarly on a Stepping 1 device. Stepping 1 devices have been shipping since 2006. The faster speed grade (-5), Industrial (I grade), Automotive devices, and -4C devices with date codes 0901 (2009) and later, are always Stepping 1 devices. Only -4C devices have shipped as Stepping 0 devices.

To specify only the later stepping for the -4C, append an S# suffix to the standard ordering code, where # is the stepping number, as indicated in [Table 3](#).

**Table 3: Spartan-3E Optional Stepping Level Ordering**

| Stepping Number | Suffix Code | Status     |
|-----------------|-------------|------------|
| 0               | None or S0  | Production |
| 1               | S1          | Production |

The stepping level is optionally marked on the device using a single number character, as shown in [Figure 2](#), [Figure 3](#), and [Figure 4](#).

## Revision History

The following table shows the revision history for this document.

| Date       | Version | Revision  |
|------------|---------|---|
| 03/01/2005 | 1.0     | Initial Xilinx release.   |
| 03/21/2005 | 1.1     | Added XC3S250E in CP132 package to <a href="#">Table 2</a> . Corrected number of differential I/O pairs for CP132 package. Added package markings for QFP packages ( <a href="#">Figure 2</a> ) and CP132/CPG132 packages ( <a href="#">Figure 4</a> ).   |
| 11/23/2005 | 2.0     | Added differential HSTL and SSTL I/O standards. Updated <a href="#">Table 2</a> to indicate number of input-only pins. Added <a href="#">Production Stepping</a> information, including example top marking diagrams.   |
| 03/22/2006 | 3.0     | Upgraded data sheet status to Preliminary. Added XC3S100E in CP132 package and updated I/O counts for the XC3S1600E in FG320 package ( <a href="#">Table 2</a> ). Added information about dual markings for –5C and –41 product combinations to <a href="#">Package Marking</a> .   |
| 11/09/2006 | 3.4     | Added 66 MHz PCI support and links to the Xilinx PCI LogiCORE data sheet. Indicated that Stepping 1 parts are Production status. Promoted Module 1 to Production status. Synchronized all modules to v3.4.  |
| 04/18/2008 | 3.7     | Added XC3S500E VQG100 package. Added reference to <a href="#">XA Automotive</a> version. Updated links.   |
| 08/26/2009 | 3.8     | Added paragraph to <a href="#">Configuration</a> indicating the device supports MultiBoot configuration. Added package sizes to <a href="#">Table 2</a> . Described the speed grade and temperature range guarantee for devices having a single mark in paragraph 3 under <a href="#">Package Marking</a> . Deleted Pb-Free Packaging example under <a href="#">Ordering Information</a> . Revised information under <a href="#">Production Stepping</a> . Revised description of <a href="#">Table 3</a> . |
| 10/29/2012 | 4.0     | Added <a href="#">Notice of Disclaimer</a> . This product is not recommended for new designs. Updated <a href="#">Table 2</a> footprint size of PQ208.  |
| 07/19/2013 | 4.1     | Removed banner. This product IS recommended for new designs.  |
| 12/14/2018 | 4.2     | Updated for <i>Lead-Frame Plating Composition Change For Legacy Eutectic Products</i> ( <a href="#">XCN18024</a> ).   |

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## Design Documentation Available

The functionality of the Spartan®-3E FPGA family is now described and updated in the following documents. The topics covered in each guide are listed below.

- [UG331: Spartan-3 Generation FPGA User Guide](#)
  - Clocking Resources
  - Digital Clock Managers (DCMs)
  - Block RAM
  - Configurable Logic Blocks (CLBs)
    - Distributed RAM
    - SRL16 Shift Registers
    - Carry and Arithmetic Logic
  - I/O Resources
  - Embedded Multiplier Blocks
  - Programmable Interconnect
  - ISE® Design Tools
  - IP Cores
  - Embedded Processing and Control Solutions
  - Pin Types and Package Overview
  - Package Drawings
  - Powering FPGAs
  - Power Management
- [UG332: Spartan-3 Generation Configuration User Guide](#)
  - Configuration Overview
    - Configuration Pins and Behavior
    - Bitstream Sizes
  - Detailed Descriptions by Mode
    - Master Serial Mode using Xilinx® Platform Flash PROM
    - Master SPI Mode using Commodity SPI Serial Flash PROM
    - Master BPI Mode using Commodity Parallel NOR Flash PROM
    - Slave Parallel (SelectMAP) using a Processor
    - Slave Serial using a Processor
    - JTAG Mode
  - ISE iMPACT Programming Examples
  - MultiBoot Reconfiguration

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## Spartan-3E FPGA Starter Kit

For specific hardware examples, please see the Spartan-3E FPGA Starter Kit board web page, which has links to various design examples and the user guide.

- Spartan-3E FPGA Starter Kit Board page  
<http://www.xilinx.com/s3estarter>
- [UG230: Spartan-3E FPGA Starter Kit User Guide](#)

## Introduction

As described in [Architectural Overview](#), the Spartan-3E FPGA architecture consists of five fundamental functional elements:

- [Input/Output Blocks \(IOBs\)](#)
- [Configurable Logic Block \(CLB\) and Slice Resources](#)
- [Block RAM](#)
- [Dedicated Multipliers](#)
- [Digital Clock Managers \(DCMs\)](#)

The following sections provide detailed information on each of these functions. In addition, this section also describes the following functions:

- [Clocking Infrastructure](#)
- [Interconnect](#)
- [Configuration](#)
- [Powering Spartan-3E FPGAs](#)

## Input/Output Blocks (IOBs)

For additional information, refer to the “Using I/O Resources” chapter in [UG331](#).

### IOB Overview

The Input/Output Block (IOB) provides a programmable, unidirectional or bidirectional interface between a package pin and the FPGA’s internal logic. The IOB is similar to that of the Spartan-3 family with the following differences:

- Input-only blocks are added
- Programmable input delays are added to all blocks
- DDR flip-flops can be shared between adjacent IOBs

The unidirectional input-only block has a subset of the full IOB capabilities. Thus there are no connections or logic for an output path. The following paragraphs assume that any reference to output functionality does not apply to the input-only blocks. The number of input-only blocks varies with device size, but is never more than 25% of the total IOB count.

[Figure 5](#) is a simplified diagram of the IOB’s internal structure. There are three main signal paths within the IOB: the output path, input path, and 3-state path. Each path has its own pair of storage elements that can act as either registers or latches. For more information, see [Storage Element Functions](#). The three main signal paths are as follows:

- The input path carries data from the pad, which is bonded to a package pin, through an optional programmable delay element directly to the I line. After the delay element, there are alternate routes through a

pair of storage elements to the IQ1 and IQ2 lines. The IOB outputs I, IQ1, and IQ2 lead to the FPGA’s internal logic. The delay element can be set to ensure a hold time of zero (see [Input Delay Functions](#)).

- The output path, starting with the O1 and O2 lines, carries data from the FPGA’s internal logic through a multiplexer and then a three-state driver to the IOB pad. In addition to this direct path, the multiplexer provides the option to insert a pair of storage elements.
- The 3-state path determines when the output driver is high impedance. The T1 and T2 lines carry data from the FPGA’s internal logic through a multiplexer to the output driver. In addition to this direct path, the multiplexer provides the option to insert a pair of storage elements.
- All signal paths entering the IOB, including those associated with the storage elements, have an inverter option. Any inverter placed on these paths is automatically absorbed into the IOB.

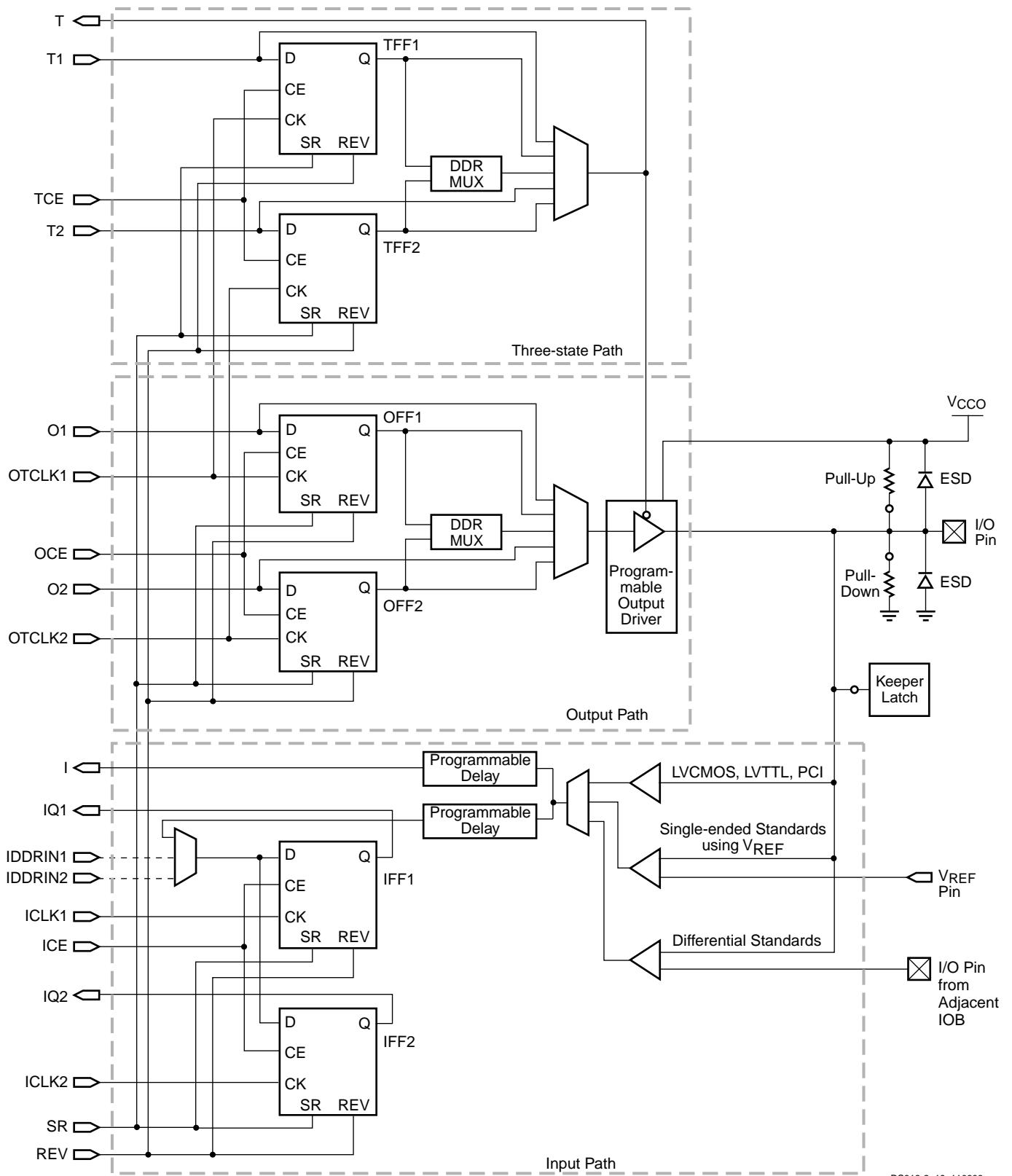


Figure 5: Simplified IOB Diagram

## Input Delay Functions

Each IOB has a programmable delay block that optionally delays the input signal. In [Figure 6](#), the signal path has a coarse delay element that can be bypassed. The input signal then feeds a 6-tap delay line. The coarse and tap delays vary; refer to timing reports for specific delay values. All six taps are available via a multiplexer for use as an asynchronous input directly into the FPGA fabric. In this way, the delay is programmable in 12 steps. Three of the six taps are also available via a multiplexer to the D inputs of the synchronous storage elements. The delay inserted in the path to the storage element can be varied in six steps. The first, coarse delay element is common to both asynchronous and synchronous paths, and must be either used or not used for both paths.

The delay values are set up in the silicon once at configuration time—they are non-modifiable in device operation.

The primary use for the input delay element is to adjust the input delay path to ensure that there is no hold time requirement when using the input flip-flop(s) with a global clock. The default value is chosen automatically by the Xilinx software tools as the value depends on device size and the specific device edge where the flip-flop resides. The value set by the Xilinx ISE software is indicated in the Map

report generated by the implementation tools, and the resulting effects on input timing are reported using the Timing Analyzer tool.

If the design uses a DCM in the clock path, then the delay element can be safely set to zero because the [Delay-Locked Loop \(DLL\)](#) compensation automatically ensures that there is still no input hold time requirement.

Both asynchronous and synchronous values can be modified, which is useful where extra delay is required on clock or data inputs, for example, in interfaces to various types of RAM.

These delay values are defined through the `IBUF_DELAY_VALUE` and the `IFD_DELAY_VALUE` parameters. The default `IBUF_DELAY_VALUE` is 0, bypassing the delay elements for the asynchronous input. The user can set this parameter to 0-12. The default `IFD_DELAY_VALUE` is `AUTO`. `IBUF_DELAY_VALUE` and `IFD_DELAY_VALUE` are independent for each input. If the same input pin uses both registered and non-registered input paths, both parameters can be used, but they must both be in the same half of the total delay (both either bypassing or using the coarse delay element).

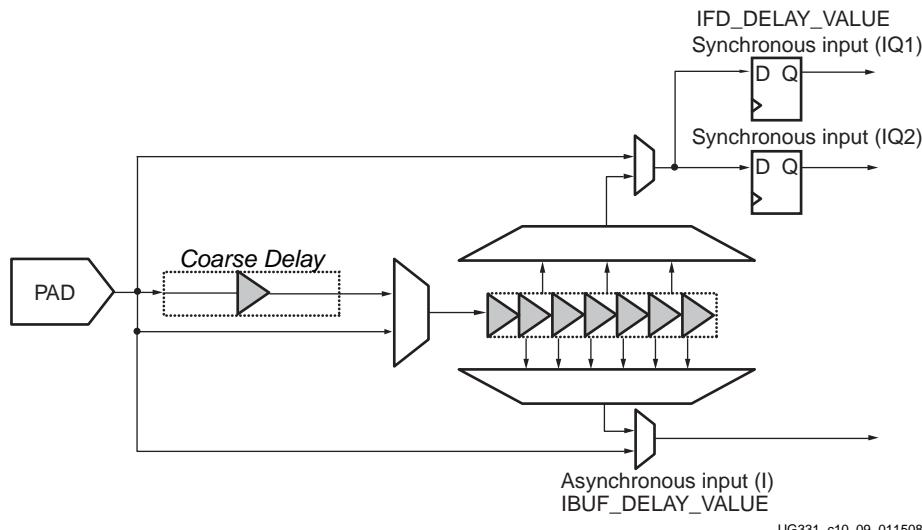


Figure 6: Programmable Fixed Input Delay Elements

## Storage Element Functions

There are three pairs of storage elements in each IOB, one pair for each of the three paths. It is possible to configure each of these storage elements as an edge-triggered D-type flip-flop (FD) or a level-sensitive latch (LD).

The storage-element pair on either the Output path or the Three-State path can be used together with a special multiplexer to produce Double-Data-Rate (DDR) transmission. This is accomplished by taking data

synchronized to the clock signal's rising edge and converting it to bits synchronized on both the rising and the falling edge. The combination of two registers and a multiplexer is referred to as a Double-Data-Rate D-type flip-flop (ODDR2).

[Table 4](#) describes the signal paths associated with the storage element.

**Table 4: Storage Element Signal Description**

| Storage Element Signal | Description        | Function  |
|------------------------|--------------------|---|
| D                      | Data input         | Data at this input is stored on the active edge of CK and enabled by CE. For latch operation when the input is enabled, data passes directly to the output Q.   |
| Q                      | Data output        | The data on this output reflects the state of the storage element. For operation as a latch in transparent mode, Q mirrors the data at D.   |
| CK                     | Clock input        | Data is loaded into the storage element on this input's active edge with CE asserted.   |
| CE                     | Clock Enable input | When asserted, this input enables CK. If not connected, CE defaults to the asserted state.  |
| SR                     | Set/Reset input    | This input forces the storage element into the state specified by the SRHIGH/SRLOW attributes. The SYNC/ASYNC attribute setting determines if the SR input is synchronized to the clock or not. If both SR and REV are active at the same time, the storage element gets a value of 0.                      |
| REV                    | Reverse input      | This input is used together with SR. It forces the storage element into the state opposite from what SR does. The SYNC/ASYNC attribute setting determines whether the REV input is synchronized to the clock or not. If both SR and REV are active at the same time, the storage element gets a value of 0. |

As shown in [Figure 5](#), the upper registers in both the output and three-state paths share a common clock. The OTCLK1 clock signal drives the CK clock inputs of the upper registers on the output and three-state paths. Similarly, OTCLK2 drives the CK inputs for the lower registers on the output and three-state paths. The upper and lower registers on the input path have independent clock lines: ICLK1 and ICLK2.

The OCE enable line controls the CE inputs of the upper and lower registers on the output path. Similarly, TCE

controls the CE inputs for the register pair on the three-state path and ICE does the same for the register pair on the input path.

The Set/Reset (SR) line entering the IOB controls all six registers, as is the Reverse (REV) line.

In addition to the signal polarity controls described in [IOB Overview](#), each storage element additionally supports the controls described in [Table 5](#).

**Table 5: Storage Element Options**

| Option Switch | Function   | Specificity  |
|---------------|--|--|
| FF/Latch      | Chooses between an edge-triggered flip-flop or a level-sensitive latch   | Independent for each storage element   |
| SYNC/ASYNC    | Determines whether the SR set/reset control is synchronous or asynchronous   | Independent for each storage element   |
| SRHIGH/SRLOW  | Determines whether SR acts as a Set, which forces the storage element to a logic 1 (SRHIGH) or a Reset, which forces a logic 0 (SRLOW)   | Independent for each storage element, except when using ODDR2. In the latter case, the selection for the upper element will apply to both elements.  |
| INIT1/INIT0   | When Global Set/Reset (GSR) is asserted or after configuration this option specifies the initial state of the storage element, either set (INIT1) or reset (INIT0). By default, choosing SRLOW also selects INIT0; choosing SRHIGH also selects INIT1. | Independent for each storage element, except when using ODDR2, which uses two IOBs. In the ODDR2 case, selecting INIT0 for one IOBs applies to both elements within the IOB, although INIT1 could be selected for the elements in the other IOB. |

## Double-Data-Rate Transmission

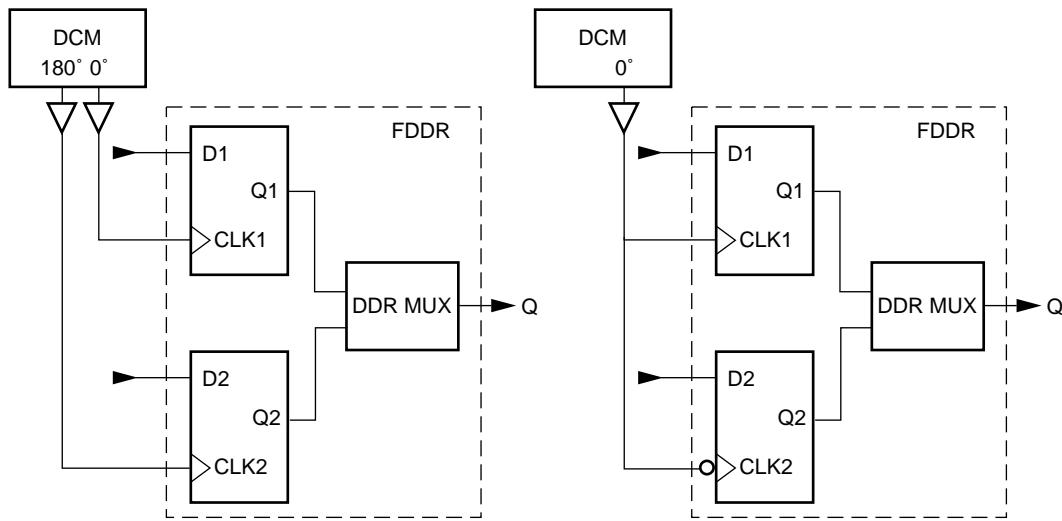
Double-Data-Rate (DDR) transmission describes the technique of synchronizing signals to both the rising and falling edges of the clock signal. Spartan-3E devices use register pairs in all three IOB paths to perform DDR operations.

The pair of storage elements on the IOB's Output path (OFF1 and OFF2), used as registers, combine with a special multiplexer to form a DDR D-type flip-flop (ODDR2). This primitive permits DDR transmission where output data bits are synchronized to both the rising and falling edges of a clock. DDR operation requires two clock signals (usually 50% duty cycle), one the inverted form of the other. These signals trigger the two registers in alternating fashion, as shown in [Figure 7](#). The Digital Clock Manager (DCM) generates the two clock signals by mirroring an incoming signal, and then shifting it 180 degrees. This approach ensures minimal skew between the two signals. Alternatively, the inverter inside the IOB can be used to invert the clock signal, thus only using one clock line and both rising and falling edges of that clock line as the two clocks for the DDR flip-flops.

The storage-element pair on the Three-State path (TFF1 and TFF2) also can be combined with a local multiplexer to form a DDR primitive. This permits synchronizing the output enable to both the rising and falling edges of a clock. This DDR operation is realized in the same way as for the output path.

The storage-element pair on the input path (IFF1 and IFF2) allows an I/O to receive a DDR signal. An incoming DDR clock signal triggers one register, and the inverted clock signal triggers the other register. The registers take turns capturing bits of the incoming DDR data signal. The primitive to allow this functionality is called IDDR2.

Aside from high bandwidth data transfers, DDR outputs also can be used to reproduce, or *mirror*, a clock signal on the output. This approach is used to transmit clock and data signals together (source synchronously). A similar approach is used to reproduce a clock signal at multiple outputs. The advantage for both approaches is that skew across the outputs is minimal.



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Figure 7: Two Methods for Clocking the DDR Register

## Register Cascade Feature

In the Spartan-3E family, one of the IOBs in a differential pair can cascade its input storage elements with those in the other IOB as part of a differential pair. This is intended to make DDR operation at high speed much simpler to implement. The new DDR connections that are available are shown in [Figure 5](#) (dashed lines), and are only available for routing between IOBs and are not accessible to the FPGA fabric. Note that this feature is only available when using the differential I/O standards LVDS, RSDS, and MINI\_LVDS.

## IDDR2

As a DDR input pair, the master IOB registers incoming data on the rising edge of ICLK1 (= D1) and the rising edge of ICLK2 (= D2), which is typically the same as the falling edge of ICLK1. This data is then transferred into the FPGA fabric. At some point, both signals must be brought into the same clock domain, typically ICLK1. This can be difficult at high frequencies because the available time is only one half of a clock cycle assuming a 50% duty cycle. See [Figure 8](#) for a graphical illustration of this function.

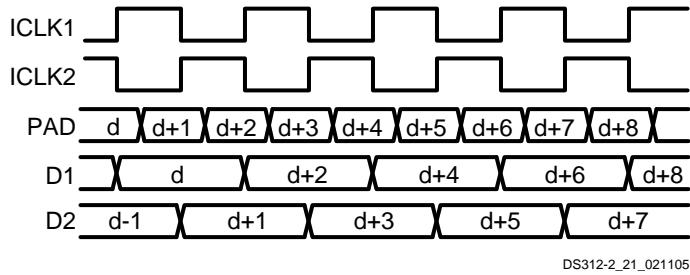
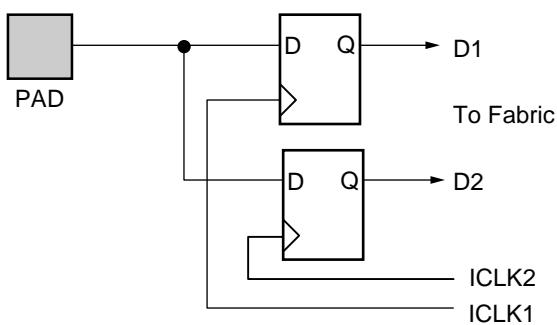


Figure 8: Input DDR (without Cascade Feature)

In the Spartan-3E device, the signal D2 can be cascaded into the storage element of the adjacent slave IOB. There it is re-registered to ICLK1, and only then fed to the FPGA fabric where it is now already in the same time domain as D1. Here, the FPGA fabric uses only the clock ICLK1 to process the received data. See [Figure 9](#) for a graphical illustration of this function.

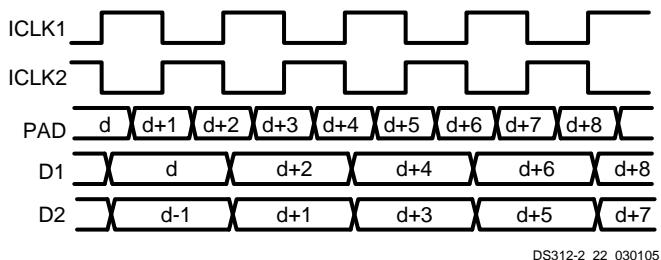
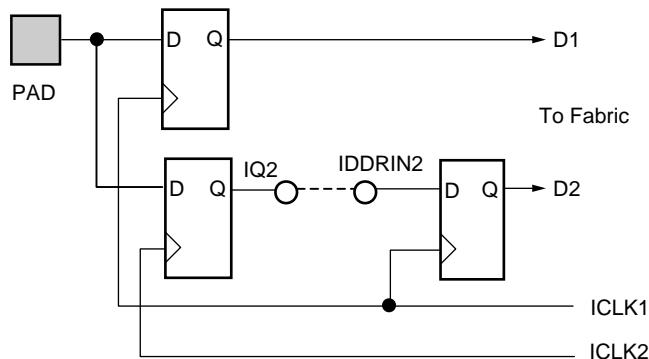


Figure 9: Input DDR Using Spartan-3E Cascade Feature

## ODDR2

As a DDR output pair, the master IOB registers data coming from the FPGA fabric on the rising edge of OCLK1 (= D1)

and the rising edge of OCLK2 (= D2), which is typically the same as the falling edge of OCLK1. These two bits of data are multiplexed by the DDR mux and forwarded to the output pin. The D2 data signal must be re-synchronized from the OCLK1 clock domain to the OCLK2 domain using FPGA slice flip-flops. Placement is critical at high frequencies, because the time available is only one half a clock cycle. See [Figure 10](#) for a graphical illustration of this function.

The C0 or C1 alignment feature of the ODDR2 flip-flop, originally introduced in the Spartan-3E FPGA family, is not recommended or supported in the ISE development software. The ODDR2 flip-flop without the alignment feature remains fully supported. Without the alignment feature, the ODDR2 feature behaves equivalent to the ODDR flip-flop on previous Xilinx FPGA families.

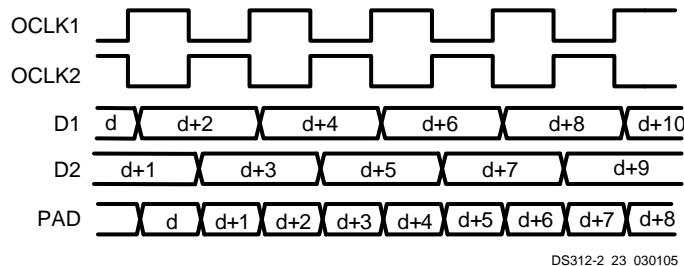
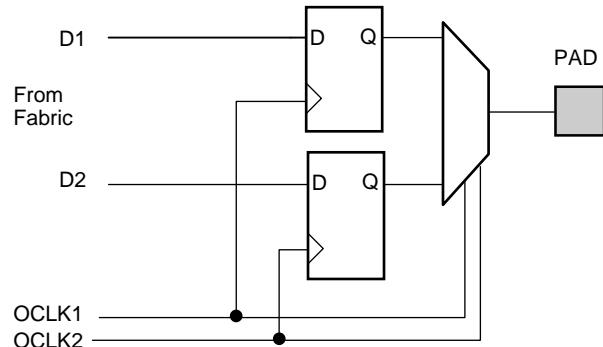


Figure 10: Output DDR

## SelectIO Signal Standards

The Spartan-3E I/Os feature inputs and outputs that support a wide range of I/O signaling standards ([Table 6](#) and [Table 7](#)). The majority of the I/Os also can be used to form differential pairs to support any of the differential signaling standards ([Table 7](#)).

To define the I/O signaling standard in a design, set the IOSTANDARD attribute to the appropriate setting. Xilinx provides a variety of different methods for applying the IOSTANDARD for maximum flexibility. For a full description of different methods of applying attributes to control IOSTANDARD, refer to the Xilinx Software Manuals and Help.

Spartan-3E FPGAs provide additional input flexibility by allowing I/O standards to be mixed in different banks. For a particular  $V_{CCO}$  voltage, [Table 6](#) and [Table 7](#) list all of the

IOSTANDARDs that can be combined and if the IOSTANDARD is supported as an input only or can be used for both inputs and outputs.

**Table 6: Single-Ended IOSTANDARD Bank Compatibility**

| Single-Ended IOSTANDARD | $V_{CCO}$ Supply/Compatibility |              |              |              |              | Input Requirements |
|-------------------------|--------------------------------|--------------|--------------|--------------|--------------|--------------------|
|                         | 1.2V                           | 1.5V         | 1.8V         | 2.5V         | 3.3V         |                    |
| LVTTL                   | -                              | -            | -            | -            | Input/Output | N/R <sup>(1)</sup> |
| LVCMOS33                | -                              | -            | -            | -            | Input/Output | N/R                |
| LVCMOS25                | -                              | -            | -            | Input/Output | Input        | N/R                |
| LVCMOS18                | -                              | -            | Input/Output | Input        | Input        | N/R                |
| LVCMOS15                | -                              | Input/Output | Input        | Input        | Input        | N/R                |
| LVCMOS12                | Input/Output                   | Input        | Input        | Input        | Input        | N/R                |
| PCI33_3                 | -                              | -            | -            | -            | Input/Output | N/R                |
| PCI66_3                 | -                              | -            | -            | -            | Input/Output | N/R                |
| HSTL_I_18               | -                              | -            | Input/Output | Input        | Input        | 0.9                |
| HSTL_III_18             | -                              | -            | Input/Output | Input        | Input        | 1.1                |
| SSTL18_I                | -                              | -            | Input/Output | Input        | Input        | 0.9                |
| SSTL2_I                 | -                              | -            | -            | Input/Output | Input        | 1.25               |

**Notes:**

1. N/R - Not required for input operation.

Table 7: Differential IOSTANDARD Bank Compatibility

| Differential IOSTANDARD | V <sub>CCO</sub> Supply |   |       | Input Requirements: V <sub>REF</sub>   | Differential Bank Restriction <sup>(1)</sup>   |
|-------------------------|-------------------------|---|-------|--|--|
|                         | 1.8V                    | 2.5V  | 3.3V  |  |  |
| LVDS_25                 | Input                   | Input,<br>On-chip Differential Termination,<br>Output | Input | V <sub>REF</sub> is not used for<br>these I/O standards                                | Applies to Outputs Only  |
| RSDS_25                 | Input                   | Input,<br>On-chip Differential Termination,<br>Output | Input |  | Applies to Outputs Only  |
| MINI_LVDS_25            | Input                   | Input,<br>On-chip Differential Termination,<br>Output | Input |  | Applies to Outputs Only  |
| LVPECL_25               | Input                   | Input   | Input | No Differential Bank<br>Restriction<br>(other I/O bank<br>restrictions might<br>apply) | No Differential Bank<br>Restriction<br>(other I/O bank<br>restrictions might<br>apply) |
| BLVDS_25                | Input                   | Input,<br>Output                                      | Input |  |  |
| DIFF_HSTL_I_18          | Input,<br>Output        | Input   | Input |  |  |
| DIFF_HSTL_III_18        | Input,<br>Output        | Input   | Input |  |  |
| DIFF_SSTL18_I           | Input,<br>Output        | Input   | Input |  |  |
| DIFF_SSTL2_I            | Input                   | Input,<br>Output                                      | Input |  |  |

**Notes:**

1. Each bank can support any two of the following: LVDS\_25 outputs, MINI\_LVDS\_25 outputs, RSDS\_25 outputs.

HSTL and SSTL inputs use the Reference Voltage (V<sub>REF</sub>) to bias the input-switching threshold. Once a configuration data file is loaded into the FPGA that calls for the I/Os of a given bank to use HSTL/SSTL, a few specifically reserved I/O pins on the same bank automatically convert to V<sub>REF</sub> inputs. For banks that do not contain HSTL or SSTL, V<sub>REF</sub> pins remain available for user I/Os or input pins.

Differential standards employ a pair of signals, one the opposite polarity of the other. The noise canceling properties (for example, Common-Mode Rejection) of these standards permit exceptionally high data transfer rates. This subsection introduces the differential signaling capabilities of Spartan-3E devices.

Each device-package combination designates specific I/O pairs specially optimized to support differential standards. A unique *L-number*, part of the pin name, identifies the line-pairs associated with each bank (see Module 4, [Pinout Descriptions](#)). For each pair, the letters *P* and *N* designate the true and inverted lines, respectively. For example, the pin names IO\_L43P\_3 and IO\_L43N\_3 indicate the true and inverted lines comprising the line pair L43 on Bank 3.

V<sub>CCO</sub> provides current to the outputs and additionally powers the On-Chip Differential Termination. V<sub>CCO</sub> must be 2.5V when using the On-Chip Differential Termination. The V<sub>REF</sub> lines are not required for differential operation.

To further understand how to combine multiple IOSTANDARDs within a bank, refer to [IOBs Organized into Banks, page 19](#).

**On-Chip Differential Termination**

Spartan-3E devices provide an on-chip  $\sim 120\Omega$  differential termination across the input differential receiver terminals. The on-chip input differential termination in Spartan-3E devices potentially eliminates the external  $100\Omega$  termination resistor commonly found in differential receiver circuits. Differential termination is used for LVDS, mini-LVDS, and RSDS as applications permit.

On-chip Differential Termination is available in banks with V<sub>CCO</sub> = 2.5V and is not supported on dedicated input pins. Set the DIFF\_TERM attribute to TRUE to enable Differential Termination on a differential I/O pin pair.

The DIFF\_TERM attribute uses the following syntax in the UCF file:

```
INST <I/O_BUFFER_INSTANTIATION_NAME>
  DIFF_TERM = "<TRUE/FALSE>";
```

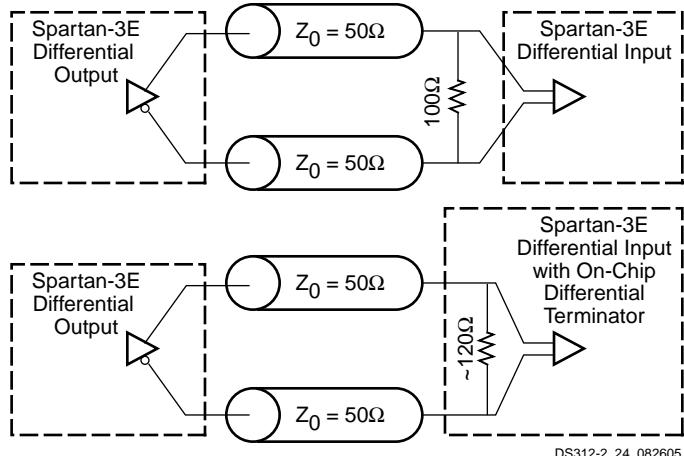


Figure 11: Differential Inputs and Outputs

## Pull-Up and Pull-Down Resistors

Pull-up and pull-down resistors inside each IOB optionally force a floating I/O or Input-only pin to a determined state. Pull-up and pull-down resistors are commonly applied to unused I/Os, inputs, and three-state outputs, but can be used on any I/O or Input-only pin. The pull-up resistor connects an IOB to  $V_{CCO}$  through a resistor. The resistance value depends on the  $V_{CCO}$  voltage (see Module 3, [DC and Switching Characteristics](#) for the specifications). The pull-down resistor similarly connects an IOB to ground with a resistor. The PULLUP and PULLDOWN attributes and library primitives turn on these optional resistors.

By default, PULLDOWN resistors terminate all unused I/O and Input-only pins. Unused I/O and Input-only pins can alternatively be set to PULLUP or FLOAT. To change the unused I/O Pad setting, set the Bitstream Generator (BitGen) option [UnusedPin](#) to PULLUP, PULLDOWN, or FLOAT. The [UnusedPin](#) option is accessed through the Properties for Generate Programming File in ISE. See [Bitstream Generator \(BitGen\) Options](#).

During configuration a Low logic level on the HSWAP pin activates pull-up resistors on all I/O and Input-only pins not actively used in the selected configuration mode.

## Keeper Circuit

Each I/O has an optional keeper circuit (see [Figure 12](#)) that keeps bus lines from floating when not being actively driven. The KEEPER circuit retains the last logic level on a line after all drivers have been turned off. Apply the KEEPER attribute or use the KEEPER library primitive to use the KEEPER circuitry. Pull-up and pull-down resistors override the KEEPER settings.

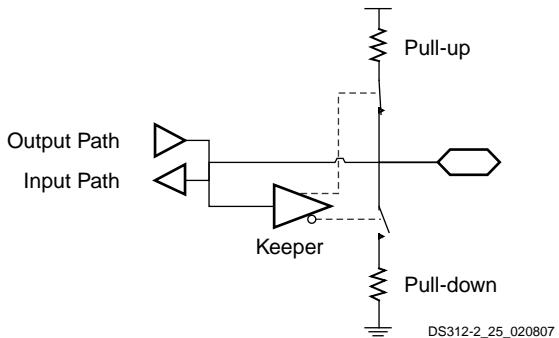


Figure 12: Keeper Circuit

## Slew Rate Control and Drive Strength

Each IOB has a slew-rate control that sets the output switching edge-rate for LVCMOS and LVTTL outputs. The SLEW attribute controls the slew rate and can either be set to SLOW (default) or FAST.

Each LVCMOS and LVTTL output additionally supports up to six different drive current strengths as shown in [Table 8](#). To adjust the drive strength for each output, the DRIVE attribute is set to the desired drive strength: 2, 4, 6, 8, 12, and 16. Unless otherwise specified in the FPGA application, the software default IOSTANDARD is LVCMOS25, SLOW slew rate, and 12 mA output drive.

Table 8: Programmable Output Drive Current

| IOSTANDARD | Output Drive Current (mA) |   |   |   |    |    |
|------------|---------------------------|---|---|---|----|----|
|            | 2                         | 4 | 6 | 8 | 12 | 16 |
| LVTTL      | ✓                         | ✓ | ✓ | ✓ | ✓  | ✓  |
| LVCMOS33   | ✓                         | ✓ | ✓ | ✓ | ✓  | ✓  |
| LVCMOS25   | ✓                         | ✓ | ✓ | ✓ | ✓  | -  |
| LVCMOS18   | ✓                         | ✓ | ✓ | ✓ | -  | -  |
| LVCMOS15   | ✓                         | ✓ | ✓ | - | -  | -  |
| LVCMOS12   | ✓                         | - | - | - | -  | -  |

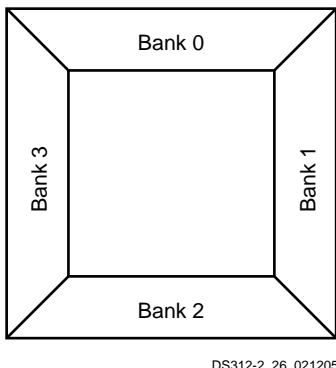
High output current drive strength and FAST output slew rates generally result in fastest I/O performance. However, these same settings generally also result in transmission line effects on the printed circuit board (PCB) for all but the shortest board traces. Each IOB has independent slew rate and drive strength controls. Use the slowest slew rate and lowest output drive current that meets the performance requirements for the end application.

Likewise, due to lead inductance, a given package supports a limited number of simultaneous switching outputs (SSOs) when using fast, high-drive outputs. Only use fast, high-drive outputs when required by the application.

## IOBs Organized into Banks

The Spartan-3E architecture organizes IOBs into four I/O banks as shown in [Figure 13](#). Each bank maintains separate  $V_{CCO}$  and  $V_{REF}$  supplies. The separate supplies allow each bank to independently set  $V_{CCO}$ . Similarly, the  $V_{REF}$  supplies can be set for each bank. Refer to [Table 6](#) and [Table 7](#) for  $V_{CCO}$  and  $V_{REF}$  requirements.

When working with Spartan-3E devices, most of the differential I/O standards are compatible and can be combined within any given bank. Each bank can support any two of the following differential standards: LVDS\_25 outputs, MINI\_LVDS\_25 outputs, and RSRS\_25 outputs. As an example, LVDS\_25 outputs, RSRS\_25 outputs, and any other differential inputs while using on-chip differential termination are a valid combination. A combination not allowed is a single bank with LVDS\_25 outputs, RSRS\_25 outputs, and MINI\_LVDS\_25 outputs.



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Figure 13: Spartan-3E I/O Banks (top view)

## I/O Banking Rules

When assigning I/Os to banks, these  $V_{CCO}$  rules must be followed:

1. All  $V_{CCO}$  pins on the FPGA must be connected even if a bank is unused.
2. All  $V_{CCO}$  lines associated within a bank must be set to the same voltage level.
3. The  $V_{CCO}$  levels used by all standards assigned to the I/Os of any given bank must agree. The Xilinx development software checks for this. [Table 6](#) and [Table 7](#) describe how different standards use the  $V_{CCO}$  supply.
4. If a bank does not have any  $V_{CCO}$  requirements, connect  $V_{CCO}$  to an available voltage, such as 2.5V or 3.3V. Some configuration modes might place additional  $V_{CCO}$  requirements. Refer to [Configuration](#) for more information.

If any of the standards assigned to the Inputs of the bank use  $V_{REF}$ , then the following additional rules must be observed:

1. All  $V_{REF}$  pins must be connected within a bank.
2. All  $V_{REF}$  lines associated with the bank must be set to the same voltage level.
3. The  $V_{REF}$  levels used by all standards assigned to the Inputs of the bank must agree. The Xilinx development software checks for this. [Table 6](#) describes how different standards use the  $V_{REF}$  supply.

If  $V_{REF}$  is not required to bias the input switching thresholds, all associated  $V_{REF}$  pins within the bank can be used as user I/Os or input pins.

## Package Footprint Compatibility

Sometimes, applications outgrow the logic capacity of a specific Spartan-3E FPGA. Fortunately, the Spartan-3E family is designed so that multiple part types are available in pin-compatible package footprints, as described in [Module 4, Pinout Descriptions](#). In some cases, there are subtle differences between devices available in the same footprint. These differences are outlined for each package, such as pins that are unconnected on one device but connected on another in the same package or pins that are dedicated inputs on one package but full I/O on another. When designing the printed circuit board (PCB), plan for potential future upgrades and package migration.

The Spartan-3E family is not pin-compatible with any previous Xilinx FPGA family.

## Dedicated Inputs

Dedicated Inputs are IOBs used only as inputs. Pin names designate a Dedicated Input if the name starts with *IP*, for example, *IP* or *IP\_Lxxx\_x*. Dedicated inputs retain the full functionality of the IOB for input functions with a single exception for differential inputs (*IP\_Lxxx\_x*). For the differential Dedicated Inputs, the on-chip differential termination is not available. To replace the on-chip differential termination, choose a differential pair that supports outputs (*IO\_Lxxx\_x*) or use an external  $100\Omega$  termination resistor on the board.

## ESD Protection

Clamp diodes protect all device pads against damage from Electro-Static Discharge (ESD) as well as excessive voltage transients. Each I/O has two clamp diodes: one diode extends P-to-N from the pad to  $V_{CCO}$  and a second diode extends N-to-P from the pad to GND. During operation, these diodes are normally biased in the off state. These clamp diodes are always connected to the pad, regardless of the signal standard selected. The presence of diodes limits the ability of Spartan-3E I/Os to tolerate high signal voltages. The  $V_{IN}$  absolute maximum rating in [Table 73](#) of [Module 3, DC and Switching Characteristics](#) specifies the voltage range that I/Os can tolerate.

## Supply Voltages for the IOBs

The IOBs are powered by three supplies:

1. The  $V_{CCO}$  supplies, one for each of the FPGA's I/O banks, power the output drivers. The voltage on the  $V_{CCO}$  pins determines the voltage swing of the output signal.
2.  $V_{CCINT}$  is the main power supply for the FPGA's internal logic.
3.  $V_{CCAUX}$  is an auxiliary source of power, primarily to optimize the performance of various FPGA functions such as I/O switching.

## I/O and Input-Only Pin Behavior During Power-On, Configuration, and User Mode

In this section, all behavior described for I/O pins also applies to input-only pins and dual-purpose I/O pins that are not actively involved in the currently-selected configuration mode.

All I/O pins have ESD clamp diodes to their respective  $V_{CCO}$  supply and from GND, as shown in [Figure 5](#). The  $V_{CCINT}$  (1.2V),  $V_{CCAUX}$  (2.5V), and  $V_{CCO}$  supplies can be applied in any order. Before the FPGA can start its configuration process,  $V_{CCINT}$ ,  $V_{CCO}$  Bank 2, and  $V_{CCAUX}$  must have reached their respective minimum recommended operating levels indicated in [Table 74](#). At this time, all output drivers are in a high-impedance state.  $V_{CCO}$  Bank 2,  $V_{CCINT}$ , and  $V_{CCAUX}$  serve as inputs to the internal Power-On Reset circuit (POR).

A Low level applied to the HSWAP input enables pull-up resistors on user-I/O and input-only pins from power-on throughout configuration. A High level on HSWAP disables the pull-up resistors, allowing the I/Os to float. HSWAP contains an internal pull-up resistor and defaults to High if left floating. As soon as power is applied, the FPGA begins initializing its configuration memory. At the same time, the FPGA internally asserts the Global Set-Reset (GSR), which asynchronously resets all IOB storage elements to a default Low state. Also see [Pin Behavior During Configuration](#).

Upon the completion of initialization and the beginning of configuration, INIT\_B goes High, sampling the M0, M1, and M2 inputs to determine the configuration mode.

Configuration data is then loaded into the FPGA. The I/O drivers remain in a high-impedance state (with or without pull-up resistors, as determined by the HSWAP input) throughout configuration.

At the end of configuration, the GSR net is released, placing the IOB registers in a Low state by default, unless the loaded design reverses the polarity of their respective SR inputs.

The Global Three State (GTS) net is released during Start-Up, marking the end of configuration and the

beginning of design operation in the User mode. After the GTS net is released, all user I/Os go active while all unused I/Os are pulled down (PULLDOWN). The designer can control how the unused I/Os are terminated after GTS is released by setting the Bitstream Generator (BitGen) option UnusedPin to PULLUP, PULLDOWN, or FLOAT.

One clock cycle later (default), the Global Write Enable (GWE) net is released allowing the RAM and registers to change states. Once in User mode, any pull-up resistors enabled by HSWAP revert to the user settings and HSWAP is available as a general-purpose I/O. For more information on PULLUP and PULLDOWN, see [Pull-Up and Pull-Down Resistors](#).

## Behavior of Unused I/O Pins After Configuration

By default, the Xilinx ISE development software automatically configures all unused I/O pins as input pins with individual internal pull-down resistors to GND.

This default behavior is controlled by the [UnusedPin](#) bitstream generator (BitGen) option, as described in [Table 69](#).

## JTAG Boundary-Scan Capability

All Spartan-3E IOBs support boundary-scan testing compatible with IEEE 1149.1/1532 standards. During boundary-scan operations such as EXTEST and HIGHZ the pull-down resistor is active. See [JTAG Mode](#) for more information on programming via JTAG.

## Configurable Logic Block (CLB) and Slice Resources

For additional information, refer to the “Using Configurable Logic Blocks (CLBs)” chapter in [UG331](#).

### CLB Overview

The Configurable Logic Blocks (CLBs) constitute the main logic resource for implementing synchronous as well as combinatorial circuits. Each CLB contains four slices, and each slice contains two Look-Up Tables (LUTs) to implement logic and two dedicated storage elements that can be used as flip-flops or latches. The LUTs can be used as a 16x1 memory (RAM16) or as a 16-bit shift register

(SRL16), and additional multiplexers and carry logic simplify wide logic and arithmetic functions. Most general-purpose logic in a design is automatically mapped to the slice resources in the CLBs. Each CLB is identical, and the Spartan-3E family CLB structure is identical to that for the Spartan-3 family.

### CLB Array

The CLBs are arranged in a regular array of rows and columns as shown in [Figure 14](#).

Each density varies by the number of rows and columns of CLBs (see [Table 9](#)).

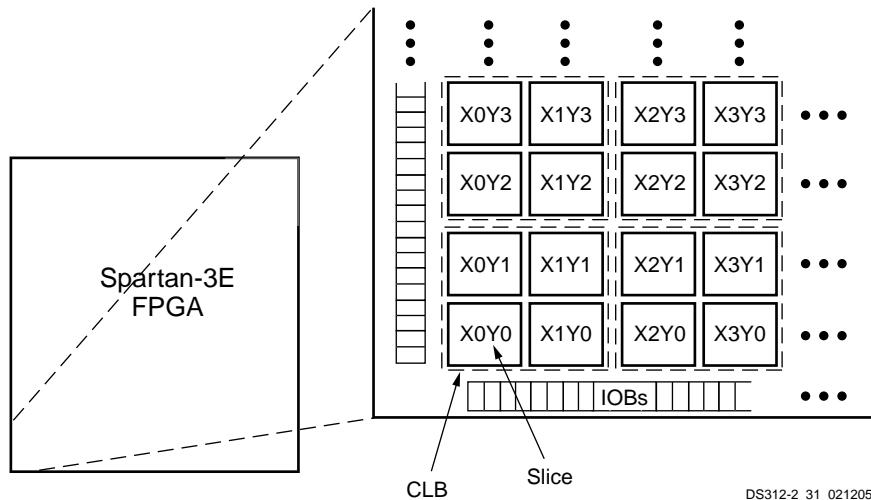


Figure 14: CLB Locations

Table 9: Spartan-3E CLB Resources

| Device    | CLB Rows | CLB Columns | CLB Total <sup>(1)</sup> | Slices | LUTs / Flip-Flops | Equivalent Logic Cells | RAM16 / SRL16 | Distributed RAM Bits |
|-----------|----------|-------------|--------------------------|--------|-------------------|------------------------|---------------|----------------------|
| XC3S100E  | 22       | 16          | 240                      | 960    | 1,920             | 2,160                  | 960           | 15,360               |
| XC3S250E  | 34       | 26          | 612                      | 2,448  | 4,896             | 5,508                  | 2,448         | 39,168               |
| XC3S500E  | 46       | 34          | 1,164                    | 4,656  | 9,312             | 10,476                 | 4,656         | 74,496               |
| XC3S1200E | 60       | 46          | 2,168                    | 8,672  | 17,344            | 19,512                 | 8,672         | 138,752              |
| XC3S1600E | 76       | 58          | 3,688                    | 14,752 | 29,504            | 33,192                 | 14,752        | 236,032              |

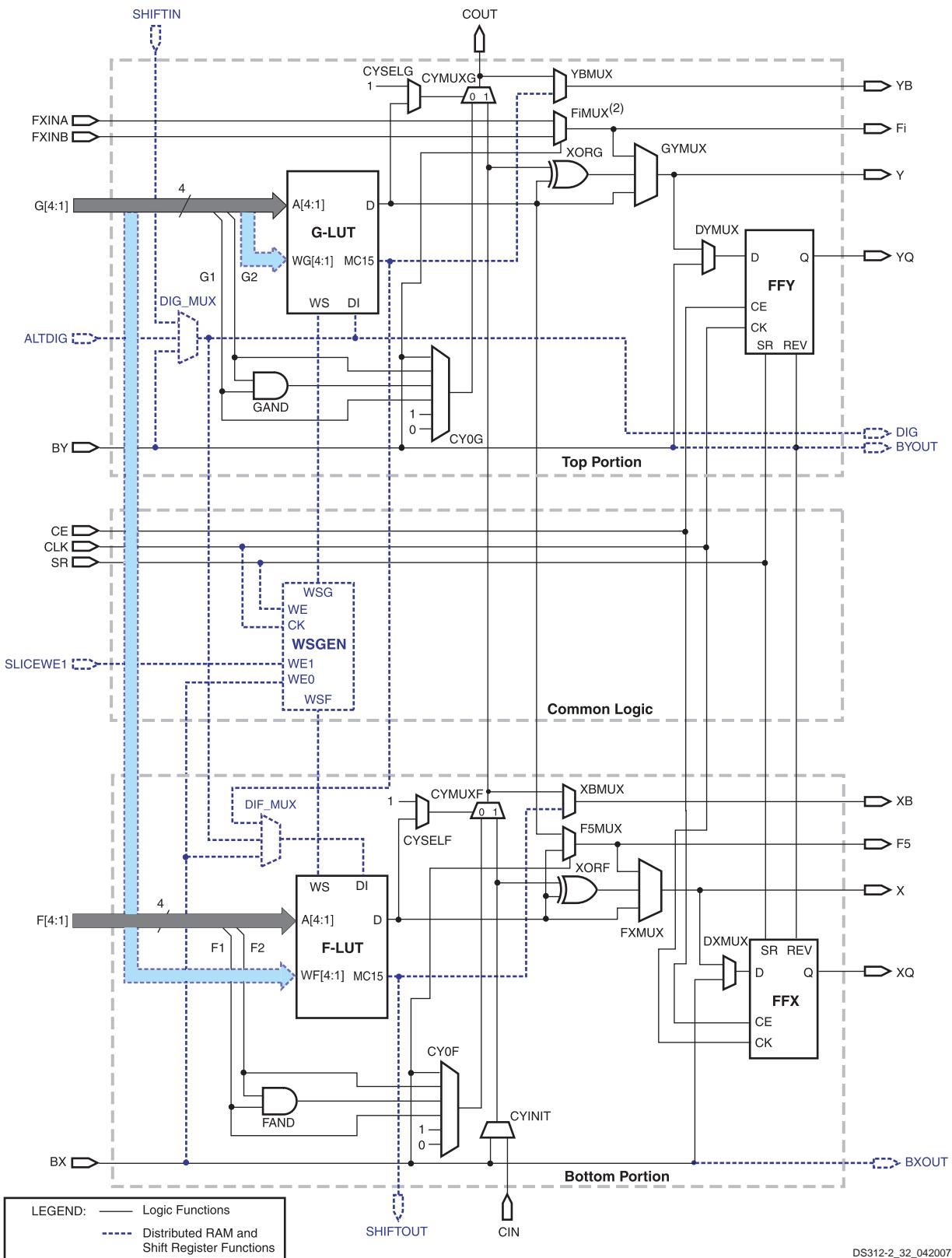
#### Notes:

1. The number of CLBs is less than the multiple of the rows and columns because the block RAM/multiplier blocks and the DCMs are embedded in the array (see [Figure 1](#) in Module 1).

### Slices

Each CLB comprises four interconnected slices, as shown in [Figure 16](#). These slices are grouped in pairs. Each pair is organized as a column with an independent carry chain. The left pair supports both logic and memory functions and its slices are called SLICEM. The right pair supports logic only and its slices are called SLICEL. Therefore half the

LUTs support both logic and memory (including both RAM16 and SRL16 shift registers) while half support logic only, and the two types alternate throughout the array columns. The SLICEL reduces the size of the CLB and lowers the cost of the device, and can also provide a performance advantage over the SLICEM.



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**Notes:**

1. Options to invert signal polarity as well as other options that enable lines for various functions are not shown.
2. The index  $i$  can be 6, 7, or 8, depending on the slice. The upper SLICEL has an F8MUX, and the upper SLICEM has an F7MUX. The lower SLICEL and SLICEM both have an F6MUX.

Figure 15: Simplified Diagram of the Left-Hand SLICEM

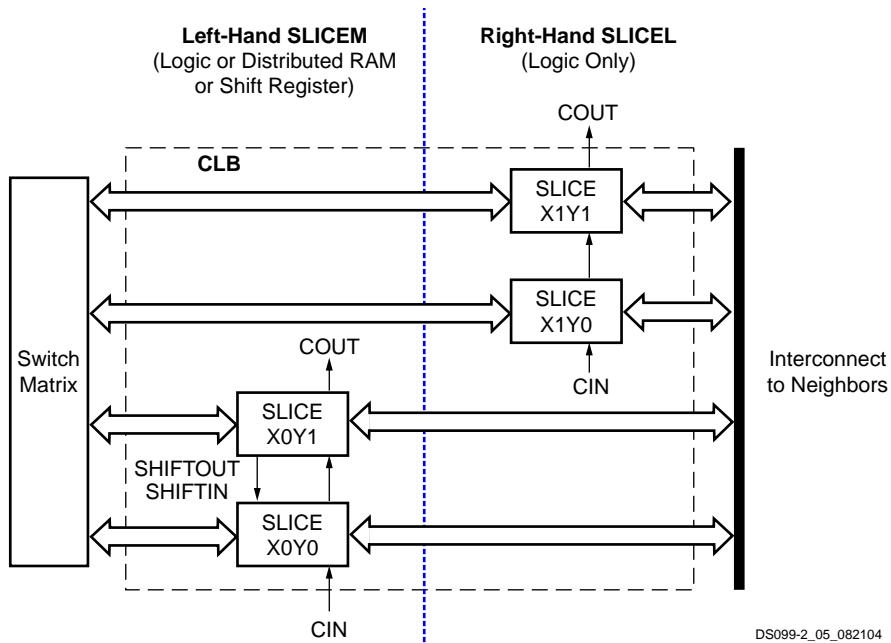


Figure 16: Arrangement of Slices within the CLB

## Slice Location Designations

The Xilinx development software designates the location of a slice according to its X and Y coordinates, starting in the bottom left corner, as shown in Figure 14. The letter 'X' followed by a number identifies columns of slices, incrementing from the left side of the die to the right. The letter 'Y' followed by a number identifies the position of each slice in a pair as well as indicating the CLB row, incrementing from the bottom of the die. Figure 16 shows the CLB located in the lower left-hand corner of the die. The SLICEM always has an even 'X' number, and the SLICEL always has an odd 'X' number.

## Slice Overview

A slice includes two LUT function generators and two storage elements, along with additional logic, as shown in Figure 17.

Both SLICEM and SLICEL have the following elements in common to provide logic, arithmetic, and ROM functions:

- Two 4-input LUT function generators, F and G
- Two storage elements
- Two wide-function multiplexers, F5MUX and FiMUX
- Carry and arithmetic logic

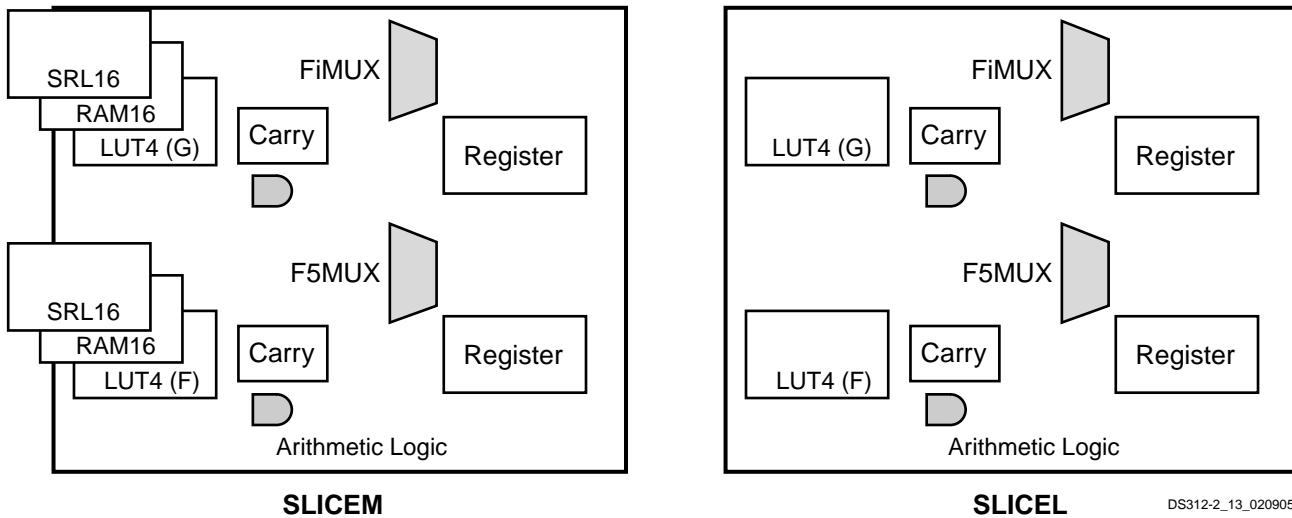


Figure 17: Resources in a Slice

The SLICEM pair supports two additional functions:

- Two 16x1 distributed RAM blocks, RAM16
- Two 16-bit shift registers, SRL16

Each of these elements is described in more detail in the following sections.

## Logic Cells

The combination of a LUT and a storage element is known as a “Logic Cell”. The additional features in a slice, such as the wide multiplexers, carry logic, and arithmetic gates, add to the capacity of a slice, implementing logic that would otherwise require additional LUTs. Benchmarks have shown that the overall slice is equivalent to 2.25 simple logic cells. This calculation provides the equivalent logic cell count shown in [Table 9](#).

## Slice Details

[Figure 15](#) is a detailed diagram of the SLICEM. It represents a superset of the elements and connections to be found in all slices. The dashed and gray lines (blue when viewed in color) indicate the resources found only in the SLICEM and not in the SLICEL.

Each slice has two halves, which are differentiated as top and bottom to keep them distinct from the upper and lower slices in a CLB. The control inputs for the clock (CLK), Clock

Enable (CE), Slice Write Enable (SLICEWE1), and Reset/Set (RS) are shared in common between the two halves.

The LUTs located in the top and bottom portions of the slice are referred to as “G” and “F”, respectively, or the “G-LUT” and the “F-LUT”. The storage elements in the top and bottom portions of the slice are called FFY and FFX, respectively.

Each slice has two multiplexers with F5MUX in the bottom portion of the slice and FiMUX in the top portion. Depending on the slice, the FiMUX takes on the name F6MUX, F7MUX, or F8MUX, according to its position in the multiplexer chain. The lower SLICEL and SLICEM both have an F6MUX. The upper SLICEM has an F7MUX, and the upper SLICEL has an F8MUX.

The carry chain enters the bottom of the slice as CIN and exits at the top as COUT. Five multiplexers control the chain: CYINIT, CY0F, and CYMUXF in the bottom portion and CY0G and CYMUXG in the top portion. The dedicated arithmetic logic includes the exclusive-OR gates XORF and XORG (bottom and top portions of the slice, respectively) as well as the AND gates FAND and GAND (bottom and top portions, respectively).

See [Table 10](#) for a description of all the slice input and output signals.

**Table 10: Slice Inputs and Outputs**

| Name     | Location        | Direction | Description   |
|----------|-----------------|-----------|---|
| F[4:1]   | SLICEL/M Bottom | Input     | F-LUT and FAND inputs   |
| G[4:1]   | SLICEL/M Top    | Input     | G-LUT and GAND inputs or Write Address (SLICEM)   |
| BX       | SLICEL/M Bottom | Input     | Bypass to or output (SLICEM) or storage element, or control input to F5MUX, input to carry logic, or data input to RAM (SLICEM) |
| BY       | SLICEL/M Top    | Input     | Bypass to or output (SLICEM) or storage element, or control input to FiMUX, input to carry logic, or data input to RAM (SLICEM) |
| BXOUT    | SLICEM Bottom   | Output    | BX bypass output  |
| BYOUT    | SLICEM Top      | Output    | BY bypass output  |
| ALTDIG   | SLICEM Top      | Input     | Alternate data input to RAM   |
| DIG      | SLICEM Top      | Output    | ALTDIG or SHIFTIN bypass output   |
| SLICEWE1 | SLICEM Common   | Input     | RAM Write Enable  |
| F5       | SLICEL/M Bottom | Output    | Output from F5MUX; direct feedback to FiMUX   |
| FXINA    | SLICEL/M Top    | Input     | Input to FiMUX; direct feedback from F5MUX or another FiMUX   |
| FXINB    | SLICEL/M Top    | Input     | Input to FiMUX; direct feedback from F5MUX or another FiMUX   |
| Fi       | SLICEL/M Top    | Output    | Output from FiMUX; direct feedback to another FiMUX   |
| CE       | SLICEL/M Common | Input     | FFX/Y Clock Enable  |
| SR       | SLICEL/M Common | Input     | FFX/Y Set or Reset or RAM Write Enable (SLICEM)   |
| CLK      | SLICEL/M Common | Input     | FFX/Y Clock or RAM Clock (SLICEM)   |
| SHIFTIN  | SLICEM Top      | Input     | Data input to G-LUT RAM   |

Table 10: Slice Inputs and Outputs (Cont'd)

| Name     | Location        | Direction | Description   |
|----------|-----------------|-----------|---|
| SHIFTOUT | SLICEM Bottom   | Output    | Shift data output from F-LUT RAM                        |
| CIN      | SLICEL/M Bottom | Input     | Carry chain input                                       |
| COUT     | SLICEL/M Top    | Output    | Carry chain output                                      |
| X        | SLICEL/M Bottom | Output    | Combinatorial output                                    |
| Y        | SLICEL/M Top    | Output    | Combinatorial output                                    |
| XB       | SLICEL/M Bottom | Output    | Combinatorial output from carry or F-LUT SRL16 (SLICEM) |
| YB       | SLICEL/M Top    | Output    | Combinatorial output from carry or G-LUT SRL16 (SLICEM) |
| XQ       | SLICEL/M Bottom | Output    | FFX output  |
| YQ       | SLICEL/M Top    | Output    | FFY output  |

## Main Logic Paths

Central to the operation of each slice are two nearly identical data paths at the top and bottom of the slice. The description that follows uses names associated with the bottom path. (The top path names appear in parentheses.) The basic path originates at an interconnect switch matrix outside the CLB. See [Interconnect](#) for more information on the switch matrix and the routing connections.

Four lines, F1 through F4 (or G1 through G4 on the upper path), enter the slice and connect directly to the LUT. Once inside the slice, the lower 4-bit path passes through a LUT 'F' (or 'G') that performs logic operations. The LUT Data output, 'D', offers five possible paths:

1. Exit the slice via line "X" (or "Y") and return to interconnect.
2. Inside the slice, "X" (or "Y") serves as an input to the DXMUX (or DYMUX) which feeds the data input, "D", of the FFX (or FFY) storage element. The "Q" output of the storage element drives the line XQ (or YQ) which exits the slice.
3. Control the CYMUXF (or CYMUXG) multiplexer on the carry chain.
4. With the carry chain, serve as an input to the XORG (or XORG) exclusive-OR gate that performs arithmetic operations, producing a result on "X" (or "Y").
5. Drive the multiplexer F5MUX to implement logic functions wider than four bits. The "D" outputs of both the F-LUT and G-LUT serve as data inputs to this multiplexer.

In addition to the main logic paths described above, there are two bypass paths that enter the slice as BX and BY. Once inside the FPGA, BX in the bottom half of the slice (or BY in the top half) can take any of several possible branches:

1. Bypass both the LUT and the storage element, and then exit the slice as BXOUT (or BYOUT) and return to interconnect.

2. Bypass the LUT, and then pass through a storage element via the D input before exiting as XQ (or YQ).
3. Control the wide function multiplexer F5MUX (or FiMUX).
4. Via multiplexers, serve as an input to the carry chain.
5. Drive the DI input of the LUT.
6. BY can control the REV inputs of both the FFY and FFX storage elements. See [Storage Element Functions](#).
7. Finally, the DIG\_MUX multiplexer can switch BY onto the DIG line, which exits the slice.

The control inputs CLK, CE, SR, BX and BY have programmable polarity. The LUT inputs do not need programmable polarity because their function can be inverted inside the LUT.

The sections that follow provide more detail on individual functions of the slice.

## Look-Up Tables

The Look-Up Table or LUT is a RAM-based function generator and is the main resource for implementing logic functions. Furthermore, the LUTs in each SLICEM pair can be configured as Distributed RAM or a 16-bit shift register, as described later.

Each of the two LUTs (F and G) in a slice have four logic inputs (A1-A4) and a single output (D). Any four-variable Boolean logic operation can be implemented in one LUT. Functions with more inputs can be implemented by cascading LUTs or by using the wide function multiplexers that are described later.

The output of the LUT can connect to the wide multiplexer logic, the carry and arithmetic logic, or directly to a CLB output or to the CLB storage element. See [Figure 18](#).

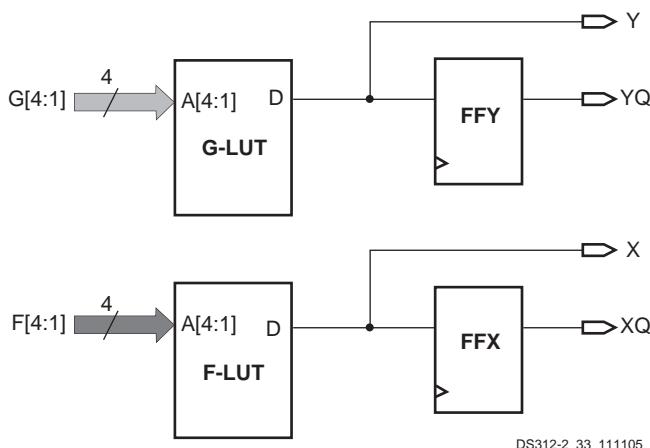


Figure 18: LUT Resources in a Slice

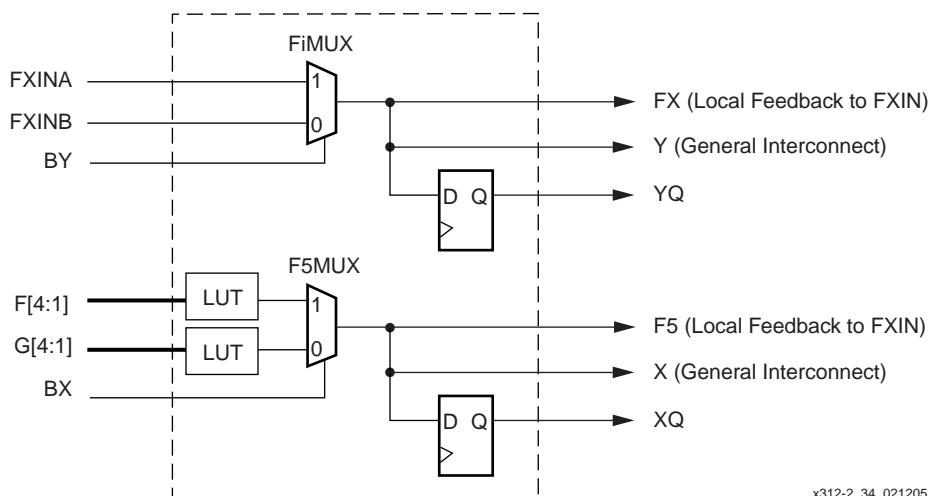


Figure 19: Dedicated Multiplexers in Spartan-3E CLB

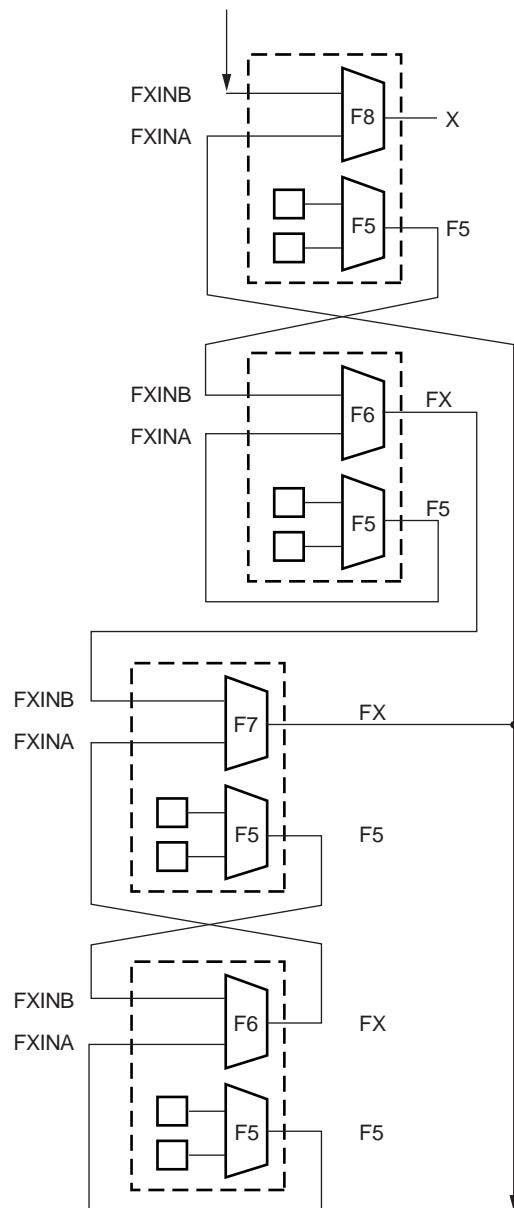
Depending on the slice, FiMUX takes on the name F6MUX, F7MUX, or F8MUX. The designation indicates the number of inputs possible without restriction on the function. For example, an F7MUX can generate any function of seven inputs. Figure 20 shows the names of the multiplexers in each position in the Spartan-3E CLB. The figure also includes the direct connections within the CLB, along with the F7MUX connection to the CLB below.

Each mux can create logic functions of more inputs than indicated by its name. The F5MUX, for example, can generate any function of five inputs, with four inputs duplicated to two LUTs and the fifth input controlling the mux. Because each LUT can implement independent 2:1 muxes, the F5MUX can combine them to create a 4:1 mux, which is a six-input function. If the two LUTs have completely independent sets of inputs, some functions of all nine inputs can be implemented. Table 11 shows the connections for each multiplexer and the number of inputs possible for different types of functions.

## Wide Multiplexers

For additional information, refer to the “Using Dedicated Multiplexers” chapter in [UG331](#).

Wide-function multiplexers effectively combine LUTs in order to permit more complex logic operations. Each slice has two of these multiplexers with F5MUX in the bottom portion of the slice and FiMUX in the top portion. The F5MUX multiplexes the two LUTs in a slice. The FiMUX multiplexes two CLB inputs which connect directly to the F5MUX and FiMUX results from the same slice or from other slices. See [Figure 19](#).



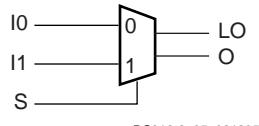
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Figure 20: MUXes and Dedicated Feedback in Spartan-3E CLB

Table 11: MUX Capabilities

| MUX   | Usage | Input Source | Total Number of Inputs per Function |               |                       |
|-------|-------|--------------|-------------------------------------|---------------|-----------------------|
|       |       |              | For Any Function                    | For MUX       | For Limited Functions |
| F5MUX | F5MUX | LUTs         | 5                                   | 6 (4:1 MUX)   | 9                     |
| FiMUX | F6MUX | F5MUX        | 6                                   | 11 (8:1 MUX)  | 19                    |
|       | F7MUX | F6MUX        | 7                                   | 20 (16:1 MUX) | 39                    |
|       | F8MUX | F7MUX        | 8                                   | 37 (32:1 MUX) | 79                    |

The wide multiplexers can be used by the automatic tools or instantiated in a design using a component such as the F5MUX. The symbol, signals, and function are described in [Figure 21](#), [Table 12](#), and [Table 13](#). The description is similar for the F6MUX, F7MUX, and F8MUX. Each has versions with a general output, local output, or both.



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**Figure 21: F5MUX with Local and General Outputs**

**Table 12: F5MUX Inputs and Outputs**

| Signal | Function  |
|--------|---|
| I0     | Input selected when S is Low  |
| I1     | Input selected when S is High   |
| S      | Select input  |
| LO     | Local Output that connects to the F5 or FX CLB pins, which use local feedback to the FXIN inputs to the FiMUX for cascading |
| O      | General Output that connects to the general-purpose combinatorial or registered outputs of the CLB                          |

**Table 13: F5MUX Function**

| Inputs |    |    | Outputs |    |
|--------|----|----|---------|----|
| S      | I0 | I1 | O       | LO |
| 0      | 1  | X  | 1       | 1  |
| 0      | 0  | X  | 0       | 0  |
| 1      | X  | 1  | 1       | 1  |
| 1      | X  | 0  | 0       | 0  |

## Carry and Arithmetic Logic

For additional information, refer to the “Using Carry and Arithmetic Logic” chapter in [UG331](#).

The carry chain, together with various dedicated arithmetic logic gates, support fast and efficient implementations of math operations. The carry logic is automatically used for most arithmetic functions in a design. The gates and multiplexers of the carry and arithmetic logic can also be used for general-purpose logic, including simple wide Boolean functions.

The carry chain enters the slice as CIN and exits as COUT, controlled by several multiplexers. The carry chain connects directly from one CLB to the CLB above. The carry chain can be initialized at any point from the BX (or BY) inputs.

The dedicated arithmetic logic includes the exclusive-OR gates XORF and XORG (upper and lower portions of the slice, respectively) as well as the AND gates GAND and FAND (upper and lower portions, respectively). These gates work in conjunction with the LUTs to implement efficient arithmetic functions, including counters and multipliers, typically at two bits per slice. See [Figure 22](#) and [Table 14](#).

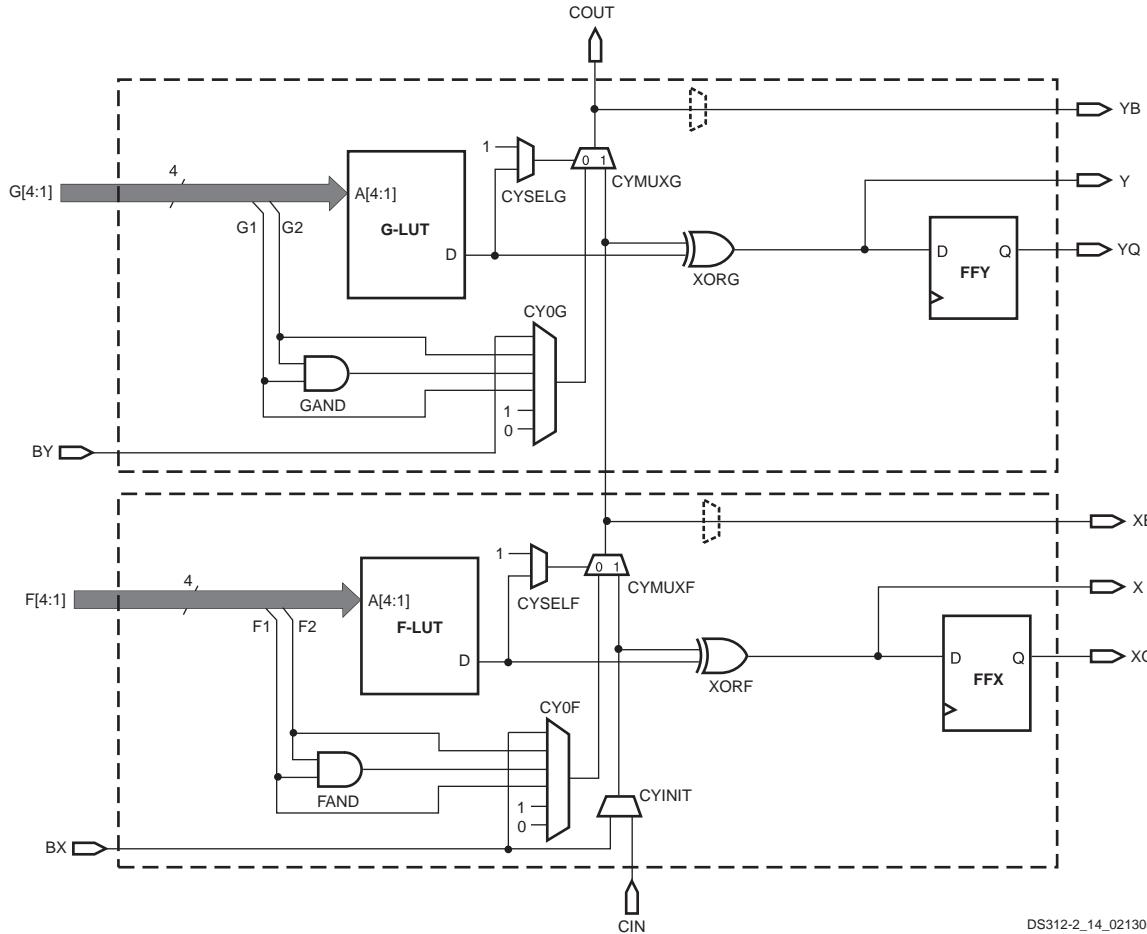


Figure 22: Carry Logic

Table 14: Carry Logic Functions

| Function | Description  |
|----------|--|
| CYINIT   | Initializes carry chain for a slice. Fixed selection of: <ul style="list-style-type: none"> <li>CIN carry input from the slice below</li> <li>BX input</li> </ul>  |
| CYOF     | Carry generation for bottom half of slice. Fixed selection of: <ul style="list-style-type: none"> <li>F1 or F2 inputs to the LUT (both equal 1 when a carry is to be generated)</li> <li>FAND gate for multiplication</li> <li>BX input for carry initialization</li> <li>Fixed 1 or 0 input for use as a simple Boolean function</li> </ul> |

Table 14: Carry Logic Functions (Cont'd)

| Function | Description   |
|----------|---|
| CY0G     | Carry generation for top half of slice. Fixed selection of: <ul style="list-style-type: none"> <li>• G1 or G2 inputs to the LUT (both equal 1 when a carry is to be generated)</li> <li>• GAND gate for multiplication</li> <li>• BY input for carry initialization</li> <li>• Fixed 1 or 0 input for use as a simple Boolean function</li> </ul> |
| CYMUXF   | Carry generation or propagation mux for bottom half of slice. Dynamic selection via CYSELF of: <ul style="list-style-type: none"> <li>• CYINIT carry propagation (CYSELF = 1)</li> <li>• CY0F carry generation (CYSELF = 0)</li> </ul>  |
| CYMUXG   | Carry generation or propagation mux for top half of slice. Dynamic selection via CYSELG of: <ul style="list-style-type: none"> <li>• CYMUXF carry propagation (CYSELG = 1)</li> <li>• CY0G carry generation (CYSELG = 0)</li> </ul>   |
| CYSELF   | Carry generation or propagation select for bottom half of slice. Fixed selection of: <ul style="list-style-type: none"> <li>• F-LUT output (typically XOR result)</li> <li>• Fixed 1 to always propagate</li> </ul>   |
| CYSELG   | Carry generation or propagation select for top half of slice. Fixed selection of: <ul style="list-style-type: none"> <li>• G-LUT output (typically XOR result)</li> <li>• Fixed 1 to always propagate</li> </ul>  |
| XORF     | Sum generation for bottom half of slice. Inputs from: <ul style="list-style-type: none"> <li>• F-LUT</li> <li>• CYINIT carry signal from previous stage</li> </ul> Result is sent to either the combinatorial or registered output for the top of the slice.  |
| XORG     | Sum generation for top half of slice. Inputs from: <ul style="list-style-type: none"> <li>• G-LUT</li> <li>• CYMUXF carry signal from previous stage</li> </ul> Result is sent to either the combinatorial or registered output for the top of the slice.   |
| FAND     | Multiplier partial product for bottom half of slice. Inputs: <ul style="list-style-type: none"> <li>• F-LUT F1 input</li> <li>• F-LUT F2 input</li> </ul> Result is sent through CY0F to become the carry generate signal into CYMUXF   |
| GAND     | Multiplier partial product for top half of slice. Inputs: <ul style="list-style-type: none"> <li>• G-LUT G1 input</li> <li>• G-LUT G2 input</li> </ul> Result is sent through CY0G to become the carry generate signal into CYMUXG  |

The basic usage of the carry logic is to generate a half-sum in the LUT via an XOR function, which generates or propagates a carry out COUT via the carry mux CYMUXF (or CYMUXG), and then complete the sum with the dedicated XORF (or XORG) gate and the carry input CIN. This structure allows two bits of an arithmetic function in each slice. The CYMUXF (or CYMUXG) can be instantiated using the MUXCY element, and the XORF (or XORG) can be instantiated using the XORCY element.

The FAND (or GAND) gate is used for partial product multiplication and can be instantiated using the MULT\_AND component. Partial products are generated by two-input AND gates and then added. The carry logic is efficient for the adder, but one of the inputs must be outside the LUT as shown in Figure 23.

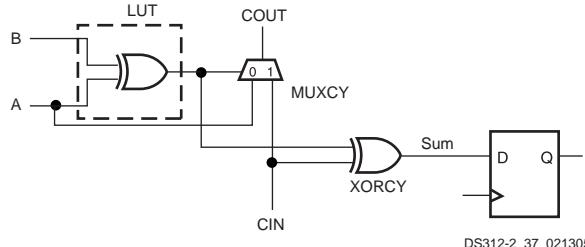


Figure 23: Using the MUXCY and XORCY in the Carry Logic

The FAND (or GAND) gate is used to duplicate one of the partial products, while the LUT generates both partial products and the XOR function, as shown in Figure 24.

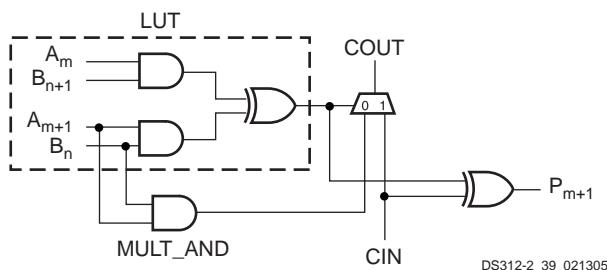


Figure 24: Using the MULT\_AND for Multiplication in Carry Logic

The MULT\_AND is useful for small multipliers. Larger multipliers can be built using the dedicated 18x18 multiplier blocks (see [Dedicated Multipliers](#)).

Table 15: Storage Element Signals

| Signal | Description  |
|--------|--|
| D      | Input. For a flip-flop data on the D input is loaded when R and S (or CLR and PRE) are Low and CE is High during the Low-to-High clock transition. For a latch, Q reflects the D input while the gate (G) input and gate enable (GE) are High and R and S (or CLR and PRE) are Low. The data on the D input during the High-to-Low gate transition is stored in the latch. The data on the Q output of the latch remains unchanged as long as G or GE remains Low. |
| Q      | Output. Toggles after the Low-to-High clock transition for a flip-flop and immediately for a latch.  |
| C      | Clock for edge-triggered flip-flops.   |
| G      | Gate for level-sensitive latches.  |
| CE     | Clock Enable for flip-flops.   |
| GE     | Gate Enable for latches.   |
| S      | Synchronous Set (Q = High). When the S input is High and R is Low, the flip-flop is set, output High, during the Low-to-High clock (C) transition. A latch output is immediately set, output High.   |
| R      | Synchronous Reset (Q = Low); has precedence over Set.  |
| PRE    | Asynchronous Preset (Q = High). When the PRE input is High and CLR is Low, the flip-flop is set, output High, during the Low-to-High clock (C) transition. A latch output is immediately set, output High.   |
| CLR    | Asynchronous Clear (Q = Low); has precedence over Preset to reset Q output Low   |
| SR     | CLB input for R, S, CLR, or PRE  |
| REV    | CLB input for opposite of SR. Must be asynchronous or synchronous to match SR.   |

The control inputs R, S, CE, and C are all shared between the two flip-flops in a slice.

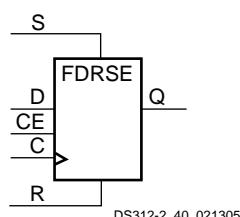


Figure 25: FD Flip-Flop Component with Synchronous Reset, Set, and Clock Enable

## Storage Elements

The storage element, which is programmable as either a D-type flip-flop or a level-sensitive transparent latch, provides a means for synchronizing data to a clock signal, among other uses. The storage elements in the top and bottom portions of the slice are called FFY and FFX, respectively. FFY has a fixed multiplexer on the D input selecting either the combinatorial output Y or the bypass signal BY. FFX selects between the combinatorial output X or the bypass signal BX.

The functionality of a slice storage element is identical to that described earlier for the I/O storage elements. All signals have programmable polarity; the default active-High function is described.

Table 16: FD Flip-Flop Functionality with Synchronous Reset, Set, and Clock Enable

| Inputs |   |    |   |   | Outputs   |
|--------|---|----|---|---|-----------|
| R      | S | CE | D | C | Q         |
| 1      | X | X  | X | ↑ | 0         |
| 0      | 1 | X  | X | ↑ | 1         |
| 0      | 0 | 0  | X | X | No Change |
| 0      | 0 | 1  | 1 | ↑ | 1         |
| 0      | 0 | 1  | 0 | ↑ | 0         |

## Initialization

The CLB storage elements are initialized at power-up, during configuration, by the global GSR signal, and by the individual SR or REV inputs to the CLB. The storage elements can also be re-initialized using the GSR input on the STARTUP\_SPARTAN3E primitive. See [Global Controls \(STARTUP\\_SPARTAN3E\)](#).

Table 17: Slice Storage Element Initialization

| Signal | Description   |
|--------|---|
| SR     | Set/Reset input. Forces the storage element into the state specified by the attribute SRHIGH or SRLOW. SRHIGH forces a logic 1 when SR is asserted. SRLOW forces a logic 0. For each slice, set and reset can be set to be synchronous or asynchronous.   |
| REV    | Reverse of Set/Reset input. A second input (BY) forces the storage element into the opposite state. The reset condition is predominant over the set condition if both are active. Same synchronous/asynchronous setting as for SR.  |
| GSR    | Global Set/Reset. GSR defaults to active High but can be inverted by adding an inverter in front of the GSR input of the STARTUP_SPARTAN3E element. The initial state after configuration or GSR is defined by a separate INIT0 and INIT1 attribute. By default, setting the SRLOW attribute sets INIT0, and setting the SRHIGH attribute sets INIT1. |

## Distributed RAM

For additional information, refer to the “Using Look-Up Tables as Distributed RAM” chapter in [UG331](#).

The LUTs in the SLICEM can be programmed as distributed RAM. This type of memory affords moderate amounts of data buffering anywhere along a data path. One SLICEM LUT stores 16 bits (RAM16). The four LUT inputs F[4:1] or G[4:1] become the address lines labeled A[4:1] in the device model and A[3:0] in the design components, providing a 16x1 configuration in one LUT. Multiple SLICEM LUTs can be combined in various ways to store larger amounts of data, including 16x4, 32x2, or 64x1 configurations in one CLB. The fifth and sixth address lines required for the 32-deep and 64-deep configurations, respectively, are implemented using the BX and BY inputs, which connect to the write enable logic for writing and the F5MUX and F6MUX for reading.

Writing to distributed RAM is always synchronous to the SLICEM clock (WCLK for distributed RAM) and enabled by the SLICEM SR input which functions as the active-High Write Enable (WE). The read operation is asynchronous, and, therefore, during a write, the output initially reflects the old data at the address being written.

The distributed RAM outputs can be captured using the flip-flops within the SLICEM element. The WE write-enable control for the RAM and the CE clock-enable control for the flip-flop are independent, but the WCLK and CLK clock inputs are shared. Because the RAM read operation is asynchronous, the output data always reflects the currently addressed RAM location.

A dual-port option combines two LUTs so that memory access is possible from two independent data lines. The same data is written to both 16x1 memories but they have independent read address lines and outputs. The dual-port function is implemented by cascading the G-LUT address lines, which are used for both read and write, to the F-LUT write address lines (WF[4:1] in [Figure 15](#)), and by cascading the G-LUT data input D1 through the DIF\_MUX in [Figure 15](#) and to the D1 input on the F-LUT. One CLB provides a 16x1 dual-port memory as shown in [Figure 26](#).

Any write operation on the D input and any read operation on the SPO output can occur simultaneously with and independently from a read operation on the second read-only port, DPO.

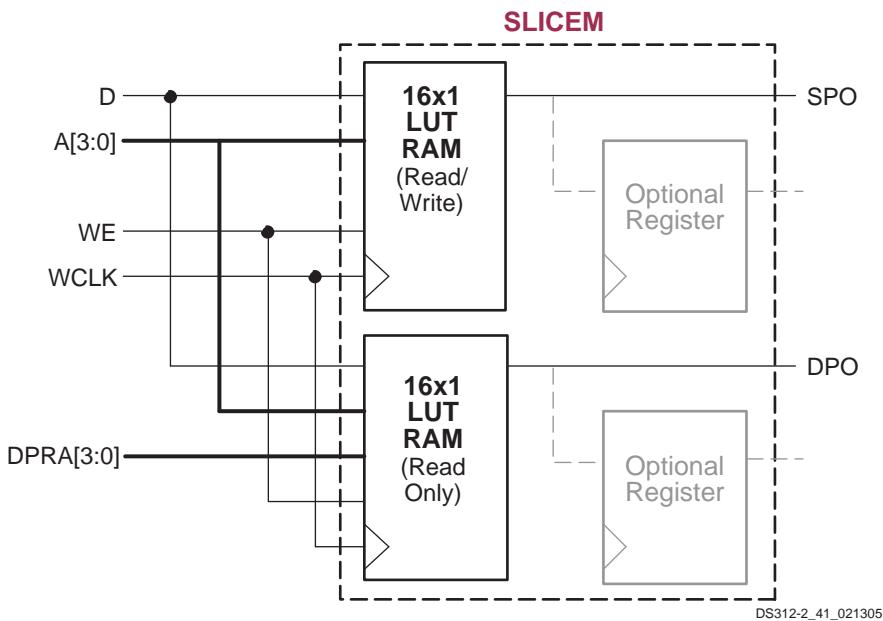


Figure 26: RAM16X1D Dual-Port Usage

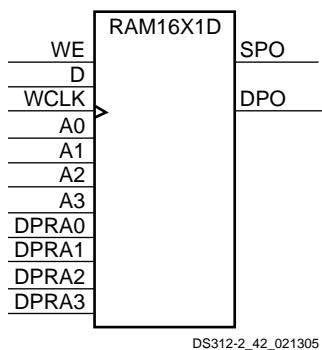


Figure 27: Dual-Port RAM Component

Table 18: Dual-Port RAM Function

| Inputs    |      |   | Outputs |        |
|-----------|------|---|---------|--------|
| WE (mode) | WCLK | D | SPO     | DPO    |
| 0 (read)  | X    | X | data_a  | data_d |
| 1 (read)  | 0    | X | data_a  | data_d |
| 1 (read)  | 1    | X | data_a  | data_d |
| 1 (write) | ↑    | D | D       | data_d |
| 1 (read)  | ↓    | X | data_a  | data_d |

**Notes:**

1. data\_a = word addressed by bits A3-A0.
2. data\_d = word addressed by bits DPRA3-DPRA0.

Table 19: Distributed RAM Signals

| Signal                  | Description   |
|-------------------------|---|
| WCLK                    | The clock is used for synchronous writes. The data and the address input pins have setup times referenced to the WCLK pin. Active on the positive edge by default with built-in programmable polarity.  |
| WE                      | The enable pin affects the write functionality of the port. An inactive Write Enable prevents any writing to memory cells. An active Write Enable causes the clock edge to write the data input signal to the memory location pointed to by the address inputs. Active High by default with built-in programmable polarity. |
| A0, A1, A2, A3 (A4, A5) | The address inputs select the memory cells for read or write. The width of the port determines the required address inputs.   |
| D                       | The data input provides the new data value to be written into the RAM.  |
| O, SPO, and DPO         | The data output O on single-port RAM or the SPO and DPO outputs on dual-port RAM reflects the contents of the memory cells referenced by the address inputs. Following an active write clock edge, the data out (O or SPO) reflects the newly written data.   |

The INIT attribute can be used to preload the memory with data during FPGA configuration. The default initial contents for RAM is all zeros. If the WE is held Low, the element can be considered a ROM. The ROM function is possible even in the SLICEL.

The global write enable signal, GWE, is asserted automatically at the end of device configuration to enable all writable elements. The GWE signal guarantees that the

initialized distributed RAM contents are not disturbed during the configuration process.

The distributed RAM is useful for smaller amounts of memory. Larger memory requirements can use the dedicated 18kbit RAM blocks (see [Block RAM](#)).

# Shift Registers

For additional information, refer to the “Using Look-Up Tables as Shift Registers (SRL16)” chapter in [UG331](#).

It is possible to program each SLICEM LUT as a 16-bit shift register (see [Figure 28](#)). Used in this way, each LUT can delay serial data anywhere from 1 to 16 clock cycles without using any of the dedicated flip-flops. The resulting programmable delays can be used to balance the timing of data pipelines.

The SLICEM LUTs cascade from the G-LUT to the F-LUT through the DIFMUX (see [Figure 15](#)). SHIFTIN and SHIFTOUT lines cascade a SLICEM to the SLICEM below to form larger shift registers. The four SLICEM LUTs of a single CLB can be combined to produce delays up to 64 clock cycles. It is also possible to combine shift registers across more than one CLB.

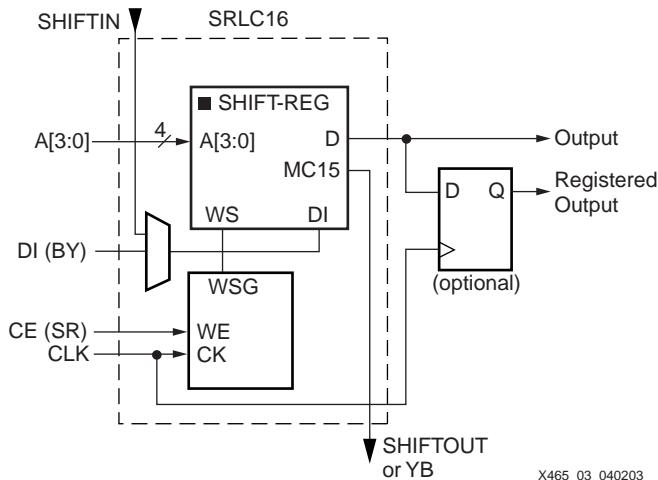


Figure 28: Logic Cell SRL16 Structure

Each shift register provides a shift output MC15 for the last bit in each LUT, in addition to providing addressable access to any bit in the shift register through the normal D output. The address inputs A[3:0] are the same as the distributed RAM address lines, which come from the LUT inputs F[4:1] or G[4:1]. At the end of the shift register, the CLB flip-flop can be used to provide one more shift delay for the addressable bit.

The shift register element is known as the SRL16 (Shift Register LUT 16-bit), with a 'C' added to signify a cascade ability (Q15 output) and 'E' to indicate a Clock Enable. See Figure 29 for an example of the SRLC16E component.

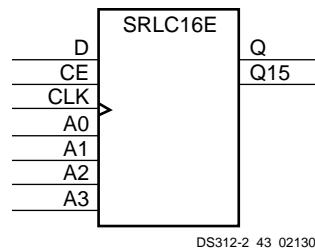


Figure 29: SRL16 Shift Register Component with Cascade and Clock Enable

The functionality of the shift register is shown in [Table 20](#). The SRL16 shifts on the rising edge of the clock input when the Clock Enable control is High. This shift register cannot be initialized either during configuration or during operation except by shifting data into it. The clock enable and clock inputs are shared between the two LUTs in a SLICEM. The clock enable input is automatically kept active if unused.

Table 20: SRL16 Shift Register Function

| Inputs |     |    |   | Outputs |       |
|--------|-----|----|---|---------|-------|
| Am     | CLK | CE | D | Q       | Q15   |
| Am     | X   | 0  | X | Q[Am]   | Q[15] |
| Am     | ↑   | 1  | D | Q[Am-1] | Q[15] |

## Notes:

$$1. \quad m = 0, 1, 2, 3.$$

## Block RAM

For additional information, refer to the “Using Block RAM” chapter in [UG331](#).

Spartan-3E devices incorporate 4 to 36 dedicated block RAMs, which are organized as dual-port configurable 18 Kbit blocks. Functionally, the block RAM is identical to the Spartan-3 architecture block RAM. Block RAM synchronously stores large amounts of data while distributed RAM, previously described, is better suited for buffering small amounts of data anywhere along signal paths. This section describes basic block RAM functions.

Each block RAM is configurable by setting the content's initial values, default signal value of the output registers, port aspect ratios, and write modes. Block RAM can be used in single-port or dual-port modes.

### Arrangement of RAM Blocks on Die

The block RAMs are located together with the multipliers on the die in one or two columns depending on the size of the device. The XC3S100E has one column of block RAM. The Spartan-3E devices ranging from the XC3S250E to XC3S1600E have two columns of block RAM. [Table 21](#) shows the number of RAM blocks, the data storage capacity, and the number of columns for each device. Row(s) of CLBs are located above and below each block RAM column.

**Table 21: Number of RAM Blocks by Device**

| Device    | Total Number of RAM Blocks | Total Addressable Locations (bits) | Number of Columns |
|-----------|----------------------------|------------------------------------|-------------------|
| XC3S100E  | 4                          | 73,728                             | 1                 |
| XC3S250E  | 12                         | 221,184                            | 2                 |
| XC3S500E  | 20                         | 368,640                            | 2                 |
| XC3S1200E | 28                         | 516,096                            | 2                 |
| XC3S1600E | 36                         | 663,552                            | 2                 |

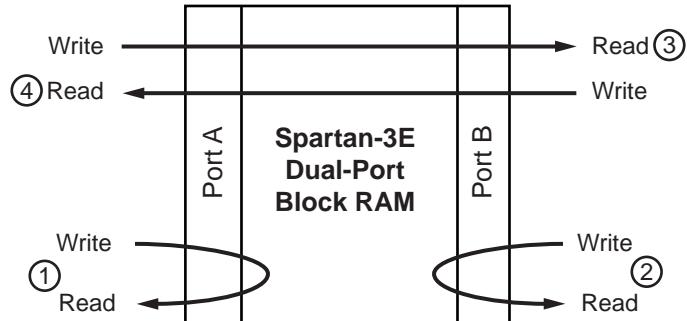
Immediately adjacent to each block RAM is an embedded 18x18 hardware multiplier. The upper 16 bits of the block RAM's Port A Data input bus are shared with the upper 16 bits of the A multiplicand input bus of the multiplier. Similarly, the upper 16 bits of Port B's data input bus are shared with the B multiplicand input bus of the multiplier.

### The Internal Structure of the Block RAM

The block RAM has a dual port structure. The two identical data ports called A and B permit independent access to the common block RAM, which has a maximum capacity of 18,432 bits, or 16,384 bits with no parity bits (see parity bits description in [Table 22](#)). Each port has its own dedicated set of data, control, and clock lines for synchronous read

and write operations. There are four basic data paths, as shown in [Figure 30](#):

1. Write to and read from Port A
2. Write to and read from Port B
3. Data transfer from Port A to Port B
4. Data transfer from Port B to Port A



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**Figure 30: Block RAM Data Paths**

### Number of Ports

A choice among primitives determines whether the block RAM functions as dual- or single-port memory. A name of the form `RAMB16_S[wA]_S[wB]` calls out the dual-port primitive, where the integers  $w_A$  and  $w_B$  specify the total data path width at ports A and B, respectively. Thus, a `RAMB16_S9_S18` is a dual-port RAM with a 9-bit Port A and an 18-bit Port B. A name of the form `RAMB16_S[w]` identifies the single-port primitive, where the integer  $w$  specifies the total data path width of the lone port A. A `RAMB16_S18` is a single-port RAM with an 18-bit port.

### Port Aspect Ratios

Each port of the block RAM can be configured independently to select a number of different possible widths for the data input (DI) and data output (DO) signals as shown in [Table 22](#).

Table 22: Port Aspect Ratios

| Total Data Path Width (w bits) | DI/DO Data Bus Width (w-p bits) <sup>(1)</sup> | DIP/DOP Parity Bus Width (p bits) | ADDR Bus Width (r bits) <sup>(2)</sup> | DI/DO [w-p-1:0] | DIP/DOP [p-1:0] | ADDR [r-1:0] | No. of Addressable Locations (n) <sup>(3)</sup> | Block RAM Capacity (w*n bits) <sup>(4)</sup> |
|--------------------------------|--|-----------------------------------|--|-----------------|-----------------|--------------|---|--|
| 1                              | 1  | 0                                 | 14                                     | [0:0]           | -               | [13:0]       | 16,384  | 16,384                                       |
| 2                              | 2  | 0                                 | 13                                     | [1:0]           | -               | [12:0]       | 8,192   | 16,384                                       |
| 4                              | 4  | 0                                 | 12                                     | [3:0]           | -               | [11:0]       | 4,096   | 16,384                                       |
| 9                              | 8  | 1                                 | 11                                     | [7:0]           | [0:0]           | [10:0]       | 2,048   | 18,432                                       |
| 18                             | 16   | 2                                 | 10                                     | [15:0]          | [1:0]           | [9:0]        | 1,024   | 18,432                                       |
| 36                             | 32   | 4                                 | 9                                      | [31:0]          | [3:0]           | [8:0]        | 512   | 18,432                                       |

**Notes:**

1. The width of the total data path (w) is the sum of the DI/DO bus width (w-p) and any parity bits (p).
2. The width selection made for the DI/DO bus determines the number of address lines (r) according to the relationship expressed as:  $r = 14 - \lceil \log(w-p)/\log(2) \rceil$ .
3. The number of address lines delimits the total number (n) of addressable locations or depth according to the following equation:  $n = 2^r$ .
4. The product of w and n yields the total block RAM capacity.

If the data bus width of Port A differs from that of Port B, the block RAM automatically performs a bus-matching function as described in [Figure 31](#). When data is written to a port with a narrow bus and then read from a port with a wide bus, the latter port effectively combines “narrow” words to form “wide” words. Similarly, when data is written into a port with a wide bus and then read from a port with a narrow bus, the latter port divides “wide” words to form “narrow” words.

Parity bits are not available if the data port width is configured as x4, x2, or x1. For example, if a x36 data word (32 data, 4 parity) is addressed as two x18 halfwords (16 data, 2 parity), the parity bits associated with each data byte are mapped within the block RAM to the appropriate parity bits. The same effect happens when the x36 data word is mapped as four x9 words.

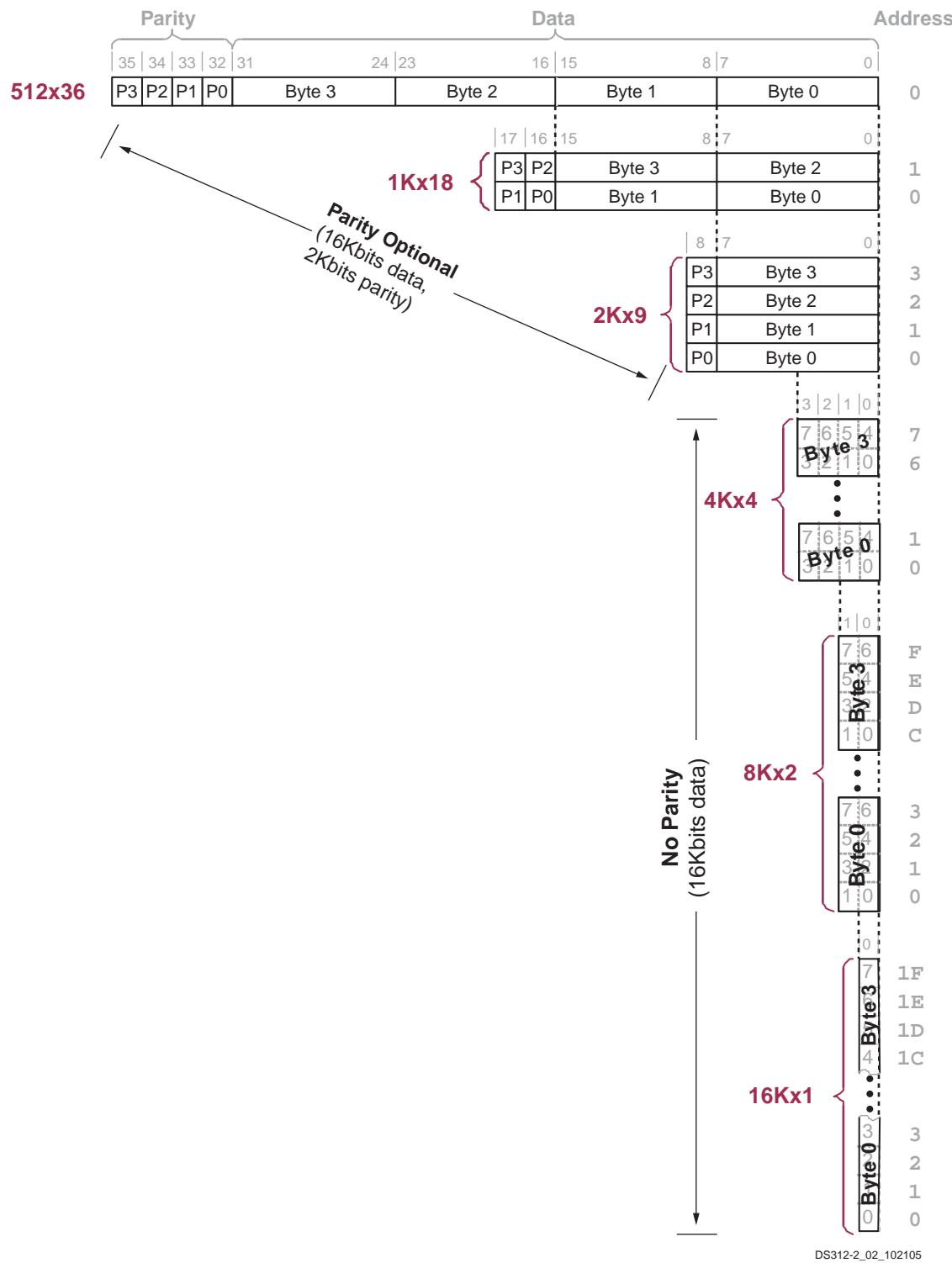


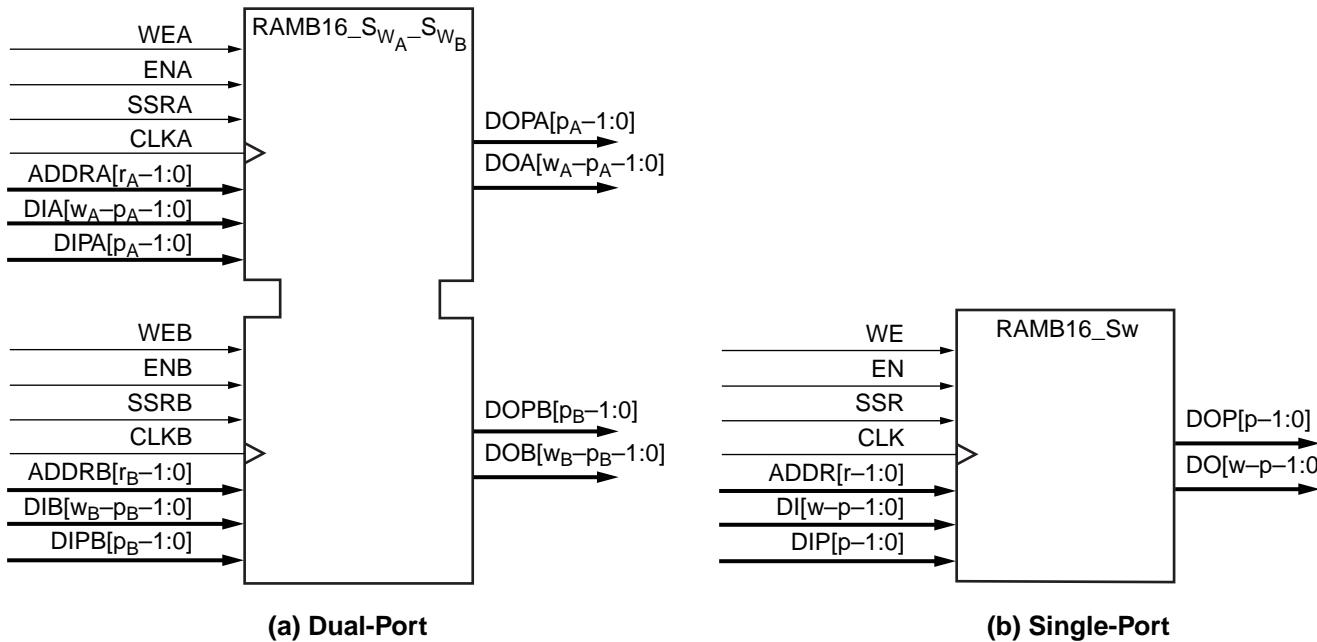
Figure 31: Data Organization and Bus-matching Operation with Different Port Widths on Port A and Port B

## Block RAM Port Signal Definitions

Representations of the dual-port primitive RAMB16\_S[w<sub>A</sub>]-S[w<sub>B</sub>] and the single-port primitive RAMB16\_S[w] with their associated signals are shown in Figure 32a and Figure 32b, respectively. These signals are defined in Table 23. The control signals (WE, EN, CLK, and SSR) on the block RAM are active High. However, optional inverters on the control signals change the polarity of the active edge to active Low.

### Design Note

Whenever a block RAM port is enabled (ENA or ENB = High), all address transitions must meet the data sheet setup and hold times with respect to the port clock (CLKA or CLKB), as shown in Table 103, page 139. This requirement must be met even if the RAM read output is of no interest.



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### Notes:

1.  $w_A$  and  $w_B$  are integers representing the total data path width (i.e., data bits plus parity bits) at Ports A and B, respectively.
2.  $p_A$  and  $p_B$  are integers that indicate the number of data path lines serving as parity bits.
3.  $r_A$  and  $r_B$  are integers representing the address bus width at ports A and B, respectively.
4. The control signals CLK, WE, EN, and SSR on both ports have the option of inverted polarity.

Figure 32: Block RAM Primitives

Table 23: Block RAM Port Signals

| Signal Description    | Port A Signal Name | Port B Signal Name | Direction | Function   |
|-----------------------|--------------------|--------------------|-----------|--|
| Address Bus           | ADDRA              | ADDRB              | Input     | <p>The Address Bus selects a memory location for read or write operations. The width (w) of the port's associated data path determines the number of available address lines (r), as per <a href="#">Table 22</a>.</p> <p>Whenever a port is enabled (ENA or ENB = High), address transitions must meet the data sheet setup and hold times with respect to the port clock (CLKA or CLKB), as shown in <a href="#">Table 103, page 139</a>. This requirement must be met even if the RAM read output is of no interest.</p>  |
| Data Input Bus        | DIA                | DIB                | Input     | <p>Data at the DI input bus is written to the RAM location specified by the address input bus (ADDR) during the active edge of the CLK input, when the clock enable (EN) and write enable (WE) inputs are active.</p> <p>It is possible to configure a port's DI input bus width (w-p) based on <a href="#">Table 22</a>. This selection applies to both the DI and DO paths of a given port.</p>  |
| Parity Data Input(s)  | DIPA               | DIPB               | Input     | <p>Parity inputs represent additional bits included in the data input path. Although referred to herein as "parity" bits, the parity inputs and outputs have no special functionality for generating or checking parity and can be used as additional data bits. The number of parity bits 'p' included in the DI (same as for the DO bus) depends on a port's total data path width (w). See <a href="#">Table 22</a>.</p>  |
| Data Output Bus       | DOA                | DOB                | Output    | <p>Data is written to the DO output bus from the RAM location specified by the address input bus, ADDR. See the DI signal description for DO port width configurations.</p> <p>Basic data access occurs on the active edge of the CLK when WE is inactive and EN is active. The DO outputs mirror the data stored in the address ADDR memory location. Data access with WE active if the <a href="#">WRITE_MODE</a> attribute is set to the value: <a href="#">WRITE_FIRST</a>, which accesses data after the write takes place. <a href="#">READ_FIRST</a> accesses data before the write occurs. A third attribute, <a href="#">NO_CHANGE</a>, latches the DO outputs upon the assertion of WE. See <a href="#">Block RAM Data Operations</a> for details on the <a href="#">WRITE_MODE</a> attribute.</p> |
| Parity Data Output(s) | DOPA               | DOPB               | Output    | <p>Parity outputs represent additional bits included in the data input path. The number of parity bits 'p' included in the DI bus (same as for the DO bus) depends on a port's total data path width (w). See the DIP signal description for configuration details.</p>  |
| Write Enable          | WEA                | WEB                | Input     | <p>When asserted together with EN, this input enables the writing of data to the RAM. When WE is inactive with EN asserted, read operations are still possible. In this case, a latch passes data from the addressed memory location to the DO outputs.</p>  |
| Clock Enable          | ENA                | ENB                | Input     | <p>When asserted, this input enables the CLK signal to perform read and write operations to the block RAM. When inactive, the block RAM does not perform any read or write operations.</p>   |
| Set/Reset             | SSRA               | SSRB               | Input     | <p>When asserted, this pin forces the DO output latch to the value of the SRVAL attribute. It is synchronized to the CLK signal.</p>   |
| Clock                 | CLKA               | CLKB               | Input     | <p>This input accepts the clock signal to which read and write operations are synchronized. All associated port inputs are required to meet setup times with respect to the clock signal's active edge. The data output bus responds after a clock-to-out delay referenced to the clock signal's active edge.</p>  |

## Block RAM Attribute Definitions

A block RAM has a number of attributes that control its behavior as shown in [Table 24](#).

**Table 24: Block RAM Attributes**

| Function   | Attribute   | Possible Values   |
|--|---|---|
| Initial Content for Data Memory, Loaded during Configuration                             | INIT <sub>xx</sub><br>(INIT_00 through INIT3F)      | Each initialization string defines 32 hex values of the 16384-bit data memory of the block RAM.       |
| Initial Content for Parity Memory, Loaded during Configuration                           | INITP <sub>xx</sub><br>(INITP_00 through INITP0F)   | Each initialization string defines 32 hex values of the 2048-bit parity data memory of the block RAM. |
| Data Output Latch Initialization   | INIT (single-port)<br>INITA, INITB (dual-port)      | Hex value the width of the chosen port.   |
| Data Output Latch Synchronous Set/Reset Value  | SRVAL (single-port)<br>SRVAL_A, SRVAL_B (dual-port) | Hex value the width of the chosen port.   |
| Data Output Latch Behavior during Write (see <a href="#">Block RAM Data Operations</a> ) | WRITE_MODE  | WRITE_FIRST, READ_FIRST, NO_CHANGE  |

## Block RAM Data Operations

Writing data to and accessing data from the block RAM are synchronous operations that take place independently on each of the two ports. [Table 25](#) describes the data operations of each port as a result of the block RAM control signals in their default active-High edges.

The waveforms for the write operation are shown in the top half of [Figure 33](#), [Figure 34](#), and [Figure 35](#). When the WE and EN signals enable the active edge of CLK, data at the DI input bus is written to the block RAM location addressed by the ADDR lines.

**Table 25: Block RAM Function Table**

| Input Signals   |    |     |    |     |      |       |      | Output Signals           |           | RAM Data             |                     |
|---|----|-----|----|-----|------|-------|------|--------------------------|-----------|----------------------|---------------------|
| GSR   | EN | SSR | WE | CLK | ADDR | DIP   | DI   | DOP                      | DO        | Parity               | Data                |
| <b>Immediately After Configuration</b>                  |    |     |    |     |      |       |      |                          |           |                      |                     |
| <b>Loaded During Configuration</b>                      |    |     |    |     |      |       |      | X                        | X         | INITP_xx             | INIT_xx             |
| <b>Global Set/Reset Immediately After Configuration</b> |    |     |    |     |      |       |      |                          |           |                      |                     |
| 1   | X  | X   | X  | X   | X    | X     | X    | INIT                     | INIT      | No Chg               | No Chg              |
| <b>RAM Disabled</b>                                     |    |     |    |     |      |       |      |                          |           |                      |                     |
| 0   | 0  | X   | X  | X   | X    | X     | X    | No Chg                   | No Chg    | No Chg               | No Chg              |
| <b>Synchronous Set/Reset</b>                            |    |     |    |     |      |       |      |                          |           |                      |                     |
| 0   | 1  | 1   | 0  | ↑   | X    | X     | X    | SRVAL                    | SRVAL     | No Chg               | No Chg              |
| <b>Synchronous Set/Reset During Write RAM</b>           |    |     |    |     |      |       |      |                          |           |                      |                     |
| 0   | 1  | 1   | 1  | ↑   | addr | pdata | Data | SRVAL                    | SRVAL     | RAM(addr)<br>← pdata | RAM(addr)<br>← data |
| <b>Read RAM, no Write Operation</b>                     |    |     |    |     |      |       |      |                          |           |                      |                     |
| 0   | 1  | 0   | 0  | ↑   | addr | X     | X    | RAM(pdata)               | RAM(data) | No Chg               | No Chg              |
| <b>Write RAM, Simultaneous Read Operation</b>           |    |     |    |     |      |       |      |                          |           |                      |                     |
| 0   | 1  | 0   | 1  | ↑   | addr | pdata | Data | WRITE_MODE = WRITE_FIRST |           |                      |                     |
|   |    |     |    |     |      |       |      | pdata                    | data      | RAM(addr)<br>← pdata | RAM(addr)<br>← data |
|   |    |     |    |     |      |       |      | WRITE_MODE = READ_FIRST  |           |                      |                     |
|   |    |     |    |     |      |       |      | RAM(data)                | RAM(data) | RAM(addr)<br>← pdata | RAM(addr)<br>← data |
|   |    |     |    |     |      |       |      | WRITE_MODE = NO_CHANGE   |           |                      |                     |
|   |    |     |    |     |      |       |      | No Chg                   | No Chg    | RAM(addr)<br>← pdata | RAM(addr)<br>← data |

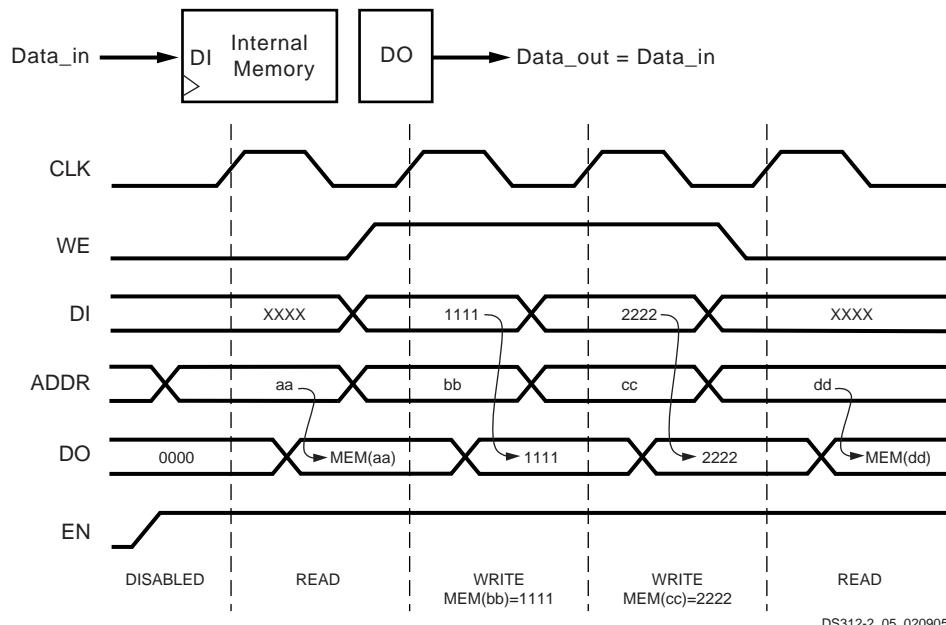
There are a number of different conditions under which data can be accessed at the DO outputs. Basic data access always occurs when the WE input is inactive. Under this condition, data stored in the memory location addressed by the ADDR lines passes through a output latch to the DO outputs. The timing for basic data access is shown in the

portions of [Figure 33](#), [Figure 34](#), and [Figure 35](#) during which WE is Low.

Data also can be accessed on the DO outputs when asserting the WE input based on the value of the [WRITE\\_MODE](#) attribute as described in [Table 26](#).

**Table 26: WRITE\_MODE Effect on Data Output Latches During Write Operations**

| Write Mode                      | Effect on Same Port  | Effect on Opposite Port<br>(dual-port only with same address)   |
|---------------------------------|--|---|
| WRITE_FIRST<br>Read After Write | Data on DI and DIP inputs is written into specified RAM location and simultaneously appears on DO and DOP outputs.               | Invalidates data on DO and DOP outputs.                         |
| READ_FIRST<br>Read Before Write | Data from specified RAM location appears on DO and DOP outputs.<br>Data on DI and DIP inputs is written into specified location. | Data from specified RAM location appears on DO and DOP outputs. |
| NO_CHANGE<br>No Read on Write   | Data on DO and DOP outputs remains unchanged.<br>Data on DI and DIP inputs is written into specified location.                   | Invalidates data on DO and DOP outputs.                         |



**Figure 33: Waveforms of Block RAM Data Operations with WRITE\_FIRST Selected**

Setting the WRITE\_MODE attribute to a value of [WRITE\\_FIRST](#), data is written to the addressed memory location on an enabled active CLK edge and is also passed to the DO outputs. WRITE\_FIRST timing is shown in the portion of [Figure 33](#) during which WE is High.

Setting the WRITE\_MODE attribute to a value of [READ\\_FIRST](#), data already stored in the addressed location passes to the DO outputs before that location is overwritten with new data from the DI inputs on an enabled active CLK edge. READ\_FIRST timing is shown in the portion of [Figure 34](#) during which WE is High.

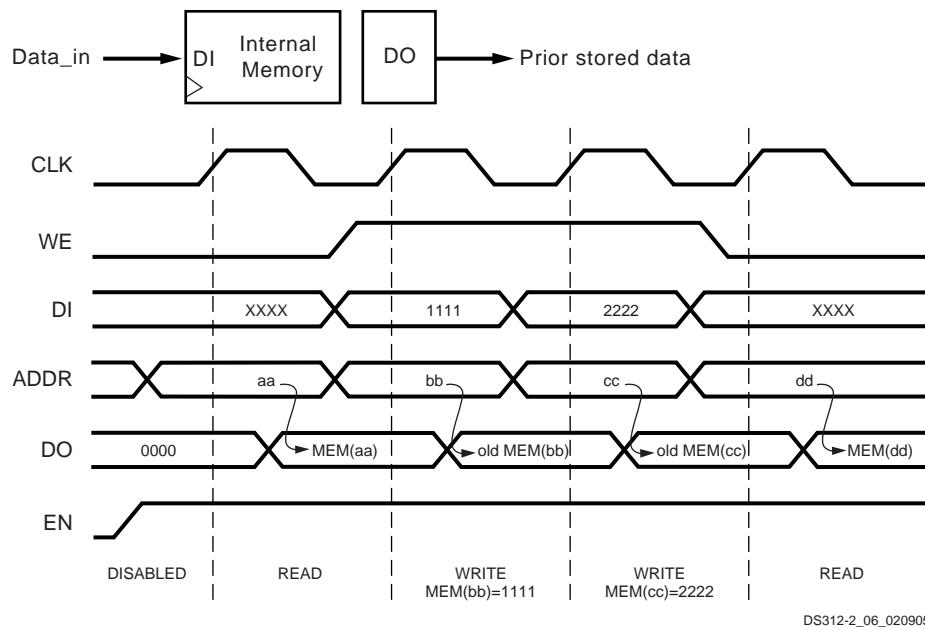


Figure 34: Waveforms of Block RAM Data Operations with READ\_FIRST Selected

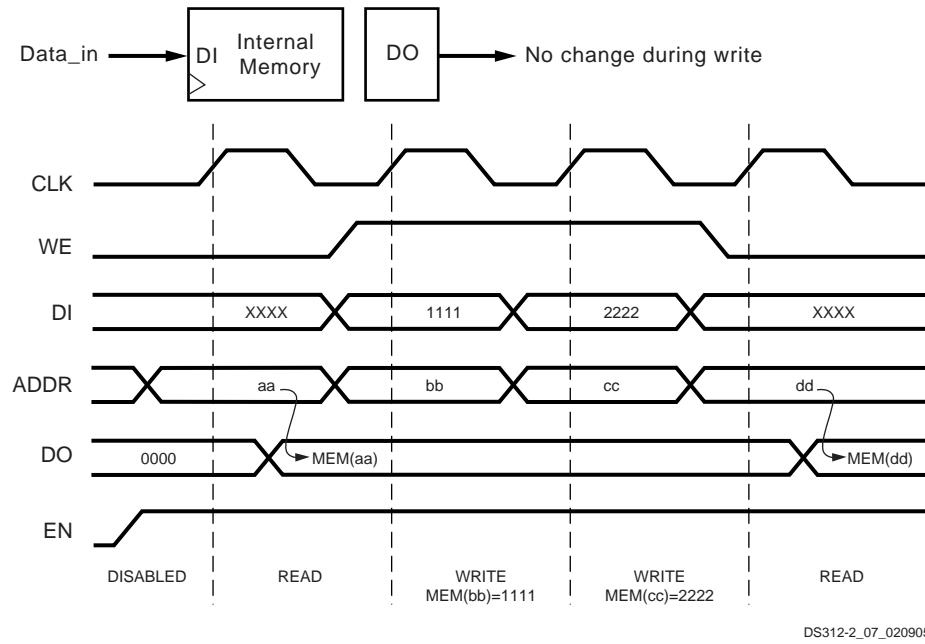


Figure 35: Waveforms of Block RAM Data Operations with NO\_CHANGE Selected

Setting the WRITE\_MODE attribute to a value of **NO\_CHANGE**, puts the DO outputs in a latched state when asserting WE. Under this condition, the DO outputs retain the data driven just before WE is asserted. NO\_CHANGE timing is shown in the portion of Figure 35 during which WE is High.

## Dedicated Multipliers

For additional information, refer to the “Using Embedded Multipliers” chapter in [UG331](#).

The Spartan-3E devices provide 4 to 36 dedicated multiplier blocks per device. The multipliers are located together with the block RAM in one or two columns depending on device density. See [Arrangement of RAM Blocks on Die](#) for details on the location of these blocks and their connectivity.

## Operation

The multiplier blocks primarily perform two's complement numerical multiplication but can also perform some less obvious applications, such as simple data storage and barrel shifting. Logic slices also implement efficient small multipliers and thereby supplement the dedicated multipliers. The Spartan-3E dedicated multiplier blocks have additional features beyond those provided in Spartan-3 FPGAs.

Each multiplier performs the principle operation  $P = A \times B$ , where 'A' and 'B' are 18-bit words in two's complement form, and 'P' is the full-precision 36-bit product, also in two's complement form. The 18-bit inputs represent values ranging from  $-131,072_{10}$  to  $+131,071_{10}$  with a resulting

product ranging from  $-17,179,738,112_{10}$  to  $+17,179,869,184_{10}$ .

Implement multipliers with inputs less than 18 bits by sign-extending the inputs (i.e., replicating the most-significant bit). Wider multiplication operations are performed by combining the dedicated multipliers and slice-based logic in any viable combination or by time-sharing a single multiplier. Perform unsigned multiplication by restricting the inputs to the positive range. Tie the most-significant bit Low and represent the unsigned value in the remaining 17 lesser-significant bits.

## Optional Pipeline Registers

As shown in [Figure 36](#), each multiplier block has optional registers on each of the multiplier inputs and the output. The registers are named AREG, BREG, and PREG and can be used in any combination. The clock input is common to all the registers within a block, but each register has an independent clock enable and synchronous reset controls making them ideal for storing data samples and coefficients. When used for pipelining, the registers boost the multiplier clock rate, beneficial for higher performance applications.

[Figure 36](#) illustrates the principle features of the multiplier block.

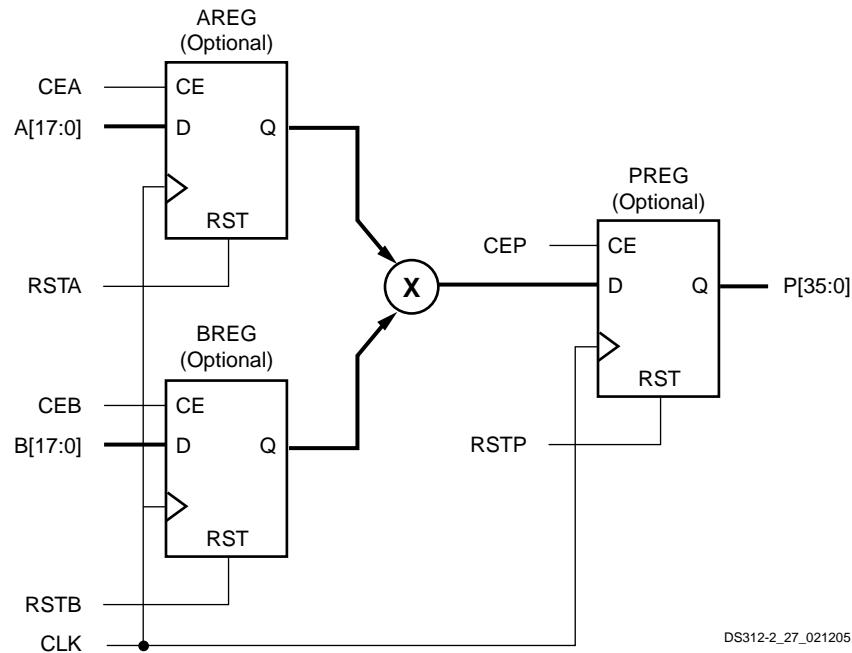


Figure 36: Principle Ports and Functions of Dedicated Multiplier Blocks

Use the MULT18X18SIO primitive shown in [Figure 37](#) to instantiate a multiplier within a design. Although high-level logic synthesis software usually automatically infers a multiplier, adding the pipeline registers might require the MULT18X18SIO primitive. Connect the appropriate signals to the MULT18X18SIO multiplier ports and set the individual AREG, BREG, and PREG attributes to '1' to insert the

associated register, or to 0 to remove it and make the signal path combinatorial.

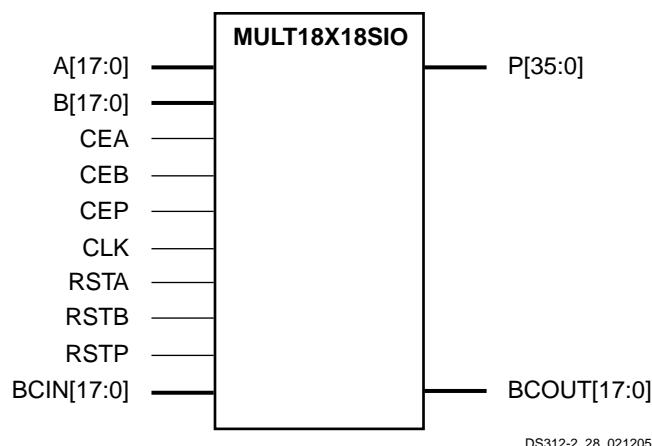


Figure 37: MULT18X18SIO Primitive

## Cascading Multipliers

The MULT18X18SIO primitive has two additional ports called BCIN and BCOUT to cascade or share the multiplier's 'B' input among several multiplier blocks. The 18-bit BCIN "cascade" input port offers an alternate input source from the more typical 'B' input. The B\_INPUT attribute specifies whether the specific implementation uses the BCIN or 'B' input path. Setting B\_INPUT to DIRECT chooses the 'B' input. Setting B\_INPUT to CASCADE selects the alternate BCIN input. The BREG register then optionally holds the selected input value, if required.

BCOUT is an 18-bit output port that always reflects the value that is applied to the multiplier's second input, which is either the 'B' input, the cascaded value from the BCIN input, or the output of the BREG if it is inserted.

Figure 38 illustrates the four possible configurations using different settings for the B\_INPUT attribute and the BREG attribute.

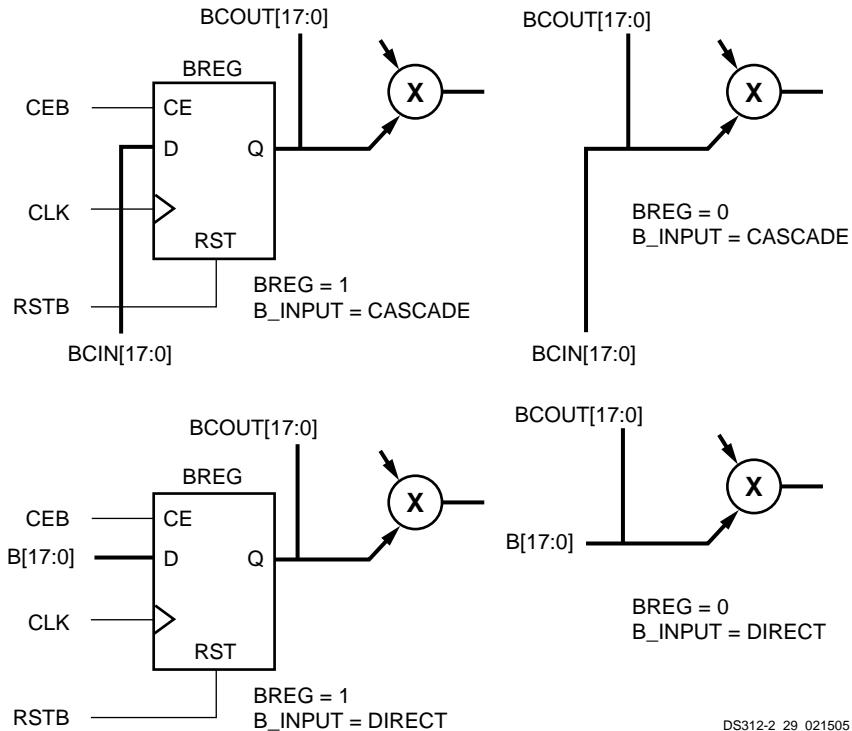


Figure 38: Four Configurations of the B Input

The BCIN and BCOUT ports have associated dedicated routing that connects adjacent multipliers within the same column. Via the cascade connection, the BCOUT port of one multiplier block drives the BCIN port of the multiplier block directly above it. There is no connection to the BCIN port of the bottom-most multiplier block in a column or a connection from the BCOUT port of the top-most block in a column. As an example, Figure 39 shows the multiplier cascade capability within the XC3S100E FPGA, which has a single column of multiplier, four blocks tall. For clarity, the figure omits the register control inputs.

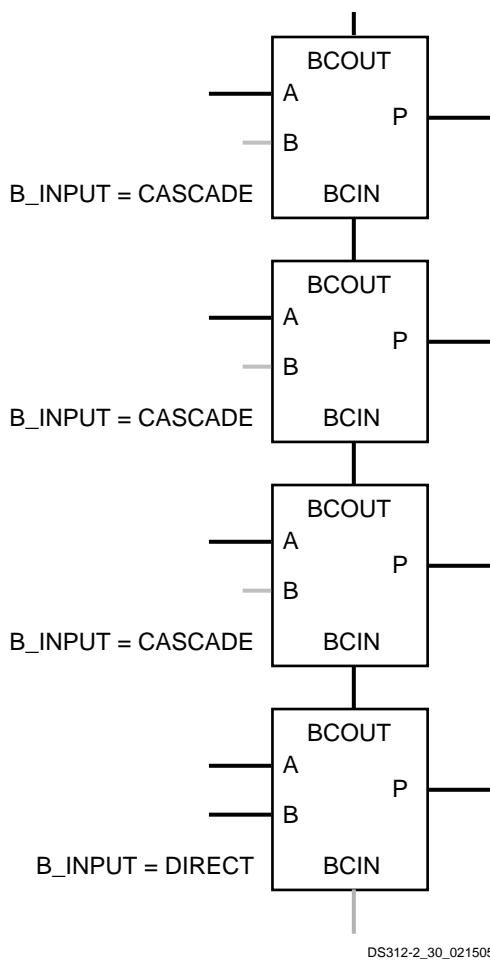


Figure 39: Multiplier Cascade Connection

When using the BREG register, the cascade connection forms a shift register structure typically used in DSP algorithms such as direct-form FIR filters. When the BREG register is omitted, the cascade structure essentially feeds the same input value to more than one multiplier. This parallel connection serves to create wide-input multipliers, implement transpose FIR filters, and is used in any application that requires that several multipliers have the same input value.

## Multiplier/Block RAM Interaction

Each multiplier is located adjacent to an 18 Kbit block RAM and shares some interconnect resources. Configuring an 18 Kbit block RAM for 36-bit wide data (512 x 36 mode) prevents use of the associated dedicated multiplier.

The upper 16 bits of the 'A' multiplicand input are shared with the upper 16 bits of the block RAM's Port A Data input. Similarly, the upper 16 bits of the 'B' multiplicand input are shared with Port B's data input. See also [Figure 48, page 63](#).

[Table 27](#) defines each port of the MULT18X18SIO primitive.

**Table 27: MULT18X18SIO Embedded Multiplier Primitives Description**

| Signal Name | Direction | Function  |
|-------------|-----------|---|
| A[17:0]     | Input     | The primary 18-bit two's complement value for multiplication. The block multiplies by this value asynchronously if the optional AREG and PREG registers are omitted. When AREG and/or PREG are used, the value provided on this port is qualified by the rising edge of CLK, subject to the appropriate register controls.  |
| B[17:0]     | Input     | The second 18-bit two's complement value for multiplication if the B_INPUT attribute is set to DIRECT. The block multiplies by this value asynchronously if the optional BREG and PREG registers are omitted. When BREG and/or PREG are used, the value provided on this port is qualified by the rising edge of CLK, subject to the appropriate register controls.   |
| BCIN[17:0]  | Input     | The second 18-bit two's complement value for multiplication if the B_INPUT attribute is set to CASCADE. The block multiplies by this value asynchronously if the optional BREG and PREG registers are omitted. When BREG and/or PREG are used, the value provided on this port is qualified by the rising edge of CLK, subject to the appropriate register controls.  |
| P[35:0]     | Output    | The 36-bit two's complement product resulting from the multiplication of the two input values applied to the multiplier. If the optional AREG, BREG and PREG registers are omitted, the output operates asynchronously. Use of PREG causes this output to respond to the rising edge of CLK with the value qualified by CEP and RSTP. If PREG is omitted, but AREG and BREG are used, this output responds to the rising edge of CLK with the value qualified by CEA, RSTA, CEB, and RSTB. If PREG is omitted and only one of AREG or BREG is used, this output responds to both asynchronous and synchronous events. |
| BCOUT[17:0] | Output    | The value being applied to the second input of the multiplier. When the optional BREG register is omitted, this output responds asynchronously in response to changes at the B[17:0] or BCIN[17:0] ports according to the setting of the B_INPUT attribute. If BREG is used, this output responds to the rising edge of CLK with the value qualified by CEB and RSTB.   |
| CEA         | Input     | Clock enable qualifier for the optional AREG register. The value provided on the A[17:0] port is captured by AREG in response to a rising edge of CLK when this signal is High, provided that RSTA is Low.  |
| RSTA        | Input     | Synchronous reset for the optional AREG register. AREG content is forced to the value zero in response to a rising edge of CLK when this signal is High.  |
| CEB         | Input     | Clock enable qualifier for the optional BREG register. The value provided on the B[17:0] or BCIN[17:0] port is captured by BREG in response to a rising edge of CLK when this signal is High, provided that RSTB is Low.  |
| RSTB        | Input     | Synchronous reset for the optional BREG register. BREG content is forced to the value zero in response to a rising edge of CLK when this signal is High.  |
| CEP         | Input     | Clock enable qualifier for the optional PREG register. The value provided on the output of the multiplier port is captured by PREG in response to a rising edge of CLK when this signal is High, provided that RSTP is Low.   |
| RSTP        | Input     | Synchronous reset for the optional PREG register. PREG content is forced to the value zero in response to a rising edge of CLK when this signal is High.  |

### Notes:

1. The control signals CLK, CEA, RSTA, CEB, RSTB, CEP, and RSTP have the option of inverted polarity.

## Digital Clock Managers (DCMs)

For additional information, refer to the “Using Digital Clock Managers (DCMs)” chapter in [UG331](#).

### Differences from the Spartan-3 Architecture

- Spartan-3E FPGAs have two, four, or eight DCMs, depending on device size.
- The variable phase shifting feature functions differently on Spartan-3E FPGAs than from Spartan-3 FPGAs.
- The Spartan-3E DLLs support lower input frequencies, down to 5 MHz. Spartan-3 DLLs support down to 18 MHz.

### Overview

Spartan-3E FPGA Digital Clock Managers (DCMs) provide flexible, complete control over clock frequency, phase shift and skew. To accomplish this, the DCM employs a Delay-Locked Loop (DLL), a fully digital control system that uses feedback to maintain clock signal characteristics with a high degree of precision despite normal variations in operating temperature and voltage. This section provides a fundamental description of the DCM.

The XC3S100E FPGA has two DCMs, one at the top and one at the bottom of the device. The XC3S250E and XC3S500E FPGAs each include four DCMs, two at the top and two at the bottom. The XC3S1200E and XC3S1600E FPGAs contain eight DCMs with two on each edge (see also [Figure 45](#)). The DCM in Spartan-3E FPGAs is

surrounded by CLBs within the logic array and is no longer located at the top and bottom of a column of block RAM as in the Spartan-3 architecture. The Digital Clock Manager is instantiated within a design using a “DCM” primitive.

The DCM supports three major functions:

- **Clock-skew Elimination:** Clock skew within a system occurs due to the different arrival times of a clock signal at different points on the die, typically caused by the clock signal distribution network. Clock skew increases setup and hold time requirements and increases clock-to-out times, all of which are undesirable in high frequency applications. The DCM eliminates clock skew by phase-aligning the output clock signal that it generates with the incoming clock signal. This mechanism effectively cancels out the clock distribution delays.
- **Frequency Synthesis:** The DCM can generate a wide range of different output clock frequencies derived from the incoming clock signal. This is accomplished by either multiplying and/or dividing the frequency of the input clock signal by any of several different factors.
- **Phase Shifting:** The DCM provides the ability to shift the phase of all its output clock signals with respect to the input clock signal.

Although a single design primitive, the DCM consists of four interrelated functional units: the Delay-Locked Loop (DLL), the Digital Frequency Synthesizer (DFS), the Phase Shifter (PS), and the Status Logic. Each component has its associated signals, as shown in [Figure 40](#).

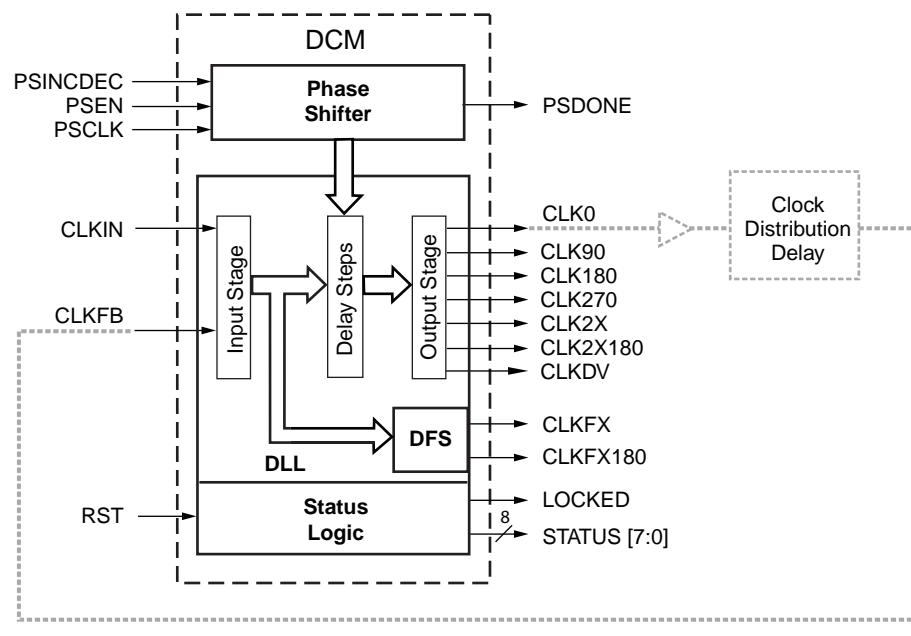


Figure 40: DCM Functional Blocks and Associated Signals

## Delay-Locked Loop (DLL)

The most basic function of the DLL component is to eliminate clock skew. The main signal path of the DLL consists of an input stage, followed by a series of discrete delay elements or *steps*, which in turn leads to an output stage. This path together with logic for phase detection and control forms a system complete with feedback as shown in [Figure 41](#). In Spartan-3E FPGAs, the DLL is implemented using a counter-based delay line.

The DLL component has two clock inputs, CLKIN and CLKFB, as well as seven clock outputs, CLK0, CLK90, CLK180, CLK270, CLK2X, CLK2X180, and CLKDV as described in [Table 28](#). The clock outputs drive simultaneously. Signals that initialize and report the state of the DLL are discussed in [Status Logic](#).

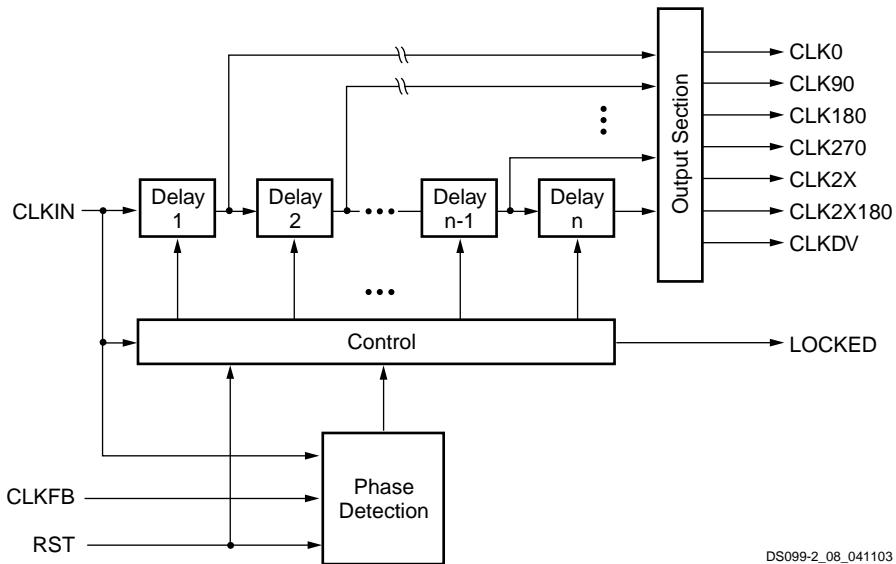


Figure 41: Simplified Functional Diagram of DLL

Table 28: DLL Signals

| Signal   | Direction | Description  |
|----------|-----------|--|
| CLKIN    | Input     | Receives the incoming clock signal. See <a href="#">Table 30</a> , <a href="#">Table 31</a> , and <a href="#">Table 32</a> for optimal external inputs to a DCM. |
| CLKFB    | Input     | Accepts either CLK0 or CLK2X as the feedback signal. (Set the CLK_FEEDBACK attribute accordingly).   |
| CLK0     | Output    | Generates a clock signal with the same frequency and phase as CLKIN.   |
| CLK90    | Output    | Generates a clock signal with the same frequency as CLKIN, phase-shifted by 90°.   |
| CLK180   | Output    | Generates a clock signal with the same frequency as CLKIN, phase-shifted by 180°.  |
| CLK270   | Output    | Generates a clock signal with the same frequency as CLKIN, phase-shifted by 270°.  |
| CLK2X    | Output    | Generates a clock signal with the same phase as CLKIN, and twice the frequency.  |
| CLK2X180 | Output    | Generates a clock signal with twice the frequency of CLKIN, and phase-shifted 180° with respect to CLK2X.  |
| CLKDV    | Output    | Divides the CLKIN frequency by CLKDV_DIVIDE value to generate lower frequency clock signal that is phase-aligned to CLKIN.                                       |

The clock signal supplied to the CLKIN input serves as a reference waveform. The DLL seeks to align the rising-edge of feedback signal at the CLKFB input with the rising-edge of CLKIN input. When eliminating clock skew, the common approach to using the DLL is as follows: The CLK0 signal is passed through the clock distribution network that feeds all the registers it synchronizes. These registers are either

internal or external to the FPGA. After passing through the clock distribution network, the clock signal returns to the DLL via a feedback line called CLKFB. The control block inside the DLL measures the phase error between CLKFB and CLKIN. This phase error is a measure of the clock skew that the clock distribution network introduces. The control block activates the appropriate number of delay steps to

cancel out the clock skew. When the DLL phase-aligns the CLK0 signal with the CLKIN signal, it asserts the LOCKED output, indicating a lock on to the CLKIN signal.

Table 29: DLL Attributes

| Attribute         | Description   | Values  |
|-------------------|---|---|
| CLK_FEEDBACK      | Chooses either the CLK0 or CLK2X output to drive the CLKFB input  | NONE, <u>1X</u> , 2X  |
| CLKIN_DIVIDE_BY_2 | Halves the frequency of the CLKIN signal just as it enters the DCM  | <u>FALSE</u> , TRUE   |
| CLKDV_DIVIDE      | Selects the constant used to divide the CLKIN input frequency to generate the CLKDV output frequency                  | 1.5, <u>2</u> , 2.5, 3, 3.5, 4, 4.5, 5, 5.5, 6.0, 6.5, 7.0, 7.5, <u>8</u> , 9, 10, 11, 12, 13, 14, 15, and 16 |
| CLKIN_PERIOD      | Additional information that allows the DLL to operate with the most efficient lock time and the best jitter tolerance | Floating-point value representing the CLKIN period in nanoseconds   |

## DLL Clock Input Connections

For best results, an external clock source enters the FPGA via a Global Clock Input (GCLK). Each specific DCM has four possible direct, optimal GCLK inputs that feed the DCM's CLKIN input, as shown in Table 30. Table 30 also provides the specific pin numbers by package for each GCLK input. The two additional DCM's on the XC3S1200E and XC3S1600E have similar optimal connections from the left-edge LHCLK and the right-edge RHCLK inputs, as described in Table 31 and Table 32.

- The DCM supports differential clock inputs (for example, LVDS, LVPECL\_25) via a pair of GCLK inputs that feed an internal single-ended signal to the DCM's CLKIN input.

### Design Note

Avoid using global clock input GCLK1 as it is always shared with the M2 mode select pin. Global clock inputs GCLK0, GCLK2, GCLK3, GCLK12, GCLK13, GCLK14, and GCLK15 have shared functionality in some configuration modes.

Table 30: Direct Clock Input Connections and Optional External Feedback to Associated DCMs

| Package | Differential Pair                 |        | Differential Pair |       |                           | Differential Pair                 |               | Differential Pair |                                |  |
|---------|-----------------------------------|--------|-------------------|-------|---------------------------|-----------------------------------|---------------|-------------------|--------------------------------|--|
|         | N                                 | P      | N                 | P     |                           | N                                 | P             | N                 | P                              |  |
|         | Pin Number for Single-Ended Input |        |                   |       |                           | Pin Number for Single-Ended Input |               |                   |                                |  |
| VQ100   | P91                               | P90    | P89               | P88   |                           |                                   |               | P86               | P85                            |  |
| CP132   | B7                                | A7     | C8                | B8    |                           |                                   |               | A9                | B9                             |  |
| TQ144   | P131                              | P130   | P129              | P128  |                           |                                   |               | P126              | P125                           |  |
| PQ208   | P186                              | P185   | P184              | P183  |                           |                                   |               | P181              | P180                           |  |
| FT256   | D8                                | C8     | B8                | A8    |                           |                                   |               | A9                | A10                            |  |
| FG320   | D9                                | C9     | B9                | B8    |                           |                                   |               | A10               | B10                            |  |
| FG400   | A9                                | A10    | G10               | H10   |                           |                                   |               | E10               | E11                            |  |
| FG484   | B11                               | C11    | H11               | H12   |                           |                                   |               | C12               | B12                            |  |
|         | ↓                                 | ↓      | ↓                 | ↓     | Associated Global Buffers |                                   |               |                   | ↓                              |  |
|         | GCLK11                            | GCLK10 | GCLK9             | GCLK8 | BUFGMUX_X1Y10             | BUFGMUX_X1Y11                     | BUFGMUX_X2Y10 | BUFGMUX_X2Y11     | GCLK7                          |  |
|         | Top Left DCM                      |        |                   |       |                           |                                   |               |                   | Top Right DCM                  |  |
|         | XC3S100: N/A                      |        |                   |       |                           |                                   |               |                   | XC3S100: DCM_X0Y1              |  |
|         | XC3S250E, XC3S500E: DCM_X0Y1      |        |                   |       |                           |                                   |               |                   | XC3S250E, XC3S500E: DCM_X1Y1   |  |
|         | XC3S1200E, XC3S1600E: DCM_X1Y3    |        |                   |       |                           |                                   |               |                   | XC3S1200E, XC3S1600E: DCM_X2Y3 |  |
|         |                                   |        |                   |       | ↓                         | ↓                                 | ↓             | ↓                 |                                |  |
|         |                                   |        |                   |       | H                         | G                                 | F             | E                 |                                |  |
|         |                                   |        |                   |       | Clock Line (see Table 41) |                                   |               |                   |                                |  |
|         |                                   |        |                   |       | D                         | C                                 | B             | A                 |                                |  |
|         |                                   |        |                   |       | ↑                         | ↑                                 | ↑             | ↑                 |                                |  |
|         | Bottom Left DCM                   |        |                   |       | BUFGMUX_X1Y0              | BUFGMUX_X1Y1                      | BUFGMUX_X2Y0  | BUFGMUX_X2Y1      | Bottom Right DCM               |  |
|         | XC3S100: N/A                      |        |                   |       |                           |                                   |               |                   | XC3S100: DCM_X0Y0              |  |
|         | XC3S250E, XC3S500E: DCM_X0Y0      |        |                   |       |                           |                                   |               |                   | XC3S250E, XC3S500E: DCM_X1Y0   |  |
|         | XC3S1200E, XC3S1600E: DCM_X1Y0    |        |                   |       |                           |                                   |               |                   | XC3S1200E, XC3S1600E: DCM_X2Y0 |  |
|         | GCLK12                            |        |                   |       | ↑                         | ↑                                 | ↑             | ↑                 | GCLK0                          |  |
|         | GCLK13                            |        |                   |       |                           |                                   |               |                   | GCLK1                          |  |
|         | GCLK14                            |        |                   |       |                           |                                   |               |                   | GCLK2                          |  |
|         | GCLK15                            |        |                   |       |                           |                                   |               |                   | GCLK3                          |  |
|         |                                   |        |                   |       | Associated Global Buffers |                                   |               |                   |                                |  |
| Package | Differential Pair                 |        | Differential Pair |       |                           | Differential Pair                 |               | Differential Pair |                                |  |
|         | P                                 | N      | P                 | N     |                           | P                                 | N             | P                 | N                              |  |
|         | Pin Number for Single-Ended Input |        |                   |       |                           | Pin Number for Single-Ended Input |               |                   |                                |  |
| VQ100   | P32                               | P33    | P35               | P36   |                           |                                   |               | P38               | P39                            |  |
| CP132   | M4                                | N4     | M5                | N5    |                           |                                   |               | M6                | N6                             |  |
| TQ144   | P50                               | P51    | P53               | P54   |                           |                                   |               | P56               | P57                            |  |
| PQ208   | P74                               | P75    | P77               | P78   |                           |                                   |               | P80               | P81                            |  |
| FT256   | M8                                | L8     | N8                | P8    |                           |                                   |               | T9                | R9                             |  |
| FG320   | N9                                | M9     | U9                | V9    |                           |                                   |               | U10               | T10                            |  |
| FG400   | W9                                | W10    | R10               | P10   |                           |                                   |               | P11               | P12                            |  |
| FG484   | V11                               | U11    | R11               | T11   |                           |                                   |               | R12               | P12                            |  |
|         | ↑                                 | ↑      | ↑                 | ↑     |                           |                                   |               | Y12               | W12                            |  |

Table 31: Direct Clock Input and Optional External Feedback to Left-Edge DCMs (XC3S1200E and XC3S1600E)

| Diff. Clock | Single-Ended Pin Number by Package Type |       |       |       |       |       |       |       | Left Edge |              |
|-------------|---|-------|-------|-------|-------|-------|-------|-------|-----------|--------------|
|             | VQ100                                   | CP132 | TQ144 | PQ208 | FT256 | FG320 | FG400 | FG484 | LHCLK     | DCM/BUFGMUX  |
|             |   |       |       |       |       |       |       |       |           |              |
| Pair        | P                                       | P9    | F3    | P14   | P22   | H5    | J5    | K3    | M5        | BUFGMUX_X0Y5 |
|             | N                                       | P10   | F2    | P15   | P23   | H6    | J4    | K2    | L5        | BUFGMUX_X0Y4 |
| Pair        | P                                       | P11   | F1    | P16   | P24   | H3    | J1    | K7    | L8        | LHCLK0       |
|             | N                                       | P12   | G1    | P17   | P25   | H4    | J2    | L7    | M8        | LHCLK1       |
|             |   |       |       |       |       |       |       |       |           | LHCLK2       |
| Pair        | P                                       | P15   | G3    | P20   | P28   | J2    | K3    | M1    | M1        | LHCLK3       |
|             | N                                       | P16   | H1    | P21   | P29   | J3    | K4    | L1    | N1        | BUFGMUX_X0Y3 |
| Pair        | P                                       | P17   | H2    | P22   | P30   | J5    | K6    | M3    | M3        | BUFGMUX_X0Y2 |
|             | N                                       | P18   | H3    | P23   | P31   | J4    | K5    | L3    | M4        | BUFGMUX_X0Y9 |
|             |   |       |       |       |       |       |       |       |           | BUFGMUX_X0Y8 |
| Pair        | P                                       | P19   | G4    | P24   | P32   | J6    | K7    | M2    | M2        | LHCLK4       |
|             | N                                       | P20   | H5    | P25   | P33   | J7    | K8    | L2    | N2        | LHCLK5       |
|             |   |       |       |       |       |       |       |       |           | LHCLK6       |
| Pair        | P                                       | P21   | G5    | P26   | P34   | J8    | K9    | M3    | M3        | LHCLK7       |
|             | N                                       | P22   | H6    | P27   | P35   | J9    | K10   | L3    | N3        | BUFGMUX_X0Y7 |
|             |   |       |       |       |       |       |       |       |           | BUFGMUX_X0Y6 |

Table 32: Direct Clock Input and Optional External Feedback to Right-Edge DCMs (XC3S1200E and XC3S1600E)

| Right Edge |   | Single-Ended Pin Number by Package Type |        |       |       |       |       |       |       | Diff. Clock |
|------------|---|---|--------|-------|-------|-------|-------|-------|-------|-------------|
|            |   | VQ100                                   | CP132  | TQ144 | PQ208 | FT256 | FG320 | FG400 | FG484 |             |
| D          | ← | DCM/BUFGMUX                             | RHCLK  |       |       |       |       |       |       |             |
| C          | ← | BUFGMUX_X3Y5                            |        |       |       |       |       |       |       |             |
|            | ← | BUFGMUX_X3Y4                            |        |       |       |       |       |       |       |             |
|            | ← | DCM_X3Y2                                | RHCLK7 |       |       |       |       |       |       |             |
|            | ← |   | RHCLK6 |       |       |       |       |       |       |             |
|            | ← |   | RHCLK5 |       |       |       |       |       |       |             |
|            | ← |   | RHCLK4 |       |       |       |       |       |       |             |
| B          | ← | BUFGMUX_X3Y3                            |        |       |       |       |       |       |       |             |
| A          | ← | BUFGMUX_X3Y2                            |        |       |       |       |       |       |       |             |
| H          | ← | BUFGMUX_X3Y9                            |        |       |       |       |       |       |       |             |
| G          | ← | BUFGMUX_X3Y8                            |        |       |       |       |       |       |       |             |
|            | ← | DCM_X3Y1                                | RHCLK3 |       |       |       |       |       |       |             |
|            | ← |   | RHCLK2 |       |       |       |       |       |       |             |
|            | ← |   | RHCLK1 |       |       |       |       |       |       |             |
|            | ← |   | RHCLK0 |       |       |       |       |       |       |             |
| F          | ← | BUFGMUX_X3Y7                            |        |       |       |       |       |       |       |             |
| E          | ← | BUFGMUX_X3Y6                            |        |       |       |       |       |       |       |             |

Every FPGA input provides a possible DCM clock input, but the path is not temperature and voltage compensated like the GCLKs. Alternatively, clock signals within the FPGA optionally provide a DCM clock input via a Global Clock Multiplexer Buffer (BUFGMUX). The global clock net

connects directly to the CLKIN input. The internal and external connections are shown in Figure 42a and Figure 42c, respectively.

## DLL Clock Output and Feedback Connections

As many as four of the nine DCM clock outputs can simultaneously drive four of the BUFGMUX buffers on the same die edge. All DCM clock outputs can simultaneously drive general routing resources, including interconnect leading to OBUF buffers.

The feedback loop is essential for DLL operation. Either the CLK0 or CLK2X outputs feed back to the CLKFB input via a BUFGMUX global buffer to eliminate the clock distribution delay. The specific BUFGMUX buffer used to feed back the CLK0 or CLK2X signal is ideally one of the BUFGMUX buffers associated with a specific DCM, as shown in [Table 30](#), [Table 31](#), and [Table 32](#).

The feedback path also phase-aligns the other seven DLL outputs: CLK0, CLK90, CLK180, CLK270, CLKDV, CLK2X, or CLK2X180. The CLK\_FEEDBACK attribute value must agree with the physical feedback connection. Use "1X" for CLK0 feedback and "2X" for CLK2X feedback. If the DFS unit is used stand-alone, without the DLL, then no feedback is required and set the CLK\_FEEDBACK attribute to "NONE".

Two basic cases determine how to connect the DLL clock outputs and feedback connections: on-chip synchronization and off-chip synchronization, which are illustrated in [Figure 42a](#) through [Figure 42d](#).

In the on-chip synchronization case in [Figure 42a](#) and [Figure 42b](#), it is possible to connect any of the DLL's seven output clock signals through general routing resources to the FPGA's internal registers. Either a Global Clock Buffer (BUFG) or a BUFGMUX affords access to the global clock network. As shown in [Figure 42a](#), the feedback loop is created by routing CLK0 (or CLK2X) in [Figure 42b](#) to a global clock net, which in turn drives the CLKFB input.

In the off-chip synchronization case in [Figure 42c](#) and [Figure 42d](#), CLK0 (or CLK2X) plus any of the DLL's other output clock signals exit the FPGA using output buffers (OBUF) to drive an external clock network plus registers on the board. As shown in [Figure 42c](#), the feedback loop is formed by feeding CLK0 (or CLK2X) in [Figure 42d](#) back into the FPGA, then to the DCM's CLKFB input via a Global Buffer Input, specified in [Table 30](#).

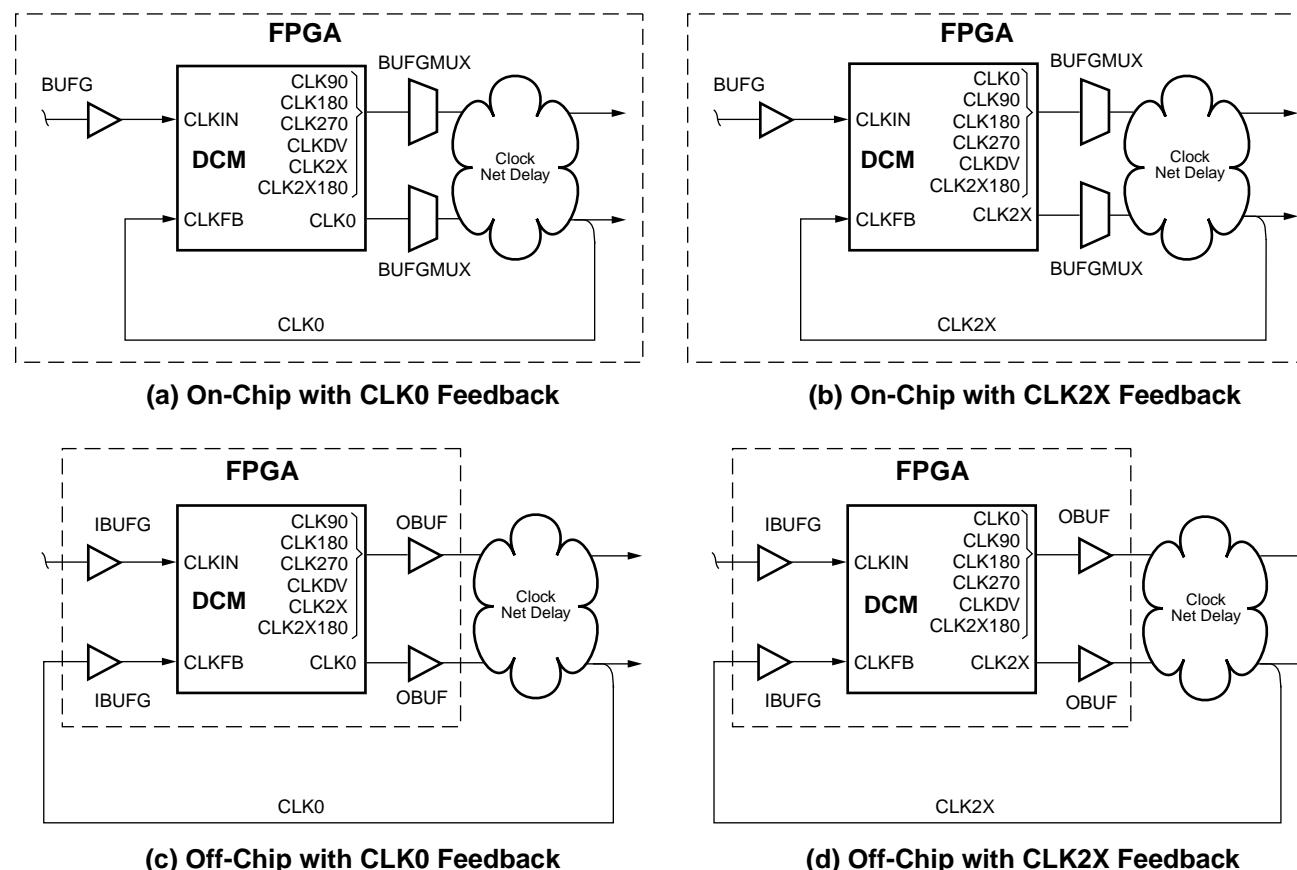


Figure 42: Input Clock, Output Clock, and Feedback Connections for the DLL

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## Accommodating Input Frequencies Beyond Specified Maximums

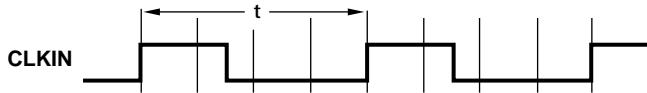
If the CLKIN input frequency exceeds the maximum permitted, divide it down to an acceptable value using the CLKIN\_DIVIDE\_BY\_2 attribute. When this attribute is set to "TRUE", the CLKIN frequency is divided by a factor of two as it enters the DCM. In addition, the CLKIN\_DIVIDE\_BY\_2 option produces a 50% duty-cycle on the input clock, although at half the CLKIN frequency.

## Quadrant and Half-Period Phase Shift Outputs

In addition to CLK0 for zero-phase alignment to the CLKIN signal, the DLL also provides the CLK90, CLK180, and CLK270 outputs for 90°, 180°, and 270° phase-shifted signals, respectively. These signals are described in [Table 28, page 48](#) and their relative timing is shown in [Figure 43](#). For control in finer increments than 90°, see [Phase Shifter \(PS\)](#).

Phase: 0° 90° 180° 270° 0° 90° 180° 270° 0°

### Input Signal (40%/60% Duty Cycle)



### Output Signal - Duty Cycle Corrected

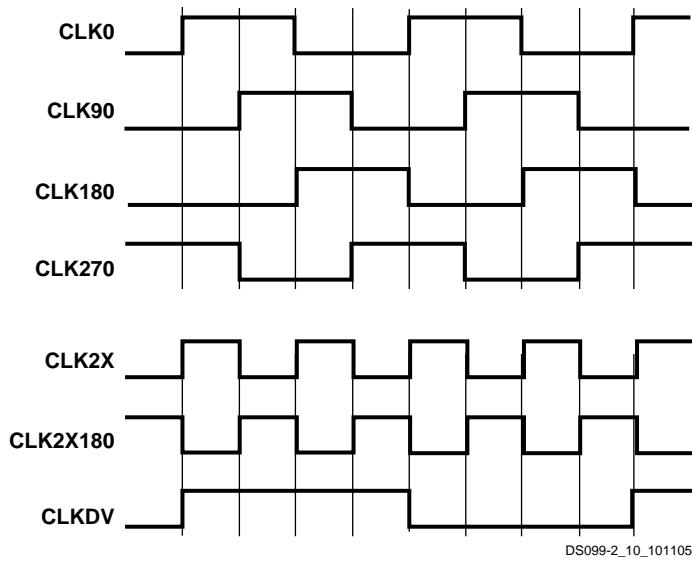


Figure 43: Characteristics of the DLL Clock Outputs

## Basic Frequency Synthesis Outputs

The DLL component provides basic options for frequency multiplication and division in addition to the more flexible synthesis capability of the DFS component, described in a later section. These operations result in output clock signals with frequencies that are either a fraction (for division) or a

multiple (for multiplication) of the incoming clock frequency. The CLK2X output produces an in-phase signal that is twice the frequency of CLKIN. The CLK2X180 output also doubles the frequency, but is 180° out-of-phase with respect to CLKIN. The CLKDIV output generates a clock frequency that is a predetermined fraction of the CLKIN frequency. The CLKDV\_DIVIDE attribute determines the factor used to divide the CLKIN frequency. The attribute can be set to various values as described in [Table 29](#). The basic frequency synthesis outputs are described in [Table 28](#).

## Duty Cycle Correction of DLL Clock Outputs

The DLL output signals exhibit a 50% duty cycle, even if the incoming CLKIN signal has a different duty cycle. Fifty-percent duty cycle means that the High and Low times of each clock cycle are equal.

## DLL Performance Differences Between Steppings

As indicated in [Digital Clock Manager \(DCM\) Timing](#) (Module 3), the Stepping 1 revision silicon supports higher maximum input and output frequencies. Stepping 1 devices are backwards compatible with Stepping 0 devices.

## Digital Frequency Synthesizer (DFS)

The DFS unit generates clock signals where the output frequency is a product of the CLKIN input clock frequency and a ratio of two user-specified integers. The two dedicated outputs from the DFS unit, CLKFX and CLKFX180, are defined in [Table 33](#).

Table 33: DFS Signals

| Signal   | Direction | Description   |
|----------|-----------|---|
| CLKFX    | Output    | Multiplies the CLKIN frequency by the attribute-value ratio (CLKFX_MULTIPLY/CLKFX_DIVIDE) to generate a clock signal with a new target frequency. |
| CLKFX180 | Output    | Generates a clock signal with the same frequency as CLKFX, but shifted 180° out-of-phase.   |

The signal at the CLKFX180 output is essentially an inversion of the CLKFX signal. These two outputs always exhibit a 50% duty cycle, even when the CLKIN signal does not. The DFS clock outputs are active coincident with the seven DLL outputs and their output phase is controlled by the Phase Shifter unit (PS).

The output frequency ( $f_{CLKFX}$ ) of the DFS is a function of the incoming clock frequency ( $f_{CLKIN}$ ) and two integer attributes, as follows.

$$f_{CLKFX} = f_{CLKIN} \cdot \left( \frac{CLKFX\_MULTIPLY}{CLKFX\_DIVIDE} \right) \quad Eq\ 1$$

The CLKFX\_MULTIPLY attribute is an integer ranging from 2 to 32, inclusive, and forms the numerator in [Equation 1](#).

The CLKFX\_DIVIDE is an integer ranging from 1 to 32, inclusive and forms the denominator in [Equation 1](#). For example, if CLKFX\_MULTIPLY = 5 and CLKFX\_DIVIDE = 3, the frequency of the output clock signal is 5/3 that of the input clock signal. These attributes and their acceptable ranges are described in [Table 34](#).

**Table 34: DFS Attributes**

| Attribute      | Description                   | Values                          |
|----------------|-------------------------------|---------------------------------|
| CLKFX_MULTIPLY | Frequency multiplier constant | Integer from 2 to 32, inclusive |
| CLKFX_DIVIDE   | Frequency divisor constant    | Integer from 1 to 32, inclusive |

Any combination of integer values can be assigned to the CLKFX\_MULTIPLY and CLKFX\_DIVIDE attributes, provided that two conditions are met:

1. The two values fall within their corresponding ranges, as specified in [Table 34](#).
2. The  $f_{CLKFX}$  output frequency calculated in [Equation 1](#) falls within the DCM's operating frequency specifications (see [Table 107](#) in Module 3).

### DFS With or Without the DLL

Although the CLKIN input is shared with both units, the DFS unit functions with or separately from the DLL unit. Separate from the DLL, the DFS generates an output frequency from the CLKIN frequency according to the respective CLKFX\_MULTIPLY and CLKFX\_DIVIDE values. Frequency synthesis does not require a feedback loop. Furthermore, without the DLL, the DFS unit supports a broader operating frequency range.

With the DLL, the DFS unit operates as described above, only with the additional benefit of eliminating the clock distribution delay. In this case, a feedback loop from the CLK0 or CLK2X output to the CLKFB input must be present.

When operating with the DLL unit, the DFS's CLKFX and CLKFX180 outputs are phase-aligned with the CLKIN input every CLKFX\_DIVIDE cycles of CLKIN and every CLKFX\_MULTIPLY cycles of CLKFX. For example, when CLKFX\_MULTIPLY = 5 and CLKFX\_DIVIDE = 3, the input and output clock edges coincide every three CLKIN input

periods, which is equivalent in time to five CLKFX output periods.

Smaller CLKFX\_MULTIPLY and CLKFX\_DIVIDE values result in faster lock times. Therefore, CLKFX\_MULTIPLY and CLKFX\_DIVIDE must be factored to reduce their values wherever possible. For example, given CLKFX\_MULTIPLY = 9 and CLKFX\_DIVIDE = 6, removing a factor of three yields CLKFX\_MULTIPLY = 3 and CLKFX\_DIVIDE = 2. While both value-pairs result in the multiplication of clock frequency by 3/2, the latter value-pair enables the DLL to lock more quickly.

### Phase Shifter (PS)

The DCM provides two approaches to controlling the phase of a DCM clock output signal relative to the CLKIN signal: First, eight of the nine DCM clock outputs – CLK0, CLK90, CLK180, CLK270, CLK2X, CLK2X180, CLKFX, and CLKFX180 – provide either quadrant or half-period phase shifting of the input clock.

Second, the PS unit provides additional fine phase shift control of all nine DCM outputs. The PS unit accomplishes this by introducing a “fine phase shift” delay ( $T_{PS}$ ) between the CLKFB and CLKIN signals inside the DLL unit. In FIXED phase shift mode, the fine phase shift is specified at design time with a resolution down to  $1/256$ th of a CLKIN cycle or one delay step (DCM\_DELAY\_STEP), whichever is greater. This fine phase shift value is relative to the coarser quadrant or half-period phase shift of the DCM clock output. When used, the PS unit shifts the phase of all nine DCM clock output signals.

### Enabling Phase Shifting and Selecting an Operating Mode

The CLKOUT\_PHASE\_SHIFT attribute controls the PS unit for the specific DCM instantiation. As described in [Table 35](#), this attribute has three possible values: NONE, FIXED, and VARIABLE. When CLKOUT\_PHASE\_SHIFT = NONE, the PS unit is disabled and the DCM output clocks are phase-aligned to the CLKIN input via the CLKFB feedback path. [Figure 44a](#) shows this case.

The PS unit is enabled when the CLKOUT\_PHASE\_SHIFT attribute is set to FIXED or VARIABLE modes. These two modes are described in the sections that follow.

**Table 35: PS Attributes**

| Attribute          | Description  | Values                        |
|--------------------|--|-------------------------------|
| CLKOUT_PHASE_SHIFT | Disables the PS component or chooses between Fixed Phase and Variable Phase modes. | <u>NONE</u> , FIXED, VARIABLE |
| PHASE_SHIFT        | Determines size and direction of initial fine phase shift.                         | Integers from -255 to +255    |

## FIXED Phase Shift Mode

The FIXED phase shift mode shifts the DCM outputs by a fixed amount ( $T_{PS}$ ), controlled by the user-specified PHASE\_SHIFT attribute. The PHASE\_SHIFT value (shown as P in [Figure 44](#)) must be an integer ranging from -255 to +255. PHASE\_SHIFT specifies a phase shift delay as a fraction of the  $T_{CLKIN}$ . The phase shift behavior is different between ISE 8.1, Service Pack 3 and prior software versions, as described below.

### Design Note

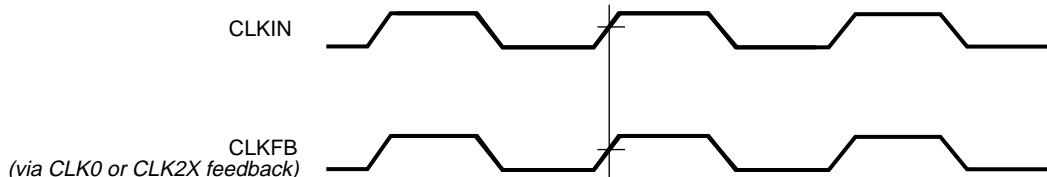
Prior to ISE 8.1i, Service Pack 3, the FIXED phase shift feature operated differently than the Spartan-3 DCM design primitive and simulation model. Designs using software prior to ISE 8.1i, Service Pack 3 require recompilation using the latest ISE software release. The following Answer Record contains additional information:

<http://www.xilinx.com/support/answers/23153.htm>.

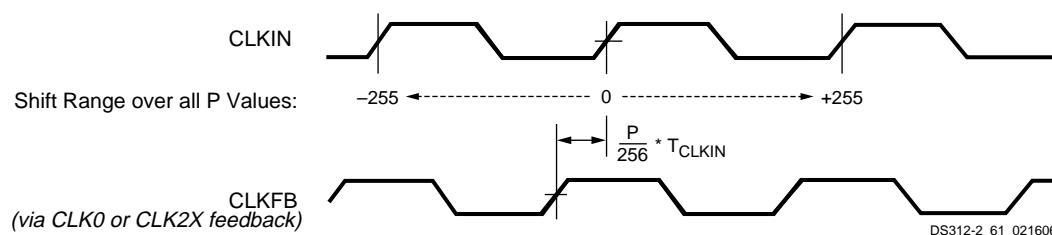
**FIXED Phase Shift using ISE 8.1i, Service Pack 3 and later:** See [Equation 2](#). The value corresponds to a phase shift range of  $-360^\circ$  to  $+360^\circ$ , which matches behavior of the Spartan-3 DCM design primitive and simulation model.

$$t_{PS} = \left( \frac{PHASESHIFT}{256} \right) \cdot T_{CLKIN} \quad Eq\ 2$$

### a. CLKOUT\_PHASE\_SHIFT = NONE



### b. CLKOUT\_PHASE\_SHIFT = FIXED



*Figure 44: NONE and FIXED Phase Shifter Waveforms (ISE 8.1i, Service Pack 3 and later)*

**FIXED Phase Shift prior to ISE 8.1i, Service Pack 3:** See [Equation 3](#). The value corresponds to a phase shift range of  $-180^\circ$  to  $+180^\circ$  degrees, which is different from the Spartan-3 DCM design primitive and simulation model. Designs created prior to ISE 8.1i, Service Pack 3 must be recompiled using the most recent ISE development software.

$$t_{PS} = \left( \frac{PHASESHIFT}{512} \right) \cdot T_{CLKIN} \quad Eq\ 3$$

When the PHASE\_SHIFT value is zero, CLKFB and CLKIN are in phase, the same as when the PS unit is disabled.

When the PHASE\_SHIFT value is positive, the DCM outputs are shifted later in time with respect to CLKIN input. When the attribute value is negative, the DCM outputs are shifted earlier in time with respect to CLKIN.

[Figure 44b](#) illustrates the relationship between CLKFB and CLKIN in the Fixed Phase mode. In the Fixed Phase mode, the PSEN, PSCLK, and PSINCDEC inputs are not used and must be tied to GND.

[Equation 2](#) or [Equation 3](#) applies only to FIXED phase shift mode. The VARIABLE phase shift mode operates differently.

## VARIABLE Phase Shift Mode

In VARIABLE phase shift mode, the FPGA application dynamically adjusts the fine phase shift value using three

inputs to the PS unit (PSEN, PSCLK, and PSINCDEC), as defined in [Table 36](#) and shown in [Figure 40](#).

**Table 36: Signals for Variable Phase Mode**

| Signal                  | Direction | Description  |
|-------------------------|-----------|--|
| PSEN <sup>(1)</sup>     | Input     | Enables the Phase Shift unit for variable phase adjustment.  |
| PSCLK <sup>(1)</sup>    | Input     | Clock to synchronize phase shift adjustment.   |
| PSINCDEC <sup>(1)</sup> | Input     | When High, increments the current phase shift value. When Low, decrements the current phase shift value. This signal is synchronized to the PSCLK signal.                    |
| PSDONE                  | Output    | Goes High to indicate that the present phase adjustment is complete and PS unit is ready for next phase adjustment request. This signal is synchronized to the PSCLK signal. |

**Notes:**

1. This input supports either a true or inverted polarity.

The FPGA application uses the three PS inputs on the Phase Shift unit to dynamically and incrementally increase or decrease the phase shift amount on all nine DCM clock outputs.

To adjust the current phase shift value, the PSEN enable signal must be High to enable the PS unit. Coincidentally, PSINCDEC must be High to increment the current phase shift amount or Low to decrement the current amount. All VARIABLE phase shift operations are controlled by the PSCLK input, which can be the CLKIN signal or any other clock signal.

### Design Note

The VARIABLE phase shift feature operates differently from the Spartan-3 DCM; use the DCM\_SP primitive, not the DCM primitive.

### DCM\_DELAY\_STEP

DCM\_DELAY\_STEP is the finest delay resolution available in the PS unit. Its value is provided at the bottom of [Table 105](#) in Module 3. For each enabled PSCLK cycle that PSINCDEC is High, the PS unit adds one DCM\_DELAY\_STEP of phase shift to all nine DCM outputs. Similarly, for each enabled PSCLK cycle that PSINCDEC is Low, the PS unit subtracts one DCM\_DELAY\_STEP of phase shift from all nine DCM outputs.

Because each DCM\_DELAY\_STEP has a minimum and maximum value, the actual phase shift delay for the present phase increment/decrement value (VALUE) falls within the minimum and maximum values according to [Equation 4](#) and [Equation 5](#).

$$T_{PS}(\text{Max}) = \text{VALUE} \cdot \text{DCM\_DELAY\_STEP\_MAX} \quad \text{Eq 4}$$

$$T_{PS}(\text{Min}) = \text{VALUE} \cdot \text{DCM\_DELAY\_STEP\_MIN} \quad \text{Eq 5}$$

The maximum variable phase shift steps, MAX\_STEPS, is described in [Equation 6](#) or [Equation 7](#), for a given CLKIN input period,  $T_{CLKIN}$ , in nanoseconds. To convert this to a

phase shift range measured in time and not steps, use MAX\_STEPS derived in [Equation 6](#) and [Equation 7](#) for VALUE in [Equation 4](#) and [Equation 5](#).

If  $CLKIN < 60$  MHz:

$$\text{MAX\_STEPS} = \pm[\text{INTEGER}(10 \cdot (T_{CLKIN} - 3))] \quad \text{Eq 6}$$

If  $CLKIN \geq 60$  MHz:

$$\text{MAX\_STEPS} = \pm[\text{INTEGER}(15 \cdot (T_{CLKIN} - 3))] \quad \text{Eq 7}$$

The phase adjustment might require as many as 100 CLKIN cycles plus 3 PSCLK cycles to take effect, at which point the DCM's PSDONE output goes High for one PSCLK cycle. This pulse indicates that the PS unit completed the previous adjustment and is now ready for the next request.

Asserting the Reset (RST) input returns the phase shift to zero.

## Status Logic

The Status Logic indicates the present state of the DCM and a means to reset the DCM to its initial known state. The Status Logic signals are described in [Table 37](#).

In general, the Reset (RST) input is only asserted upon configuring the FPGA or when changing the CLKIN

frequency. The RST signal must be asserted for three or more CLKIN cycles. A DCM reset does not affect attribute values (for example, CLKFX\_MULTIPLY and CLKFX\_DIVIDE). If not used, RST is tied to GND.

The eight bits of the STATUS bus are described in [Table 38](#).

**Table 37: Status Logic Signals**

| Signal      | Direction | Description   |
|-------------|-----------|---|
| RST         | Input     | A High resets the entire DCM to its initial power-on state. Initializes the DLL taps for a delay of zero. Sets the LOCKED output Low. This input is asynchronous. |
| STATUS[7:0] | Output    | The bit values on the STATUS bus provide information regarding the state of DLL and PS operation  |
| LOCKED      | Output    | Indicates that the CLKIN and CLKFB signals are in phase by going High. The two signals are out-of-phase when Low.   |

**Table 38: DCM Status Bus**

| Bit | Name          | Description  |
|-----|---------------|--|
| 0   | Reserved      | -  |
| 1   | CLKIN Stopped | When High, indicates that the CLKIN input signal is not toggling. When Low, indicates CLKIN is toggling. This bit functions only when the CLKFB input is connected. <sup>(1)</sup>     |
| 2   | CLKFX Stopped | When High, indicates that the CLKFX output is not toggling. When Low, indicates the CLKFX output is toggling. This bit functions only when the CLKFX or CLKFX180 output are connected. |
| 3-6 | Reserved      | -  |

### Notes:

- When only the DFS clock outputs but none of the DLL clock outputs are used, this bit does not go High when the CLKIN signal stops.

## Stabilizing DCM Clocks Before User Mode

The STARTUP\_WAIT attribute shown in [Table 39](#) optionally delays the end of the FPGA's configuration process until after the DCM locks to its incoming clock frequency. This option ensures that the FPGA remains in the Startup phase of configuration until all clock outputs generated by the DCM are stable. When all DCMs that have their STARTUP\_WAIT attribute set to TRUE assert the LOCKED signal, then the FPGA completes its configuration process and proceeds to user mode. The associated bitstream generator (BitGen) option **LCK\_cycle** specifies one of the six cycles in the Startup phase. The selected cycle defines the point at which configuration stalls until all the LOCKED outputs go High. See [Start-Up, page 106](#) for more information.

## Spread Spectrum

DCMs accept typical spread spectrum clocks as long as they meet the input requirements. The DLL will track the frequency changes created by the spread spectrum clock to drive the global clocks to the FPGA logic. See [XAPP469, Spread-Spectrum Clocking Reception for Displays](#) for details.

**Table 39: STARTUP\_WAIT Attribute**

| Attribute    | Description  | Values             |
|--------------|--|--------------------|
| STARTUP_WAIT | When TRUE, delays transition from configuration to user mode until DCM locks to the input clock. | TRUE, <u>FALSE</u> |

## Clocking Infrastructure

For additional information, refer to the “Using Global Clock Resources” chapter in [UG331](#).

The Spartan-3E clocking infrastructure, shown in [Figure 45](#), provides a series of low-capacitance, low-skew interconnect lines well-suited to carrying high-frequency signals throughout the FPGA. The infrastructure also includes the clock inputs and BUFGMUX clock buffers/multiplexers. The Xilinx Place-and-Route (PAR) software automatically routes high-fanout clock signals using these resources.

### Clock Inputs

Clock pins accept external clock signals and connect directly to DCMs and BUFGMUX elements. Each Spartan-3E FPGA has:

- 16 Global Clock inputs (GCLK0 through GCLK15) located along the top and bottom edges of the FPGA
- 8 Right-Half Clock inputs (RHCLK0 through RHCLK7) located along the right edge
- 8 Left-Half Clock inputs (LHCLK0 through LHCLK7) located along the left edge

Clock inputs optionally connect directly to DCMs using dedicated connections. [Table 30](#), [Table 31](#), and [Table 32](#) show the clock inputs that best feed a specific DCM within a given Spartan-3E part number. Different Spartan-3E FPGA densities have different numbers of DCMs. The XC3S1200E and XC3S1600E are the only two densities with the left- and right-edge DCMs.

Each clock input is also optionally a user-I/O pin and connects to internal interconnect. Some clock pad pins are input-only pins as indicated in Module 4, [Pinout Descriptions](#).

#### Design Note

Avoid using global clock input GCLK1 as it is always shared with the M2 mode select pin. Global clock inputs GCLK0, GCLK2, GCLK3, GCLK12, GCLK13, GCLK14, and GCLK15 have shared functionality in some configuration modes.

## Clock Buffers/Multiplexers

Clock Buffers/Multiplexers either drive clock input signals directly onto a clock line (BUFG) or optionally provide a multiplexer to switch between two unrelated, possibly asynchronous clock signals (BUFGMUX).

Each BUFGMUX element, shown in [Figure 46](#), is a 2-to-1 multiplexer. The select line, S, chooses which of the two inputs, I0 or I1, drives the BUFGMUX’s output signal, O, as described in [Table 40](#). The switching from one clock to the other is glitch-less, and done in such a way that the output High and Low times are never shorter than the shortest

High or Low time of either input clock. The two clock inputs can be asynchronous with regard to each other, and the S input can change at any time, except for a short setup time prior to the rising edge of the presently selected clock (I0 or I1). This setup time is specified as TGSI in [Table 101](#), [page 137](#). Violating this setup time requirement possibly results in an undefined runt pulse output.

**Table 40: BUFGMUX Select Mechanism**

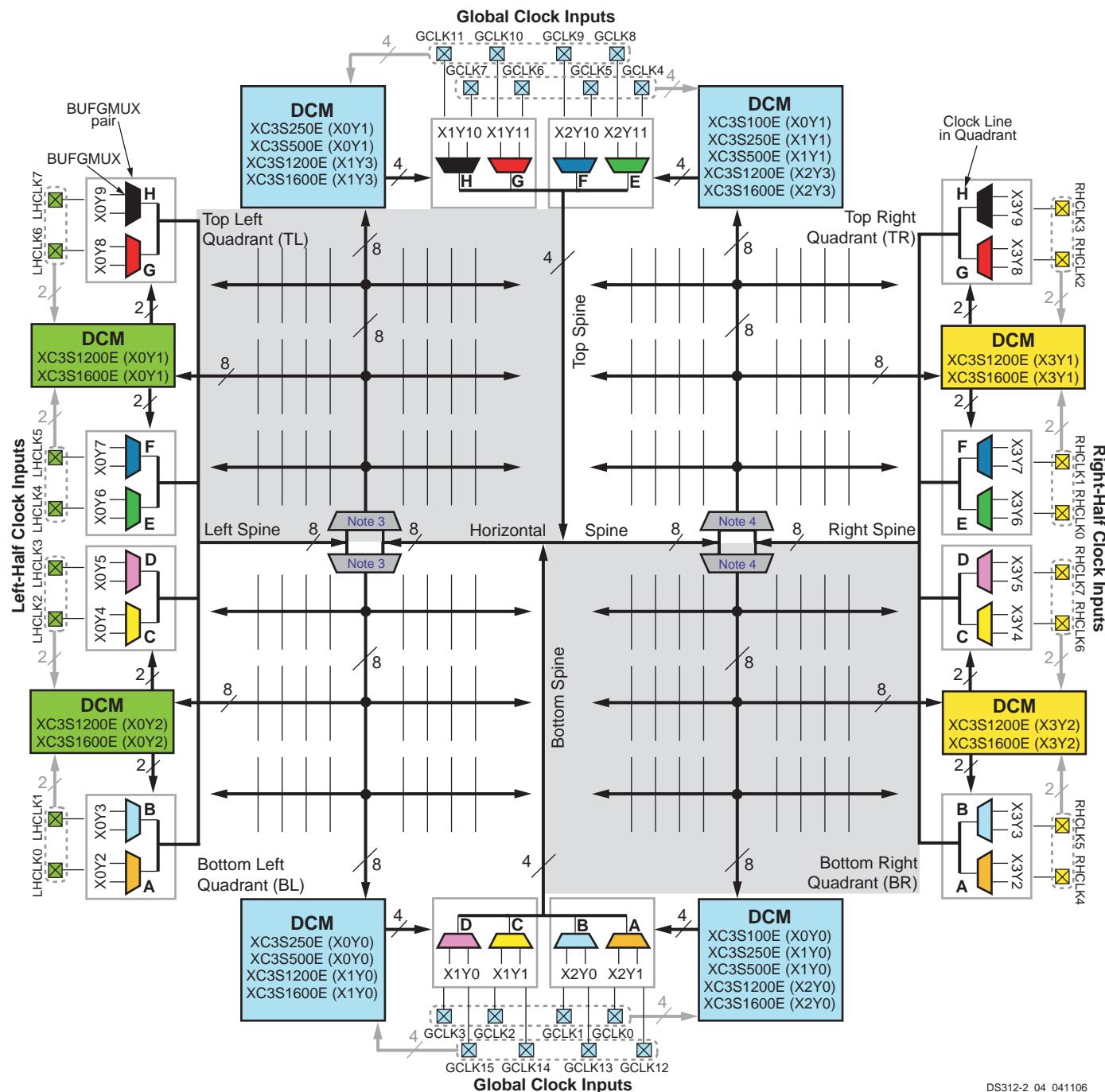
| S Input | O Output |
|---------|----------|
| 0       | I0 Input |
| 1       | I1 Input |

The BUFG clock buffer primitive drives a single clock signal onto the clock network and is essentially the same element as a BUFGMUX, just without the clock select mechanism. Similarly, the BUFGCE primitive creates an enabled clock buffer using the BUFGMUX select mechanism.

The I0 and I1 inputs to an BUFGMUX element originate from clock input pins, DCMs, or Double-Line interconnect, as shown in [Figure 46](#). As shown in [Figure 45](#), there are 24 BUFGMUX elements distributed around the four edges of the device. Clock signals from the four BUFGMUX elements at the top edge and the four at the bottom edge are truly global and connect to all clocking quadrants. The eight left-edge BUFGMUX elements only connect to the two clock quadrants in the left half of the device. Similarly, the eight right-edge BUFGMUX elements only connect to the right half of the device.

BUFGMUX elements are organized in pairs and share I0 and I1 connections with adjacent BUFGMUX elements from a common clock switch matrix as shown in [Figure 46](#). For example, the input on I0 of one BUFGMUX is also a shared input to I1 of the adjacent BUFGMUX.

The clock switch matrix for the left- and right-edge BUFGMUX elements receive signals from any of the three following sources: an LHCLK or RHCLK pin as appropriate, a Double-Line interconnect, or a DCM in the XC3S1200E and XC3S1600E devices.



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Figure 45: Spartan-3E Internal Quadrant-Based Clock Network (Electrical Connectivity View)

By contrast, the clock switch matrixes on the top and bottom edges receive signals from any of the five following sources: two GCLK pins, two DCM outputs, or one Double-Line interconnect.

**Table 41** indicates permissible connections between clock inputs and BUFGMUX elements. The I0-input provides the best input path to a clock buffer. The I1-input provides the secondary input for the clock multiplexer function.

**Table 41: Connections from Clock Inputs to BUFGMUX Elements and Associated Quadrant Clock**

| Quadrant Clock Line <sup>(1)</sup> | Left-Half BUFGMUX       |          |          | Top or Bottom BUFGMUX   |                 |                 | Right-Half BUFGMUX      |          |          |
|------------------------------------|-------------------------|----------|----------|-------------------------|-----------------|-----------------|-------------------------|----------|----------|
|                                    | Location <sup>(2)</sup> | I0 Input | I1 Input | Location <sup>(2)</sup> | I0 Input        | I1 Input        | Location <sup>(2)</sup> | I0 Input | I1 Input |
| <b>H</b>                           | X0Y9                    | LHCLK7   | LHCLK6   | X1Y10                   | GCLK7 or GCLK11 | GCLK6 or GCLK10 | X3Y9                    | RHCLK3   | RHCLK2   |
| <b>G</b>                           | X0Y8                    | LHCLK6   | LHCLK7   | X1Y11                   | GCLK6 or GCLK10 | GCLK7 or GCLK11 | X3Y8                    | RHCLK2   | RHCLK3   |
| <b>F</b>                           | X0Y7                    | LHCLK5   | LHCLK4   | X2Y10                   | GCLK5 or GCLK9  | GCLK4 or GCLK8  | X3Y7                    | RHCLK1   | RHCLK0   |
| <b>E</b>                           | X0Y6                    | LHCLK4   | LHCLK5   | X2Y11                   | GCLK4 or GCLK8  | GCLK5 or GCLK9  | X3Y6                    | RHCLK0   | RHCLK1   |
| <b>D</b>                           | X0Y5                    | LHCLK3   | LHCLK2   | X1Y0                    | GCLK3 or GCLK15 | GCLK2 or GCLK14 | X3Y5                    | RHCLK7   | RHCLK6   |
| <b>C</b>                           | X0Y4                    | LHCLK2   | LHCLK3   | X1Y1                    | GCLK2 or GCLK14 | GCLK3 or GCLK15 | X3Y4                    | RHCLK6   | RHCLK7   |
| <b>B</b>                           | X0Y3                    | LHCLK1   | LHCLK0   | X2Y0                    | GCLK1 or GCLK13 | GCLK0 or GCLK12 | X3Y3                    | RHCLK5   | RHCLK4   |
| <b>A</b>                           | X0Y2                    | LHCLK0   | LHCLK1   | X2Y1                    | GCLK0 or GCLK12 | GCLK1 or GCLK13 | X3Y2                    | RHCLK4   | RHCLK5   |

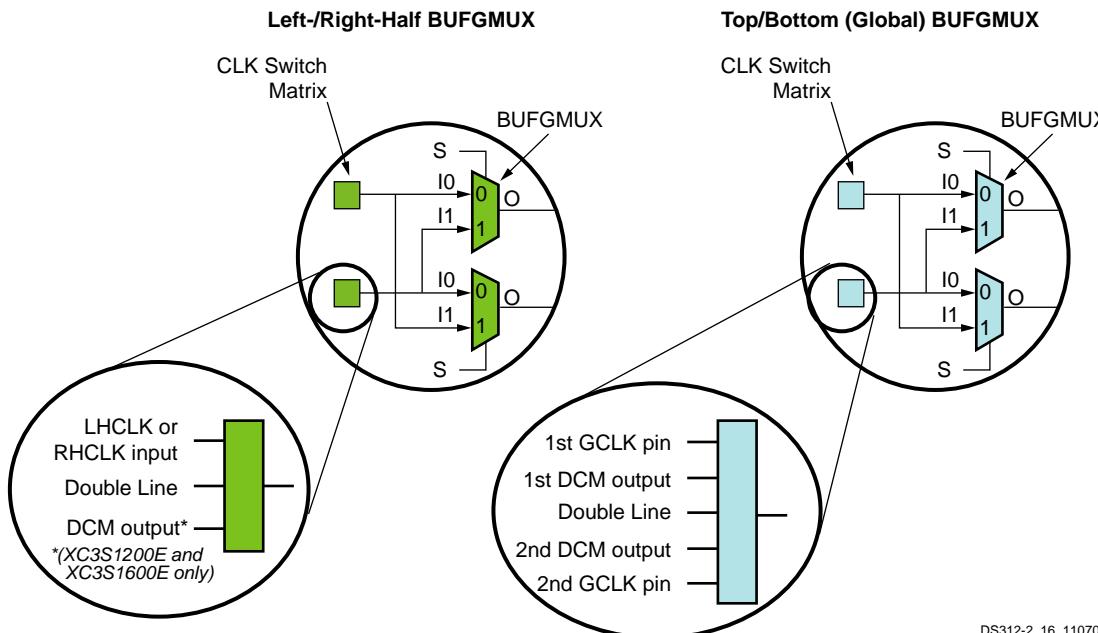
**Notes:**

1. See [Quadrant Clock Routing](#) for connectivity details for the eight quadrant clocks.
2. See [Figure 45](#) for specific BUFGMUX locations, and [Figure 47](#) for information on how BUFGMUX elements drive onto a specific clock line within a quadrant.

The four BUFGMUX elements on the top edge are paired together and share inputs from the eight global clock inputs along the top edge. Each BUFGMUX pair connects to four of the eight global clock inputs, as shown in [Figure 45](#). This optionally allows differential inputs to the global clock inputs without wasting a BUFGMUX element.

The connections for the bottom-edge BUFGMUX elements are similar to the top-edge connections (see [Figure 46](#)).

On the left and right edges, only two clock inputs feed each pair of BUFGMUX elements.



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*Figure 46: Clock Switch Matrix to BUFGMUX Pair Connectivity*

## Quadrant Clock Routing

The clock routing within the FPGA is quadrant-based, as shown in [Figure 45](#). Each clock quadrant supports eight total clock signals, labeled 'A' through 'H' in [Table 41](#) and [Figure 47](#). The clock source for an individual clock line originates either from a global BUFGMUX element along the top and bottom edges or from a BUFGMUX element along the associated edge, as shown in [Figure 47](#). The clock lines feed the synchronous resource elements (CLBs, IOBs, block RAM, multipliers, and DCMs) within the quadrant.

The four quadrants of the device are:

- Top Right (TR)
- Bottom Right (BR)
- Bottom Left (BL)
- Top Left (TL)

Note that the quadrant clock notation (TR, BR, BL, TL) is separate from that used for similar IOB placement constraints.

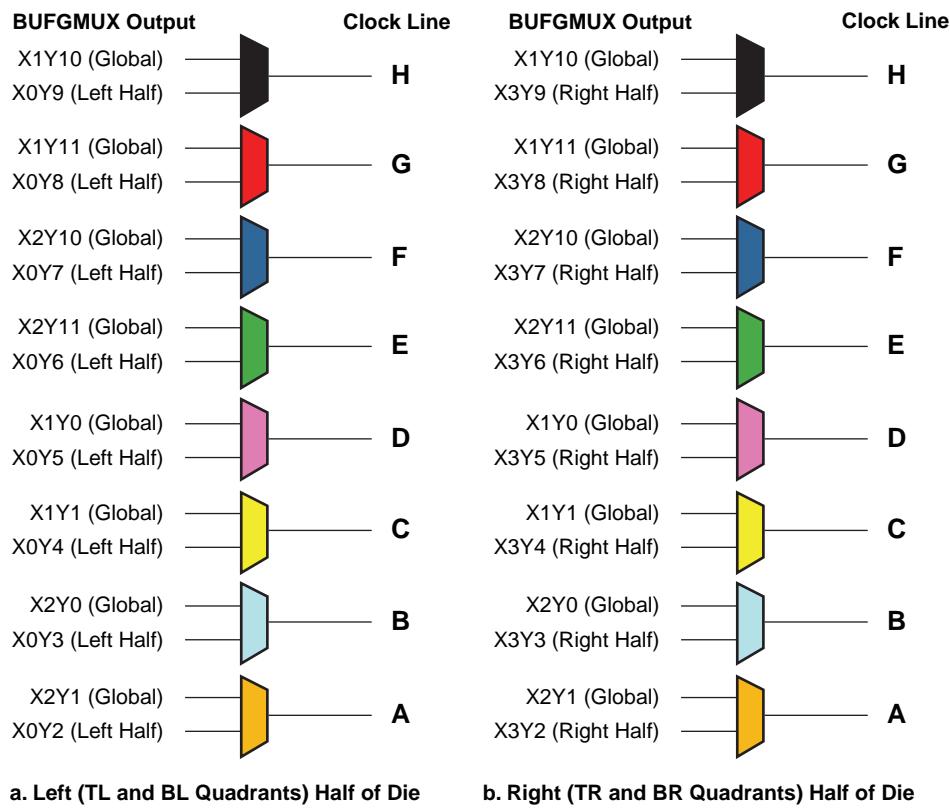
To estimate the quadrant location for a particular I/O, see the footprint diagrams in Module 4, [Pinout Descriptions](#). For exact quadrant locations, use the floorplanning tool. In the QFP packages (VQ100, TQ144 and PQ208) the quadrant borders fall in the middle of each side of the package, at a GND pin. The clock inputs fall on the quadrant boundaries, as indicated in [Table 42](#).

*Table 42: QFP Package Clock Quadrant Locations*

| Clock Pins  | Quadrant |
|-------------|----------|
| GCLK[3:0]   | BR       |
| GCLK[7:4]   | TR       |
| GCLK[11:8]  | TL       |
| GCLK[15:12] | BL       |
| RHCLK[3:0]  | BR       |
| RHCLK[7:4]  | TR       |
| LHCLK[3:0]  | TL       |
| LHCLK[7:4]  | BL       |

In a few cases, a dedicated input is physically in one quadrant of the device but connects to a different clock quadrant:

- FT256, H16 is in clock quadrant BR
- FG320, K2 is in clock quadrant BL
- FG400, L8 is in clock quadrant TL and the I/O at N11 is in clock quadrant BL
- FG484, M2 is in clock quadrant TL and L15 is in clock quadrant BR



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Figure 47: Clock Sources for the Eight Clock Lines within a Clock Quadrant

The outputs of the top or bottom BUFGMUX elements connect to two vertical spines, each comprising four vertical clock lines as shown in Figure 45. At the center of the die, these clock signals connect to the eight-line horizontal clock spine.

Outputs of the left and right BUFGMUX elements are routed onto the left or right horizontal spines, each comprising eight horizontal clock lines.

Each of the eight clock signals in a clock quadrant derives either from a global clock signal or a half clock signal. In other words, there are up to 24 total potential clock inputs to the FPGA, eight of which can connect to clocked elements in a single clock quadrant. Figure 47 shows how the clock lines in each quadrant are selected from associated BUFGMUX sources. For example, if quadrant clock 'A' in the bottom left (BL) quadrant originates from BUFGMUX\_X2Y1, then the clock signal from BUFGMUX\_X0Y2 is unavailable in the bottom left quadrant. However, the top left (TL) quadrant clock 'A' can still solely use the output from either BUFGMUX\_X2Y1 or BUFGMUX\_X0Y2 as the source.

To minimize the dynamic power dissipation of the clock network, the Xilinx development software automatically disables all clock segments not in use.

## Interconnect

For additional information, refer to the “Using Interconnect” chapter in [UG331](#).

Interconnect is the programmable network of signal pathways between the inputs and outputs of functional elements within the FPGA, such as IOBs, CLBs, DCMs, and block RAM.

### Overview

Interconnect, also called routing, is segmented for optimal connectivity. Functionally, interconnect resources are identical to that of the Spartan-3 architecture. There are four kinds of interconnects: long lines, hex lines, double lines, and direct lines. The Xilinx Place and Route (PAR) software

exploits the rich interconnect array to deliver optimal system performance and the fastest compile times.

### Switch Matrix

The switch matrix connects to the different kinds of interconnects across the device. An interconnect tile, shown in [Figure 48](#), is defined as a single switch matrix connected to a functional element, such as a CLB, IOB, or DCM. If a functional element spans across multiple switch matrices such as the block RAM or multipliers, then an interconnect tile is defined by the number of switch matrices connected to that functional element. A Spartan-3E device can be represented as an array of interconnect tiles where interconnect resources are for the channel between any two adjacent interconnect tile rows or columns as shown in [Figure 49](#).

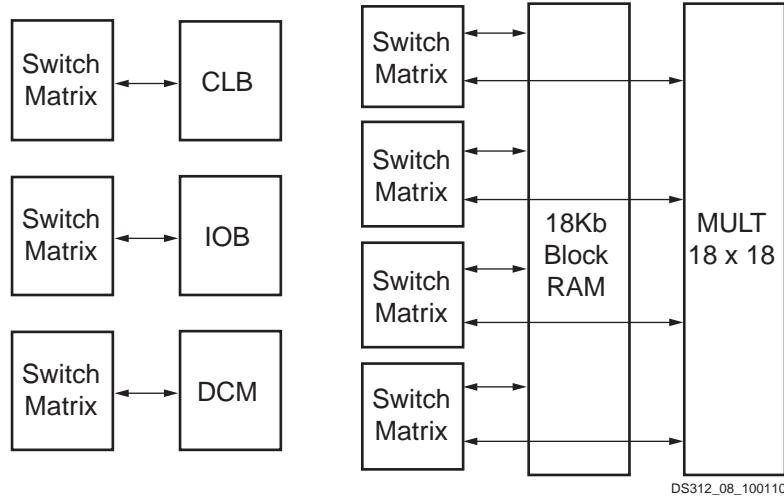


Figure 48: Four Types of Interconnect Tiles (CLBs, IOBs, DCMs, and Block RAM/Multiplier)

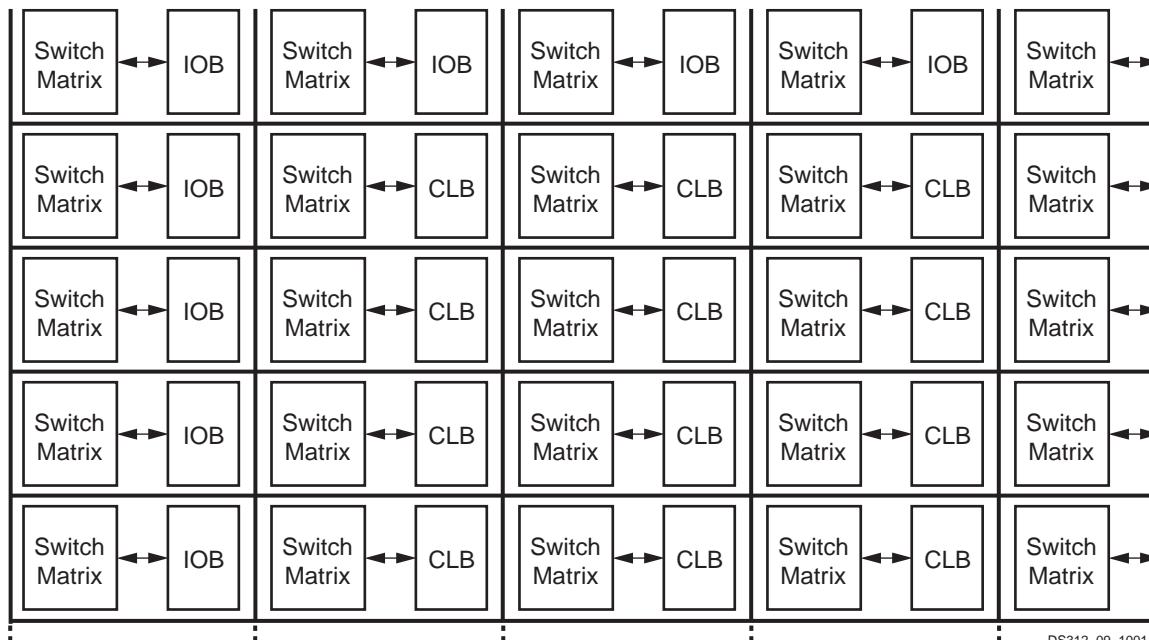


Figure 49: Array of Interconnect Tiles in Spartan-3E FPGA

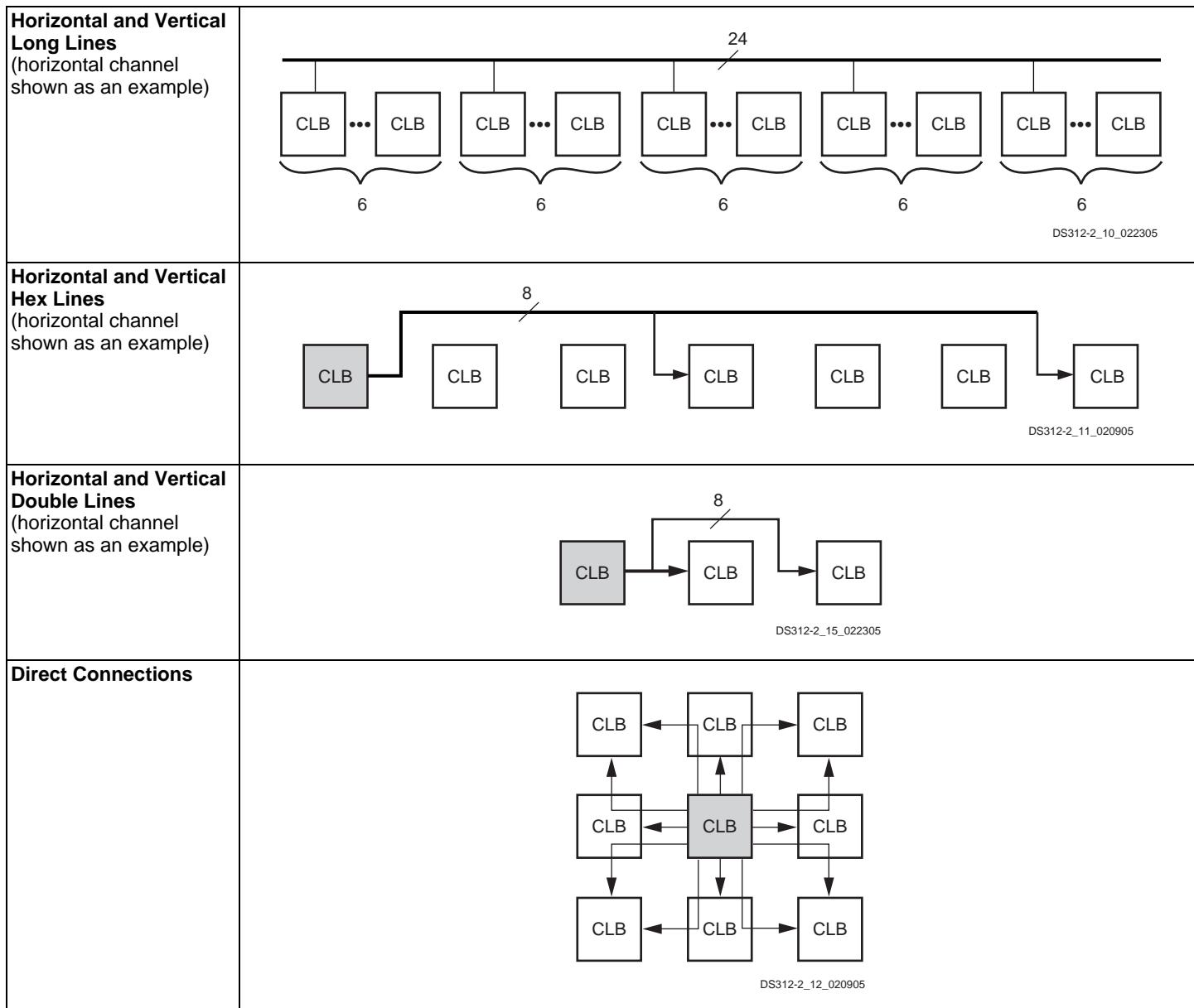


Figure 50: Interconnect Types between Two Adjacent Interconnect Tiles

The four types of general-purpose interconnect available in each channel, shown in [Figure 50](#), are described below.

## Long Lines

Each set of 24 long line signals spans the die both horizontally and vertically and connects to one out of every six interconnect tiles. At any tile, four of the long lines drive or receive signals from a switch matrix. Because of their low capacitance, these lines are well-suited for carrying high-frequency signals with minimal loading effects (e.g. skew). If all global clock lines are already committed and additional clock signals remain to be assigned, long lines serve as a good alternative.

## Hex Lines

Each set of eight hex lines are connected to one out of every three tiles, both horizontally and vertically. Thirty-two hex lines are available between any given interconnect tile. Hex lines are only driven from one end of the route.

## Double Lines

Each set of eight double lines are connected to every other tile, both horizontally and vertically, in all four directions. Thirty-two double lines available between any given interconnect tile. Double lines are more connections and more flexibility, compared to long line and hex lines.

## Direct Connections

Direct connect lines route signals to neighboring tiles: vertically, horizontally, and diagonally. These lines most often drive a signal from a “source” tile to a double, hex, or long line and conversely from the longer interconnect back to a direct line accessing a “destination” tile.

## Global Controls (STARTUP\_SPARTAN3E)

In addition to the general-purpose interconnect, Spartan-3E FPGAs have two global logic control signals, as described in [Table 43](#). These signals are available to the FPGA application via the STARTUP\_SPARTAN3E primitive.

*Table 43: Spartan-3E Global Logic Control Signals*

| Global Control Input | Description   |
|----------------------|---|
| GSR                  | <b>Global Set/Reset:</b> When High, asynchronously places all registers and flip-flops in their initial state (see <a href="#">Initialization, page 32</a> ). Asserted automatically during the FPGA configuration process (see <a href="#">Start-Up, page 106</a> ). |
| GTS                  | <b>Global Three-State:</b> When High, asynchronously forces all I/O pins to a high-impedance state (Hi-Z, three-state).   |

The Global Set/Reset (GSR) signal replaces the global reset signal included in many ASIC-style designs. Use the GSR control instead of a separate global reset signal in the design to free up CLB inputs, resulting in a smaller, more efficient design. Similarly, the GSR signal is asserted automatically during the FPGA configuration process, guaranteeing that the FPGA starts-up in a known state.

The STARTUP\_SPARTAN3E primitive also includes two other signals used specifically during configuration. The MBT signals are for [Dynamically Loading Multiple Configuration Images Using MultiBoot Option, page 92](#). The CLK input is an alternate clock for configuration [Start-Up, page 106](#).

## Configuration

For additional information on configuration, refer to [UG332: Spartan-3 Generation Configuration User Guide](#).

## Differences from Spartan-3 FPGAs

In general, Spartan-3E FPGA configuration modes are a superset to those available in Spartan-3 FPGAs. Two new modes added in Spartan-3E FPGAs provide a glueless configuration interface to industry-standard parallel NOR Flash and SPI serial Flash memories.

## Configuration Process

The function of a Spartan-3E FPGA is defined by loading application-specific configuration data into the FPGA's internal, reprogrammable CMOS configuration latches (CCLs), similar to the way a microprocessor's function is defined by its application program. For FPGAs, this configuration process uses a subset of the device pins, some of which are dedicated to configuration; other pins are

merely borrowed and returned to the application as general-purpose user I/Os after configuration completes.

Spartan-3E FPGAs offer several configuration options to minimize the impact of configuration on the overall system design. In some configuration modes, the FPGA generates a clock and loads itself from an external memory source, either serially or via a byte-wide data path. Alternatively, an external host such as a microprocessor downloads the FPGA's configuration data using a simple synchronous serial interface or via a byte-wide peripheral-style interface. Furthermore, multiple-FPGA designs share a single configuration memory source, creating a structure called a daisy chain.

Three FPGA pins—M2, M1, and M0—select the desired configuration mode. The mode pin settings appear in [Table 44](#). The mode pin values are sampled during the start of configuration when the FPGA's INIT\_B output goes High. After the FPGA completes configuration, the mode pins are available as user I/Os.

**Table 44: Spartan-3E Configuration Mode Options and Pin Settings**

|   | Master Serial                         | SPI                                | BPI  | Slave Parallel   | Slave Serial  | JTAG   |
|---|---------------------------------------|------------------------------------|--|--|---|--|
| M[2:0] mode pin settings                                  | <0:0:0>                               | <0:0:1>                            | <0:1:0>=Up<br><0:1:1>=Down   | <1:1:0>  | <1:1:1>   | <1:0:1>  |
| Data width  | Serial                                | Serial                             | Byte-wide  | Byte-wide  | Serial  | Serial   |
| Configuration memory source                               | Xilinx <a href="#">Platform Flash</a> | Industry-standard SPI serial Flash | Industry-standard parallel NOR Flash or Xilinx parallel <a href="#">Platform Flash</a> | Any source via microcontroller, CPU, Xilinx parallel <a href="#">Platform Flash</a> , etc. | Any source via microcontroller, CPU, Xilinx <a href="#">Platform Flash</a> , etc. | Any source via microcontroller, CPU, <a href="#">System ACE™ CF</a> , etc. |
| Clock source  | Internal oscillator                   | Internal oscillator                | Internal oscillator  | External clock on CCLK pin   | External clock on CCLK pin  | External clock on TCK pin  |
| Total I/O pins borrowed during configuration              | 8                                     | 13                                 | 46   | 21   | 8   | 0  |
| Configuration mode for downstream daisy-chained FPGAs     | Slave Serial                          | Slave Serial                       | Slave Parallel   | Slave Parallel or Memory Mapped  | Slave Serial  | JTAG   |
| Stand-alone FPGA applications (no external download host) | ✓                                     | ✓                                  | ✓  | Possible using XCFxxP Platform Flash, which optionally generates CCLK                      | Possible using XCFxxP Platform Flash, which optionally generates CCLK             |  |
| Uses low-cost, industry-standard Flash                    |                                       | ✓                                  | ✓  |  |   |  |
| Supports optional MultiBoot, multi-configuration mode     |                                       |                                    | ✓  |  |   |  |

## Configuration Bitstream Image Sizes

A specific Spartan-3E part type always requires a constant number of configuration bits, regardless of design complexity, as shown in [Table 45](#). The configuration file size for a multiple-FPGA daisy-chain design roughly equals the sum of the individual file sizes.

**Table 45: Number of Bits to Program a Spartan-3E FPGA (Uncompressed Bitstreams)**

| Spartan-3E FPGA | Number of Configuration Bits |
|-----------------|------------------------------|
| XC3S100E        | 581,344                      |
| XC3S250E        | 1,353,728                    |
| XC3S500E        | 2,270,208                    |
| XC3S1200E       | 3,841,184                    |
| XC3S1600E       | 5,969,696                    |

## Pin Behavior During Configuration

For additional information, refer to the “Configuration Pins and Behavior during Configuration” chapter in [UG332](#).

[Table 46](#) shows how various pins behave during the FPGA configuration process. The actual behavior depends on the

**Table 46: Pin Behavior during Configuration**

| Pin Name                           | Master Serial | SPI (Serial Flash) | BPI (Parallel NOR Flash) | JTAG   | Slave Parallel | Slave Serial | I/O Bank <sup>(3)</sup> |
|------------------------------------|---------------|--------------------|--------------------------|--------|----------------|--------------|-------------------------|
| IO* (user-I/O)<br>IP* (input-only) |               |                    |                          |        |                |              | -                       |
| TDI                                | TDI           | TDI                | TDI                      | TDI    | TDI            | TDI          | V <sub>CCAUX</sub>      |
| TMS                                | TMS           | TMS                | TMS                      | TMS    | TMS            | TMS          | V <sub>CCAUX</sub>      |
| TCK                                | TCK           | TCK                | TCK                      | TCK    | TCK            | TCK          | V <sub>CCAUX</sub>      |
| TDO                                | TDO           | TDO                | TDO                      | TDO    | TDO            | TDO          | V <sub>CCAUX</sub>      |
| PROG_B                             | PROG_B        | PROG_B             | PROG_B                   | PROG_B | PROG_B         | PROG_B       | V <sub>CCAUX</sub>      |
| DONE                               | DONE          | DONE               | DONE                     | DONE   | DONE           | DONE         | V <sub>CCAUX</sub>      |
| HSWAP                              | HSWAP         | HSWAP              | HSWAP                    | HSWAP  | HSWAP          | HSWAP        | 0                       |
| M2                                 | 0             | 0                  | 0                        | 1      | 1              | 1            | 2                       |
| M1                                 | 0             | 0                  | 1                        | 0      | 1              | 1            | 2                       |
| M0                                 | 0             | 1                  | 0 = Up<br>1 = Down       | 1      | 0              | 1            | 2                       |
| CCLK                               | CCLK (I/O)    | CCLK (I/O)         | CCLK (I/O)               |        | CCLK (I)       | CCLK (I)     | 2                       |
| INIT_B                             | INIT_B        | INIT_B             | INIT_B                   |        | INIT_B         | INIT_B       | 2                       |
| CSO_B                              |               | CSO_B              | CSO_B                    |        | CSO_B          |              | 2                       |
| DOUT/BUSY                          | DOUT          | DOUT               | BUSY                     |        | BUSY           | DOUT         | 2                       |
| MOSI/CSI_B                         |               | MOSI               | CSI_B                    |        | CSI_B          |              | 2                       |
| D7                                 |               |                    | D7                       |        | D7             |              | 2                       |
| D6                                 |               |                    | D6                       |        | D6             |              | 2                       |
| D5                                 |               |                    | D5                       |        | D5             |              | 2                       |
| D4                                 |               |                    | D4                       |        | D4             |              | 2                       |
| D3                                 |               |                    | D3                       |        | D3             |              | 2                       |
| D2                                 |               |                    | D2                       |        | D2             |              | 2                       |
| D1                                 |               |                    | D1                       |        | D1             |              | 2                       |

values applied to the M2, M1, and M0 mode select pins and the HSWAP pin. The mode select pins determine which of the I/O pins are borrowed during configuration and how they function. In JTAG configuration mode, no user-I/O pins are borrowed for configuration.

All user-I/O pins, input-only pins, and dual-purpose pins that are not actively involved in the currently-select configuration mode are high impedance (floating, three-stated, Hi-Z) during the configuration process. These pins are indicated in [Table 46](#) as gray shaded table entries or cells.

The HSWAP input controls whether all user-I/O pins, input-only pins, and dual-purpose pins have a pull-up resistor to the supply rail or not. When HSWAP is Low, each pin has an internal pull-up resistor that is active throughout configuration. After configuration, pull-up and pull-down resistors are available in the FPGA application as described in [Pull-Up and Pull-Down Resistors](#).

The yellow-shaded table entries or cells represent pins where the pull-up resistor is always enabled during configuration, regardless of the HSWAP input. The post-configuration behavior of these pins is defined by Bitstream Generator options as defined in [Table 69](#).

Table 46: Pin Behavior during Configuration (Cont'd)

| Pin Name       | Master Serial | SPI (Serial Flash) | BPI (Parallel NOR Flash) | JTAG | Slave Parallel | Slave Serial | I/O Bank <sup>(3)</sup> |
|----------------|---------------|--------------------|--------------------------|------|----------------|--------------|-------------------------|
| <b>D0/DIN</b>  | DIN           | DIN                | D0                       |      | D0             | DIN          | 2                       |
| <b>RDWR_B</b>  |               |                    | RDWR_B                   |      | RDWR_B         |              | 2                       |
| <b>A23</b>     |               |                    | A23                      |      |                |              | 2                       |
| <b>A22</b>     |               |                    | A22                      |      |                |              | 2                       |
| <b>A21</b>     |               |                    | A21                      |      |                |              | 2                       |
| <b>A20</b>     |               |                    | A20                      |      |                |              | 2                       |
| <b>A19/VS2</b> |               | VS2                | A19                      |      |                |              | 2                       |
| <b>A18/VS1</b> |               | VS1                | A18                      |      |                |              | 2                       |
| <b>A17/VS0</b> |               | VS0                | A17                      |      |                |              | 2                       |
| <b>A16</b>     |               |                    | A16                      |      |                |              | 1                       |
| <b>A15</b>     |               |                    | A15                      |      |                |              | 1                       |
| <b>A14</b>     |               |                    | A14                      |      |                |              | 1                       |
| <b>A13</b>     |               |                    | A13                      |      |                |              | 1                       |
| <b>A12</b>     |               |                    | A12                      |      |                |              | 1                       |
| <b>A11</b>     |               |                    | A11                      |      |                |              | 1                       |
| <b>A10</b>     |               |                    | A10                      |      |                |              | 1                       |
| <b>A9</b>      |               |                    | A9                       |      |                |              | 1                       |
| <b>A8</b>      |               |                    | A8                       |      |                |              | 1                       |
| <b>A7</b>      |               |                    | A7                       |      |                |              | 1                       |
| <b>A6</b>      |               |                    | A6                       |      |                |              | 1                       |
| <b>A5</b>      |               |                    | A5                       |      |                |              | 1                       |
| <b>A4</b>      |               |                    | A4                       |      |                |              | 1                       |
| <b>A3</b>      |               |                    | A3                       |      |                |              | 1                       |
| <b>A2</b>      |               |                    | A2                       |      |                |              | 1                       |
| <b>A1</b>      |               |                    | A1                       |      |                |              | 1                       |
| <b>A0</b>      |               |                    | A0                       |      |                |              | 1                       |
| <b>LDC0</b>    |               |                    | LDC0                     |      |                |              | 1                       |
| <b>LDC1</b>    |               |                    | LDC1                     |      |                |              | 1                       |
| <b>LDC2</b>    |               |                    | LDC2                     |      |                |              | 1                       |
| <b>HDC</b>     |               |                    | HDC                      |      |                |              | 1                       |

**Notes:**

1. Gray shaded cells represent pins that are in a high-impedance state (Hi-Z, floating) during configuration. These pins have an optional internal pull-up resistor to their respective  $V_{CCO}$  supply pin that is active throughout configuration if the HSWAP input is Low.
2. Yellow shaded cells represent pins with an internal pull-up resistor to its respective voltage supply rail that is active during configuration, regardless of the HSWAP pin.
3. Note that dual-purpose outputs are supplied by  $V_{CCO}$ , and configuration inputs are supplied by  $V_{CCAUX}$ .

The HSWAP pin itself has a pull-up resistor enabled during configuration. However, the  $V_{CCO\_0}$  supply voltage must be applied before the pull-up resistor becomes active. If the  $V_{CCO\_0}$  supply ramps after the  $V_{CCO\_2}$  power supply, do not let HSWAP float; tie HSWAP to the desired logic level externally.

Spartan-3E FPGAs have only six dedicated configuration pins, including the DONE and PROG\_B pins, and the four JTAG boundary-scan pins: TDI, TDO, TMS, and TCK. All other configuration pins are dual-purpose I/O pins and are available to the FPGA application after the DONE pin goes High. See [Start-Up](#) for additional information.

Table 47 shows the default I/O standard setting for the various configuration pins during the configuration process. The configuration interface is designed primarily for 2.5V operation when the  $V_{CCO\_2}$  (and  $V_{CCO\_1}$  in BPI mode) connects to 2.5V.

Table 47: Default I/O Standard Setting During Configuration ( $V_{CCO\_2} = 2.5V$ )

| Pin(s)              | I/O Standard | Output Drive | Slew Rate |
|---------------------|--------------|--------------|-----------|
| All, including CCLK | LVCMS25      | 8 mA         | Slow      |

The configuration pins also operate at other voltages by setting V<sub>CCO\_2</sub> (and V<sub>CCO\_1</sub> in BPI mode) to either 3.3V or 1.8V. The change on the V<sub>CCO</sub> supply also changes the I/O characteristics, including the effective IOSTANDARD. For example, with V<sub>CCO</sub> = 3.3V, the output characteristics will be similar to those of LVCMOS33, and the current when driving High, I<sub>OH</sub>, increases to approximately 12 to 16 mA, while the current when driving Low, I<sub>OL</sub>, remains 8 mA. At V<sub>CCO</sub> = 1.8V, the output characteristics will be similar to those of LVCMOS18, and the current when driving High, I<sub>OH</sub>, decreases slightly to approximately 6 to 8 mA. Again, the current when driving Low, I<sub>OL</sub>, remains 8 mA. The output voltages are determined by the V<sub>CCO</sub> level, LVCMOS18 for 1.8V, LVCMOS25 for 2.5V, and LVCMOS33 for 3.3V. For more details see [UG332](#).

## CCLK Design Considerations

For additional information, refer to the “Configuration Pins and Behavior during Configuration” chapter in [UG332](#).

The FPGA’s configuration process is controlled by the CCLK configuration clock. Consequently, signal integrity of CCLK is important to guarantee successful configuration. Poor CCLK signal integrity caused by ringing or reflections might cause double-clocking, causing the configuration process to fail.

Although the CCLK frequency is relatively low, Spartan-3E FPGA output edge rates are fast. Therefore, careful attention must be paid to the CCLK signal integrity on the printed circuit board. Signal integrity simulation with IBIS is recommended. For all configuration modes except JTAG, the signal integrity must be considered at every CCLK trace destination, including the FPGA’s CCLK pin.

This analysis is especially important when the FPGA re-uses the CCLK pin as a user-I/O after configuration. In these cases, there might be unrelated devices attached to CCLK, which add additional trace length and signal destinations.

In the Master Serial, SPI, and BPI configuration modes, the FPGA drives the CCLK pin and CCLK should be treated as a full bidirectional I/O pin for signal integrity analysis. In BPI mode, CCLK is only used in multi-FPGA daisy-chains.

The best signal integrity is ensured by following these basic PCB guidelines:

- Route the CCLK signal as a 50  $\Omega$  controlled-impedance transmission line.
- Route the CCLK signal without any branching. Do not use a “star” topology.
- Keep stubs, if required, shorter than 10 mm (0.4 inches).
- Terminate the end of the CCLK transmission line.

## Design Considerations for the HSWAP, M[2:0], and VS[2:0] Pins

For additional information, refer to the “Configuration Pins and Behavior during Configuration” chapter in [UG332](#).

Unlike previous Spartan FPGA families, nearly all of the Spartan-3E dual-purpose configuration pins are available as full-featured user I/O pins after successful configuration, when the DONE output goes High.

The HSWAP pin, the mode select pins (M[2:0]), and the variant-select pins (VS[2:0]) must have valid and stable logic values at the start of configuration. VS[2:0] are only used in the SPI configuration mode. The levels on the M[2:0] pins and VS[2:0] pins are sampled when the INIT\_B pin returns High. See [Figure 76](#) for a timing example.

The HSWAP pin defines whether FPGA user I/O pins have a pull-up resistor connected to their associated V<sub>CCO</sub> supply pin during configuration or not, as shown [Table 48](#). HSWAP must be valid at the start of configuration and remain constant throughout the configuration process.

*Table 48: HSWAP Behavior*

| HSWAP Value | Description   |
|-------------|---|
| 0           | Pull-up resistors connect to the associated V <sub>CCO</sub> supply for all user-I/O or dual-purpose I/O pins during configuration. Pull-up resistors are active until configuration completes. |
| 1           | Pull-up resistors disabled during configuration. All user-I/O or dual-purpose I/O pins are in a high-impedance state.   |

The Configuration section provides detailed schematics for each configuration mode. The schematics indicate the required logic values for HSWAP, M[2:0], and VS[2:0] but do not specify how the application provides the logic Low or High value. The HSWAP, M[2:0], and VS[2:0] pins can be either dedicated or reused by the FPGA application.

### Dedicating the HSWAP, M[2:0], and VS[2:0] Pins

If the HSWAP, M[2:0], and VS[2:0] pins are not required by the FPGA design after configuration, simply connect these pins directly to the V<sub>CCO</sub> or GND supply rail shown in the appropriate configuration schematic.

### Reusing HSWAP, M[2:0], and VS[2:0] After Configuration

To reuse the HSWAP, M[2:0], and VS[2:0] pin after configuration, use pull-up or pull-down resistors to define the logic values shown in the appropriate configuration schematic.

Table 49: Pull-up or Pull-down Values for HSWAP, M[2:0], and VS[2:0]

| HSWAP Value | I/O Pull-up Resistors during Configuration | Required Resistor Value to Define Logic Level on HSWAP, M[2:0], or VS[2:0]  |  |
|-------------|--|---|--|
|             |  | High  | Low  |
| 0           | Enabled                                    | Pulled High via an internal pull-up resistor to the associated $V_{CCO}$ supply. No external pull-up resistor is necessary. | Pulled Low using an appropriately sized pull-down resistor to GND.<br>For a 2.5V or 3.3V interface: $R \leq 560\Omega$ . For a 1.8V interface: $R \leq 1.1k\Omega$ . |
| 1           | Disabled                                   | Pulled High using a 3.3 to $4.7k\Omega$ resistor to the associated $V_{CCO}$ supply.  | Pulled Low using a 3.3 to $4.7k\Omega$ resistor to GND.  |

The logic level on HSWAP dictates how to define the logic levels on M[2:0] and VS[2:0], as shown in Table 49. If the application requires HSWAP to be High, the HSWAP pin is pulled High using an external  $3.3k\Omega$  to  $4.7k\Omega$  resistor to  $V_{CCO\_0}$ . If the application requires HSWAP to be Low during configuration, then HSWAP is either connected to GND or pulled Low using an appropriately sized external pull-down resistor to GND. When HSWAP is Low, its pin has an internal pull-up resistor to  $V_{CCO\_0}$ . The external pull-down resistor must be strong enough to define a logic Low on HSWAP for the I/O standard used during configuration. For 2.5V or 3.3V I/O, the pull-down resistor is  $560\Omega$  or lower. For 1.8V I/O, the pull-down resistor is  $1.1k\Omega$  or lower.

Once HSWAP is defined, use Table 49 to define the logic values for M[2:0] and VS[2:0].

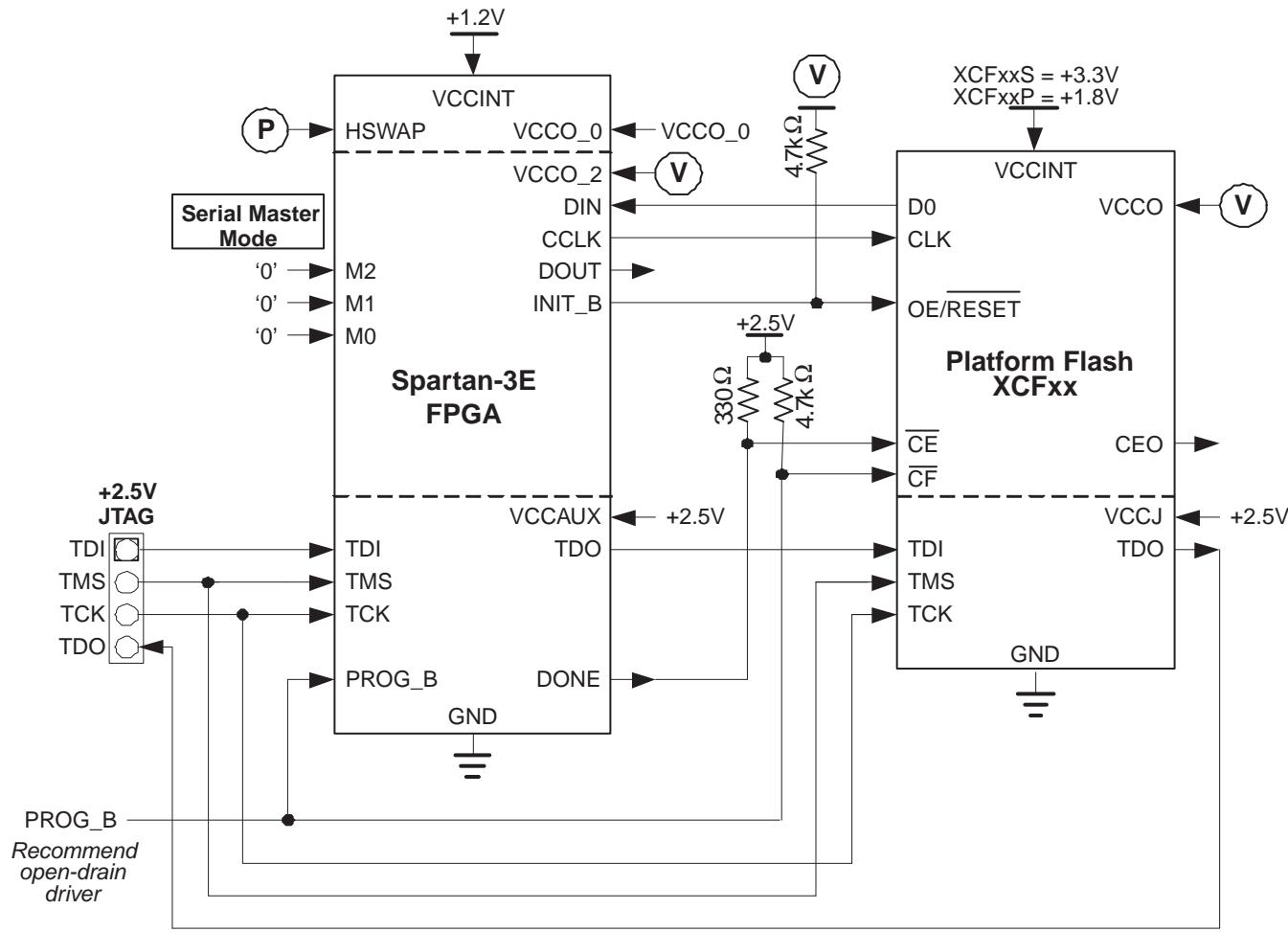
Use the weakest external pull-up or pull-down resistor value allowed by the application. The resistor must be strong enough to define a logic Low or High during configuration. However, when driving the HSWAP, M[2:0], or VS[2:0] pins after configuration, the output driver must be strong enough to overcome the pull-up or pull-down resistor value and generate the appropriate logic levels. For example, to overcome a  $560\Omega$  pull-down resistor, a 3.3V FPGA I/O pin must use a 6 mA or stronger driver.

## Master Serial Mode

For additional information, refer to the “Master Serial Mode” chapter in [UG332](#).

In Master Serial mode ( $M[2:0] = <0:0:0>$ ), the Spartan-3E FPGA configures itself from an attached Xilinx Platform

Flash PROM, as illustrated in [Figure 51](#). The FPGA supplies the CCLK output clock from its internal oscillator to the attached Platform Flash PROM. In response, the Platform Flash PROM supplies bit-serial data to the FPGA’s DIN input, and the FPGA accepts this data on each rising CCLK edge.



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Figure 51: Master Serial Mode using Platform Flash PROM

All mode select pins,  $M[2:0]$ , must be Low when sampled, when the FPGA’s INIT\_B output goes High. After configuration, when the FPGA’s DONE output goes High, the mode select pins are available as full-featured user-I/O pins.

**P** Similarly, the FPGA's HSWAP pin must be Low to enable pull-up resistors on all user-I/O pins during configuration or High to disable the pull-up resistors. The HSWAP control must remain at a constant logic level throughout FPGA configuration. After configuration, when the FPGA's DONE output goes High, the HSWAP pin is

available as full-featured user-I/O pin and is powered by the VCCO\_0 supply.

The FPGA's DOUT pin is used in daisy-chain applications, described later. In a single-FPGA application, the FPGA's DOUT pin is not used but is actively driving during the configuration process.

Table 50: Serial Master Mode Connections

| Pin Name          | FPGA Direction               | Description   | During Configuration   | After Configuration   |
|-------------------|------------------------------|---|--|---|
| HSWAP<br><b>P</b> | Input                        | <b>User I/O Pull-Up Control.</b> When Low during configuration, enables pull-up resistors in all I/O pins to respective I/O bank VCCO input.<br>0: Pull-ups during configuration<br>1: No pull-ups  | Drive at valid logic level throughout configuration.   | User I/O  |
| M[2:0]            | Input                        | <b>Mode Select.</b> Selects the FPGA configuration mode. See <a href="#">Design Considerations for the HSWAP, M[2:0], and VS[2:0] Pins</a> .  | M2 = 0, M1 = 0, M0 = 0. Sampled when INIT_B goes High.   | User I/O  |
| DIN               | Input                        | <b>Serial Data Input.</b>   | Receives serial data from PROM's D0 output.  | User I/O  |
| CCLK              | Output                       | <b>Configuration Clock.</b> Generated by FPGA internal oscillator. Frequency controlled by <b>ConfigRate</b> bitstream generator option. If CCLK PCB trace is long or has multiple connections, terminate this output to maintain signal integrity. See <a href="#">CCLK Design Considerations</a> .  | Drives PROM's CLK clock input.   | User I/O  |
| DOUT              | Output                       | <b>Serial Data Output.</b>  | Actively drives. Not used in single-FPGA designs. In a daisy-chain configuration, this pin connects to DIN input of the next FPGA in the chain.  | User I/O  |
| INIT_B            | Open-drain bidirectional I/O | <b>Initialization Indicator.</b> Active Low. Goes Low at start of configuration during Initialization memory clearing process. Released at end of memory clearing, when mode select pins are sampled. Requires external 4.7 kΩ pull-up resistor to VCCO_2.  | Connects to PROM's OE/RESET input. FPGA clears PROM's address counter at start of configuration, enables outputs during configuration. PROM also holds FPGA in Initialization state until PROM reaches Power-On Reset (POR) state. If CRC error detected during configuration, FPGA drives INIT_B Low. | User I/O. If unused in the application, drive INIT_B High.                                    |
| DONE              | Open-drain bidirectional I/O | <b>FPGA Configuration Done.</b> Low during configuration. Goes High when FPGA successfully completes configuration. Requires external 330 Ω pull-up resistor to 2.5V.   | Connects to PROM's chip-enable (CE) input. Enables PROM during configuration. Disables PROM after configuration.   | Pulled High via external pull-up. When High, indicates that the FPGA successfully configured. |
| PROG_B            | Input                        | <b>Program FPGA.</b> Active Low. When asserted Low for 500 ns or longer, forces the FPGA to restart its configuration process by clearing configuration memory and resetting the DONE and INIT_B pins once PROG_B returns High. Recommend external 4.7 kΩ pull-up resistor to 2.5V. Internal pull-up value may be weaker (see <a href="#">Table 78</a> ). If driving externally with a 3.3V output, use an open-drain or open-collector driver or use a current limiting series resistor. | Must be High during configuration to allow configuration to start. Connects to PROM's CF pin, allowing JTAG PROM programming algorithm to reprogram the FPGA.  | Drive PROG_B Low and release to reprogram FPGA.   |

## Voltage Compatibility

The PROM's  $V_{CCINT}$  supply must be either 3.3V for the serial XCFxxS Platform Flash PROMs or 1.8V for the serial/parallel XCFxxP PROMs.

**V** The FPGA's  $V_{CCO\_2}$  supply input and the Platform Flash PROM's  $V_{CCO}$  supply input must be the same voltage, ideally +2.5V. Both devices also support 1.8V and 3.3V interfaces but the FPGA's PROG\_B and DONE pins require special attention as they are powered by the FPGA's  $V_{CCAUX}$  supply, nominally 2.5V. See application note [XAPP453: The 3.3V Configuration of Spartan-3 FPGAs](#) for additional information.

## Supported Platform Flash PROMs

[Table 51](#) shows the smallest available Platform Flash PROM to program one Spartan-3E FPGA. A multiple-FPGA daisy-chain application requires a [Platform Flash PROM](#) large enough to contain the sum of the various FPGA file sizes.

**Table 51: Number of Bits to Program a Spartan-3E FPGA and Smallest Platform Flash PROM**

| Spartan-3E FPGA | Number of Configuration Bits | Smallest Available Platform Flash |
|-----------------|------------------------------|-----------------------------------|
| XC3S100E        | 581,344                      | XCF01S                            |
| XC3S250E        | 1,353,728                    | XCF02S                            |
| XC3S500E        | 2,270,208                    | XCF04S                            |
| XC3S1200E       | 3,841,184                    | XCF04S                            |
| XC3S1600E       | 5,969,696                    | XCF08P or 2 x XCF04S              |

The XC3S1600E requires an 8 Mbit PROM. Two solutions are possible: either a single 8 Mbit XCF08P parallel/serial PROM or two 4 Mbit XCF04S serial PROMs cascaded. The two XCF04S PROMs use a 3.3V  $V_{CCINT}$  supply while the XCF08P requires a 1.8V  $V_{CCINT}$  supply. If the board does not already have a 1.8V supply available, the two cascaded XCF04S PROM solution is recommended.

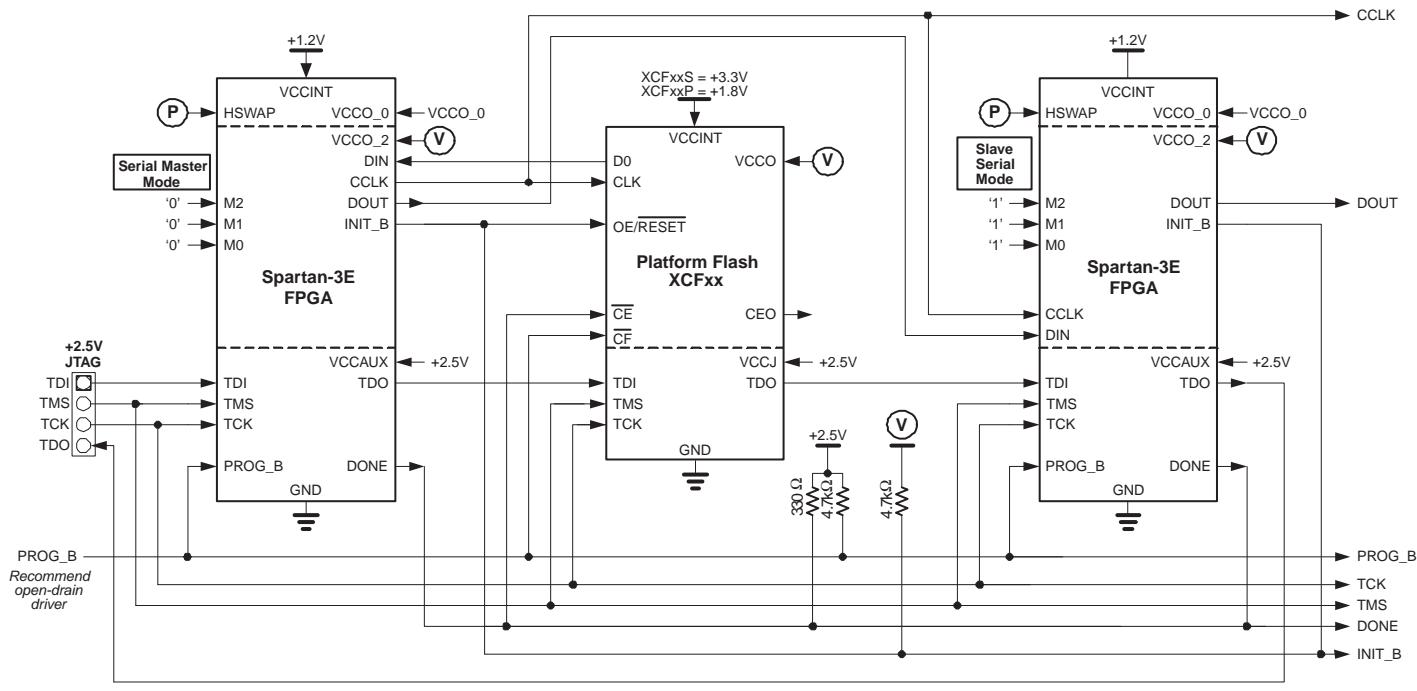
## CCLK Frequency

In Master Serial mode, the FPGA's internal oscillator generates the configuration clock frequency. The FPGA provides this clock on its CCLK output pin, driving the PROM's CLK input pin. The FPGA starts configuration at its lowest frequency and increases its frequency for the remainder of the configuration process if so specified in the configuration bitstream. The maximum frequency is specified using the [ConfigRate](#) bitstream generator option.

[Table 52](#) shows the maximum **ConfigRate** settings, approximately equal to MHz, for various Platform Flash devices and I/O voltages. For the serial XCFxxS PROMs, the maximum frequency also depends on the interface voltage.

**Table 52: Maximum ConfigRate Settings for Platform Flash**

| Platform Flash Part Number | I/O Voltage ( $V_{CCO\_2}$ , $V_{CCO}$ ) | Maximum ConfigRate Setting |
|----------------------------|--|----------------------------|
| XCF01S<br>XCF02S<br>XCF04S | 3.3V or 2.5V                             | 25                         |
|                            | 1.8V                                     | 12                         |
| XCF08P<br>XCF16P<br>XCF32P | 3.3V, 2.5V, or 1.8V                      | 25                         |



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Figure 52: Daisy-Chaining from Master Serial Mode

## Daisy-Chaining

If the application requires multiple FPGAs with different configurations, then configure the FPGAs using a daisy chain, as shown in Figure 52. Use Master Serial mode ( $M[2:0] = <0:0:0>$ ) for the FPGA connected to the Platform Flash PROM and Slave Serial mode ( $M[2:0] = <1:1:1>$ ) for all other FPGAs in the daisy-chain. After the master FPGA—the FPGA on the left in the diagram—finishes loading its configuration data from the Platform Flash, the master device supplies data using its DOUT output pin to the next device in the daisy-chain, on the falling CCLK edge.

## JTAG Interface

Both the Spartan-3E FPGA and the Platform Flash PROM have a four-wire IEEE 1149.1/1532 JTAG port. Both devices share the TCK clock input and the TMS mode select input. The devices may connect in either order on the JTAG chain with the TDO output of one device feeding the TDI input of the following device in the chain. The TDO output of the last device in the JTAG chain drives the JTAG connector.

The JTAG interface on Spartan-3E FPGAs is powered by the 2.5V  $V_{CCAUX}$  supply. Consequently, the PROM's  $V_{CC}$  supply input must also be 2.5V. To create a 3.3V JTAG interface, please refer to application note [XAPP453: The 3.3V Configuration of Spartan-3 FPGAs](#) for additional information.

## In-System Programming Support

Both the FPGA and the Platform Flash PROM are in-system programmable via the JTAG chain. Download support is provided by the Xilinx iMPACT programming software and the associated Xilinx [Parallel Cable IV](#) or [Platform Cable USB](#) programming cables.

## Storing Additional User Data in Platform Flash

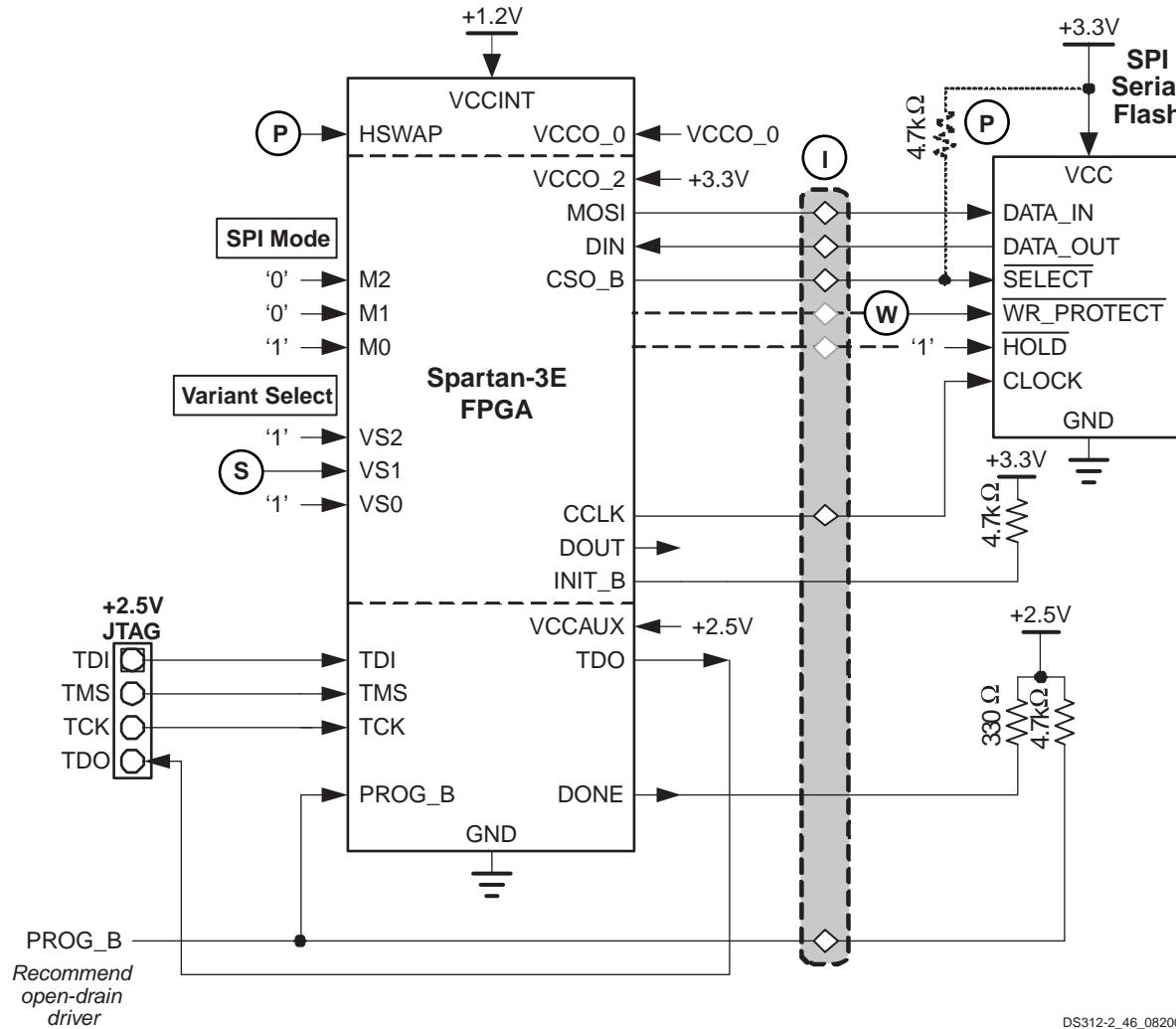
After configuration, the FPGA application can continue to use the Master Serial interface pins to communicate with the Platform Flash PROM. If desired, use a larger Platform Flash PROM to hold additional non-volatile application data, such as MicroBlaze processor code, or other user data such as serial numbers and Ethernet MAC IDs. The FPGA first configures from Platform Flash PROM. Then using FPGA logic after configuration, the FPGA copies MicroBlaze code from Platform Flash into external DDR SDRAM for code execution.

See [XAPP694: Reading User Data from Configuration PROMs](#) and [XAPP482: MicroBlaze Platform Flash/PROM Boot Loader and User Data Storage](#) for specific details on how to implement such an interface.

## SPI Serial Flash Mode

For additional information, refer to the “Master SPI Mode” chapter in [UG332](#).

In SPI Serial Flash mode ( $M[2:0] = <0:0:1>$ ), the Spartan-3E FPGA configures itself from an attached industry-standard SPI serial Flash PROM, as illustrated in [Figure 53](#) and [Figure 54](#). The FPGA supplies the CCLK output clock from its internal oscillator to the clock input of the attached SPI Flash PROM.



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**Figure 53: SPI Flash PROM Interface for PROMs Supporting READ (0x03) and FAST\_READ (0x0B) Commands**

**S** Although SPI is a standard four-wire interface, various available SPI Flash PROMs use different command protocols. The FPGA’s variant select pins, VS[2:0], define how the FPGA communicates with the SPI Flash, including which SPI Flash command the FPGA issues to start the read operation and the number of dummy bytes inserted before the FPGA expects to receive valid data from the SPI Flash. [Table 53](#) shows the available SPI Flash PROMs expected to operate with Spartan-3E FPGAs. Other compatible devices might work but have not been tested for suitability with Spartan-3E FPGAs. All other VS[2:0] values are reserved for future use. Consult the data sheet for the desired SPI Flash device to determine its suitability. The basic timing requirements and waveforms are provided in

[Serial Peripheral Interface \(SPI\) Configuration Timing in Module 3](#).

[Figure 53](#) shows the general connection diagram for those SPI Flash PROMs that support the 0x03 READ command or the 0x0B FAST READ commands.

[Figure 54](#) shows the connection diagram for Atmel DataFlash serial PROMs, which also use an SPI-based protocol. ‘B’-series DataFlash devices are limited to FPGA applications operating over the commercial temperature range. Industrial temperature range applications must use ‘C’- or ‘D’-series DataFlash devices, which have a shorter DataFlash select setup time, because of the faster FPGA CCLK frequency at cold temperatures.

Figure 57, page 83 demonstrates how to configure multiple FPGAs with different configurations, all stored in a single SPI Flash. The diagram uses standard SPI Flash memories

but the same general technique applies for Atmel DataFlash.

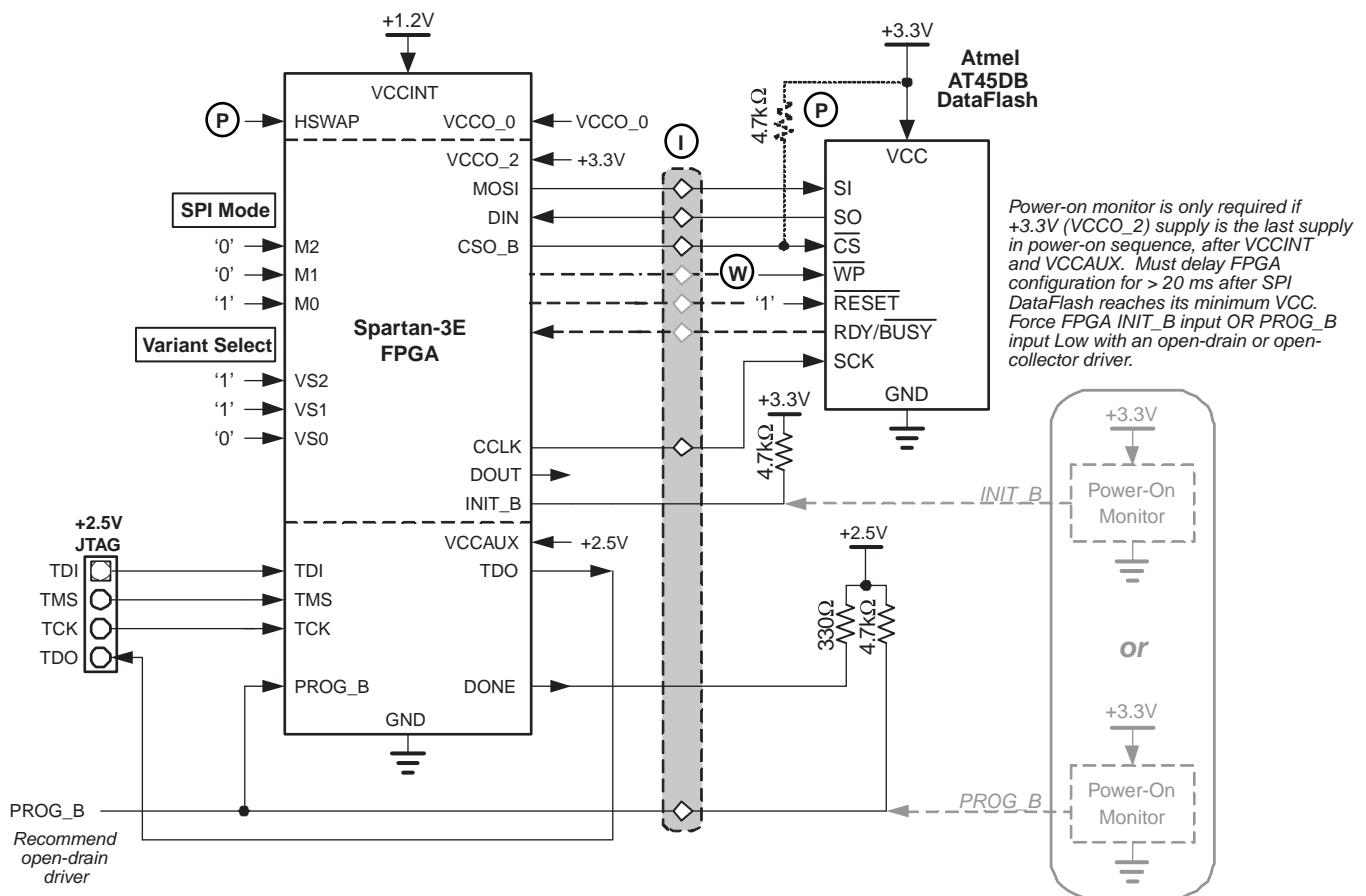


Figure 54: Atmel SPI-based DataFlash Configuration Interface

Table 53: Variant Select Codes for Various SPI Serial Flash PROMs

| VS2    | VS1 | VS0      | SPI Read Command                     | Dummy Bytes | SPI Serial Flash Vendor                   | SPI Flash Family  | iMPACT Programming Support |
|--------|-----|----------|--------------------------------------|-------------|---|---|----------------------------|
| 1      | 1   | 1        | FAST READ (0x0B)<br>(see Figure 53)  | 1           | STMicroelectronics (ST)                   | <a href="#">M25Pxx</a><br><a href="#">M25PExx/M45PExx</a>   | Yes                        |
|        |     |          |                                      |             | Atmel                                     | <a href="#">AT45DB 'D'-Series Data Flash</a>  | Yes                        |
|        |     |          |                                      |             |   | AT26 / AT25 <sup>(1)</sup>  |                            |
|        |     |          |                                      |             | Intel                                     | <a href="#">S33</a>   |                            |
|        |     |          |                                      |             | Spansion (AMD, Fujitsu)                   | <a href="#">S25FLxxxA</a>   |                            |
|        |     |          |                                      |             | Winbond (NexFlash)                        | <a href="#">NX25 / W25</a>  |                            |
|        |     |          |                                      |             | Macronix                                  | <a href="#">MX25Lxxxx</a>   |                            |
|        |     |          |                                      |             | Silicon Storage Technology (SST)          | <a href="#">SST25LFxxxA</a><br><a href="#">SST25VFxxxA</a>  |                            |
|        |     |          |                                      |             | Programmable Microelectronics Corp. (PMC) | <a href="#">Pm25LVxxx</a>   |                            |
|        |     |          |                                      |             | AMIC Technology                           | <a href="#">A25L</a>  |                            |
|        |     |          |                                      |             | Eon Silicon Solution, Inc.                | <a href="#">EN25</a>  |                            |
| 1      | 0   | 1        | READ (0x03)<br>(see Figure 53)       | 0           | STMicroelectronics (ST)                   | <a href="#">M25Pxx</a><br><a href="#">M25PExx/M45PExx</a>   | Yes                        |
|        |     |          |                                      |             | Spansion (AMD, Fujitsu)                   | <a href="#">S25FLxxxA</a>   |                            |
|        |     |          |                                      |             | Winbond (NexFlash)                        | <a href="#">NX25 / W25</a>  |                            |
|        |     |          |                                      |             | Macronix                                  | <a href="#">MX25Lxxxx</a>   |                            |
|        |     |          |                                      |             | Silicon Storage Technology (SST)          | <a href="#">SST25LFxxxA</a><br><a href="#">SST25VFxxxA</a><br><a href="#">SST25VFxxx</a>          |                            |
|        |     |          |                                      |             | Programmable Microelectronics Corp. (PMC) | <a href="#">Pm25LVxxx</a>   |                            |
| 1      | 1   | 0        | READ ARRAY (0xE8)<br>(see Figure 54) | 4           | Atmel Corporation                         | <a href="#">AT45DB DataFlash</a><br>(use only 'C' or 'D' Series for Industrial temperature range) | Yes                        |
| Others |     | Reserved |                                      |             |   |   |                            |

**Notes:**

1. See iMPACT documentation for specific device support.

**W** Table 54 shows the connections between the SPI Flash PROM and the FPGA's SPI configuration interface. Each SPI Flash PROM vendor uses slightly different signal naming. The SPI Flash PROM's write protect and hold

controls are not used by the FPGA during configuration. However, the **HOLD** pin must be High during the configuration process. The PROM's write protect input must be High in order to write or program the Flash memory.

Table 54: Example SPI Flash PROM Connections and Pin Naming

| SPI Flash Pin               | FPGA Connection  | STMicro     | NexFlash    | Silicon Storage Technology | Atmel DataFlash |
|-----------------------------|--|-------------|-------------|----------------------------|-----------------|
| DATA_IN                     | MOSI   | D           | DI          | SI                         | SI              |
| DATA_OUT                    | DIN  | Q           | DO          | SO                         | SO              |
| SELECT                      | CSO_B  | $\bar{S}$   | $\bar{CS}$  | CE#                        | $\bar{CS}$      |
| CLOCK                       | CCLK   | C           | CLK         | SCK                        | SCK             |
| WR_PROTECT<br><b>W</b>      | Not required for FPGA configuration. Must be High to program SPI Flash. Optional connection to FPGA user I/O after configuration.  | $\bar{W}$   | $\bar{WP}$  | WP#                        | $\bar{WP}$      |
| HOLD<br>(see Figure 53)     | Not required for FPGA configuration but must be High during configuration. Optional connection to FPGA user I/O after configuration. Not applicable to Atmel DataFlash.  | <b>HOLD</b> | <b>HOLD</b> | HOLD#                      | N/A             |
| RESET<br>(see Figure 54)    | Only applicable to Atmel DataFlash. Not required for FPGA configuration but must be High during configuration. Optional connection to FPGA user I/O after configuration. Do not connect to FPGA's PROG_B as this will prevent direct programming of the DataFlash. | N/A         | N/A         | N/A                        | <b>RESET</b>    |
| RDY/BUSY<br>(see Figure 54) | Only applicable to Atmel DataFlash and only available on certain packages. Not required for FPGA configuration. Output from DataFlash PROM. Optional connection to FPGA user I/O after configuration.  | N/A         | N/A         | N/A                        | <b>RDY/BUSY</b> |

The mode select pins, M[2:0], and the variant select pins, VS[2:0] are sampled when the FPGA's INIT\_B output goes High and must be at defined logic levels during this time. After configuration, when the FPGA's DONE output goes High, these pins are all available as full-featured user-I/O pins.

**P** Similarly, the FPGA's HSWAP pin must be Low to enable pull-up resistors on all user-I/O pins or High to

disable the pull-up resistors. The HSWAP control must remain at a constant logic level throughout FPGA configuration. After configuration, when the FPGA's DONE output goes High, the HSWAP pin is available as full-featured user-I/O pin and is powered by the VCCO\_0 supply.

In a single-FPGA application, the FPGA's DOUT pin is not used but is actively driving during the configuration process.

Table 55: Serial Peripheral Interface (SPI) Connections

| Pin Name          | FPGA Direction | Description  | During Configuration                                      | After Configuration |
|-------------------|----------------|--|---|---------------------|
| HSWAP<br><b>P</b> | Input          | <b>User I/O Pull-Up Control.</b> When Low during configuration, enables pull-up resistors in all I/O pins to respective I/O bank V <sub>CCO</sub> input.<br>0: Pull-ups during configuration<br>1: No pull-ups | Drive at valid logic level throughout configuration.      | User I/O            |
| M[2:0]            | Input          | <b>Mode Select.</b> Selects the FPGA configuration mode. See <a href="#">Design Considerations for the HSWAP, M[2:0], and VS[2:0] Pins</a> .   | M2 = 0, M1 = 0, M0 = 1.<br>Sampled when INIT_B goes High. | User I/O            |

Table 55: Serial Peripheral Interface (SPI) Connections (Cont'd)

| Pin Name   | FPGA Direction               | Description   | During Configuration  | After Configuration   |
|--|------------------------------|---|---|---|
| VS[2:0]<br> | Input                        | <b>Variant Select.</b> Instructs the FPGA how to communicate with the attached SPI Flash PROM. See <a href="#">Design Considerations for the HSWAP, M[2:0], and VS[2:0] Pins</a> .  | Must be at the logic levels shown in <a href="#">Table 53</a> . Sampled when INIT_B goes High.  | User I/O  |
| MOSI   | Output                       | <b>Serial Data Output.</b>  | FPGA sends SPI Flash memory read commands and starting address to the PROM's serial data input.   | User I/O  |
| DIN  | Input                        | <b>Serial Data Input.</b>   | FPGA receives serial data from PROM's serial data output.   | User I/O  |
| CSO_B  | Output                       | <b>Chip Select Output.</b> Active Low.  | Connects to the SPI Flash PROM's chip-select input. If HSWAP = 1, connect this signal to a 4.7 kΩ pull-up resistor to 3.3V.   | Drive CSO_B High after configuration to disable the SPI Flash and reclaim the MOSI, DIN, and CCLK pins. Optionally, re-use this pin and MOSI, DIN, and CCLK to continue communicating with SPI Flash. |
| CCLK   | Output                       | <b>Configuration Clock.</b> Generated by FPGA internal oscillator. Frequency controlled by <a href="#">ConfigRate</a> bitstream generator option. If CCLK PCB trace is long or has multiple connections, terminate this output to maintain signal integrity. See <a href="#">CCLK Design Considerations</a> .   | Drives PROM's clock input.  | User I/O  |
| DOUT   | Output                       | <b>Serial Data Output.</b>  | Actively drives. Not used in single-FPGA designs. In a daisy-chain configuration, this pin connects to DIN input of the next FPGA in the chain.   | User I/O  |
| INIT_B   | Open-drain bidirectional I/O | <b>Initialization Indicator.</b> Active Low. Goes Low at start of configuration during Initialization memory clearing process. Released at end of memory clearing, when mode select pins are sampled. In daisy-chain applications, this signal requires an external 4.7 kΩ pull-up resistor to VCCO_2.  | Active during configuration. If SPI Flash PROM requires > 2 ms to awake after powering on, hold INIT_B Low until PROM is ready. If CRC error detected during configuration, FPGA drives INIT_B Low. | User I/O. If unused in the application, drive INIT_B High.  |
| DONE   | Open-drain bidirectional I/O | <b>FPGA Configuration Done.</b> Low during configuration. Goes High when FPGA successfully completes configuration. Requires external 330 Ω pull-up resistor to 2.5V.   | Low indicates that the FPGA is not yet configured.  | Pulled High via external pull-up. When High, indicates that the FPGA successfully configured.   |
| PROG_B   | Input                        | <b>Program FPGA.</b> Active Low. When asserted Low for 500 ns or longer, forces the FPGA to restart its configuration process by clearing configuration memory and resetting the DONE and INIT_B pins once PROG_B returns High. Recommend external 4.7 kΩ pull-up resistor to 2.5V. Internal pull-up value may be weaker (see <a href="#">Table 78</a> ). If driving externally with a 3.3V output, use an open-drain or open-collector driver or use a current limiting series resistor. | Must be High to allow configuration to start.   | Drive PROG_B Low and release to reprogram FPGA. Hold PROG_B to force FPGA I/O pins into Hi-Z, allowing direct programming access to SPI Flash PROM pins.  |

## Voltage Compatibility

Available SPI Flash PROMs use a single 3.3V supply voltage. All of the FPGA's SPI Flash interface signals are within I/O Bank 2. Consequently, the FPGA's VCCO\_2 supply voltage must also be 3.3V to match the SPI Flash PROM.

## Power-On Precautions if 3.3V Supply is Last in Sequence

Spartan-3E FPGAs have a built-in power-on reset (POR) circuit, as shown in [Figure 66, page 103](#). The FPGA waits

for its three power supplies —  $V_{CCINT}$ ,  $V_{CCAUX}$ , and  $V_{CCO}$  to I/O Bank 2 ( $VCCO\_2$ ) — to reach their respective power-on thresholds before beginning the configuration process.

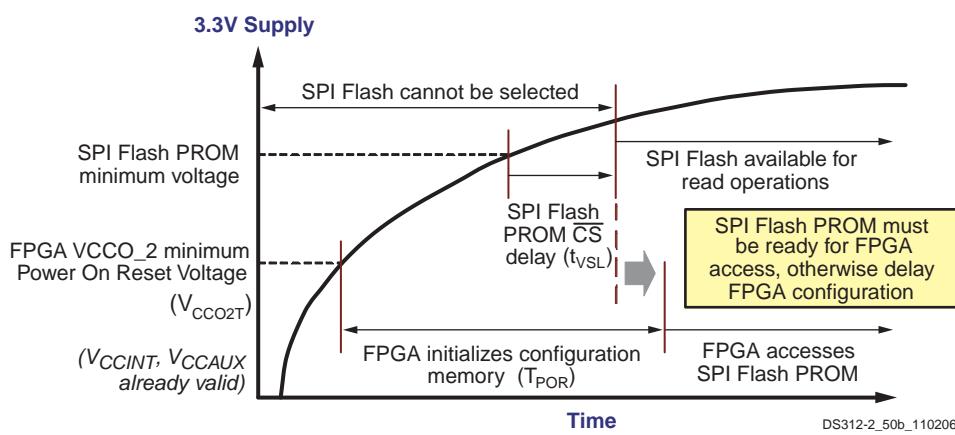
The SPI Flash PROM is powered by the same voltage supply feeding the FPGA's  $VCCO_2$  voltage input, typically 3.3V. SPI Flash PROMs specify that they cannot be accessed until their  $V_{CC}$  supply reaches its minimum data sheet voltage, followed by an additional delay. For some devices, this additional delay is as little as 10  $\mu$ s as shown in [Table 56](#). For other vendors, this delay is as much as 20 ms.

**Table 56: Example Minimum Power-On to Select Times for Various SPI Flash PROMs**

| Vendor                                    | SPI Flash PROM Part Number | Data Sheet Minimum Time from $V_{CC}$ min to Select = Low |       |         |
|---|----------------------------|---|-------|---------|
|   |                            | Symbol  | Value | Units   |
| STMicroelectronics                        | M25Pxx                     | $T_{VSL}$   | 10    | $\mu$ s |
| Spansion                                  | S25FLxxxA                  | $t_{PU}$  | 10    | ms      |
| NexFlash                                  | NX25xx                     | $T_{VSL}$   | 10    | $\mu$ s |
| Macronix                                  | MX25Lxxxx                  | $t_{VSL}$   | 10    | $\mu$ s |
| Silicon Storage Technology                | SST25LFxx                  | $T_{PU-READ}$   | 10    | $\mu$ s |
| Programmable Microelectronics Corporation | Pm25LVxxx                  | $T_{VCS}$   | 50    | $\mu$ s |
| Atmel Corporation                         | AT45DBxxxxD                | $t_{VCSL}$  | 30    | $\mu$ s |
|   | AT45DBxxxxB                |   | 20    | ms      |

In many systems, the 3.3V supply feeding the FPGA's  $VCCO_2$  input is valid before the FPGA's other  $V_{CCINT}$  and  $V_{CCAUX}$  supplies, and consequently, there is no issue. However, if the 3.3V supply feeding the FPGA's  $VCCO_2$

supply is last in the sequence, a potential race occurs between the FPGA and the SPI Flash PROM, as shown in [Figure 55](#).



**Figure 55: SPI Flash PROM/FPGA Power-On Timing if 3.3V Supply is Last in Power-On Sequence**

If the FPGA's  $V_{CCINT}$  and  $V_{CCAUX}$  supplies are already valid, then the FPGA waits for  $VCCO_2$  to reach its minimum threshold voltage before starting configuration. This threshold voltage is labeled as  $V_{CCO2T}$  in [Table 74](#) of Module 3 and ranges from approximately 0.4V to 1.0V, substantially lower than the SPI Flash PROM's minimum voltage. Once all three FPGA supplies reach their

respective Power On Reset (POR) thresholds, the FPGA starts the configuration process and begins initializing its internal configuration memory. Initialization requires approximately 1 ms ( $T_{POR}$ , minimum in [Table 111](#) of Module 3, after which the FPGA de-asserts INIT\_B, selects the SPI Flash PROM, and starts sending the appropriate read command. The SPI Flash PROM must be ready for

read operations at this time. Spartan-3E FPGAs issue the read command just once. If the SPI Flash is not ready, then the FPGA does not properly configure.

If the 3.3V supply is last in the sequence and does not ramp fast enough, or if the SPI Flash PROM cannot be ready when required by the FPGA, delay the FPGA configuration process by holding either the FPGA's PROG\_B input or INIT\_B input Low, as highlighted in [Figure 54](#). Release the FPGA when the SPI Flash PROM is ready. For example, a simple R-C delay circuit attached to the INIT\_B pin forces the FPGA to wait for a preselected amount of time.

Alternately, a Power Good signal from the 3.3V supply or a system reset signal accomplishes the same purpose. Use an open-drain or open-collector output when driving PROG\_B or INIT\_B.

## SPI Flash PROM Density Requirements

[Table 57](#) shows the smallest usable SPI Flash PROM to program a single Spartan-3E FPGA. Commercially available SPI Flash PROMs range in density from 1 Mbit to 128 Mbits. A multiple-FPGA daisy-chained application requires a SPI Flash PROM large enough to contain the sum of the FPGA file sizes. An application can also use a larger-density SPI Flash PROM to hold additional data beyond just FPGA configuration data. For example, the SPI Flash PROM can also store application code for a [MicroBlaze™](#) RISC processor core integrated in the Spartan-3E FPGA. See [Using the SPI Flash Interface after Configuration](#).

**Table 57: Number of Bits to Program a Spartan-3E FPGA and Smallest SPI Flash PROM**

| Device    | Number of Configuration Bits | Smallest Usable SPI Flash PROM |
|-----------|------------------------------|--------------------------------|
| XC3S100E  | 581,344                      | 1 Mbit                         |
| XC3S250E  | 1,353,728                    | 2 Mbit                         |
| XC3S500E  | 2,270,208                    | 4 Mbit                         |
| XC3S1200E | 3,841,184                    | 4 Mbit                         |
| XC3S1600E | 5,969,696                    | 8 Mbit                         |

## CCLK Frequency

In SPI Flash mode, the FPGA's internal oscillator generates the configuration clock frequency. The FPGA provides this clock on its CCLK output pin, driving the PROM's clock input pin. The FPGA starts configuration at its lowest frequency and increases its frequency for the remainder of the configuration process if so specified in the configuration bitstream. The maximum frequency is specified using the [ConfigRate](#) bitstream generator option. The maximum frequency supported by the FPGA configuration logic depends on the timing for the SPI Flash device. Without examining the timing for a specific SPI Flash PROM, use [ConfigRate](#) = 12 or lower. SPI Flash PROMs that support the FAST READ command support higher data rates. Some

such PROMs support up to [ConfigRate](#) = 25 and beyond but require careful data sheet analysis. See [Serial Peripheral Interface \(SPI\) Configuration Timing](#) for more detailed timing analysis.

## Using the SPI Flash Interface after Configuration

After the FPGA successfully completes configuration, all of the pins connected to the SPI Flash PROM are available as user-I/O pins.

If not using the SPI Flash PROM after configuration, drive CSO\_B High to disable the PROM. The MOSI, DIN, and CCLK pins are then available to the FPGA application.

Because all the interface pins are user I/O after configuration, the FPGA application can continue to use the SPI Flash interface pins to communicate with the SPI Flash PROM, as shown in [Figure 56](#). SPI Flash PROMs offer random-accessible, byte-addressable, read/write, non-volatile storage to the FPGA application.

SPI Flash PROMs are available in densities ranging from 1 Mbit up to 128 Mbits. However, a single Spartan-3E FPGA requires less than 6 Mbits. If desired, use a larger SPI Flash PROM to contain additional non-volatile application data, such as MicroBlaze processor code, or other user data such as serial numbers and Ethernet MAC IDs. In the example shown in [Figure 56](#), the FPGA configures from SPI Flash PROM. Then using FPGA logic after configuration, the FPGA copies MicroBlaze code from SPI Flash into external DDR SDRAM for code execution. Similarly, the FPGA application can store non-volatile application data within the SPI Flash PROM.

The FPGA configuration data is stored starting at location 0. Store any additional data beginning in the next available SPI Flash PROM sector or page. Do not mix configuration data and user data in the same sector or page.

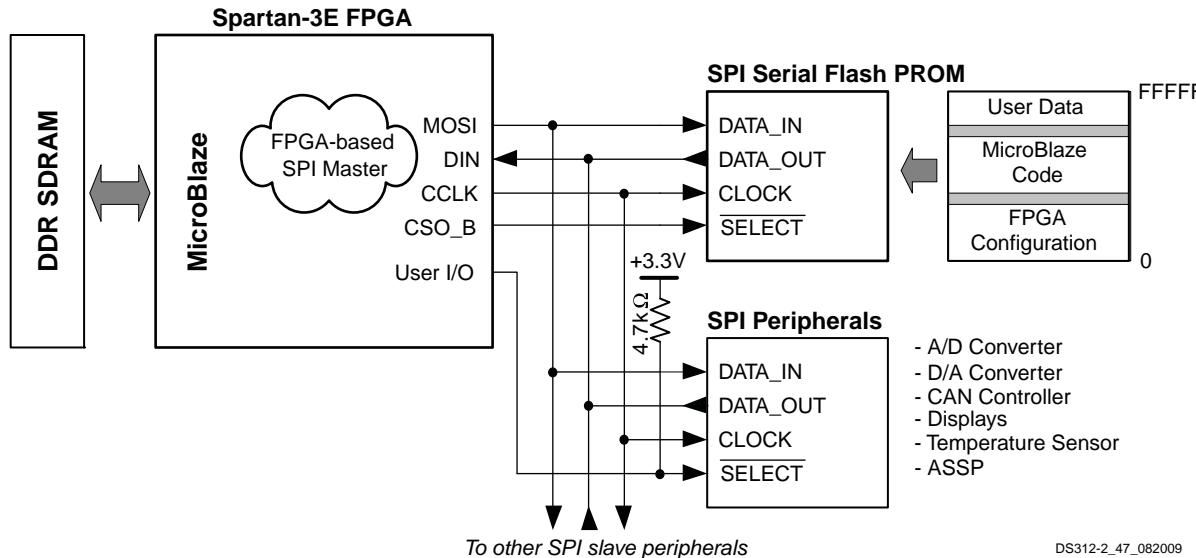
Similarly, the SPI bus can be expanded to additional SPI peripherals. Because SPI is a common industry-standard interface, various SPI-based peripherals are available, such as analog-to-digital (A/D) converters, digital-to-analog (D/A) converters, CAN controllers, and temperature sensors. However, if sufficient I/O pins are available in the application, Xilinx recommends creating a separate SPI bus to control peripherals. Creating a second port reduces the loading on the CCLK and DIN pins, which are crucial for configuration.

The MOSI, DIN, and CCLK pins are common to all SPI peripherals. Connect the select input on each additional SPI peripheral to one of the FPGA user I/O pins. If HSWAP = 0 during configuration, the FPGA holds the select line High. If HSWAP = 1, connect the select line to +3.3V via an external 4.7 kΩ pull-up resistor to avoid spurious read or write operations. After configuration, drive the select line Low to select the desired SPI peripheral.

During the configuration process, CCLK is controlled by the FPGA and limited to the frequencies generated by the FPGA. After configuration, the FPGA application can use

other clock signals to drive the CCLK pin and can further optimize SPI-based communication.

Refer to the individual SPI peripheral data sheet for specific interface and communication protocol requirements.



DS312-2\_47\_082009

Figure 56: Using the SPI Flash Interface After Configuration

## Daisy-Chaining

If the application requires multiple FPGAs with different configurations, then configure the FPGAs using a daisy chain, as shown in [Figure 57](#). Daisy-chaining from a single SPI serial Flash PROM is supported in Stepping 1 devices. It is not supported in Stepping 0 devices. Use SPI Flash mode ( $M[2:0] = <0:0:1>$ ) for the FPGA connected to the Platform Flash PROM and Slave Serial mode ( $M[2:0] = <1:1:1>$ ) for all other FPGAs in the daisy-chain. After the master FPGA—the FPGA on the left in the

diagram—finishes loading its configuration data from the SPI Flash PROM, the master device uses its DOUT output pin to supply data to the next device in the daisy-chain, on the falling CCLK edge.

### Design Note

SPI mode daisy chains are supported only in Stepping 1 silicon versions.

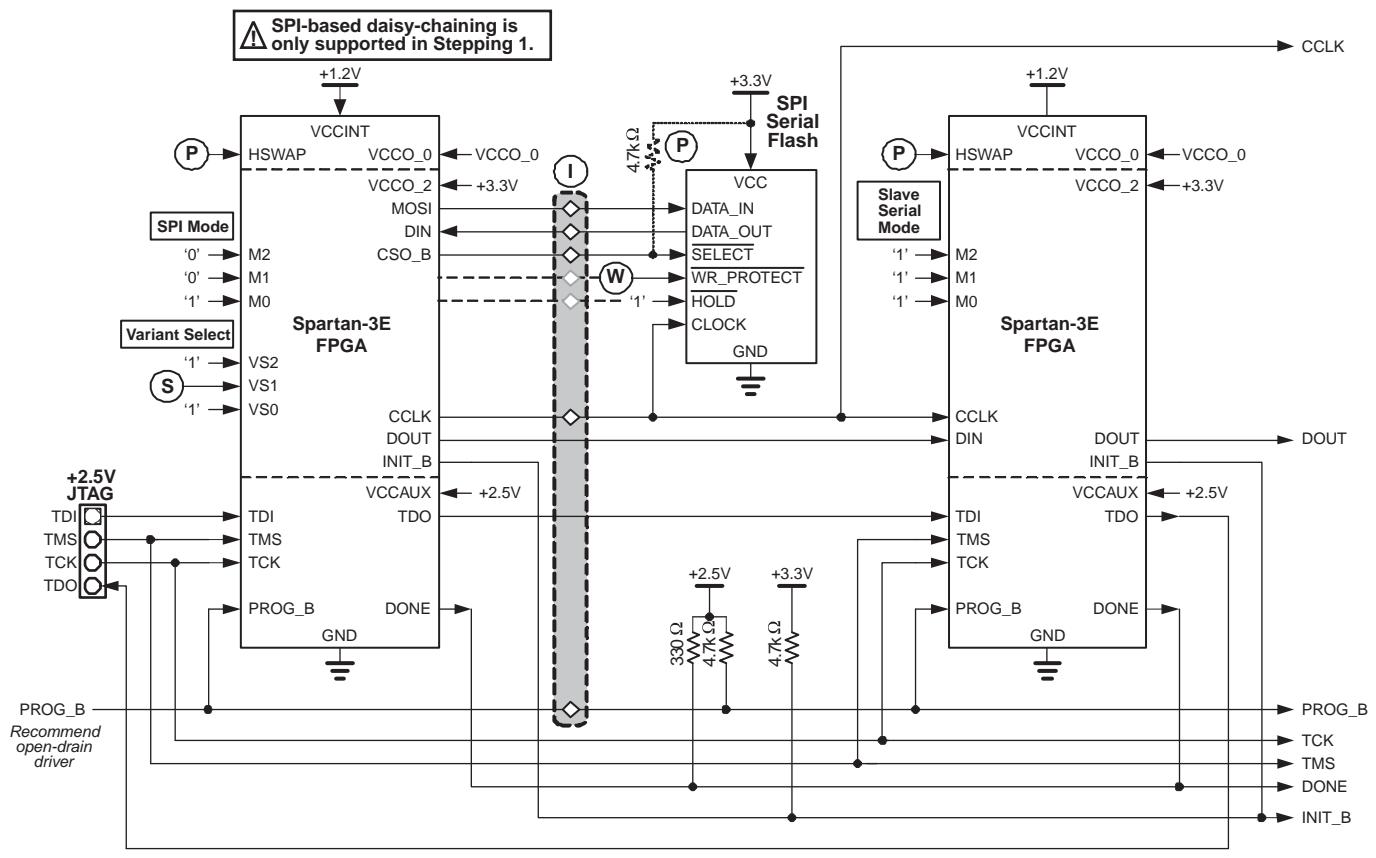


Figure 57: Daisy-Chaining from SPI Flash Mode (Stepping 1)

## Programming Support

For successful daisy-chaining, the **DONE\_cycle** configuration option must be set to cycle 5 or sooner. The default cycle is 4. See [Table 69](#) and the [Start-Up](#) section for additional information.

**I** In production applications, the SPI Flash PROM is usually pre-programmed before it is mounted on the printed circuit board. The [Xilinx ISE development software](#) produces industry-standard programming files that can be used with third-party gang programmers. Consult your specific SPI Flash vendor for recommended production programming solutions.

In-system programming support is available from some third-party PROM programmers using a socket adapter with attached wires. To gain access to the SPI Flash signals, drive the FPGA's PROG\_B input Low with an open-drain driver. This action places all FPGA I/O pins, including those attached to the SPI Flash, in high-impedance (Hi-Z). If the HSWAP input is Low, the I/Os have pull-up resistors to the Vcc0 input on their respective I/O bank. The external programming hardware then has direct access to the SPI Flash pins. The programming access points are highlighted in the gray box in [Figure 53](#), [Figure 54](#), and [Figure 57](#).

Beginning with the Xilinx ISE 8.2i software release, the iMPACT programming utility provides direct, in-system prototype programming support for STMicro M25P-series

SPI serial Flash PROMs and the Atmel AT45DB-series Data Flash PROMs using the [Platform Cable USB](#), [Xilinx Parallel IV](#), or other compatible programming cable.

## Byte-Wide Peripheral Interface (BPI) Parallel Flash Mode

For additional information, refer to the “Master BPI Mode” chapter in [UG332](#).

In Byte-wide Peripheral Interface (BPI) mode ( $M[2:0] = <0:1:0>$  or  $<0:1:1>$ ), a Spartan-3E FPGA configures itself from an industry-standard parallel NOR Flash PROM, as illustrated in [Figure 58](#). The FPGA generates up to 24-bit address lines to access an attached parallel Flash. Only 20 address lines are generated for Spartan-3E FPGAs in the TQ144 package. Similarly, the XC3S100E FPGA in the CP132 package only has 20 address lines while the XC3S250E and XC3S500E FPGAs in the same package have 24 address lines. When using the VQ100 package, the BPI mode is not available when using parallel NOR Flash, but is supported using parallel Platform Flash (XCFxxP).

The BPI configuration interface is primarily designed for standard parallel NOR Flash PROMs and supports both byte-wide (x8) and byte-wide/halfword (x8/x16) PROMs. The interface functions with halfword-only (x16) PROMs, but the upper byte in a portion of the PROM remains unused. For configuration, the BPI interface does not require any specific Flash PROM features, such as boot block or a specific sector size.

The BPI interface also functions with Xilinx parallel Platform Flash PROMs (XCFxxP), although the FPGA’s address lines are left unconnected.

The BPI interface also works equally well with other asynchronous memories that use a similar SRAM-style interface such as SRAM, NVRAM, EEPROM, EPROM, or masked ROM.

NAND Flash memory is commonly used in memory cards for digital cameras. Spartan-3E FPGAs do not configure directly from NAND Flash memories.

The FPGA’s internal oscillator controls the interface timing and the FPGA supplies the clock on the CCLK output pin. However, the CCLK signal is not used in single FPGA applications. Similarly, the FPGA drives three pins Low during configuration (LDC[2:0]) and one pin High during configuration (HDC) to the PROM’s control inputs.

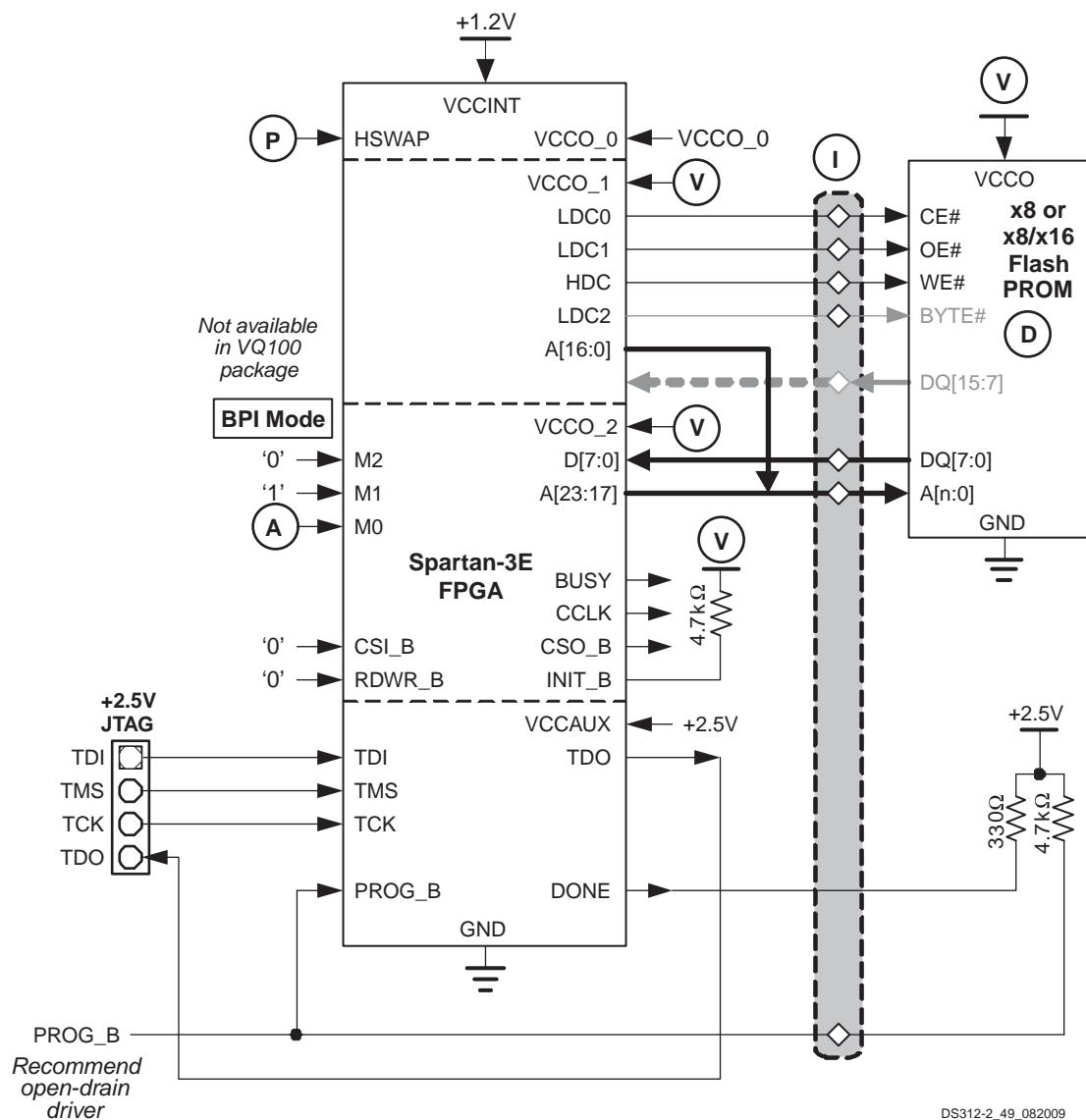


Figure 58: Byte-wide Peripheral Interface (BPI) Mode Configured from Parallel NOR Flash PROMs

(A) During configuration, the value of the M0 mode pin determines how the FPGA generates addresses, as shown in Table 58. When M0 = 0, the FPGA generates addresses starting at 0 and increments the address on every falling CCLK edge. Conversely, when M0 = 1, the FPGA generates addresses starting at 0xFF\_FFFF (all ones) and decrements the address on every falling CCLK edge.

Table 58: BPI Addressing Control

| M2 | M1 | M0 | Start Address | Addressing   |
|----|----|----|---------------|--------------|
| 0  | 1  | 0  | 0             | Incrementing |
|    |    | 1  | 0xFF_FFFF     | Decrementing |

This addressing flexibility allows the FPGA to share the parallel Flash PROM with an external or embedded processor. Depending on the specific processor architecture, the processor boots either from the top or bottom of memory. The FPGA is flexible and boots from the opposite end of memory from the processor. Only the processor or the FPGA can boot at any given time. The FPGA can configure first, holding the processor in reset or the processor can boot first, asserting the FPGA's PROG\_B pin.

The mode select pins, M[2:0], are sampled when the FPGA's INIT\_B output goes High and must be at defined logic levels during this time. After configuration, when the FPGA's DONE output goes High, the mode pins are available as full-featured user-I/O pins.

(P) Similarly, the FPGA's HSWAP pin must be Low to enable pull-up resistors on all user-I/O pins or High to disable the pull-up resistors. The HSWAP control must remain at a constant logic level throughout FPGA configuration. After configuration, when the FPGA's DONE output goes High, the HSWAP pin is available as

full-featured user-I/O pin and is powered by the VCCO\_0 supply.

The RDWR\_B and CSI\_B must be Low throughout the configuration process. After configuration, these pins also become user I/O.

In a single-FPGA application, the FPGA's CSO\_B and CCLK pins are not used but are actively driving during the configuration process. The BUSY pin is not used but also actively drives during configuration and is available as a user I/O after configuration.

After configuration, all of the interface pins except DONE and PROG\_B are available as user I/Os. Furthermore, the bidirectional SelectMAP configuration peripheral interface (see [Slave Parallel Mode](#)) is available after configuration. To continue using SelectMAP mode, set the **Persist** bitstream generator option to **Yes**. An external host can then read and verify configuration data.

The Persist option will maintain A20-A23 as configuration pins although they are not used in SelectMAP mode.

Table 59: Byte-Wide Peripheral Interface (BPI) Connections

| Pin Name      | FPGA Direction | Description  | During Configuration  | After Configuration   |
|---------------|----------------|--|---|---|
| HSWAP<br>(P)  | Input          | <b>User I/O Pull-Up Control.</b> When Low during configuration, enables pull-up resistors in all I/O pins to respective I/O bank V <sub>CCO</sub> input.<br>0: Pull-ups during configuration<br>1: No pull-ups | Drive at valid logic level throughout configuration.  | User I/O  |
| M[2:0]<br>(A) | Input          | <b>Mode Select.</b> Selects the FPGA configuration mode. See <a href="#">Design Considerations for the HSWAP, M[2:0], and VS[2:0] Pins</a> .   | M2 = 0, M1 = 1. Set M0 = 0 to start at address 0, increment addresses. Set M0 = 1 to start at address 0xFFFFFFF and decrement addresses. Sampled when INIT_B goes High. | User I/O  |
| CSI_B         | Input          | <b>Chip Select Input.</b> Active Low.  | Must be Low throughout configuration.   | User I/O. If bitstream option <b>Persist=Yes</b> , becomes part of SelectMap parallel peripheral interface.   |
| RDWR_B        | Input          | <b>Read/Write Control.</b> Active Low write enable. Read functionality typically only used after configuration, if bitstream option <b>Persist=Yes</b> .   | Must be Low throughout configuration.   | User I/O. If bitstream option <b>Persist=Yes</b> , becomes part of SelectMap parallel peripheral interface.   |
| LDC0          | Output         | PROM Chip Enable   | Connect to PROM chip-select input (CE#). FPGA drives this signal Low throughout configuration.  | User I/O. If the FPGA does not access the PROM after configuration, drive this pin High to deselect the PROM. A[23:0], D[7:0], LDC[2:1], and HDC then become available as user I/O. |
| LDC1          | Output         | PROM Output Enable   | Connect to the PROM output-enable input (OE#). The FPGA drives this signal Low throughout configuration.  | User I/O  |

Table 59: Byte-Wide Peripheral Interface (BPI) Connections (Cont'd)

| Pin Name  | FPGA Direction               | Description  | During Configuration  | After Configuration   |
|---|------------------------------|--|---|---|
| HDC   | Output                       | PROM Write Enable  | Connect to PROM write-enable input (WE#). FPGA drives this signal High throughout configuration.  | User I/O  |
| LDC2<br> | Output                       | PROM Byte Mode   | This signal is not used for x8 PROMs. For PROMs with a x8/x16 data width control, connect to PROM byte-mode input (BYTE#). See <a href="#">Precautions Using x8/x16 Flash PROMs</a> . FPGA drives this signal Low throughout configuration.   | User I/O. Drive this pin High after configuration to use a x8/x16 PROM in x16 mode.                         |
| A[23:0]   | Output                       | Address  | Connect to PROM address inputs. High-order address lines may not be available in all packages and not all may be required. Number of address lines required depends on the size of the attached Flash PROM. FPGA address generation controlled by M0 mode pin. Addresses presented on falling CCLK edge.<br>Only 20 address lines are available in TQ144 package. | User I/O  |
| D[7:0]  | Input                        | Data Input   | FPGA receives byte-wide data on these pins in response the address presented on A[23:0]. Data captured by FPGA on rising edge of CCLK.  | User I/O. If bitstream option <b>Persist=Yes</b> , becomes part of SelectMap parallel peripheral interface. |
| CSO_B   | Output                       | <b>Chip Select Output.</b> Active Low.   | Not used in single FPGA applications. In a daisy-chain configuration, this pin connects to the CSI_B pin of the next FPGA in the chain. If HSWAP = 1 in a multi-FPGA daisy-chain application, connect this signal to a 4.7 kΩ pull-up resistor to VCCO_2. Actively drives Low when selecting a downstream device in the chain.                                    | User I/O  |
| BUSY  | Output                       | <b>Busy Indicator.</b> Typically only used after configuration, if bitstream option <b>Persist=Yes</b> .   | Not used during configuration but actively drives.  | User I/O. If bitstream option <b>Persist=Yes</b> , becomes part of SelectMap parallel peripheral interface. |
| CCLK  | Output                       | <b>Configuration Clock.</b> Generated by FPGA internal oscillator. Frequency controlled by <b>ConfigRate</b> bitstream generator option. If CCLK PCB trace is long or has multiple connections, terminate this output to maintain signal integrity. See <a href="#">CCLK Design Considerations</a> .               | Not used in single FPGA applications but actively drives. In a daisy-chain configuration, drives the CCLK inputs of all other FPGAs in the daisy-chain.   | User I/O. If bitstream option <b>Persist=Yes</b> , becomes part of SelectMap parallel peripheral interface. |
| INIT_B  | Open-drain bidirectional I/O | <b>Initialization Indicator.</b> Active Low. Goes Low at start of configuration during the Initialization memory clearing process. Released at the end of memory clearing, when the mode select pins are sampled. In daisy-chain applications, this signal requires an external 4.7 kΩ pull-up resistor to VCCO_2. | Active during configuration. If CRC error detected during configuration, FPGA drives INIT_B Low.  | User I/O. If unused in the application, drive INIT_B High.  |

Table 59: Byte-Wide Peripheral Interface (BPI) Connections (Cont'd)

| Pin Name | FPGA Direction               | Description  | During Configuration                               | After Configuration  |
|----------|------------------------------|--|--|--|
| DONE     | Open-drain bidirectional I/O | <b>FPGA Configuration Done.</b> Low during configuration. Goes High when FPGA successfully completes configuration. Requires external $330\ \Omega$ pull-up resistor to 2.5V.  | Low indicates that the FPGA is not yet configured. | Pulled High via external pull-up. When High, indicates that the FPGA is successfully configured.   |
| PROG_B   | Input                        | <b>Program FPGA.</b> Active Low. When asserted Low for 500 ns or longer, forces the FPGA to restart its configuration process by clearing configuration memory and resetting the DONE and INIT_B pins once PROG_B returns High. Recommend external $4.7\ k\Omega$ pull-up resistor to 2.5V. Internal pull-up value may be weaker (see Table 78). If driving externally with a 3.3V output, use an open-drain or open-collector driver or use a current limiting series resistor. | Must be High to allow configuration to start.      | Drive PROG_B Low and release to reprogram FPGA. Hold PROG_B to force FPGA I/O pins into Hi-Z, allowing direct programming access to Flash PROM pins. |

## Voltage Compatibility

**(V)** The FPGA's parallel Flash interface signals are within I/O Banks 1 and 2. The majority of parallel Flash PROMs use a single 3.3V supply voltage. Consequently, in most cases, the FPGA's VCCO\_1 and VCCO\_2 supply voltages must also be 3.3V to match the parallel Flash PROM. There are some 1.8V parallel Flash PROMs available and the FPGA interfaces with these devices if the VCCO\_1 and VCCO\_2 supplies are also 1.8V.

## Power-On Precautions if PROM Supply is Last in Sequence

Like SPI Flash PROMs, parallel Flash PROMs typically require some amount of internal initialization time when the supply voltage reaches its minimum value.

The PROM supply voltage also connects to the FPGA's VCCO\_2 supply input. In many systems, the PROM supply feeding the FPGA's VCCO\_2 input is valid before the FPGA's other  $V_{CCINT}$  and  $V_{CCAUX}$  supplies, and consequently, there is no issue. However, if the PROM supply is last in the sequence, a potential race occurs between the FPGA and the parallel Flash PROM. See

[Power-On Precautions if 3.3V Supply is Last in Sequence](#) for a similar description of the issue for SPI Flash PROMs.

## Supported Parallel NOR Flash PROM Densities

[Table 60](#) indicates the smallest usable parallel Flash PROM to program a single Spartan-3E FPGA. Parallel Flash density is specified in bits but addressed as bytes. The FPGA presents up to 24 address lines during configuration but not all are required for single FPGA applications.

[Table 60](#) shows the minimum required number of address lines between the FPGA and parallel Flash PROM. The actual number of address line required depends on the density of the attached parallel Flash PROM.

A multiple-FPGA daisy-chained application requires a parallel Flash PROM large enough to contain the sum of the FPGA file sizes. An application can also use a larger-density parallel Flash PROM to hold additional data beyond just FPGA configuration data. For example, the parallel Flash PROM can also contain the application code for a MicroBlaze RISC processor core implemented within the Spartan-3E FPGA. After configuration, the MicroBlaze processor can execute directly from external Flash or can copy the code to other, faster system memory before executing the code.

Table 60: Number of Bits to Program a Spartan-3E FPGA and Smallest Parallel Flash PROM

| Spartan-3E FPGA | Uncompressed File Sizes (bits) | Smallest Usable Parallel Flash PROM | Minimum Required Address Lines |
|-----------------|--------------------------------|-------------------------------------|--------------------------------|
| XC3S100E        | 581,344                        | 1 Mbit                              | A[16:0]                        |
| XC3S250E        | 1,353,728                      | 2 Mbit                              | A[17:0]                        |
| XC3S500E        | 2,270,208                      | 4 Mbit                              | A[18:0]                        |
| XC3S1200E       | 3,841,184                      | 4 Mbit                              | A[18:0]                        |
| XC3S1600E       | 5,969,696                      | 8 Mbit                              | A[19:0]                        |

## Compatible Flash Families

The Spartan-3E BPI configuration interface operates with a wide variety of x8 or x8/x16 parallel NOR Flash devices. Table 61 provides a few Flash memory families that operate with the Spartan-3E BPI interface. Consult the data sheet for the desired parallel NOR Flash to determine its suitability. The basic timing requirements and waveforms are provided in [Byte Peripheral Interface \(BPI\) Configuration Timing](#) (Module 3).

Table 61: Compatible Parallel NOR Flash Families

| Flash Vendor             | Flash Memory Family         |
|--------------------------|-----------------------------|
| <a href="#">Numonyx</a>  | M29W, J3D StrataFlash       |
| <a href="#">Atmel</a>    | <a href="#">AT29 / AT49</a> |
| <a href="#">Spansion</a> | S29                         |
| <a href="#">Macronix</a> | MX29                        |

## CCLK Frequency

In BPI mode, the FPGA's internal oscillator generates the configuration clock frequency that controls all the interface timing. The FPGA starts configuration at its lowest frequency and increases its frequency for the remainder of the configuration process if so specified in the configuration bitstream. The maximum frequency is specified using the **ConfigRate** bitstream generator option.

Table 62: Maximum ConfigRate Settings for Parallel Flash PROMs (Commercial Temperature Range)

| Flash Read Access Time | Maximum ConfigRate Setting |
|------------------------|----------------------------|
| 250 ns                 | 3                          |
| 115 ns                 | 6                          |
| 45 ns                  | 12                         |

Table 62 shows the maximum **ConfigRate** settings for various typical PROM read access times over the Commercial temperature operating range. See [Byte Peripheral Interface \(BPI\) Configuration Timing](#) (Module 3) and [UG332](#) for more detailed information. Despite using slower **ConfigRate** settings, BPI mode is equally fast as the other configuration modes. In BPI mode, data is accessed at the **ConfigRate** frequency and internally serialized with an 8X clock frequency.

## Using the BPI Interface after Configuration

After the FPGA successfully completes configuration, all pins connected to the parallel Flash PROM are available as user I/Os.

If not using the parallel Flash PROM after configuration, drive LDC0 High to disable the PROM's chip-select input. The remainder of the BPI pins then become available to the FPGA application, including all 24 address lines, the eight data lines, and the LDC2, LDC1, and HDC control pins.

Because all the interface pins are user I/Os after configuration, the FPGA application can continue to use the interface pins to communicate with the parallel Flash PROM. Parallel Flash PROMs are available in densities ranging from 1 Mbit up to 128 Mbits and beyond. However, a single Spartan-3E FPGA requires less than 6 Mbits for configuration. If desired, use a larger parallel Flash PROM to contain additional non-volatile application data, such as MicroBlaze processor code, or other user data, such as serial numbers and Ethernet MAC IDs. In such an example, the FPGA configures from parallel Flash PROM. Then using FPGA logic after configuration, a MicroBlaze processor embedded within the FPGA can either execute code directly from parallel Flash PROM or copy the code to external DDR SDRAM and execute from DDR SDRAM. Similarly, the FPGA application can store non-volatile application data within the parallel Flash PROM.

The FPGA configuration data is stored starting at either at location 0 or the top of memory (addresses all ones) or at both locations for MultiBoot mode. Store any additional data beginning in other available parallel Flash PROM sectors. Do not mix configuration data and user data in the same sector.

Similarly, the parallel Flash PROM interface can be expanded to additional parallel peripherals.

The address, data, and LDC1 (OE#) and HDC (WE#) control signals are common to all parallel peripherals. Connect the chip-select input on each additional peripheral to one of the FPGA user I/O pins. If HSWAP = 0 during configuration, the FPGA holds the chip-select line High via an internal pull-up resistor. If HSWAP = 1, connect the select line to +3.3V via an external 4.7 kΩ pull-up resistor to avoid spurious read or write operations. After configuration, drive the select line Low to select the desired peripheral. Refer to the individual peripheral data sheet for specific interface and communication protocol requirements.

The FPGA optionally supports a 16-bit peripheral interface by driving the LDC2 (BYTE#) control pin High after configuration. See [Precautions Using x8/x16 Flash PROMs](#) for additional information.

The FPGA provides up to 24 address lines during configuration, addressing up to 128 Mbits (16 Mbytes). If using a larger parallel PROM, connect the upper address lines to FPGA user I/O. During configuration, the upper address lines will be pulled High if HSWAP = 0. Otherwise, use external pull-up or pull-down resistors on these address lines to define their values during configuration.

## Precautions Using x8/x16 Flash PROMs

**D** Most low- to mid-density PROMs are byte-wide (x8) only. Many higher-density Flash PROMs support both byte-wide (x8) and halfword-wide (x16) data paths and include a mode input called BYTE# that switches between x8 or x16. During configuration, Spartan-3E FPGAs only

support byte-wide data. However, after configuration, the FPGA supports either x8 or x16 modes. In x16 mode, up to eight additional user I/O pins are required for the upper data bits, D[15:8].

Connecting a Spartan-3E FPGA to a x8/x16 Flash PROM is simple, but does require a precaution. Various Flash PROM vendors use slightly different interfaces to support both x8 and x16 modes. Some vendors (Intel, Micron, some STMicroelectronics devices) use a straightforward interface with pin naming that matches the FPGA connections. However, the PROM's A0 pin is wasted in x16 applications and a separate FPGA user-I/O pin is required for the D15 data line. Fortunately, the FPGA A0 pin is still available as a user I/O after configuration, even though it connects to the Flash PROM.

Table 63: FPGA Connections to Flash PROM with IO15/A-1 Pin

| FPGA Pin | Connection to Flash PROM with IO15/A-1 Pin  | x8 Flash PROM Interface After FPGA Configuration                    | x16 Flash PROM Interface After FPGA Configuration |
|----------|---|---|---|
| LDC2     | BYTE#   | Drive LDC2 Low or leave unconnected and tie PROM BYTE# input to GND | Drive LCD2 High                                   |
| LDC1     | OE#   | Active-Low Flash PROM output-enable control                         | Active-Low Flash PROM output-enable control       |
| LDC0     | CS#   | Active-Low Flash PROM chip-select control                           | Active-Low Flash PROM chip-select control         |
| HDC      | WE#   | Flash PROM write-enable control                                     | Flash PROM write-enable control                   |
| A[23:1]  | A[n:0]  | A[n:0]  | A[n:0]  |
| A0       | IO15/A-1  | IO15/A-1 is the least-significant address input                     | IO15/A-1 is the most-significant data line, IO15  |
| D[7:0]   | IO[7:0]   | IO[7:0]   | IO[7:0]   |
| User I/O | Upper data lines IO[14:8] not required unless used as x16 Flash interface after configuration | Upper data lines IO[14:8] not required                              | IO[14:8]  |

Some x8/x16 Flash PROMs have a long setup time requirement on the BYTE# signal. For the FPGA to configure correctly, the PROM must be in x8 mode with BYTE# = 0 at power-on or when the FPGA's PROG\_B pin is pulsed Low. If required, extend the BYTE# setup time for a 3.3V PROM using an external  $680\ \Omega$  pull-down resistor on the FPGA's LDC2 pin or by delaying assertion of the CSI\_B select input to the FPGA.

### Daisy-Chaining

If the application requires multiple FPGAs with different configurations, then configure the FPGAs using a daisy chain, as shown in Figure 59. Use BPI mode ( $M[2:0] = <0:1:0>$  or  $<0:1:1>$ ) for the FPGA connected to the parallel NOR Flash PROM and Slave Parallel mode ( $M[2:0] = <1:1:0>$ ) for all downstream FPGAs in the daisy-chain. If there are more than two FPGAs in the chain, then last FPGA in the chain can be from any Xilinx FPGA family. However, all intermediate FPGAs located in the

Other vendors (AMD, Atmel, Silicon Storage Technology, some STMicroelectronics devices) use a pin-efficient interface but change the function of one pin, called IO15/A-1, depending if the PROM is in x8 or x16 mode. In x8 mode, BYTE# = 0, this pin is the least-significant address line. The A0 address line selects the halfword location. The A-1 address line selects the byte location. When in x16 mode, BYTE# = 1, the IO15/A-1 pin becomes the most-significant data bit, D15 because byte addressing is not required in this mode. Check to see if the Flash PROM has a pin named "IO15/A-1" or "DQ15/A-1". If so, be careful to connect x8/x16 Flash PROMs correctly, as shown in Table 63. Also, remember that the D[14:8] data connections require FPGA user I/O pins but that the D15 data is already connected for the FPGA's A0 pin.

chain between the first and last FPGAs must from either the Spartan-3E or Virtex®-5 FPGA families.

After the master FPGA—the FPGA on the left in the diagram—finishes loading its configuration data from the parallel Flash PROM, the master device continues generating addresses to the Flash PROM and asserts its CSO\_B output Low, enabling the next FPGA in the daisy-chain. The next FPGA then receives parallel configuration data from the Flash PROM. The master FPGA's CCLK output synchronizes data capture.

If HSWAP = 1, an external  $4.7\text{k}\Omega$  pull-up resistor must be added on the CSO\_B pin. If HSWAP = 0, no external pull-up is necessary.

### Design Note

BPI mode daisy chain software support is available starting in ISE 8.2i.

<http://www.xilinx.com/support/answers/23061.htm>

Also, in a multi-FPGA daisy-chain configuration of more than two devices, all intermediate FPGAs between the first and last devices must be Spartan-3E or Virtex-5 FPGAs. The last FPGA in the chain can be from any Xilinx FPGA family.

### BPI Mode Interaction with Right and Bottom Edge Global Clock Inputs

Some of the BPI mode configuration pins are shared with global clock inputs along the right and bottom edges of the device (Bank 1 and Bank 2, respectively). These pins are not easily reclaimable for clock inputs after configuration, especially if the FPGA application access the parallel NOR Flash after configuration. **Table 64** summarizes the shared pins.

**Table 64: Shared BPI Configuration Mode and Global Buffer Input Pins**

| Device Edge | Global Buffer Input Pin | BPI Mode Configuration Pin |
|-------------|-------------------------|----------------------------|
| Bottom      | GCLK0                   | RDWR_B                     |
|             | GCLK2                   | D2                         |
|             | GCLK3                   | D1                         |
|             | GCLK12                  | D7                         |
|             | GCLK13                  | D6                         |
|             | GCLK14                  | D4                         |
|             | GCLK15                  | D3                         |
| Right       | RHCLK0                  | A10                        |
|             | RHCLK1                  | A9                         |
|             | RHCLK2                  | A8                         |
|             | RHCLK3                  | A7                         |
|             | RHCLK4                  | A6                         |
|             | RHCLK5                  | A5                         |
|             | RHCLK6                  | A4                         |
|             | RHCLK7                  | A3                         |

## Stepping 0 Limitations when Reprogramming via JTAG if FPGA Set for BPI Configuration

The FPGA can always be reprogrammed via the JTAG port, regardless of the mode pin (M[2:0]) settings. However, Stepping 0 devices have a minor limitation. If a Stepping 0 FPGA is set to configure in BPI mode and the FPGA is attached to a parallel memory containing a valid FPGA

configuration file, then subsequent reconfigurations using the JTAG port will fail. Potential workarounds include setting the mode pins for JTAG configuration (M[2:0] = <1:0:1>) or offsetting the initial memory location in Flash by 0x2000.

Stepping 1 devices fully support JTAG configuration even when the FPGA mode pins are set for BPI mode.

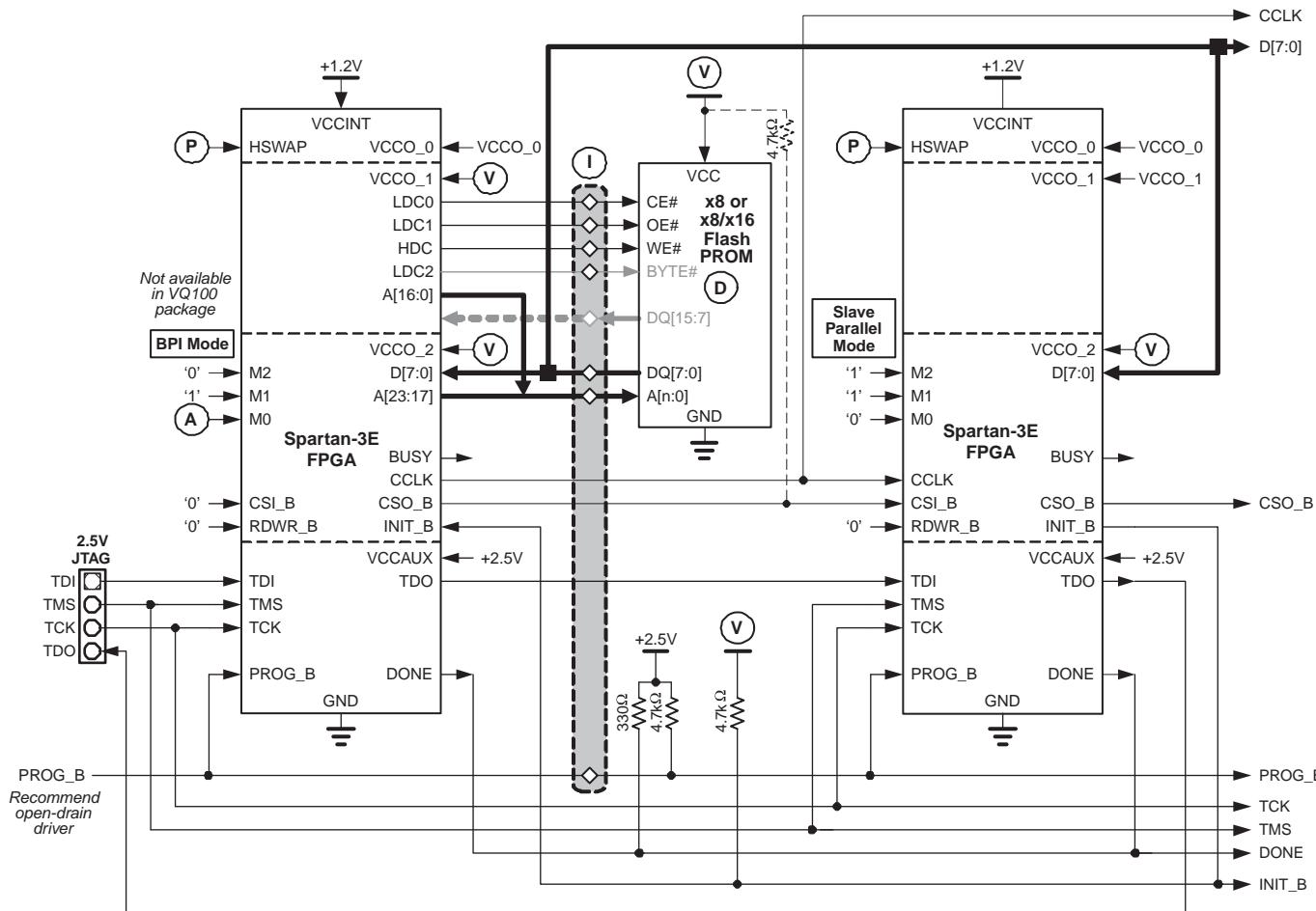


Figure 59: Daisy-Chaining from BPI Flash Mode

## In-System Programming Support

① In a production application, the parallel Flash PROM is usually preprogrammed before it is mounted on the printed circuit board. In-system programming support is available from third-party boundary-scan tool vendors and from some third-party PROM programmers using a socket adapter with attached wires. To gain access to the parallel Flash signals, drive the FPGA's PROG\_B input Low with an open-drain driver. This action places all FPGA I/O pins, including those attached to the parallel Flash, in high-impedance (Hi-Z). If the HSWAP input is Low, the I/Os have pull-up resistors to the V<sub>CCO</sub> input on their respective I/O bank. The external programming hardware then has direct access to the

parallel Flash pins. The programming access points are highlighted in the gray boxes in [Figure 58](#) and [Figure 59](#).

The FPGA itself can also be used as a parallel Flash PROM programmer during development and test phases. Initially, an FPGA-based programmer is downloaded into the FPGA via JTAG. Then the FPGA performs the Flash PROM programming algorithms and receives programming data from the host via the FPGA's JTAG interface. See the [Embedded System Tools Reference Manual](#).

## Dynamically Loading Multiple Configuration Images Using MultiBoot Option

For additional information, refer to the "Reconfiguration and MultiBoot" chapter in [UG332](#).

After the FPGA configures itself using BPI mode from one end of the parallel Flash PROM, then the FPGA can trigger a MultiBoot event and reconfigure itself from the opposite end of the parallel Flash PROM. MultiBoot is only available when using BPI mode and only for applications with a single Spartan-3E FPGA.

By default, MultiBoot mode is disabled. To trigger a MultiBoot event, assert a Low pulse lasting at least 300 ns on the MultiBoot Trigger (MBT) input to the STARTUP\_SPARTAN3E library primitive. When the MBT signal returns High after the 300 ns or longer pulse, the FPGA automatically reconfigures from the opposite end of the parallel Flash memory.

**Figure 60** shows an example usage. At power up, the FPGA loads itself from the attached parallel Flash PROM. In this example, the M0 mode pin is Low so the FPGA starts at address 0 and increments through the Flash PROM memory locations. After the FPGA completes configuration, the application initially loaded into the FPGA performs a board-level or system test using FPGA logic. If the test is successful, the FPGA then triggers a MultiBoot event, causing the FPGA to reconfigure from the opposite end of the Flash PROM memory. This second configuration contains the FPGA application for normal operation.

Similarly, the general FPGA application could trigger another MultiBoot event at any time to reload the diagnostics design, and so on.

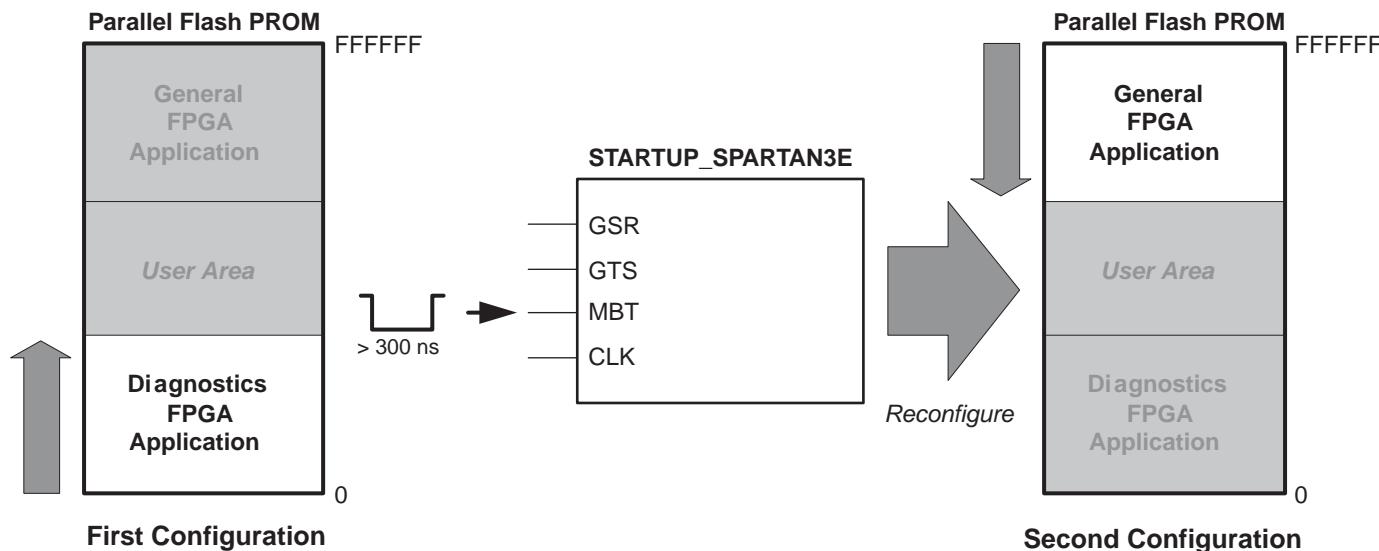


Figure 60: Use MultiBoot to Load Alternate Configuration Images

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In another potential application, the initial design loaded into the FPGA image contains a “golden” or “fail-safe” configuration image, which then communicates with the outside world and checks for a newer image. If there is a new configuration revision and the new image verifies as good, the “golden” configuration triggers a MultiBoot event to load the new image.

When a MultiBoot event is triggered, the FPGA then again drives its configuration pins as described in [Table 59](#). However, the FPGA does not assert the PROG\_B pin. The system design must ensure that no other device drives on these same pins during the reconfiguration process. The FPGA’s DONE, LDC[2:0], or HDC pins can temporarily disable any conflicting drivers during reconfiguration.

Asserting the PROG\_B pin Low overrides the MultiBoot feature and forces the FPGA to reconfigure starting from the end of memory defined by the mode pins, shown in [Table 58](#).

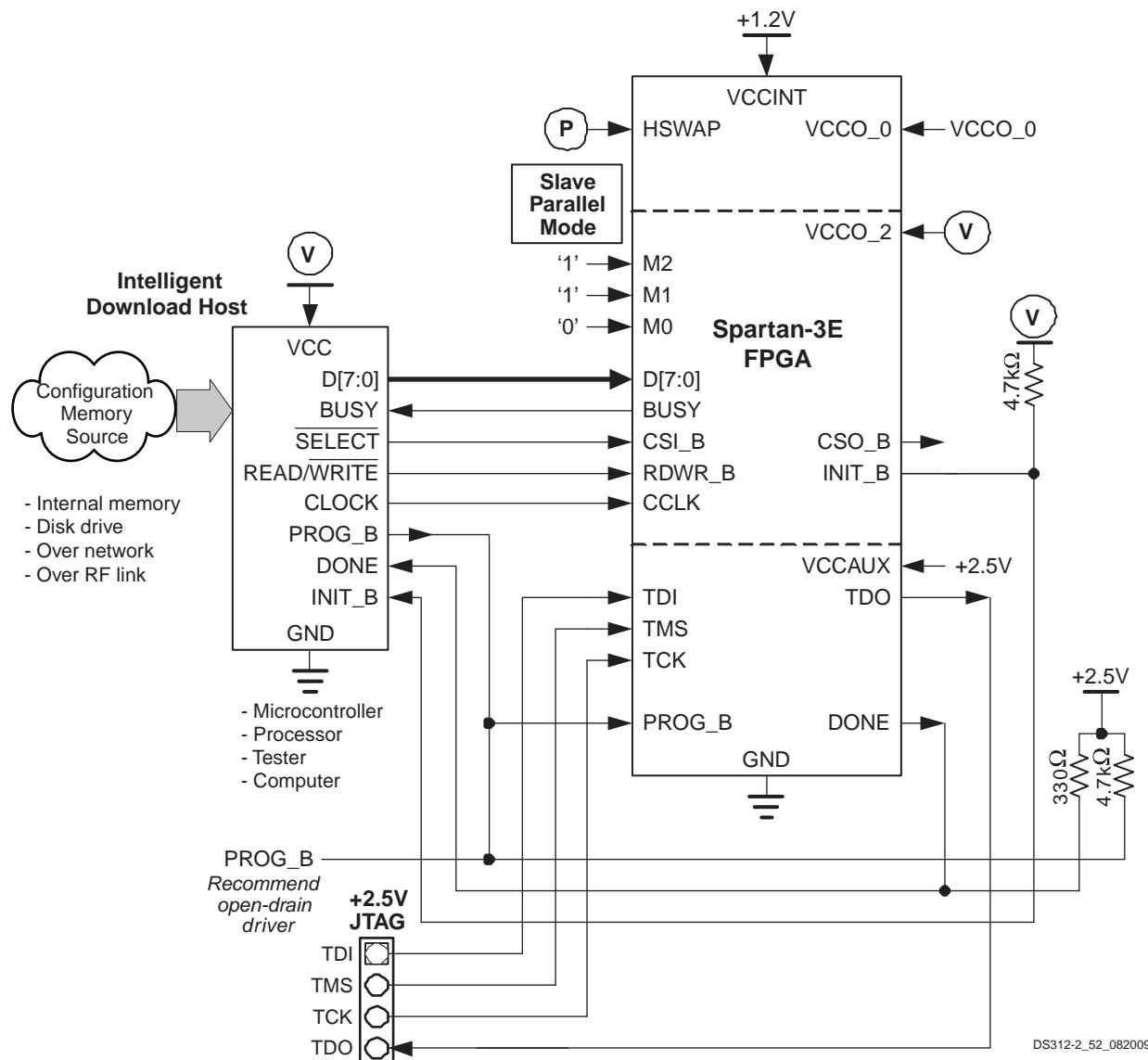


Figure 61: Slave Parallel Configuration Mode

## Slave Parallel Mode

For additional information, refer to the “Slave Parallel (SelectMAP) Mode” chapter in [UG332](#).

In Slave Parallel mode ( $M[2:0] = <1:1:0>$ ), an external host, such as a microprocessor or microcontroller, writes byte-wide configuration data into the FPGA, using a typical peripheral interface as shown in Figure 61.

The external download host starts the configuration process by pulsing PROG\_B and monitoring that the INIT\_B pin goes High, indicating that the FPGA is ready to receive its first data. The host asserts the active-Low chip-select signal (CSI\_B) and the active-Low Write signal (RDWR\_B). The host then continues supplying data and clock signals until either the FPGA’s DONE pin goes High, indicating a successful configuration, or until the FPGA’s INIT\_B pin goes Low, indicating a configuration error.

The FPGA captures data on the rising CCLK edge. If the CCLK frequency exceeds 50 MHz, then the host must also monitor the FPGA’s BUSY output. If the FPGA asserts BUSY High, the host must hold the data for an additional clock cycle, until BUSY returns Low. If the CCLK frequency is 50 MHz or below, the BUSY pin may be ignored but actively drives during configuration.

The configuration process requires more clock cycles than indicated from the configuration file size. Additional clocks are required during the FPGA’s start-up sequence, especially if the FPGA is programmed to wait for selected Digital Clock Managers (DCMs) to lock to their respective clock inputs (see [Start-Up, page 106](#)).

If the Slave Parallel interface is only used to configure the FPGA, never to read data back, then the RDWR\_B signal

can also be eliminated from the interface. However, RDWR\_B must remain Low during configuration.

After configuration, all of the interface pins except DONE and PROG\_B are available as user I/Os. Alternatively, the bidirectional SelectMAP configuration interface is available after configuration. To continue using SelectMAP mode, set the **Persist** bitstream generator option to **Yes**. The external host can then read and verify configuration data.

The Persist option will maintain A20-A23 as configuration pins although they are not used in SelectMAP mode.

The Slave Parallel mode is also used with BPI mode to create multi-FPGA daisy-chains. The lead FPGA is set for BPI mode configuration; all the downstream daisy-chain FPGAs are set for Slave Parallel configuration, as highlighted in [Figure 59](#).

Table 65: Slave Parallel Mode Connections

| Pin Name | FPGA Direction | Description   | During Configuration   | After Configuration   |
|----------|----------------|---|--|---|
| HSWAP    | Input          | <b>User I/O Pull-Up Control.</b> When Low during configuration, enables pull-up resistors in all I/O pins to respective I/O bank $V_{CCO}$ input.<br>0: Pull-ups during configuration<br>1: No pull-ups | Drive at valid logic level throughout configuration.   | User I/O  |
| M[2:0]   | Input          | <b>Mode Select.</b> Selects the FPGA configuration mode. See <a href="#">Design Considerations for the HSWAP, M[2:0], and VS[2:0] Pins</a> .  | M2 = 1, M1 = 1, M0 = 0 Sampled when INIT_B goes High.  | User I/O  |
| D[7:0]   | Input          | <b>Data Input.</b>  | Byte-wide data provided by host. FPGA captures data on rising CCLK edge.   | User I/O. If bitstream option <b>Persist=Yes</b> , becomes part of SelectMap parallel peripheral interface. |
| BUSY     | Output         | <b>Busy Indicator.</b>  | If CCLK frequency is < 50 MHz, this pin may be ignored. When High, indicates that the FPGA is not ready to receive additional configuration data. Host must hold data an additional clock cycle. | User I/O. If bitstream option <b>Persist=Yes</b> , becomes part of SelectMap parallel peripheral interface. |
| CSI_B    | Input          | <b>Chip Select Input.</b> Active Low.   | Must be Low throughout configuration.  | User I/O. If bitstream option <b>Persist=Yes</b> , becomes part of SelectMap parallel peripheral interface. |
| RDWR_B   | Input          | <b>Read/Write Control.</b> Active Low write enable.   | Must be Low throughout configuration.  | User I/O. If bitstream option <b>Persist=Yes</b> , becomes part of SelectMap parallel peripheral interface. |
| CCLK     | Input          | <b>Configuration Clock.</b> If CCLK PCB trace is long or has multiple connections, terminate this output to maintain signal integrity. See <a href="#">CCLK Design Considerations</a> .                 | External clock.  | User I/O If bitstream option <b>Persist=Yes</b> , becomes part of SelectMap parallel peripheral interface.  |
| CSO_B    | Output         | <b>Chip Select Output.</b> Active Low.  | Not used in single FPGA applications. In a daisy-chain configuration, this pin connects to the CSI_B pin of the next FPGA in the chain. Actively drives.   | User I/O  |

Table 65: Slave Parallel Mode Connections (Cont'd)

| Pin Name | FPGA Direction               | Description  | During Configuration   | After Configuration   |
|----------|------------------------------|--|--|---|
| INIT_B   | Open-drain bidirectional I/O | <b>Initialization Indicator.</b> Active Low. Goes Low at the start of configuration during the Initialization memory clearing process. Released at the end of memory clearing, when mode select pins are sampled. In daisy-chain applications, this signal requires an external 4.7 kΩ pull-up resistor to VCCO_2.   | Active during configuration. If CRC error detected during configuration, FPGA drives INIT_B Low. | User I/O. If unused in the application, drive INIT_B High.                                    |
| DONE     | Open-drain bidirectional I/O | <b>FPGA Configuration Done.</b> Low during configuration. Goes High when FPGA successfully completes configuration. Requires external 330 Ω pull-up resistor to 2.5V.  | Low indicates that the FPGA is not yet configured.   | Pulled High via external pull-up. When High, indicates that the FPGA successfully configured. |
| PROG_B   | Input                        | <b>Program FPGA.</b> Active Low. When asserted Low for 500 ns or longer, forces the FPGA to restart its configuration process by clearing configuration memory and resetting the DONE and INIT_B pins once PROG_B returns High. Recommend external 4.7 kΩ pull-up resistor to 2.5V. Internal pull-up value may be weaker (see Table 78). If driving externally with a 3.3V output, use an open-drain or open-collector driver or use a current limiting series resistor. | Must be High to allow configuration to start.  | Drive PROG_B Low and release to reprogram FPGA.   |

## Voltage Compatibility

Most Slave Parallel interface signals are within the FPGA's I/O Bank 2, supplied by the VCCO\_2 supply input. The VCCO\_2 voltage can be 1.8V, 2.5V, or 3.3V to match the requirements of the external host, ideally 2.5V. Using 1.8V or 3.3V requires additional design considerations as the DONE and PROG\_B pins are powered by the FPGA's 2.5V V<sub>CCAUX</sub> supply. See [XAPP453: The 3.3V Configuration of Spartan-3 FPGAs](#) for additional information.

## Daisy-Chaining

If the application requires multiple FPGAs with different configurations, then configure the FPGAs using a daisy chain. Use Slave Parallel mode (M[2:0] = <1:1:0>) for all FPGAs in the daisy-chain. The schematic in [Figure 62](#) is optimized for FPGA downloading and does not support the SelectMAP read interface. The FPGA's RDWR\_B pin must be Low during configuration.

After the lead FPGA is filled with its configuration data, the lead FPGA enables the next FPGA in the daisy-chain by asserting its chip-select output, CSO\_B.

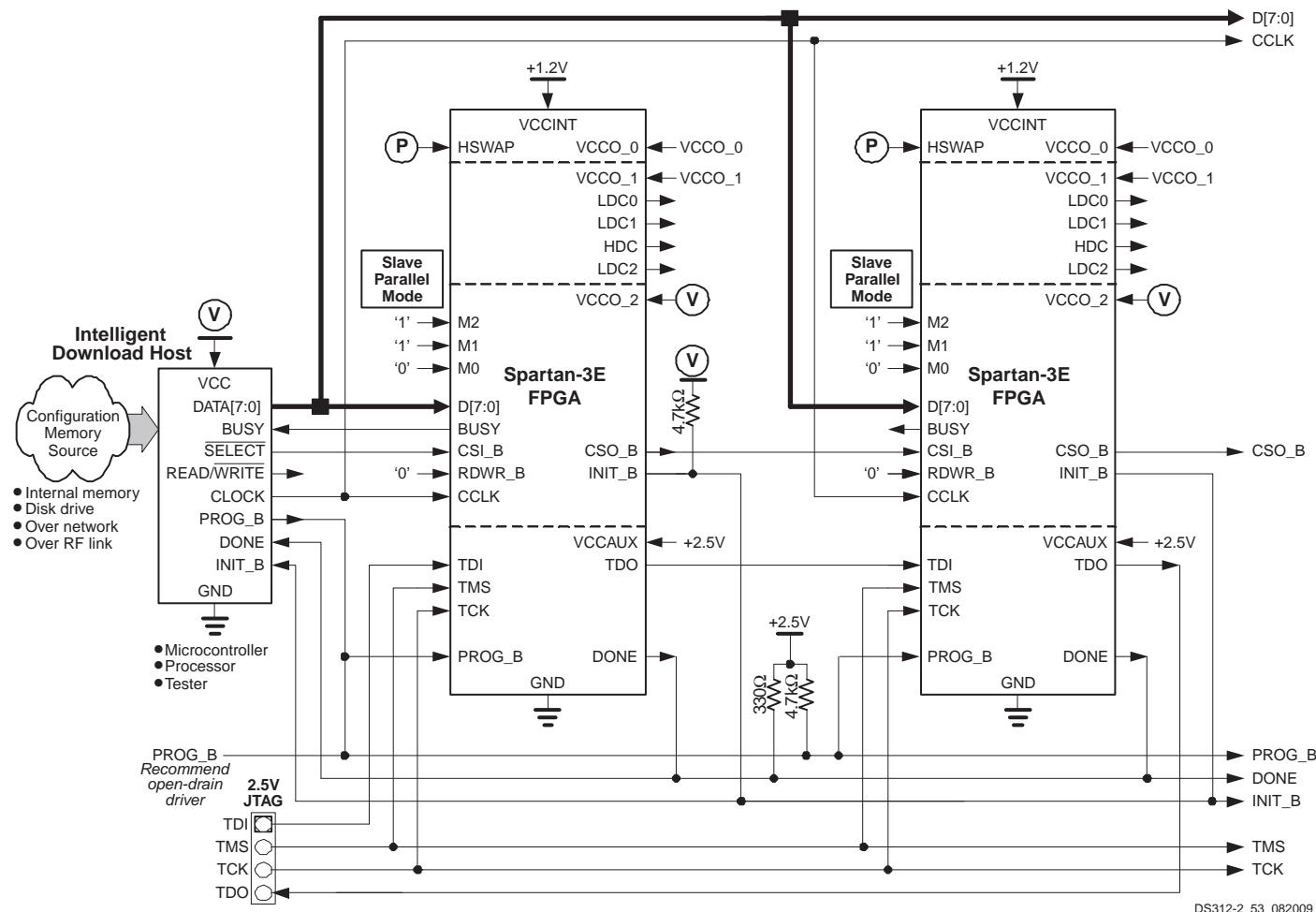


Figure 62: Daisy-Chaining using Slave Parallel Mode

## Slave Serial Mode

For additional information, refer to the “Slave Serial Mode” chapter in [UG332](#).

In Slave Serial mode ( $M[2:0] = <1:1:1>$ ), an external host such as a microprocessor or microcontroller writes serial configuration data into the FPGA, using the synchronous serial interface shown in [Figure 63](#). The serial configuration data is presented on the FPGA’s DIN input pin with sufficient setup time before each rising edge of the externally generated CCLK clock input.

The intelligent host starts the configuration process by pulsing PROG\_B and monitoring that the INIT\_B pin goes High, indicating that the FPGA is ready to receive its first data. The host then continues supplying data and clock signals until either the DONE pin goes High, indicating a successful configuration, or until the INIT\_B pin goes Low, indicating a configuration error. The configuration process requires more clock cycles than indicated from the configuration file size. Additional clocks are required during the FPGA’s start-up sequence, especially if the FPGA is programmed to wait for selected Digital Clock Managers (DCMs) to lock to their respective clock inputs (see [Start-Up, page 106](#)).

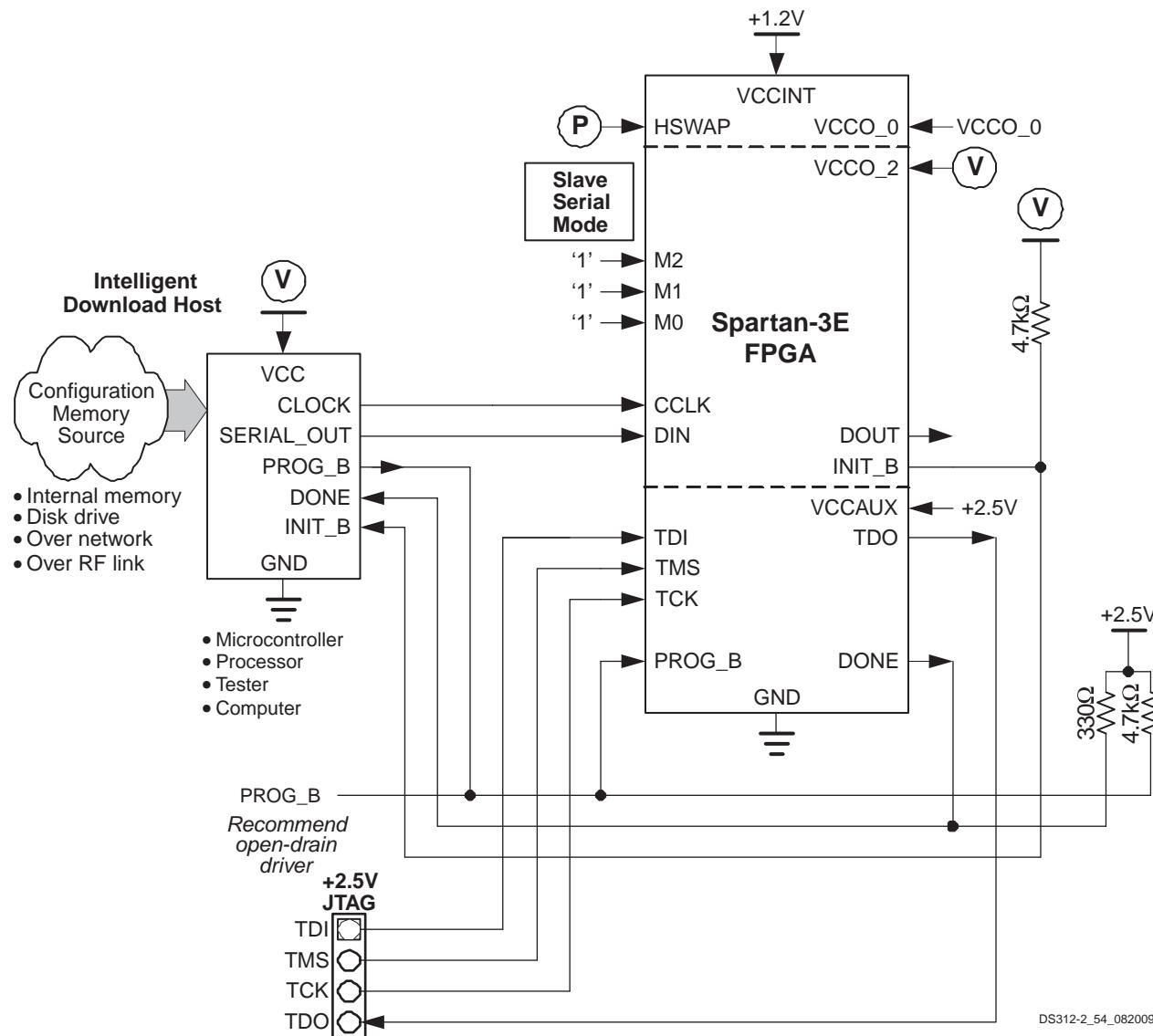


Figure 63: Slave Serial Configuration

The mode select pins, M[2:0], are sampled when the FPGA's INIT\_B output goes High and must be at defined logic levels during this time. After configuration, when the FPGA's DONE output goes High, the mode pins are available as full-featured user-I/O pins.

Similarly, the FPGA's HSWAP pin must be Low to enable pull-up resistors on all user-I/O pins or High to disable the pull-up resistors. The HSWAP control must remain at a constant logic level throughout FPGA configuration. After configuration, when the FPGA's DONE output goes High, the HSWAP pin is available as full-featured user-I/O pin and is powered by the VCCO\_0 supply.

### Voltage Compatibility

Most Slave Serial interface signals are within the FPGA's I/O Bank 2, supplied by the VCCO\_2 supply input. The VCCO\_2 voltage can be 3.3V, 2.5V, or 1.8V to match the requirements of the external host, ideally 2.5V. Using 3.3V or 1.8V requires additional design considerations as the DONE and PROG\_B pins are powered by the FPGA's 2.5V VCCAUX supply. See [XAPP453: The 3.3V Configuration of Spartan-3 FPGAs](#) for additional information.

### Daisy-Chaining

If the application requires multiple FPGAs with different configurations, then configure the FPGAs using a daisy chain, as shown in [Figure 64](#). Use Slave Serial mode (M[2:0] = <1:1:1>) for all FPGAs in the daisy-chain. After the lead FPGA is filled with its configuration data, the lead

FPGA passes configuration data via its DOUT output pin to the next FPGA on the falling CCLK edge.

Table 66: Slave Serial Mode Connections

| Pin Name | FPGA Direction               | Description   | During Configuration   | After Configuration   |
|----------|------------------------------|---|--|---|
| HSWAP    | Input                        | <b>User I/O Pull-Up Control.</b> When Low during configuration, enables pull-up resistors in all I/O pins to respective I/O bank V <sub>CCO</sub> input. 0: Pull-up during configuration 1: No pull-ups   | Drive at valid logic level throughout configuration.   | User I/O  |
| M[2:0]   | Input                        | <b>Mode Select.</b> Selects the FPGA configuration mode. See <a href="#">Design Considerations for the HSWAP, M[2:0], and VS[2:0] Pins</a> .  | M2 = 1, M1 = 1, M0 = 1 Sampled when INIT_B goes High.  | User I/O  |
| DIN      | Input                        | <b>Data Input.</b>  | Serial data provided by host. FPGA captures data on rising CCLK edge.                            | User I/O  |
| CCLK     | Input                        | <b>Configuration Clock.</b> If CCLK PCB trace is long or has multiple connections, terminate this output to maintain signal integrity. See <a href="#">CCLK Design Considerations</a> .   | External clock.  | User I/O  |
| INIT_B   | Open-drain bidirectional I/O | <b>Initialization Indicator.</b> Active Low. Goes Low at start of configuration during Initialization memory clearing process. Released at end of memory clearing, when mode select pins are sampled. In daisy-chain applications, this signal requires an external 4.7 kΩ pull-up resistor to V <sub>CCO</sub> _2.   | Active during configuration. If CRC error detected during configuration, FPGA drives INIT_B Low. | User I/O. If unused in the application, drive INIT_B High.                                    |
| DONE     | Open-drain bidirectional I/O | <b>FPGA Configuration Done.</b> Low during configuration. Goes High when FPGA successfully completes configuration. Requires external 330 Ω pull-up resistor to 2.5V.   | Low indicates that the FPGA is not yet configured.   | Pulled High via external pull-up. When High, indicates that the FPGA successfully configured. |
| PROG_B   | Input                        | <b>Program FPGA.</b> Active Low. When asserted Low for 500 ns or longer, forces the FPGA to restart its configuration process by clearing configuration memory and resetting the DONE and INIT_B pins once PROG_B returns High. Recommend external 4.7 kΩ pull-up resistor to 2.5V. Internal pull-up value may be weaker (see <a href="#">Table 78</a> ). If driving externally with a 3.3V output, use an open-drain or open-collector driver or use a current limiting series resistor. | Must be High to allow configuration to start.  | Drive PROG_B Low and release to reprogram FPGA.   |

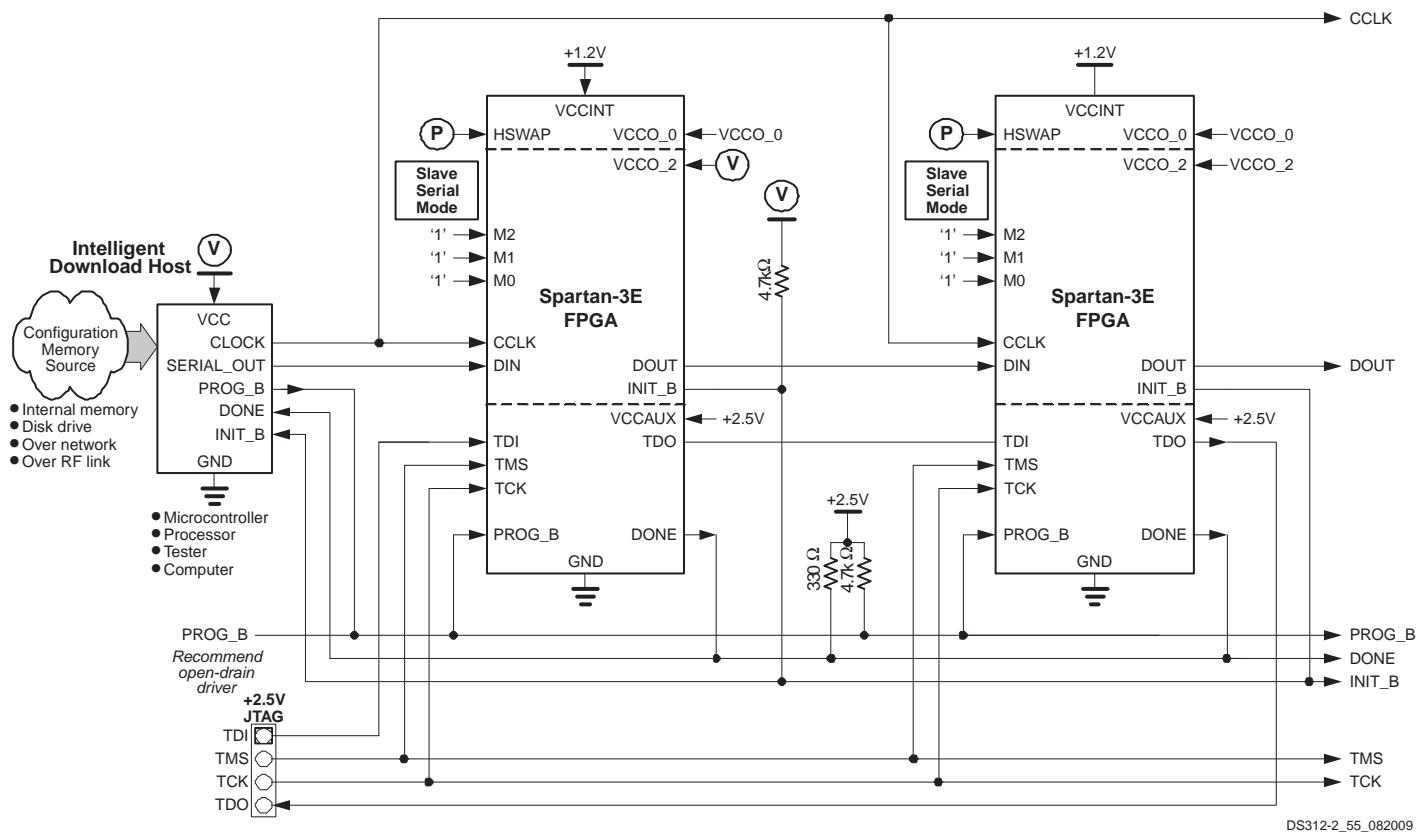


Figure 64: Daisy-Chaining using Slave Serial Mode

## JTAG Mode

For additional information, refer to the “JTAG Configuration Mode and Boundary-Scan” chapter in [UG332](#).

The Spartan-3E FPGA has a dedicated four-wire IEEE 1149.1/1532 JTAG port that is always available any time the FPGA is powered and regardless of the mode pin settings. However, when the FPGA mode pins are set for JTAG mode ( $M[2:0] = <1:0:1>$ ), the FPGA waits to be configured via the JTAG port after a power-on event or when PROG\_B is asserted. Selecting the JTAG mode simply disables the other configuration modes. No other pins are required as part of the configuration interface.

[Figure 65](#) illustrates a JTAG-only configuration interface. The JTAG interface is easily cascaded to any number of FPGAs by connecting the TDO output of one device to the TDI input of the next device in the chain. The TDO output of the last device in the chain loops back to the port connector.

### Design Note

If using software versions prior to ISE 9.1.01i, avoid configuring the FPGA using JTAG if...

- the mode pins are set for a Master mode
- the attached Master mode PROM contains a valid FPGA configuration bitstream.

The FPGA bitstream may be corrupted and the DONE pin may go High. The following Answer Record contains additional information.

<http://www.xilinx.com/support/answers/22255.htm>

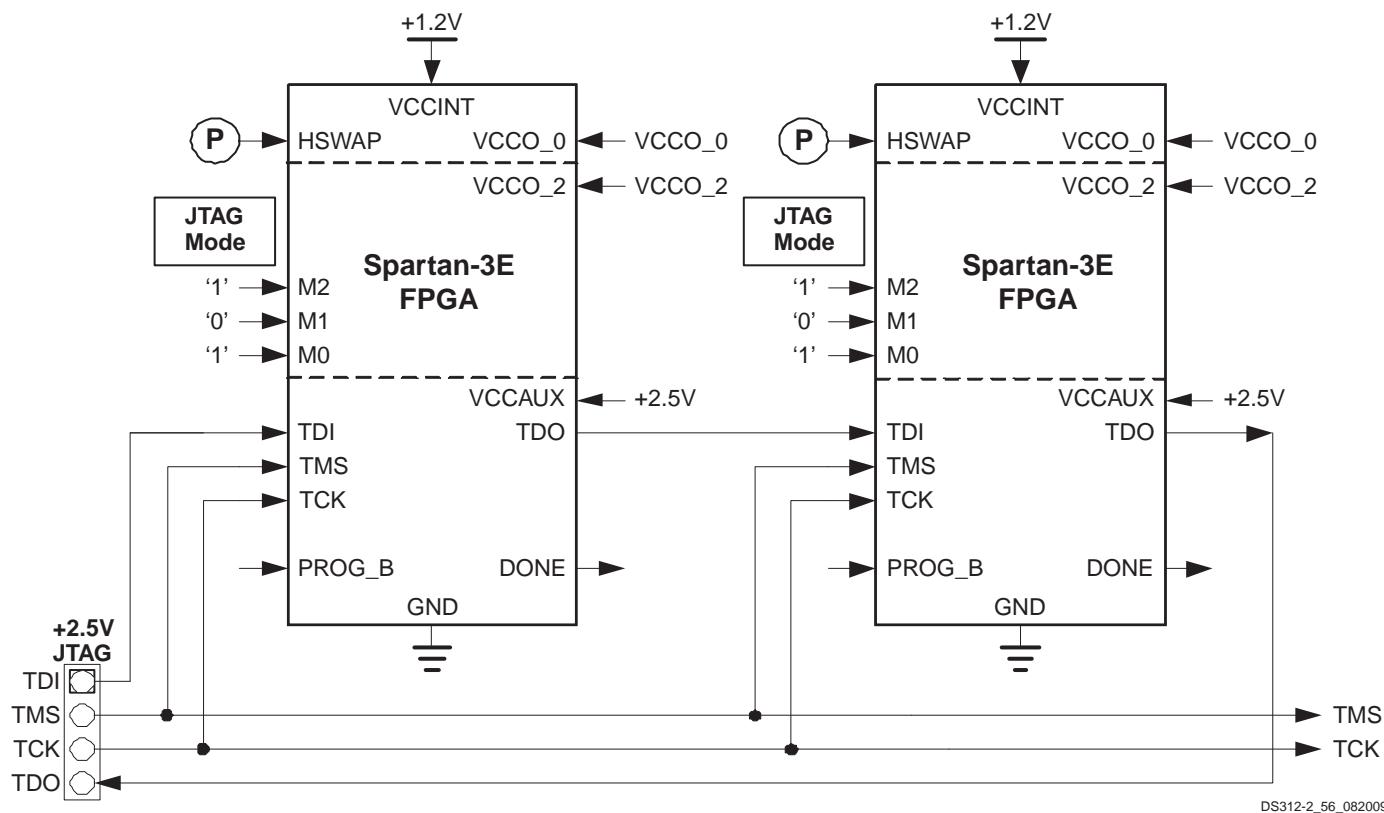


Figure 65: JTAG Configuration Mode

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## Voltage Compatibility

The 2.5V VCCAUX supply powers the JTAG interface. All of the user I/Os are separately powered by their respective VCCO\_# supplies.

When connecting the Spartan-3E JTAG port to a 3.3V interface, the JTAG input pins must be current-limited to 10 mA or less using series resistors. Similarly, the TDO pin is a CMOS output powered from +2.5V. The TDO output can directly drive a 3.3V input but with reduced noise immunity. See [XAPP453: The 3.3V Configuration of Spartan-3 FPGAs](#) for additional information.

Table 67: Spartan-3E JTAG Device Identifiers

| Spartan-3E FPGA | 4-Bit Revision Code |        | 28-Bit Vendor/Device Identifier |
|-----------------|---------------------|--------|---------------------------------|
|                 | Step 0              | Step 1 |                                 |
| XC3S100E        | 0x0                 | 0x1    | 0x1C 10 093                     |
| XC3S250E        | 0x0                 | 0x1    | 0x1C 1A 093                     |
| XC3S500E        | 0x0<br>0x2          | 0x4    | 0x1C 22 093                     |
| XC3S1200E       | 0x0<br>0x1          | 0x2    | 0x1C 2E 093                     |
| XC3S1600E       | 0x0<br>0x1          | 0x2    | 0x1C 3A 093                     |

## JTAG Device ID

Each Spartan-3E FPGA array type has a 32-bit device-specific JTAG device identifier as shown in [Table 67](#). The lower 28 bits represent the device vendor (Xilinx) and device identifier. The upper four bits, ignored by most tools, represent the revision level of the silicon mounted on the printed circuit board. [Table 67](#) associates the revision code with a specific stepping level.

## JTAG User ID

The Spartan-3E JTAG interface also provides the option to store a 32-bit User ID, loaded during configuration. The User ID value is specified via the *UserID* configuration bitstream option, shown in [Table 69, page 108](#).

## Using JTAG Interface to Communicate to a Configured FPGA Design

After the FPGA is configured, using any of the available modes, the JTAG interface offers a possible communications channel to internal FPGA logic. The BSCAN\_SPARTAN3 design primitive provides two private JTAG instructions to create an internal boundary scan chain.

## Maximum Bitstream Size for Daisy-Chains

The maximum bitstream length supported by Spartan-3E FPGAs in serial daisy-chains is 4,294,967,264 bits (4 Gbits), roughly equivalent to a daisy-chain with 720 XC3S1600E FPGAs. This is a limit only for serial daisy-chains where configuration data is passed via the FPGA's DOUT pin. There is no such limit for JTAG chains.

The FPGA configuration sequence can also be initiated by asserting PROG\_B. Once released, the FPGA begins clearing its internal configuration memory, and progresses through the remainder of the configuration process.

## Configuration Sequence

For additional information including I/O behavior before and during configuration, refer to the “Sequence of Events” chapter in [UG332](#).

The Spartan-3E configuration process is three-stage process that begins after the FPGA powers on (a POR event) or after the PROG\_B input is asserted. Power-On Reset (POR) occurs after the V<sub>CCINT</sub>, V<sub>CCAUX</sub>, and the V<sub>CCO</sub> Bank 2 supplies reach their respective input threshold levels. After either a POR or PROG\_B event, the three-stage configuration process begins.

1. The FPGA clears (initializes) the internal configuration memory.
2. Configuration data is loaded into the internal memory.
3. The user-application is activated by a start-up process.

[Figure 66](#) is a generalized block diagram of the Spartan-3E configuration logic, showing the interaction of different device inputs and Bitstream Generator (BitGen) options. A flow diagram for the configuration sequence of the Serial and Parallel modes appears in [Figure 66](#). [Figure 67](#) shows the Boundary-Scan or JTAG configuration sequence.

## Initialization

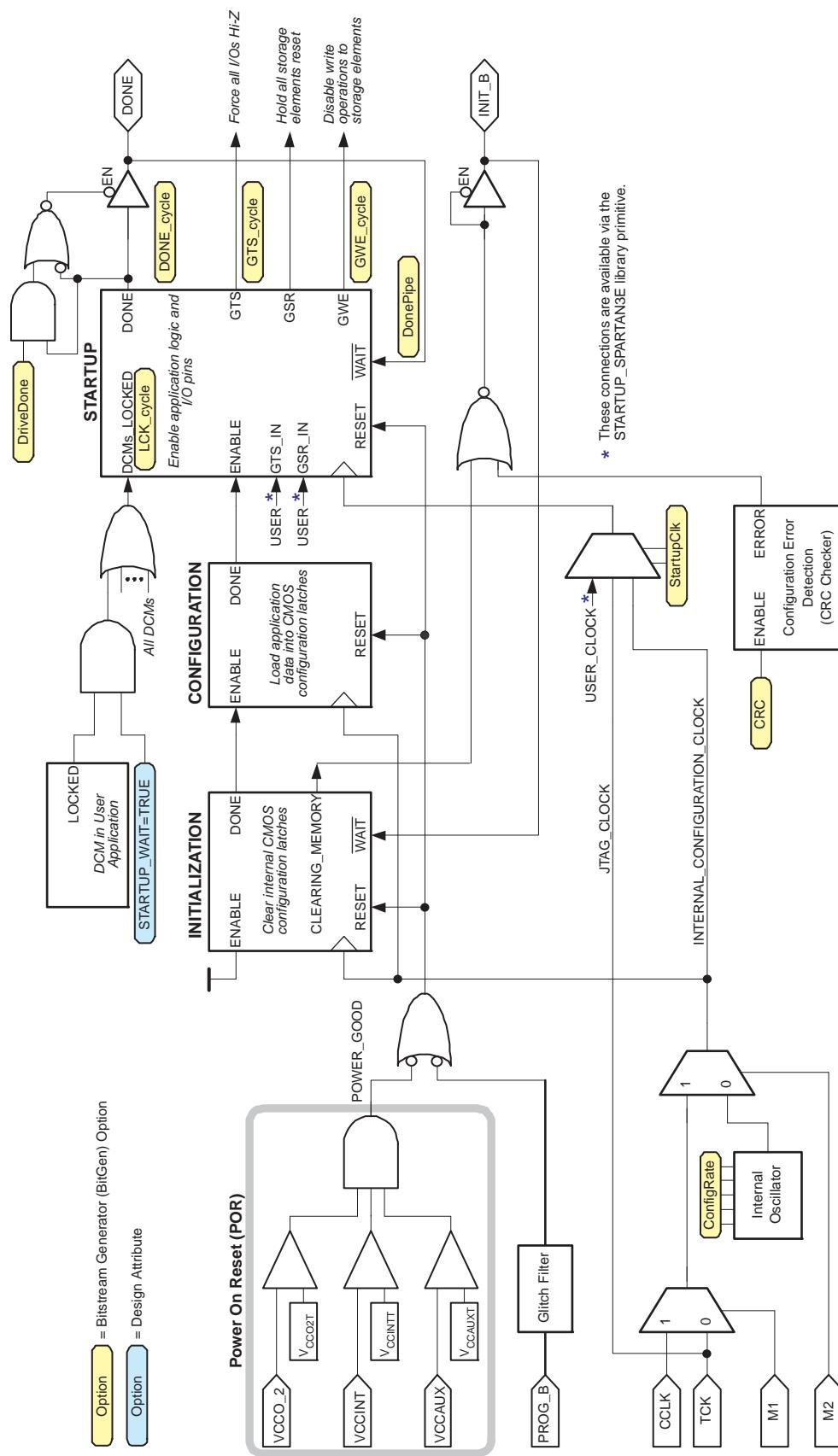
Configuration automatically begins after power-on or after asserting the FPGA PROG\_B pin, unless delayed using the FPGA's INIT\_B pin. The FPGA holds the open-drain INIT\_B signal Low while it clears its internal configuration memory.

Externally holding the INIT\_B pin Low forces the configuration sequencer to wait until INIT\_B again goes High.

The FPGA signals when the memory-clearing phase is complete by releasing the open-drain INIT\_B pin, allowing the pin to go High via the external pull-up resistor to V<sub>CCO\_2</sub>.

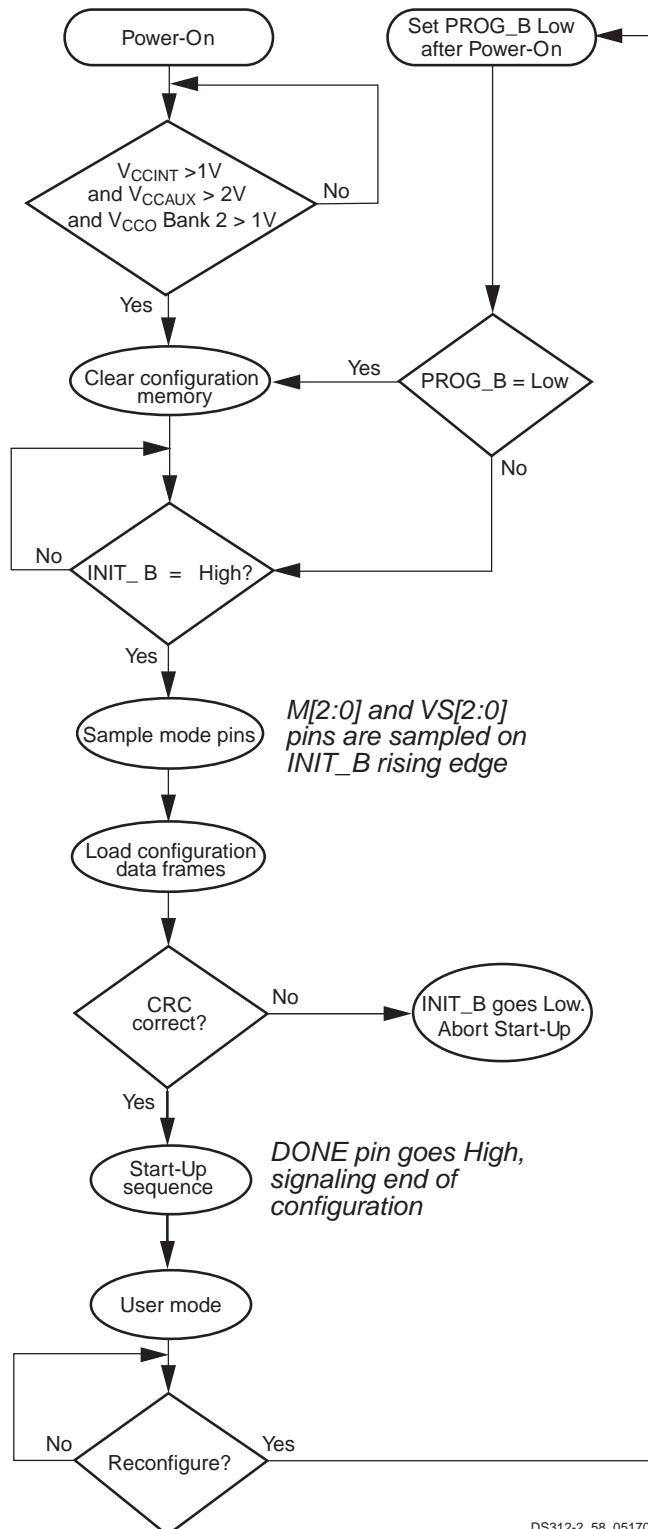
## Loading Configuration Data

After initialization, configuration data is written to the FPGA's internal memory. The FPGA holds the Global Set/Reset (GSR) signal active throughout configuration, holding all FPGA flip-flops in a reset state. The FPGA signals when the entire configuration process completes by releasing the DONE pin, allowing it to go High.



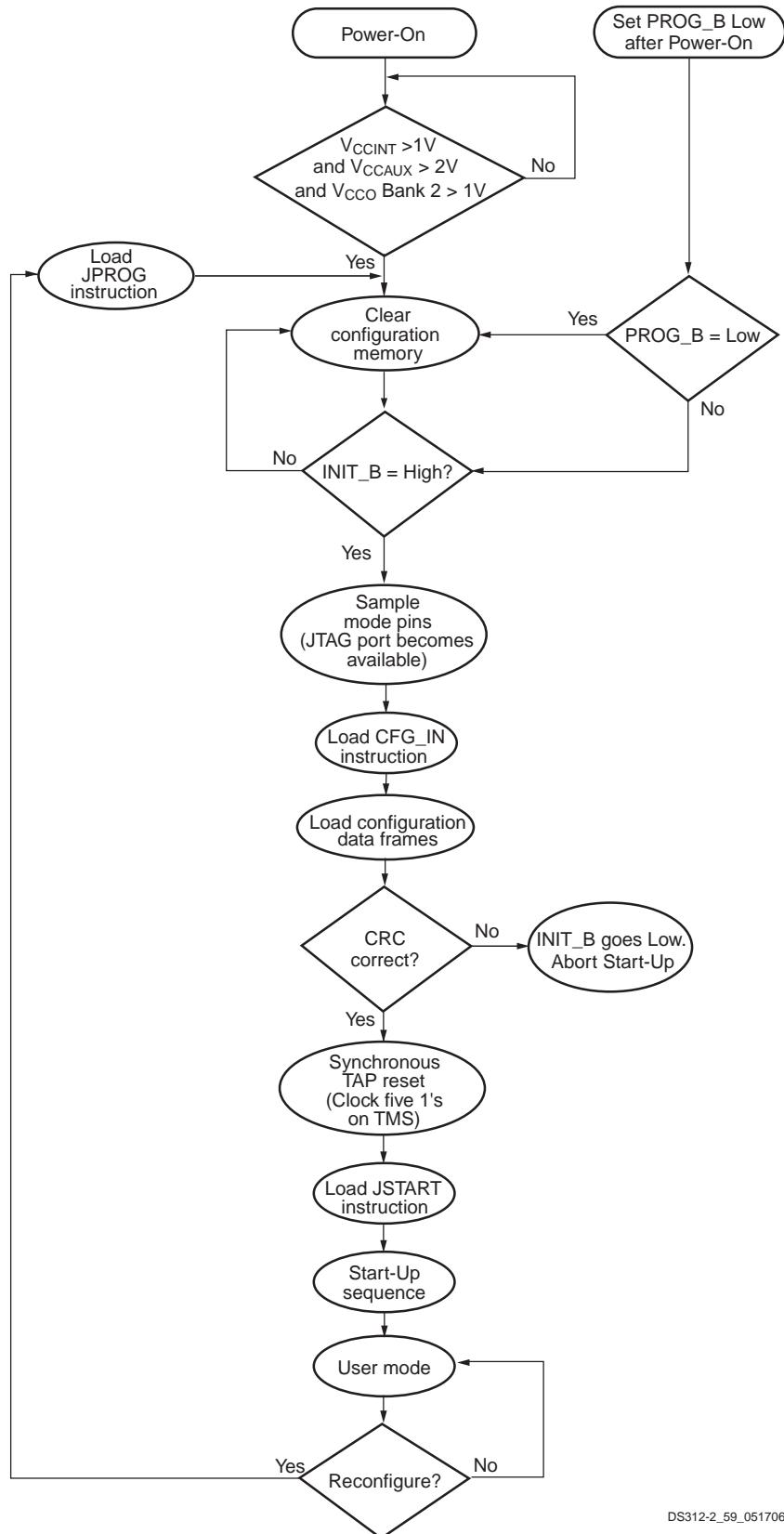
DS312-2\_57\_102605

Figure 66: Generalized Spartan-3E FPGA Configuration Logic Block Diagram



DS312-2\_58\_051706

Figure 66: General Configuration Process



DS312-2\_59\_051706

Figure 67: Boundary-Scan Configuration Flow Diagram

## Start-Up

At the end of configuration, the FPGA automatically pulses the Global Set/Reset (GSR) signal, placing all flip-flops in a known state. After configuration completes, the FPGA switches over to the user application loaded into the FPGA. The sequence and timing of how the FPGA switches over is programmable as is the clock source controlling the sequence.

The default start-up sequence appears in [Figure 68](#), where the Global Three-State signal (GTS) is released one clock cycle after DONE goes High. This sequence allows the DONE signal to enable or disable any external logic used during configuration before the user application in the FPGA starts driving output signals. One clock cycle later, the Global Write Enable (GWE) signal is released. This allows signals to propagate within the FPGA before any clocked storage elements such as flip-flops and block ROM are enabled.

The function of the dual-purpose I/O pins, such as M[2:0], VS[2:0], HSWAP, and A[23:0], also changes when the DONE pin goes High. When DONE is High, these pins become user I/Os. Like all user-I/O pins, GTS controls when the dual-purpose pins can drive out.

The relative timing of configuration events is programmed via the Bitstream Generator (BitGen) options in the Xilinx development software. For example, the GTS and GWE events can be programmed to wait for all the DONE pins to High on all the devices in a multiple-FPGA daisy-chain, forcing the FPGAs to start synchronously. Similarly, the start-up sequence can be paused at any stage, waiting for selected DCMs to lock to their respective input clock signals. See also [Stabilizing DCM Clocks Before User Mode](#).

By default, the start-up sequence is synchronized to CCLK. Alternatively, the start-up sequence can be synchronized to a user-specified clock from within the FPGA application using the STARTUP\_SPARTAN3E library primitive and by setting the **StartupClk** bitstream generator option. The FPGA application can optionally assert the GSR and GTS signals via the STARTUP\_SPARTAN3E primitive. For JTAG configuration, the start-up sequence can be synchronized to the TCK clock input.

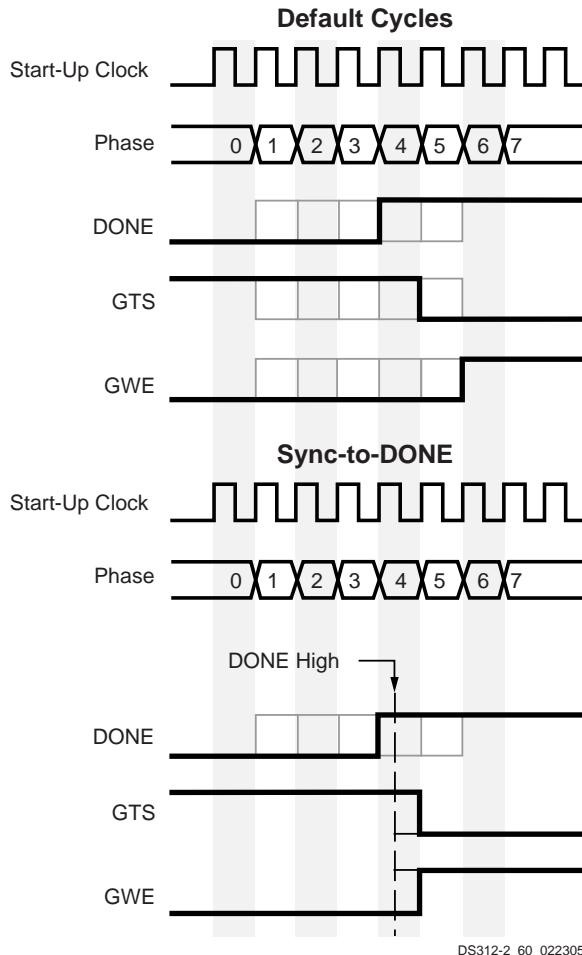


Figure 68: Default Start-Up Sequence

## Readback

FPGA configuration data can be read back using either the Slave Parallel or JTAG mode. This function is disabled if the Bitstream Generator **Security** option is set to either **Level1** or **Level2**.

Along with the configuration data, it is possible to read back the contents of all registers and distributed RAM.

To synchronously control when register values are captured for readback, use the CAPTURE\_SPARTAN3 library primitive, which applies for both Spartan-3 and Spartan-3E FPGA families.

The Readback feature is available in most Spartan-3E FPGA product options, as indicated in [Table 68](#). The Readback feature is not available in the XC3S1200E and XC3S1600E FPGAs when using the -4 speed grade in the Commercial temperature grade. Similarly, block RAM Readback support is not available in the -4 speed grade, Commercial temperature devices. If Readback is required in an XC3S1200E or XC3S1600E FPGA, or if block RAM Readback is required on any Spartan-3E FPGA, upgrade to either the Industrial temperature grade version or the -5 speed grade.

The Xilinx iMPACT programming software uses the Readback feature for its optional Verify and Readback operations. The Xilinx ChipScope™ software presently does not use Readback but may in future updates.

**Table 68: Readback Support in Spartan-3E FPGAs**

| Temperature Range                                    | Commercial | Industrial |     |
|--|------------|------------|-----|
| Speed Grade  | -4         | -5         | -4  |
| <b>Block RAM Readback</b>                            |            |            |     |
| All Spartan-3E FPGAs                                 | No         | Yes        | Yes |
| <b>General Readback (registers, distributed RAM)</b> |            |            |     |
| XC3S100E   | Yes        | Yes        | Yes |
| XC3S250E   | Yes        | Yes        | Yes |
| XC3S500E   | Yes        | Yes        | Yes |
| XC3S1200E  | No         | Yes        | Yes |
| XC3S1600E  | No         | Yes        | Yes |

## Bitstream Generator (BitGen) Options

For additional information, refer to the “Configuration Bitstream Generator (BitGen) Settings” chapter in [UG332](#).

Various Spartan-3E FPGA functions are controlled by specific bits in the configuration bitstream image. These

values are specified when creating the bitstream image with the Bitstream Generator (BitGen) software.

[Table 69](#) provides a list of all BitGen options for Spartan-3E FPGAs.

**Table 69: Spartan-3E FPGA Bitstream Generator (BitGen) Options**

| Option Name | Pins/Function Affected  | Values (default)         | Description  |
|-------------|---|--------------------------|--|
| ConfigRate  | CCLK, Configuration   | 1, 3, 6, 12, 25, 50      | Sets the approximate frequency, in MHz, of the internal oscillator using for Master Serial, SPI, and BPI configuration modes. The internal oscillator powers up at its lowest frequency, and the new setting is loaded as part of the configuration bitstream. The software default value is 1 (~1.5 MHz) starting with ISE 8.1, Service Pack 1. |
| StartupClk  | Configuration, Startup  | <b>Cclk</b>              | <b>Default.</b> The CCLK signal (internally or externally generated) controls the startup sequence when the FPGA transitions from configuration mode to the user mode. See <a href="#">Start-Up</a> .  |
|             |   | UserClk                  | A clock signal from within the FPGA application controls the startup sequence when the FPGA transitions from configuration mode to the user mode. See <a href="#">Start-Up</a> . The FPGA application supplies the user clock on the CLK pin on the STARTUP_SPARTAN3E primitive.   |
|             |   | Jtag                     | The JTAG TCK input controls the startup sequence when the FPGA transitions from the configuration mode to the user mode. See <a href="#">Start-Up</a> .  |
| UnusedPin   | Unused I/O Pins   | <b>Pulldown</b>          | <b>Default.</b> All unused I/O pins and input-only pins have a pull-down resistor to GND.  |
|             |   | Pullup                   | All unused I/O pins and input-only pins have a pull-up resistor to the VCCO_# supply for its associated I/O bank.  |
|             |   | Pullnone                 | All unused I/O pins and input-only pins are left floating (Hi-Z, high-impedance, three-state). Use external pull-up or pull-down resistors or logic to apply a valid signal level.   |
| DONE_cycle  | DONE pin, Configuration Startup   | 1, 2, 3, <b>4</b> , 5, 6 | Selects the Configuration Startup phase that activates the FPGA’s DONE pin. See <a href="#">Start-Up</a> .   |
| GWE_cycle   | All flip-flops, LUT RAMs, and SRL16 shift registers, Block RAM, Configuration Startup | 1, 2, 3, 4, 5, <b>6</b>  | Selects the Configuration Startup phase that asserts the internal write-enable signal to all flip-flops, LUT RAMs and shift registers (SRL16). It also enables block RAM read and write operations. See <a href="#">Start-Up</a> .   |
|             |   | Done                     | Waits for the DONE pin input to go High before asserting the internal write-enable signal to all flip-flops, LUT RAMs and shift registers (SRL16). Block RAM read and write operations are enabled at this time.   |
|             |   | Keep                     | Retains the current GWE_cycle setting for partial reconfiguration applications.  |
| GTS_cycle   | All I/O pins, Configuration   | 1, 2, 3, 4, <b>5</b> , 6 | Selects the Configuration Startup phase that releases the internal three-state control, holding all I/O buffers in high-impedance (Hi-Z). Output buffers actively drive, if so configured, after this point. See <a href="#">Start-Up</a> .  |
|             |   | Done                     | Waits for the DONE pin input to go High before releasing the internal three-state control, holding all I/O buffers in high-impedance (Hi-Z). Output buffers actively drive, if so configured, after this point.  |
|             |   | Keep                     | Retains the current GTS_cycle setting for partial reconfiguration applications.  |
| LCK_cycle   | DCMs, Configuration Startup   | <b>NoWait</b>            | The FPGA does not wait for selected DCMs to lock before completing configuration.  |
|             |   | 0, 1, 2, 3, 4, 5, 6      | If one or more DCMs in the design have the STARTUP_WAIT attribute set to TRUE, the FPGA waits for such DCMs to acquire their respective input clock and assert their LOCKED output. This setting selects the Configuration Startup phase where the FPGA waits for the DCMs to lock.  |
| DonePin     | DONE pin  | <b>Pullup</b>            | Internally connects a pull-up resistor between DONE pin and V <sub>CCAUX</sub> . An external 330 Ω pull-up resistor to V <sub>CCAUX</sub> is still recommended.  |
|             |   | Pullnone                 | No internal pull-up resistor on DONE pin. An external 330 Ω pull-up resistor to V <sub>CCAUX</sub> is required.  |

Table 69: Spartan-3E FPGA Bitstream Generator (BitGen) Options (Cont'd)

| Option Name | Pins/Function Affected  | Values (default) | Description   |
|-------------|---|------------------|---|
| DriveDone   | DONE pin  | <u>No</u>        | When configuration completes, the DONE pin stops driving Low and relies on an external $330\ \Omega$ pull-up resistor to $V_{CCAUX}$ for a valid logic High.  |
|             |   | Yes              | When configuration completes, the DONE pin actively drives High. When using this option, an external pull-up resistor is no longer required. Only one device in an FPGA daisy-chain should use this setting.  |
| DonePipe    | DONE pin  | <u>No</u>        | The input path from DONE pin input back to the Startup sequencer is not pipelined.  |
|             |   | Yes              | This option adds a pipeline register stage between the DONE pin input and the Startup sequencer. Used for high-speed daisy-chain configurations when DONE cannot rise in a single CCLK cycle. Releases GWE and GTS signals on the first rising edge of StartupClk after the DONE pin input goes High. |
| ProgPin     | PROG_B pin  | <u>Pullup</u>    | Internally connects a pull-up resistor or between PROG_B pin and $V_{CCAUX}$ . An external $4.7\ k\Omega$ pull-up resistor to $V_{CCAUX}$ is still recommended since the internal pull-up value may be weaker (see Table 78).   |
|             |   | Pullnone         | No internal pull-up resistor on PROG_B pin. An external $4.7\ k\Omega$ pull-up resistor to $V_{CCAUX}$ is required.   |
| TckPin      | JTAG TCK pin  | <u>Pullup</u>    | Internally connects a pull-up resistor between JTAG TCK pin and $V_{CCAUX}$ .   |
|             |   | Pulldown         | Internally connects a pull-down resistor between JTAG TCK pin and GND.  |
|             |   | Pullnone         | No internal pull-up resistor on JTAG TCK pin.   |
| TdiPin      | JTAG TDI pin  | <u>Pullup</u>    | Internally connects a pull-up resistor between JTAG TDI pin and $V_{CCAUX}$ .   |
|             |   | Pulldown         | Internally connects a pull-down resistor between JTAG TDI pin and GND.  |
|             |   | Pullnone         | No internal pull-up resistor on JTAG TDI pin.   |
| TdoPin      | JTAG TDO pin  | <u>Pullup</u>    | Internally connects a pull-up resistor between JTAG TDO pin and $V_{CCAUX}$ .   |
|             |   | Pulldown         | Internally connects a pull-down resistor between JTAG TDO pin and GND.  |
|             |   | Pullnone         | No internal pull-up resistor on JTAG TDO pin.   |
| TmsPin      | JTAG TMS pin  | <u>Pullup</u>    | Internally connects a pull-up resistor between JTAG TMS pin and $V_{CCAUX}$ .   |
|             |   | Pulldown         | Internally connects a pull-down resistor between JTAG TMS pin and GND.  |
|             |   | Pullnone         | No internal pull-up resistor on JTAG TMS pin.   |
| UserID      | JTAG User ID register   | User string      | The 32-bit JTAG User ID register value is loaded during configuration. The default value is all ones, <code>0xFFFF_FFFF</code> hexadecimal. To specify another value, enter an 8-character hexadecimal value.   |
| Security    | JTAG, SelectMAP, Readback, Partial reconfiguration            | <u>None</u>      | Readback and limited partial reconfiguration are available via the JTAG port or via the SelectMAP interface, if the <b>Persist</b> option is set to <b>Yes</b> .  |
|             |   | Level1           | Readback function is disabled. Limited partial reconfiguration is still available via the JTAG port or via the SelectMAP interface, if the <b>Persist</b> option is set to <b>Yes</b> .   |
|             |   | Level2           | Readback function is disabled. Limited partial reconfiguration is disabled.   |
| CRC         | Configuration   | <b>Enable</b>    | <b>Default.</b> Enable CRC checking on the FPGA bitstream. If error detected, FPGA asserts INIT_B Low and DONE pin stays Low.   |
|             |   | Disable          | Turn off CRC checking.  |
| Persist     | SelectMAP interface pins, BPI mode, Slave mode, Configuration | <u>No</u>        | All BPI and Slave mode configuration pins are available as user-I/O after configuration.  |
|             |   | Yes              | This option is required for Readback and partial reconfiguration using the SelectMAP interface. The SelectMAP interface pins (see <a href="#">Slave Parallel Mode</a> ) are reserved after configuration and are not available as user-I/O.   |

## Powering Spartan-3E FPGAs

For additional information, refer to the “Powering Spartan-3 Generation FPGAs” chapter in [UG331](#).

## Voltage Supplies

Like Spartan-3 FPGAs, Spartan-3E FPGAs have multiple voltage supply inputs, as shown in [Table 70](#). There are two

*Table 70: Spartan-3E Voltage Supplies*

| Supply Input | Description   | Nominal Supply Voltage                     |
|--------------|---|--|
| $V_{CCINT}$  | Internal core supply voltage. Supplies all internal logic functions, such as CLBs, block RAM, and multipliers. Input to Power-On Reset (POR) circuit.   | 1.2V                                       |
| $V_{CCAUX}$  | Auxiliary supply voltage. Supplies Digital Clock Managers (DCMs), differential drivers, dedicated configuration pins, JTAG interface. Input to Power-On Reset (POR) circuit.  | 2.5V                                       |
| $V_{CCO\_0}$ | Supplies the output buffers in I/O Bank 0, the bank along the top edge of the FPGA.   | Selectable, 3.3V, 2.5V, 1.8, 1.5V, or 1.2V |
| $V_{CCO\_1}$ | Supplies the output buffers in I/O Bank 1, the bank along the right edge of the FPGA. In <a href="#">Byte-Wide Peripheral Interface (BPI) Parallel Flash Mode</a> , connects to the same voltage as the Flash PROM. | Selectable, 3.3V, 2.5V, 1.8, 1.5V, or 1.2V |
| $V_{CCO\_2}$ | Supplies the output buffers in I/O Bank 2, the bank along the bottom edge of the FPGA. Connects to the same voltage as the FPGA configuration source. Input to Power-On Reset (POR) circuit.                        | Selectable, 3.3V, 2.5V, 1.8, 1.5V, or 1.2V |
| $V_{CCO\_3}$ | Supplies the output buffers in I/O Bank 3, the bank along the left edge of the FPGA.  | Selectable, 3.3V, 2.5V, 1.8, 1.5V, or 1.2V |

In a 3.3V-only application, all four  $V_{CCO}$  supplies connect to 3.3V. However, Spartan-3E FPGAs provide the ability to bridge between different I/O voltages and standards by applying different voltages to the  $V_{CCO}$  inputs of different banks. Refer to [I/O Banking Rules](#) for which I/O standards can be intermixed within a single I/O bank.

Each I/O bank also has an separate, optional input voltage reference supply, called  $V_{REF}$ . If the I/O bank includes an I/O standard that requires a voltage reference such as HSTL or SSTL, then all  $V_{REF}$  pins within the I/O bank must be connected to the same voltage.

supply inputs for internal logic functions,  $V_{CCINT}$  and  $V_{CCAUX}$ . Each of the four I/O banks has a separate  $V_{CCO}$  supply input that powers the output buffers within the associated I/O bank. All of the  $V_{CCO}$  connections to a specific I/O bank must be connected and must connect to the same voltage.

## Voltage Regulators

Various power supply manufacturers offer complete power solutions for Xilinx FPGAs including some with integrated three-rail regulators specifically designed for Spartan-3 and Spartan-3E FPGAs. The [Xilinx Power Corner](#) website provides links to vendor solution guides and Xilinx power estimation and analysis tools.

## Power Distribution System (PDS) Design and Decoupling/Bypass Capacitors

Good power distribution system (PDS) design is important for all FPGA designs, but especially so for high performance applications, greater than 100 MHz. Proper design results in better overall performance, lower clock and DCM jitter, and a generally more robust system. Before designing the printed circuit board (PCB) for the FPGA design, please review [XAPP623: Power Distribution System \(PDS\) Design: Using Bypass/Decoupling Capacitors](#).

## Power-On Behavior

For additional power-on behavior information, including I/O behavior before and during configuration, refer to the "Sequence of Events" chapter in [UG332](#).

Spartan-3E FPGAs have a built-in Power-On Reset (POR) circuit that monitors the three power rails required to successfully configure the FPGA. At power-up, the POR circuit holds the FPGA in a reset state until the  $V_{CCINT}$ ,  $V_{CCAUX}$ , and  $V_{CCO}$  Bank 2 supplies reach their respective input threshold levels (see [Table 74](#) in Module 3). After all three supplies reach their respective thresholds, the POR reset is released and the FPGA begins its configuration process.

## Supply Sequencing

Because the three FPGA supply inputs must be valid to release the POR reset and can be supplied in any order, there are no FPGA-specific voltage sequencing requirements. Applying the FPGA's  $V_{CCAUX}$  supply before the  $V_{CCINT}$  supply uses the least  $I_{CCINT}$  current.

Although the FPGA has no specific voltage sequence requirements, be sure to consider any potential sequencing requirement of the configuration device attached to the FPGA, such as an SPI serial Flash PROM, a parallel NOR Flash PROM, or a microcontroller. For example, Flash PROMs have a minimum time requirement before the PROM can be selected and this must be considered if the 3.3V supply is the last in the sequence. See [Power-On Precautions if 3.3V Supply is Last in Sequence](#) for more details.

When all three supplies are valid, the minimum current required to power-on the FPGA equals the worst-case quiescent current, specified in [Table 79](#). Spartan-3E FPGAs

do not require Power-On Surge (POS) current to successfully configure.

## Surplus $I_{CCINT}$ if $V_{CCINT}$ Applied before $V_{CCAUX}$

If the  $V_{CCINT}$  supply is applied before the  $V_{CCAUX}$  supply, the FPGA might draw a surplus  $I_{CCINT}$  current in addition to the  $I_{CCINT}$  quiescent current levels specified in [Table 79](#), [page 119](#). The momentary additional  $I_{CCINT}$  surplus current might be a few hundred milliamperes under nominal conditions, significantly less than the instantaneous current consumed by the bypass capacitors at power-on. However, the surplus current immediately disappears when the  $V_{CCAUX}$  supply is applied, and, in response, the FPGA's  $I_{CCINT}$  quiescent current demand drops to the levels specified in [Table 79](#). The FPGA does not use or require the surplus current to successfully power-on and configure. If applying  $V_{CCINT}$  before  $V_{CCAUX}$ , ensure that the regulator does not have a foldback feature that could inadvertently shut down in the presence of the surplus current.

## Configuration Data Retention, Brown-Out

The FPGA's configuration data is stored in robust CMOS configuration latches. The data in these latches is retained even when the voltages drop to the minimum levels necessary to preserve RAM contents, as specified in [Table 76](#).

If, after configuration, the  $V_{CCAUX}$  or  $V_{CCINT}$  supply drops below its data retention voltage, the current device configuration must be cleared using one of the following methods:

- Force the  $V_{CCAUX}$  or  $V_{CCINT}$  supply voltage below the minimum Power On Reset (POR) voltage threshold ([Table 74](#)).
- Assert PROG\_B Low.

The POR circuit does not monitor the  $V_{CCO\_2}$  supply after configuration. Consequently, dropping the  $V_{CCO\_2}$  voltage does not reset the device by triggering a Power-On Reset (POR) event.

## No Internal Charge Pumps or Free-Running Oscillators

Some system applications are sensitive to sources of analog noise. Spartan-3E FPGA circuitry is fully static and does not employ internal charge pumps.

The CCLK configuration clock is active during the FPGA configuration process. After configuration completes, the CCLK oscillator is automatically disabled unless the Bitstream Generator (BitGen) option **Persist=Yes**.

## Production Stepping

The Spartan-3E FPGA family uses production stepping to indicate improved capabilities or enhanced features.

Stepping 1 is, by definition, a functional superset of Stepping 0. Furthermore, configuration bitstreams generated for Stepping 0 are compatible with Stepping 1.

Designs operating on the Stepping 0 devices perform similarly on a Stepping 1 device.

### Differences Between Steppings

**Table 71** summarizes the feature and performance differences between Stepping 0 devices and Stepping 1 devices.

**Table 71: Differences between Spartan-3E Production Stepping Levels**

|   | Stepping 0  | Stepping 1  |
|---|---|---|
| Production status   | Production from 2005 to 2007  | Production starting March 2006                            |
| Speed grade and operating conditions  | -4C only  | -4C, -4I, -5C   |
| JTAG ID code  | Different revision fields. See <a href="#">Table 67</a> .                                   |   |
| DCM DLL maximum input frequency   | 90 MHz<br>(200 MHz for XC3S1200E)   | 240 MHz (-4 speed grade)<br>275 MHz (-5 speed grade)      |
| DCM DFS output frequency range(s)   | Split ranges at 5 – 90 MHz and<br>220 – 307 MHz<br>(single range 5 – 307 MHz for XC3S1200E) | Continuous range:<br>5 – 311 MHz (-4)<br>5 – 333 MHz (-5) |
| Supports multi-FPGA daisy-chain configurations from SPI Flash   | No, single FPGA only  | Yes   |
| JTAG configuration supported when FPGA in BPI mode with a valid image in the attached parallel NOR Flash PROM | No <sup>(1)</sup>   | Yes   |
| JTAG EXTEST, INTEST, SAMPLE support   | Yes: XC3S100E, XC3S250E, XC3S500E<br>No <sup>(2)</sup> : XC3S1200E, XC3S1600E               | Yes<br>All Devices  |
| Power sequencing when using HSWAP Pull-Up   | Requires $V_{CCINT}$ before $V_{CCAUX}$   | Any sequence  |
| PCI compliance  | No  | Yes   |

#### Notes:

1. Workarounds exist. See [Stepping 0 Limitations when Reprogramming via JTAG if FPGA Set for BPI Configuration](#).
2. JTAG BYPASS and JTAG configuration are supported.

## Ordering a Later Stepping

-5C and -4I devices, and -4C devices (with date codes 0901 (2009) and later) always support the Stepping 1 feature set independent of the stepping code. Optionally, to order only Stepping 1 for the -4C devices, append an "S1" suffix to the standard ordering code, where '1' is the stepping number, as indicated in [Table 72](#).

## Software Version Requirements

Production Spartan-3E applications must be processed using the Xilinx ISE 8.1i, Service Pack 3 or later development software, using the v1.21 or later speed files. The ISE 8.1i software implements critical bitstream generator updates.

For additional information on Spartan-3E development software and known issues, see the following Answer Record:

- Xilinx Answer #22253  
<http://www.xilinx.com/support/answers/22253.htm>

**Table 72: Spartan-3E Optional Stepping Ordering**

| Stepping Number | Suffix Code | Status     |
|-----------------|-------------|------------|
| 0               | None        | Production |
| 1               | S1          | Production |

## Revision History

The following table shows the revision history for this document.

| Date       | Version | Revision  |
|------------|---------|---|
| 03/01/2005 | 1.0     | Initial Xilinx release.   |
| 03/21/2005 | 1.1     | Updated <a href="#">Figure 45</a> . Modified title on <a href="#">Table 39</a> and <a href="#">Table 45</a> .   |
| 11/23/2005 | 2.0     | Updated values of <a href="#">On-Chip Differential Termination</a> resistors. Updated <a href="#">Table 7</a> . Updated configuration bitstream sizes for XC3S250E through XC3S1600E in <a href="#">Table 45</a> , <a href="#">Table 51</a> , <a href="#">Table 57</a> , and <a href="#">Table 60</a> . Added <a href="#">DLL Performance Differences Between Steppings</a> . Added <a href="#">Stepping 0 Limitations when Reprogramming via JTAG if FPGA Set for BPI Configuration</a> . Added Stepping 0 limitations when <a href="#">Daisy-Chaining</a> in SPI configuration mode. Added <a href="#">Multiplier/Block RAM Interaction</a> section. Updated <a href="#">Digital Clock Managers (DCMs)</a> section, especially <a href="#">Phase Shifter (PS)</a> portion. Corrected and enhanced the clock infrastructure diagram in <a href="#">Figure 45</a> and <a href="#">Table 41</a> . Added <a href="#">CCLK Design Considerations</a> section. Added <a href="#">Design Considerations for the HSWAP, M[2:0], and VS[2:0] Pins</a> section. Added Spansion, Winbond, and Macronix to list of SPI Flash vendors in <a href="#">Table 53</a> and <a href="#">Table 56</a> . Clarified that SPI mode configuration supports Atmel 'C'- and 'D'-series DataFlash. Updated the <a href="#">Programming Support</a> section for SPI Flash PROMs. Added <a href="#">Power-On Precautions if PROM Supply is Last in Sequence</a> , <a href="#">Compatible Flash Families</a> , and <a href="#">BPI Mode Interaction with Right and Bottom Edge Global Clock Inputs</a> sections to BPI configuration mode topic. Updated and amplified <a href="#">Powering Spartan-3E FPGAs</a> section. Added <a href="#">Production Stepping</a> section.  |
| 03/22/2006 | 3.0     | Upgraded data sheet status to Preliminary. Updated <a href="#">Input Delay Functions</a> and <a href="#">Figure 6</a> . Added clarification that Input-only pins also have <a href="#">Pull-Up and Pull-Down Resistors</a> . Added design note about address setup and hold requirements to <a href="#">Block RAM</a> . Added warning message about software differences between ISE 8.1i, Service Pack 3 and earlier software to <a href="#">FIXED Phase Shift Mode</a> and <a href="#">VARIABLE Phase Shift Mode</a> . Added message about using GCLK1 in <a href="#">DLL Clock Input Connections</a> and <a href="#">Clock Inputs</a> . Updated <a href="#">Figure 45</a> . Added additional information on HSWAP behavior to <a href="#">Pin Behavior During Configuration</a> . Highlighted which pins have configuration pull-up resistors unaffected by HSWAP in <a href="#">Table 46</a> . Updated bitstream image sizes for the XC3S1200E and XC3S1600E in <a href="#">Table 45</a> , <a href="#">Table 51</a> , <a href="#">Table 57</a> , and <a href="#">Table 60</a> . Clarified that 'B'-series Atmel DataFlash SPI PROMs can be used in Commercial temperature range applications in <a href="#">Table 53</a> and <a href="#">Figure 54</a> . Updated <a href="#">Figure 56</a> . Updated <a href="#">Dynamically Loading Multiple Configuration Images Using MultiBoot Option</a> section. Added design note about BPI daisy-chaining software support to <a href="#">BPI Daisy-Chaining</a> section. Updated JTAG revision codes in <a href="#">Table 67</a> . Added <a href="#">No Internal Charge Pumps or Free-Running Oscillators</a> . Updated information on production stepping differences in <a href="#">Table 71</a> . Updated <a href="#">Software Version Requirements</a> . |
| 04/10/2006 | 3.1     | Updated <a href="#">JTAG User ID</a> information. Clarified Note 1, <a href="#">Figure 5</a> . Clarified that <a href="#">Figure 45</a> shows electrical connectivity and corrected left- and right-edge DCM coordinates. Updated <a href="#">Table 30</a> , <a href="#">Table 31</a> , and <a href="#">Table 32</a> to show the specific clock line driven by the associated BUFGMUX primitive. Corrected the coordinate locations for the associated BUFGMUX primitives in <a href="#">Table 31</a> and <a href="#">Table 32</a> . Updated <a href="#">Table 41</a> to show that the I0-input is the preferred connection to a BUFGMUX.   |
| 05/19/2006 | 3.2     | Made further clarifying changes to <a href="#">Figure 46</a> , showing both direct inputs to BUFGMUX primitives and to DCMs. Added Atmel AT45DBxxxD-series DataFlash serial PROMs to <a href="#">Table 53</a> . Added details that intermediate FPGAs in a BPI-mode, multi-FPGA configuration daisy-chain must be from either the Spartan-3E or the Virtex-5 FPGA families (see <a href="#">BPI Daisy-Chaining</a> ). Added <a href="#">Using JTAG Interface to Communicate to a Configured FPGA Design</a> . Minor updates to <a href="#">Figure 66</a> and <a href="#">Figure 67</a> . Clarified which Spartan-3E FPGA product options support the Readback feature, shown in <a href="#">Table 68</a> .  |
| 05/30/2006 | 3.2.1   | Corrected various typos and incorrect links.  |
| 10/02/2006 | 3.3     | Clarified that the block RAM <a href="#">Readback</a> feature is available either on the -5 speed grade or the Industrial temperature range.  |
| 11/09/2006 | 3.4     | Updated the description of the <a href="#">Input Delay Functions</a> . The <a href="#">ODDR2</a> flip-flop with C0 or C1 Alignment is no longer supported. Updated <a href="#">Figure 5</a> . Updated <a href="#">Table 6</a> for improved PCI input voltage tolerance. Replaced missing text in <a href="#">Clock Buffers/Multiplexers</a> . Updated SPI Flash devices in <a href="#">Table 53</a> . Updated parallel NOR Flash devices in <a href="#">Table 61</a> . Direct, SPI Flash in-system <a href="#">Programming Support</a> was added beginning with ISE 8.1i iMPACT software for STMicro and Atmel SPI PROMs. Updated <a href="#">Table 71</a> and <a href="#">Table 72</a> as Stepping 1 is in full production. Freshened various hyper links. Promoted Module 2 to Production status.   |

| Date       | Version | Revision  |
|------------|---------|---|
| 03/16/2007 | 3.5     | Added information about new Spartan-3 Generation user guides ( <a href="#">Design Documentation Available</a> ). Added cross-references to <a href="#">UG331: Spartan-3 Generation FPGA User Guide</a> and to <a href="#">UG332: Spartan-3 Generation Configuration User Guide</a> . Added note about possible JTAG configuration issues when the FPGA mode pins are set for Master mode and using software prior to ISE 9.1.01i ( <a href="#">JTAG Mode</a> ). Removed a few lingering references to "weak" pull-up resistors, including in <a href="#">Figure 12</a> . Removed vestigial references regarding the LDC[2:0] and HDC pins during <a href="#">Slave Parallel Mode</a> configuration. These pins are not used in this configuration mode. |
| 05/29/2007 | 3.6     | Added information about HSWAP and PCI differences between steppings to <a href="#">Table 71</a> . Removed "Performance Differences between Global Buffers" to match improved specs in Module 3. Updated PROG_B pulse width descriptions to match specification in Module 3.   |
| 04/18/2008 | 3.7     | Corrected <a href="#">Figure 6</a> to show six taps and updated associated text. Added note for recommended pull-up on DONE in <a href="#">Table 55</a> and elsewhere. Added a caution regarding Persist of pins A20-A23. Updated Stepping description in <a href="#">Table 71</a> to note that only Stepping 1 is in production today. Updated links.  |
| 08/26/2009 | 3.8     | Added a frequency limitation to <a href="#">Equation 6</a> . Added a new <a href="#">Equation 7</a> with a frequency limitation. Added a <a href="#">Spread Spectrum, page 57</a> paragraph. Added <a href="#">Table 42, page 61</a> . Updated a Flash vendor name in <a href="#">Table 61, page 89</a> . Removed the < symbol from the flash read access times in <a href="#">Table 62, page 89</a> . Revised the first paragraph in <a href="#">Configuration Sequence, page 102</a> . Revised the first paragraph in <a href="#">Power-On Behavior, page 111</a> . Revised the second paragraph in <a href="#">Production Stepping, page 112</a> . Revised the first paragraph in <a href="#">Ordering a Later Stepping, page 112</a> .              |
| 10/29/2012 | 4.0     | Added <a href="#">Notice of Disclaimer</a> . This product is not recommended for new designs. Updated the design note section in <a href="#">VARIABLE Phase Shift Mode</a> . Added the VQ100 to the <a href="#">Quadrant Clock Routing</a> section.   |
| 07/19/2013 | 4.1     | Removed banner. This product IS recommended for new designs.  |
| 12/14/2018 | 4.2     | Updated for <a href="#">Lead-Frame Plating Composition Change For Legacy Eutectic Products (XCN18024)</a> .   |

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## DC Electrical Characteristics

In this section, specifications may be designated as Advance, Preliminary, or Production. These terms are defined as follows:

**Advance:** Initial estimates are based on simulation, early characterization, and/or extrapolation from the characteristics of other families. Values are subject to change. Use as estimates, not for production.

**Preliminary:** Based on characterization. Further changes are not expected.

**Production:** These specifications are approved once the silicon has been characterized over numerous production lots. Parameter values are considered stable with no future changes expected.

All parameter limits are representative of worst-case supply voltage and junction temperature conditions. **Unless otherwise noted, the published parameter values apply to all Spartan®-3E devices. AC and DC characteristics are specified using the same numbers for both commercial and industrial grades.**

## Absolute Maximum Ratings

Stresses beyond those listed under [Table 73, Absolute Maximum Ratings](#) may cause permanent damage to the device. These are stress ratings only; functional operation of the device at these or any other conditions beyond those listed under the Recommended Operating Conditions is not implied. Exposure to absolute maximum conditions for extended periods of time adversely affects device reliability.

**Table 73: Absolute Maximum Ratings**

| Symbol                        | Description  | Conditions  | Min              | Max                            | Units                            |  |
|-------------------------------|--|---|------------------|--------------------------------|----------------------------------|--|
| $V_{CCINT}$                   | Internal supply voltage                                    |   | -0.5             | 1.32                           | V                                |  |
| $V_{CCAUX}$                   | Auxiliary supply voltage                                   |   | -0.5             | 3.00                           | V                                |  |
| $V_{CCO}$                     | Output driver supply voltage                               |   | -0.5             | 3.75                           | V                                |  |
| $V_{REF}$                     | Input reference voltage                                    |   | -0.5             | $V_{CCO} + 0.5$ <sup>(1)</sup> | V                                |  |
| $V_{IN}$ <sup>(1,2,3,4)</sup> | Voltage applied to all User I/O pins and Dual-Purpose pins | Driver in a high-impedance state                      | Commercial       | -0.95                          | 4.4                              |  |
|                               |  |   | Industrial       | -0.85                          | 4.3                              |  |
| $I_{IK}$                      | Voltage applied to all Dedicated pins                      |   | All temp. ranges | -0.5                           | $V_{CCAUX} + 0.5$ <sup>(3)</sup> |  |
|                               |  |   |                  |                                | V                                |  |
| $I_{IK}$                      | Input clamp current per I/O pin                            | $-0.5 \text{ V} < V_{IN} < (V_{CCO} + 0.5 \text{ V})$ | -                | $\pm 100$                      | mA                               |  |
| $V_{ESD}$                     | Electrostatic Discharge Voltage                            | Human body model                                      | -                | $\pm 2000$                     | V                                |  |
|                               |  | Charged device model                                  | -                | $\pm 500$                      | V                                |  |
|                               |  | Machine model   | -                | $\pm 200$                      | V                                |  |
| $T_J$                         | Junction temperature                                       |   | -                | 125                            | °C                               |  |
| $T_{STG}$                     | Storage temperature  |   | -65              | 150                            | °C                               |  |

### Notes:

1. Each of the User I/O and Dual-Purpose pins is associated with one of the four banks'  $V_{CCO}$  rails. Keeping  $V_{IN}$  within 500 mV of the associated  $V_{CCO}$  rails or ground rail ensures that the internal diode junctions do not turn on. [Table 77](#) specifies the  $V_{CCO}$  range used to evaluate the maximum  $V_{IN}$  voltage.
2. Input voltages outside the -0.5V to  $V_{CCO} + 0.5$ V (or  $V_{CCAUX} + 0.5$ V) voltage range are require the  $I_{IK}$  input diode clamp diode rating is met and no more than 100 pins exceed the range simultaneously. Prolonged exposure to such current may compromise device reliability. A sustained current of 10 mA will not compromise device reliability. See [XAPP459: Eliminating I/O Coupling Effects when Interfacing Large-Swing Single-Ended Signals to User I/O Pins on Spartan-3 Families](#) for more details.
3. All Dedicated pins (PROG\_B, DONE, TCK, TDI, TDO, and TMS) draw power from the  $V_{CCAUX}$  rail (2.5V). Meeting the  $V_{IN}$  max limit ensures that the internal diode junctions that exist between each of these pins and the  $V_{CCAUX}$  rail do not turn on. [Table 77](#) specifies the  $V_{CCAUX}$  range used to evaluate the maximum  $V_{IN}$  voltage. As long as the  $V_{IN}$  max specification is met, oxide stress is not possible.
4. See [XAPP459: Eliminating I/O Coupling Effects when Interfacing Large-Swing Single-Ended Signals to User I/O Pins on Spartan-3 Families](#).
5. For soldering guidelines, see [UG112: Device Packaging and Thermal Characteristics](#) and [XAPP427: Implementation and Solder Reflow Guidelines for Pb-Free Packages](#).

## Power Supply Specifications

Table 74: Supply Voltage Thresholds for Power-On Reset

| Symbol       | Description                               | Min | Max | Units |
|--------------|---|-----|-----|-------|
| $V_{CCINTT}$ | Threshold for the $V_{CCINT}$ supply      | 0.4 | 1.0 | V     |
| $V_{CCAUXT}$ | Threshold for the $V_{CCAUX}$ supply      | 0.8 | 2.0 | V     |
| $V_{CCO2T}$  | Threshold for the $V_{CCO}$ Bank 2 supply | 0.4 | 1.0 | V     |

**Notes:**

1.  $V_{CCINT}$ ,  $V_{CCAUX}$ , and  $V_{CCO}$  supplies to the FPGA can be applied in any order. However, the FPGA's configuration source (Platform Flash, SPI Flash, parallel NOR Flash, microcontroller) might have specific requirements. Check the data sheet for the attached configuration source. In Step 0 devices using the HSWAP internal pull-up,  $V_{CCINT}$  must be applied before  $V_{CCAUX}$ .
2. To ensure successful power-on,  $V_{CCINT}$ ,  $V_{CCO}$  Bank 2, and  $V_{CCAUX}$  supplies must rise through their respective threshold-voltage ranges with no dips at any point.

Table 75: Supply Voltage Ramp Rate

| Symbol       | Description   | Min | Max | Units |
|--------------|---|-----|-----|-------|
| $V_{CCINTR}$ | Ramp rate from GND to valid $V_{CCINT}$ supply level      | 0.2 | 50  | ms    |
| $V_{CCAUXR}$ | Ramp rate from GND to valid $V_{CCAUX}$ supply level      | 0.2 | 50  | ms    |
| $V_{CCO2R}$  | Ramp rate from GND to valid $V_{CCO}$ Bank 2 supply level | 0.2 | 50  | ms    |

**Notes:**

1.  $V_{CCINT}$ ,  $V_{CCAUX}$ , and  $V_{CCO}$  supplies to the FPGA can be applied in any order. However, the FPGA's configuration source (Platform Flash, SPI Flash, parallel NOR Flash, microcontroller) might have specific requirements. Check the data sheet for the attached configuration source. In Step 0 devices using the HSWAP internal pull-up,  $V_{CCINT}$  must be applied before  $V_{CCAUX}$ .
2. To ensure successful power-on,  $V_{CCINT}$ ,  $V_{CCO}$  Bank 2, and  $V_{CCAUX}$  supplies must rise through their respective threshold-voltage ranges with no dips at any point.

Table 76: Supply Voltage Levels Necessary for Preserving RAM Contents

| Symbol      | Description                                   | Min | Units |
|-------------|---|-----|-------|
| $V_{DRINT}$ | $V_{CCINT}$ level required to retain RAM data | 1.0 | V     |
| $V_{DRAUX}$ | $V_{CCAUX}$ level required to retain RAM data | 2.0 | V     |

**Notes:**

1. RAM contents include configuration data.

## General Recommended Operating Conditions

Table 77: General Recommended Operating Conditions

| Symbol                   | Description  |   |                           | Min   | Nominal | Max               | Units |
|--------------------------|--|---|---------------------------|-------|---------|-------------------|-------|
| $T_J$                    | Junction temperature   |   | Commercial                | 0     | —       | 85                | °C    |
|                          |  |   | Industrial                | -40   | —       | 100               | °C    |
| $V_{CCINT}$              | Internal supply voltage  |   |                           | 1.140 | 1.200   | 1.260             | V     |
| $V_{CCO}$ <sup>(1)</sup> | Output driver supply voltage                                     |   |                           | 1.100 | -       | 3.465             | V     |
| $V_{CCAUX}$              | Auxiliary supply voltage   |   |                           | 2.375 | 2.500   | 2.625             | V     |
| $V_{IN}^{(2,3)}$         | Input voltage extremes to avoid turning on I/O protection diodes | I/O, Input-only, and Dual-Purpose pins <sup>(4)</sup> | IP or IO_#                | -0.5  | —       | $V_{CCO} + 0.5$   | V     |
|                          |  |   | IO_Lxx_y_# <sup>(5)</sup> | -0.5  | —       | $V_{CCO} + 0.5$   | V     |
|                          |  | Dedicated pins <sup>(6)</sup>                         |                           | -0.5  | —       | $V_{CCAUX} + 0.5$ | V     |
| $T_{IN}$                 | Input signal transition time <sup>(7)</sup>                      |   |                           | —     | —       | 500               | ns    |

**Notes:**

1. This  $V_{CCO}$  range spans the lowest and highest operating voltages for all supported I/O standards. Table 80 lists the recommended  $V_{CCO}$  range specific to each of the single-ended I/O standards, and Table 82 lists that specific to the differential standards.
2. Input voltages outside the recommended range require the  $I_{IK}$  input clamp diode rating is met and no more than 100 pins exceed the range simultaneously. Refer to Table 73.
3. See [XAPP459: Eliminating I/O Coupling Effects when Interfacing Large-Swing Single-Ended Signals to User I/O Pins on Spartan-3 Families](#).
4. Each of the User I/O and Dual-Purpose pins is associated with one of the four banks'  $V_{CCO}$  rails. Meeting the  $V_{IN}$  limit ensures that the internal diode junctions that exist between these pins and their associated  $V_{CCO}$  and GND rails do not turn on. The absolute maximum rating is provided in Table 73.
5. For single-ended signals that are placed on a differential-capable I/O,  $V_{IN}$  of -0.2V to -0.5V is supported but can cause increased leakage between the two pins. See *Parasitic Leakage* in [UG331, Spartan-3 Generation FPGA User Guide](#).
6. All Dedicated pins (PROG\_B, DONE, TCK, TDI, TDO, and TMS) draw power from the  $V_{CCAUX}$  rail (2.5V). Meeting the  $V_{IN}$  max limit ensures that the internal diode junctions that exist between each of these pins and the  $V_{CCAUX}$  and GND rails do not turn on.
7. Measured between 10% and 90%  $V_{CCO}$ . Follow [Signal Integrity](#) recommendations.

## General DC Characteristics for I/O Pins

Table 78: General DC Characteristics of User I/O, Dual-Purpose, and Dedicated Pins

| Symbol          | Description   | Test Conditions   | Min   | Typ | Max   | Units     |
|-----------------|---|---|-------|-----|-------|-----------|
| $I_L^{(3)}$     | Leakage current at User I/O, Input-only, Dual-Purpose, and Dedicated pins   | Driver is in a high-impedance state, $V_{IN} = 0V$ or $V_{CCO}$ max, sample-tested  | -10   | —   | +10   | $\mu A$   |
| $I_{RPU}^{(2)}$ | Current through pull-up resistor at User I/O, Dual-Purpose, Input-only, and Dedicated pins                                    | $V_{IN} = 0V, V_{CCO} = 3.3V$   | -0.36 | —   | -1.24 | $mA$      |
|                 |   | $V_{IN} = 0V, V_{CCO} = 2.5V$   | -0.22 | —   | -0.80 | $mA$      |
|                 |   | $V_{IN} = 0V, V_{CCO} = 1.8V$   | -0.10 | —   | -0.42 | $mA$      |
|                 |   | $V_{IN} = 0V, V_{CCO} = 1.5V$   | -0.06 | —   | -0.27 | $mA$      |
|                 |   | $V_{IN} = 0V, V_{CCO} = 1.2V$   | -0.04 | —   | -0.22 | $mA$      |
| $R_{PU}^{(2)}$  | Equivalent pull-up resistor value at User I/O, Dual-Purpose, Input-only, and Dedicated pins (based on $I_{RPU}$ per Note 2)   | $V_{IN} = 0V, V_{CCO} = 3.0V$ to $3.465V$   | 2.4   | —   | 10.8  | $k\Omega$ |
|                 |   | $V_{IN} = 0V, V_{CCO} = 2.3V$ to $2.7V$   | 2.7   | —   | 11.8  | $k\Omega$ |
|                 |   | $V_{IN} = 0V, V_{CCO} = 1.7V$ to $1.9V$   | 4.3   | —   | 20.2  | $k\Omega$ |
|                 |   | $V_{IN} = 0V, V_{CCO} = 1.4V$ to $1.6V$   | 5.0   | —   | 25.9  | $k\Omega$ |
|                 |   | $V_{IN} = 0V, V_{CCO} = 1.14V$ to $1.26V$   | 5.5   | —   | 32.0  | $k\Omega$ |
| $I_{RPD}^{(2)}$ | Current through pull-down resistor at User I/O, Dual-Purpose, Input-only, and Dedicated pins                                  | $V_{IN} = V_{CCO}$  | 0.10  | —   | 0.75  | $mA$      |
| $R_{PD}^{(2)}$  | Equivalent pull-down resistor value at User I/O, Dual-Purpose, Input-only, and Dedicated pins (based on $I_{RPD}$ per Note 2) | $V_{IN} = V_{CCO} = 3.0V$ to $3.465V$   | 4.0   | —   | 34.5  | $k\Omega$ |
|                 |   | $V_{IN} = V_{CCO} = 2.3V$ to $2.7V$   | 3.0   | —   | 27.0  | $k\Omega$ |
|                 |   | $V_{IN} = V_{CCO} = 1.7V$ to $1.9V$   | 2.3   | —   | 19.0  | $k\Omega$ |
|                 |   | $V_{IN} = V_{CCO} = 1.4V$ to $1.6V$   | 1.8   | —   | 16.0  | $k\Omega$ |
|                 |   | $V_{IN} = V_{CCO} = 1.14V$ to $1.26V$   | 1.5   | —   | 12.6  | $k\Omega$ |
| $I_{REF}$       | $V_{REF}$ current per pin   | All $V_{CCO}$ levels  | -10   | —   | +10   | $\mu A$   |
| $C_{IN}$        | Input capacitance   | —   | —     | —   | 10    | $pF$      |
| $R_{DT}$        | Resistance of optional differential termination circuit within a differential I/O pair. Not available on Input-only pairs.    | $V_{OCM} \text{ Min} \leq V_{ICM} \leq V_{OCM} \text{ Max}$<br>$V_{OD} \text{ Min} \leq V_{ID} \leq V_{OD} \text{ Max}$<br>$V_{CCO} = 2.5V$ | —     | 120 | —     | $\Omega$  |

### Notes:

1. The numbers in this table are based on the conditions set forth in [Table 77](#).
2. This parameter is based on characterization. The pull-up resistance  $R_{PU} = V_{CCO} / I_{RPU}$ . The pull-down resistance  $R_{PD} = V_{IN} / I_{RPD}$ .
3. For single-ended signals that are placed on a differential-capable I/O,  $V_{IN}$  of  $-0.2V$  to  $-0.5V$  is supported but can cause increased leakage between the two pins. See *Parasitic Leakage* in [UG331](#), *Spartan-3 Generation FPGA User Guide*.

## Quiescent Current Requirements

Table 79: Quiescent Supply Current Characteristics

| Symbol       | Description                          | Device    | Typical | Commercial Maximum <sup>(1)</sup> | Industrial Maximum <sup>(1)</sup> | Units |
|--------------|--------------------------------------|-----------|---------|-----------------------------------|-----------------------------------|-------|
| $I_{CCINTQ}$ | Quiescent $V_{CCINT}$ supply current | XC3S100E  | 8       | 27                                | 36                                | mA    |
|              |                                      | XC3S250E  | 15      | 78                                | 104                               | mA    |
|              |                                      | XC3S500E  | 25      | 106                               | 145                               | mA    |
|              |                                      | XC3S1200E | 50      | 259                               | 324                               | mA    |
|              |                                      | XC3S1600E | 65      | 366                               | 457                               | mA    |
| $I_{CCOQ}$   | Quiescent $V_{CCO}$ supply current   | XC3S100E  | 0.8     | 1.0                               | 1.5                               | mA    |
|              |                                      | XC3S250E  | 0.8     | 1.0                               | 1.5                               | mA    |
|              |                                      | XC3S500E  | 0.8     | 1.0                               | 1.5                               | mA    |
|              |                                      | XC3S1200E | 1.5     | 2.0                               | 2.5                               | mA    |
|              |                                      | XC3S1600E | 1.5     | 2.0                               | 2.5                               | mA    |
| $I_{CCAUXQ}$ | Quiescent $V_{CCAUX}$ supply current | XC3S100E  | 8       | 12                                | 13                                | mA    |
|              |                                      | XC3S250E  | 12      | 22                                | 26                                | mA    |
|              |                                      | XC3S500E  | 18      | 31                                | 34                                | mA    |
|              |                                      | XC3S1200E | 35      | 52                                | 59                                | mA    |
|              |                                      | XC3S1600E | 45      | 76                                | 86                                | mA    |

### Notes:

1. The maximum numbers in this table indicate the minimum current each power rail requires in order for the FPGA to power-on successfully.
2. The numbers in this table are based on the conditions set forth in [Table 77](#).
3. Quiescent supply current is measured with all I/O drivers in a high-impedance state and with all pull-up/pull-down resistors at the I/O pads disabled. Typical values are characterized using typical devices at room temperature ( $T_J$  of 25°C at  $V_{CCINT} = 1.2$  V,  $V_{CCO} = 3.3$  V, and  $V_{CCAUX} = 2.5$  V). The maximum limits are tested for each device at the respective maximum specified junction temperature and at maximum voltage limits with  $V_{CCINT} = 1.26$  V,  $V_{CCO} = 3.465$  V, and  $V_{CCAUX} = 2.625$  V. The FPGA is programmed with a “blank” configuration data file (i.e., a design with no functional elements instantiated). For conditions other than those described above, (e.g., a design including functional elements), measured quiescent current levels may be different than the values in the table. For more accurate estimates for a specific design, use the Xilinx® XPower tools.
4. There are two recommended ways to estimate the total power consumption (quiescent plus dynamic) for a specific design: a) The [Spartan-3E XPower Estimator](#) provides quick, approximate, typical estimates, and does not require a netlist of the design. b) XPower Analyzer uses a netlist as input to provide maximum estimates as well as more accurate typical estimates.

## Single-Ended I/O Standards

Table 80: Recommended Operating Conditions for User I/Os Using Single-Ended Standards

| IOSTANDARD Attribute      | V <sub>CCO</sub> for Drivers <sup>(2)</sup> |         |         | V <sub>REF</sub>                                     |         |         | V <sub>IL</sub>          | V <sub>IH</sub> <sup>(3)</sup> |
|---------------------------|---|---------|---------|--|---------|---------|--------------------------|--------------------------------|
|                           | Min (V)                                     | Nom (V) | Max (V) | Min (V)  | Nom (V) | Max (V) | Max (V)                  | Min (V)                        |
| LVTTL                     | 3.0   | 3.3     | 3.465   | V <sub>REF</sub> is not used for these I/O standards |         |         | 0.8                      | 2.0                            |
| LVCMOS33 <sup>(4)</sup>   | 3.0   | 3.3     | 3.465   |  |         |         | 0.8                      | 2.0                            |
| LVCMOS25 <sup>(4,5)</sup> | 2.3   | 2.5     | 2.7     |  |         |         | 0.7                      | 1.7                            |
| LVCMOS18                  | 1.65  | 1.8     | 1.95    |  |         |         | 0.4                      | 0.8                            |
| LVCMOS15                  | 1.4   | 1.5     | 1.6     |  |         |         | 0.4                      | 0.8                            |
| LVCMOS12                  | 1.1   | 1.2     | 1.3     |  |         |         | 0.4                      | 0.7                            |
| PCI33_3 <sup>(6)</sup>    | 3.0   | 3.3     | 3.465   |  |         |         | 0.3 • V <sub>CCO</sub>   | 0.5 • V <sub>CCO</sub>         |
| PCI66_3 <sup>(6)</sup>    | 3.0   | 3.3     | 3.465   |  |         |         | 0.3 • V <sub>CCO</sub>   | 0.5 • V <sub>CCO</sub>         |
| HSTL_I_18                 | 1.7   | 1.8     | 1.9     | 0.8  | 0.9     | 1.1     | V <sub>REF</sub> - 0.1   | V <sub>REF</sub> + 0.1         |
| HSTL_III_18               | 1.7   | 1.8     | 1.9     | -  | 1.1     | -       | V <sub>REF</sub> - 0.1   | V <sub>REF</sub> + 0.1         |
| SSTL18_I                  | 1.7   | 1.8     | 1.9     | 0.833  | 0.900   | 0.969   | V <sub>REF</sub> - 0.125 | V <sub>REF</sub> + 0.125       |
| SSTL2_I                   | 2.3   | 2.5     | 2.7     | 1.15   | 1.25    | 1.35    | V <sub>REF</sub> - 0.125 | V <sub>REF</sub> + 0.125       |

### Notes:

1. Descriptions of the symbols used in this table are as follows:
  - V<sub>CCO</sub> – the supply voltage for output drivers
  - V<sub>REF</sub> – the reference voltage for setting the input switching threshold
  - V<sub>IL</sub> – the input voltage that indicates a Low logic level
  - V<sub>IH</sub> – the input voltage that indicates a High logic level
2. The V<sub>CCO</sub> rails supply only output drivers, not input circuits.
3. For device operation, the maximum signal voltage (V<sub>IH</sub> max) may be as high as V<sub>IN</sub> max. See Table 73.
4. There is approximately 100 mV of hysteresis on inputs using LVCMOS33 and LVCMOS25 I/O standards.
5. All Dedicated pins (PROG\_B, DONE, TCK, TDI, TDO, and TMS) use the LVCMOS25 standard and draw power from the V<sub>CCAUX</sub> rail (2.5V). The Dual-Purpose configuration pins use the LVCMOS standard before the User mode. When using these pins as part of a standard 2.5V configuration interface, apply 2.5V to the V<sub>CCO</sub> lines of Banks 0, 1, and 2 at power-on as well as throughout configuration.
6. For information on PCI IP solutions, see [www.xilinx.com/pci](http://www.xilinx.com/pci). The PCIX IOSTANDARD is available and has equivalent characteristics but no PCI-X IP is supported.

Table 81: DC Characteristics of User I/Os Using Single-Ended Standards

| IOSTANDARD Attribute    | Test Conditions |               | Logic Level Characteristics |                  |                 |
|-------------------------|-----------------|---------------|-----------------------------|------------------|-----------------|
|                         | $I_{OL}$ (mA)   | $I_{OH}$ (mA) | $V_{OL}$ Max (V)            | $V_{OH}$ Min (V) |                 |
| LVTTL <sup>(3)</sup>    | 2               | 2             | -2                          | 0.4              | 2.4             |
|                         | 4               | 4             | -4                          |                  |                 |
|                         | 6               | 6             | -6                          |                  |                 |
|                         | 8               | 8             | -8                          |                  |                 |
|                         | 12              | 12            | -12                         |                  |                 |
|                         | 16              | 16            | -16                         |                  |                 |
| LVCMOS33 <sup>(3)</sup> | 2               | 2             | -2                          | 0.4              | $V_{CCO} - 0.4$ |
|                         | 4               | 4             | -4                          |                  |                 |
|                         | 6               | 6             | -6                          |                  |                 |
|                         | 8               | 8             | -8                          |                  |                 |
|                         | 12              | 12            | -12                         |                  |                 |
|                         | 16              | 16            | -16                         |                  |                 |
| LVCMOS25 <sup>(3)</sup> | 2               | 2             | -2                          | 0.4              | $V_{CCO} - 0.4$ |
|                         | 4               | 4             | -4                          |                  |                 |
|                         | 6               | 6             | -6                          |                  |                 |
|                         | 8               | 8             | -8                          |                  |                 |
|                         | 12              | 12            | -12                         |                  |                 |
| LVCMOS18 <sup>(3)</sup> | 2               | 2             | -2                          | 0.4              | $V_{CCO} - 0.4$ |
|                         | 4               | 4             | -4                          |                  |                 |
|                         | 6               | 6             | -6                          |                  |                 |
|                         | 8               | 8             | -8                          |                  |                 |
| LVCMOS15 <sup>(3)</sup> | 2               | 2             | -2                          | 0.4              | $V_{CCO} - 0.4$ |
|                         | 4               | 4             | -4                          |                  |                 |
|                         | 6               | 6             | -6                          |                  |                 |
| LVCMOS12 <sup>(3)</sup> | 2               | 2             | -2                          | 0.4              | $V_{CCO} - 0.4$ |
| PCI33_3 <sup>(4)</sup>  | 1.5             | -0.5          | 10% $V_{CCO}$               | 90% $V_{CCO}$    |                 |
| PCI66_3 <sup>(4)</sup>  | 1.5             | -0.5          | 10% $V_{CCO}$               | 90% $V_{CCO}$    |                 |
| HSTL_I_18               | 8               | -8            | 0.4                         | $V_{CCO} - 0.4$  |                 |
| HSTL_III_18             | 24              | -8            | 0.4                         | $V_{CCO} - 0.4$  |                 |
| SSTL18_I                | 6.7             | -6.7          | $V_{TT} - 0.475$            | $V_{TT} + 0.475$ |                 |

Table 81: DC Characteristics of User I/Os Using Single-Ended Standards (Cont'd)

| IOSTANDARD Attribute | Test Conditions |               | Logic Level Characteristics |                  |
|----------------------|-----------------|---------------|-----------------------------|------------------|
|                      | $I_{OL}$ (mA)   | $I_{OH}$ (mA) | $V_{OL}$ Max (V)            | $V_{OH}$ Min (V) |
| SSTL2_I              | 8.1             | -8.1          | $V_{TT} - 0.61$             | $V_{TT} + 0.61$  |

**Notes:**

1. The numbers in this table are based on the conditions set forth in Table 77 and Table 80.
2. Descriptions of the symbols used in this table are as follows:  
 $I_{OL}$  – the output current condition under which  $V_{OL}$  is tested  
 $I_{OH}$  – the output current condition under which  $V_{OH}$  is tested  
 $V_{OL}$  – the output voltage that indicates a Low logic level  
 $V_{OH}$  – the output voltage that indicates a High logic level  
 $V_{CCO}$  – the supply voltage for output drivers  
 $V_{TT}$  – the voltage applied to a resistor termination
3. For the LVCMOS and LVTTL standards: the same  $V_{OL}$  and  $V_{OH}$  limits apply for both the Fast and Slow slew attributes.
4. Tested according to the relevant PCI specifications. For information on PCI IP solutions, see [www.xilinx.com/pci](http://www.xilinx.com/pci). The PCIX IOSTANDARD is available and has equivalent characteristics but no PCI-X IP is supported.

## Differential I/O Standards

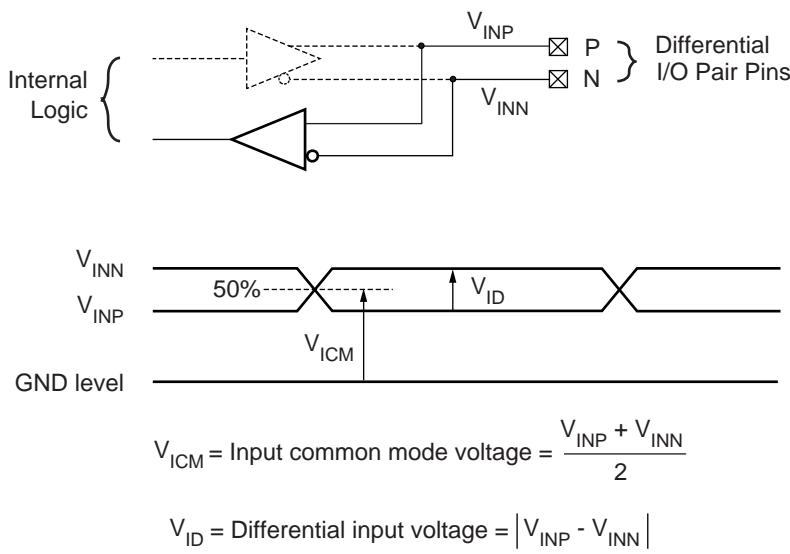


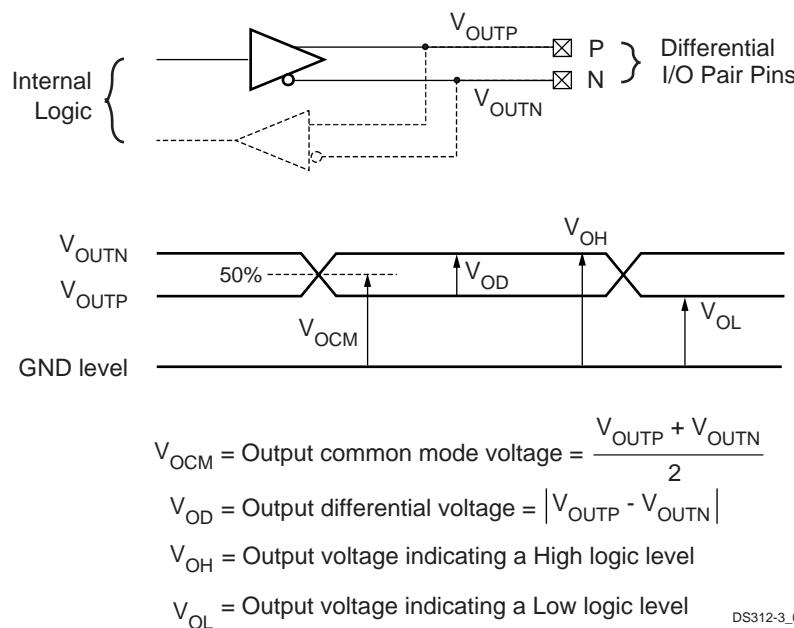
Figure 69: Differential Input Voltages

Table 82: Recommended Operating Conditions for User I/Os Using Differential Signal Standards

| IOSTANDARD Attribute     | V <sub>CCO</sub> for Drivers <sup>(1)</sup> |         |         | V <sub>ID</sub> |          |          | V <sub>ICM</sub> |         |         |
|--------------------------|---|---------|---------|-----------------|----------|----------|------------------|---------|---------|
|                          | Min (V)                                     | Nom (V) | Max (V) | Min (mV)        | Nom (mV) | Max (mV) | Min (V)          | Nom (V) | Max (V) |
| LVDS_25                  | 2.375                                       | 2.50    | 2.625   | 100             | 350      | 600      | 0.30             | 1.25    | 2.20    |
| BLVDS_25                 | 2.375                                       | 2.50    | 2.625   | 100             | 350      | 600      | 0.30             | 1.25    | 2.20    |
| MINI_LVDS_25             | 2.375                                       | 2.50    | 2.625   | 200             | -        | 600      | 0.30             | -       | 2.2     |
| LVPECL_25 <sup>(2)</sup> | Inputs Only                                 |         |         | 100             | 800      | 1000     | 0.5              | 1.2     | 2.0     |
| RSDS_25                  | 2.375                                       | 2.50    | 2.625   | 100             | 200      | -        | 0.3              | 1.20    | 1.4     |
| DIFF_HSTL_I_18           | 1.7   | 1.8     | 1.9     | 100             | -        | -        | 0.8              | -       | 1.1     |
| DIFF_HSTL_III_18         | 1.7   | 1.8     | 1.9     | 100             | -        | -        | 0.8              | -       | 1.1     |
| DIFF_SSTL18_I            | 1.7   | 1.8     | 1.9     | 100             | -        | -        | 0.7              | -       | 1.1     |
| DIFF_SSTL2_I             | 2.3   | 2.5     | 2.7     | 100             | -        | -        | 1.0              | -       | 1.5     |

**Notes:**

1. The V<sub>CCO</sub> rails supply only differential output drivers, not input circuits.
2. V<sub>REF</sub> inputs are not used for any of the differential I/O standards.



**Figure 70: Differential Output Voltages**

Table 83: DC Characteristics of User I/Os Using Differential Signal Standards

| IOSTANDARD Attribute | V <sub>OD</sub> |          |          | ΔV <sub>OD</sub> |          | V <sub>OCM</sub> |         |         | ΔV <sub>OCM</sub> |          | V <sub>OH</sub>         | V <sub>OL</sub>         |
|----------------------|-----------------|----------|----------|------------------|----------|------------------|---------|---------|-------------------|----------|-------------------------|-------------------------|
|                      | Min (mV)        | Typ (mV) | Max (mV) | Min (mV)         | Max (mV) | Min (V)          | Typ (V) | Max (V) | Min (mV)          | Max (mV) | Min (V)                 | Max (V)                 |
| LVDS_25              | 250             | 350      | 450      | —                | —        | 1.125            | —       | 1.375   | —                 | —        | —                       | —                       |
| BLVDS_25             | 250             | 350      | 450      | —                | —        | —                | 1.20    | —       | —                 | —        | —                       | —                       |
| MINI_LVDS_25         | 300             | —        | 600      | —                | 50       | 1.0              | —       | 1.4     | —                 | 50       | —                       | —                       |
| RSDS_25              | 100             | —        | 400      | —                | —        | 1.1              | —       | 1.4     | —                 | —        | —                       | —                       |
| DIFF_HSTL_I_18       | —               | —        | —        | —                | —        | —                | —       | —       | —                 | —        | V <sub>CCO</sub> – 0.4  | 0.4                     |
| DIFF_HSTL_III_18     | —               | —        | —        | —                | —        | —                | —       | —       | —                 | —        | V <sub>CCO</sub> – 0.4  | 0.4                     |
| DIFF_SSTL18_I        | —               | —        | —        | —                | —        | —                | —       | —       | —                 | —        | V <sub>TT</sub> + 0.475 | V <sub>TT</sub> – 0.475 |
| DIFF_SSTL2_I         | —               | —        | —        | —                | —        | —                | —       | —       | —                 | —        | V <sub>TT</sub> + 0.61  | V <sub>TT</sub> – 0.61  |

## Notes:

1. The numbers in this table are based on the conditions set forth in [Table 77](#) and [Table 82](#).
2. Output voltage measurements for all differential standards are made with a termination resistor ( $R_T$ ) of  $100\Omega$  across the N and P pins of the differential signal pair. The exception is for BLVDS, shown in [Figure 71](#).
3. At any given time, no more than two of the following differential output standards may be assigned to an I/O bank: LVDS\_25, RSDS\_25, MINI\_LVDS\_25

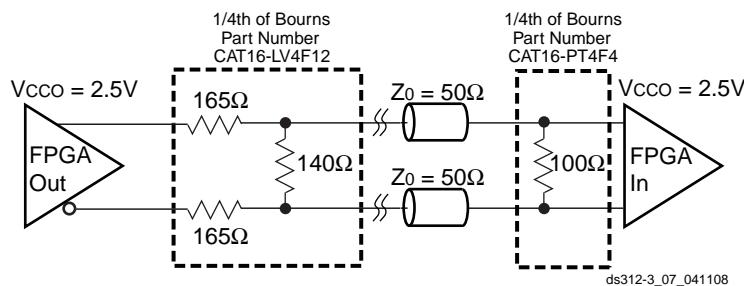


Figure 71: External Termination Resistors for BLVDS Transmitter and BLVDS Receiver

## Switching Characteristics

All Spartan-3E FPGAs ship in two speed grades: -4 and the higher performance -5. Switching characteristics in this document may be designated as Advance, Preliminary, or Production, as shown in [Table 84](#). Each category is defined as follows:

**Advance:** These specifications are based on simulations only and are typically available soon after establishing FPGA specifications. Although speed grades with this designation are considered relatively stable and conservative, some under-reporting might still occur.

**Preliminary:** These specifications are based on complete early silicon characterization. Devices and speed grades with this designation are intended to give a better indication of the expected performance of production silicon. The probability of under-reporting preliminary delays is greatly reduced compared to Advance data.

**Production:** These specifications are approved once enough production silicon of a particular device family member has been characterized to provide full correlation between speed files and devices over numerous production lots. There is no under-reporting of delays, and customers receive formal notification of any subsequent changes. Typically, the slowest speed grades transition to Production before faster speed grades.

## Software Version Requirements

Production-quality systems must use FPGA designs compiled using a speed file designated as PRODUCTION status. FPGAs designs using a less mature speed file designation should only be used during system prototyping or pre-production qualification. FPGA designs with speed files designated as Advance or Preliminary should not be used in a production-quality system.

Whenever a speed file designation changes, as a device matures toward Production status, rerun the latest Xilinx ISE software on the FPGA design to ensure that the FPGA design incorporates the latest timing information and software updates.

All parameter limits are representative of worst-case supply voltage and junction temperature conditions. **Unless otherwise noted, the published parameter values apply to all Spartan-3E devices. AC and DC characteristics are specified using the same numbers for both commercial and industrial grades.**

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Timing parameters and their representative values are selected for inclusion below either because they are important as general design requirements or they indicate fundamental device performance characteristics. The Spartan-3E speed files (v1.27), part of the Xilinx Development Software, are the original source for many but not all of the values. The speed grade designations for these files are shown in [Table 84](#). For more complete, more precise, and worst-case data, use the values reported by the Xilinx static timing analyzer (TRACE in the Xilinx development software) and back-annotated to the simulation netlist.

*Table 84: Spartan-3E v1.27 Speed Grade Designations*

| Device    | Advance | Preliminary | Production   |
|-----------|---------|-------------|--------------|
| XC3S100E  |         |             | -MIN, -4, -5 |
| XC3S250E  |         |             | -MIN, -4, -5 |
| XC3S500E  |         |             | -MIN, -4, -5 |
| XC3S1200E |         |             | -MIN, -4, -5 |
| XC3S1600E |         |             | -MIN, -4, -5 |

[Table 85](#) provides the history of the Spartan-3E speed files since all devices reached Production status.

*Table 85: Spartan-3E Speed File Version History*

| Version | ISE Release | Description  |
|---------|-------------|--|
| 1.27    | 9.2.03i     | Added XA Automotive.   |
| 1.26    | 8.2.02i     | Added -0/-MIN speed grade, which includes minimum values.                          |
| 1.25    | 8.2.01i     | Added XA Automotive devices to speed file. Improved model for left and right DCMs. |
| 1.23    | 8.2i        | Updated input setup/hold values based on default IFD_DELAY_VALUE settings.         |
| 1.21    | 8.1.03i     | All Spartan-3E FPGAs and all speed grades elevated to Production status.           |

## I/O Timing

Table 86: Pin-to-Pin Clock-to-Output Times for the IOB Output Path

| Symbol                       | Description   | Conditions   | Device    | Speed Grade        |                    | Units |
|------------------------------|---|--|-----------|--------------------|--------------------|-------|
|                              |   |  |           | -5                 | -4                 |       |
|                              |   |  |           | Max <sup>(2)</sup> | Max <sup>(2)</sup> |       |
| <b>Clock-to-Output Times</b> |   |  |           |                    |                    |       |
| T <sub>ICKOFDCM</sub>        | When reading from the Output Flip-Flop (OFF), the time from the active transition on the Global Clock pin to data appearing at the Output pin. The DCM is used. | LVC MOS25 <sup>(3)</sup> , 12 mA output drive, Fast slew rate, with DCM <sup>(4)</sup> | XC3S100E  | 2.66               | 2.79               | ns    |
|                              |   |  | XC3S250E  | 3.00               | 3.45               | ns    |
|                              |   |  | XC3S500E  | 3.01               | 3.46               | ns    |
|                              |   |  | XC3S1200E | 3.01               | 3.46               | ns    |
|                              |   |  | XC3S1600E | 3.00               | 3.45               | ns    |
| T <sub>ICKOF</sub>           | When reading from OFF, the time from the active transition on the Global Clock pin to data appearing at the Output pin. The DCM is not used.                    | LVC MOS25 <sup>(3)</sup> , 12 mA output drive, Fast slew rate, without DCM             | XC3S100E  | 5.60               | 5.92               | ns    |
|                              |   |  | XC3S250E  | 4.91               | 5.43               | ns    |
|                              |   |  | XC3S500E  | 4.98               | 5.51               | ns    |
|                              |   |  | XC3S1200E | 5.36               | 5.94               | ns    |
|                              |   |  | XC3S1600E | 5.45               | 6.05               | ns    |

### Notes:

1. The numbers in this table are tested using the methodology presented in [Table 95](#) and are based on the operating conditions set forth in [Table 77](#) and [Table 80](#).
2. For minimums, use the values reported by the Xilinx timing analyzer.
3. This clock-to-output time requires adjustment whenever a signal standard other than LVC MOS25 is assigned to the Global Clock Input or a standard other than LVC MOS25 with 12 mA drive and Fast slew rate is assigned to the data Output. If the former is true, add the appropriate Input adjustment from [Table 91](#). If the latter is true, add the appropriate Output adjustment from [Table 94](#).
4. DCM output jitter is included in all measurements.

Table 87: Pin-to-Pin Setup and Hold Times for the IOB Input Path (System Synchronous)

| Symbol             | Description  | Conditions  | IFD_DELAY_VALUE= | Device    | Speed Grade |       | Units |
|--------------------|--|---|------------------|-----------|-------------|-------|-------|
|                    |  |   |                  |           | -5          | -4    |       |
|                    |  |   |                  |           | Min         | Min   |       |
| <b>Setup Times</b> |  |   |                  |           |             |       |       |
| T <sub>PSDCM</sub> | When writing to the Input Flip-Flop (IFF), the time from the setup of data at the Input pin to the active transition at a Global Clock pin. The DCM is used. No Input Delay is programmed. | LVCMS25 <sup>(2)</sup> , IFD_DELAY_VALUE = 0, with DCM <sup>(3)</sup> | 0                | XC3S100E  | 2.65        | 2.98  | ns    |
|                    |  |   |                  | XC3S250E  | 2.25        | 2.59  | ns    |
|                    |  |   |                  | XC3S500E  | 2.25        | 2.59  | ns    |
|                    |  |   |                  | XC3S1200E | 2.25        | 2.58  | ns    |
|                    |  |   |                  | XC3S1600E | 2.25        | 2.59  | ns    |
| T <sub>PSFD</sub>  | When writing to IFF, the time from the setup of data at the Input pin to an active transition at the Global Clock pin. The DCM is not used. The Input Delay is programmed.                 | LVCMS25 <sup>(2)</sup> , IFD_DELAY_VALUE = default software setting   | 2                | XC3S100E  | 3.16        | 3.58  | ns    |
|                    |  |   |                  | XC3S250E  | 3.44        | 3.91  | ns    |
|                    |  |   |                  | XC3S500E  | 4.00        | 4.73  | ns    |
|                    |  |   |                  | XC3S1200E | 2.60        | 3.31  | ns    |
|                    |  |   |                  | XC3S1600E | 3.33        | 3.77  | ns    |
| <b>Hold Times</b>  |  |   |                  |           |             |       |       |
| T <sub>PHDCM</sub> | When writing to IFF, the time from the active transition at the Global Clock pin to the point when data must be held at the Input pin. The DCM is used. No Input Delay is programmed.      | LVCMS25 <sup>(4)</sup> , IFD_DELAY_VALUE = 0, with DCM <sup>(3)</sup> | 0                | XC3S100E  | -0.54       | -0.52 | ns    |
|                    |  |   |                  | XC3S250E  | 0.06        | 0.14  | ns    |
|                    |  |   |                  | XC3S500E  | 0.07        | 0.14  | ns    |
|                    |  |   |                  | XC3S1200E | 0.07        | 0.15  | ns    |
|                    |  |   |                  | XC3S1600E | 0.06        | 0.14  | ns    |
| T <sub>PHFD</sub>  | When writing to IFF, the time from the active transition at the Global Clock pin to the point when data must be held at the Input pin. The DCM is not used. The Input Delay is programmed. | LVCMS25 <sup>(4)</sup> , IFD_DELAY_VALUE = default software setting   | 2                | XC3S100E  | -0.31       | -0.24 | ns    |
|                    |  |   |                  | XC3S250E  | -0.32       | -0.32 | ns    |
|                    |  |   |                  | XC3S500E  | -0.77       | -0.77 | ns    |
|                    |  |   |                  | XC3S1200E | 0.13        | 0.16  | ns    |
|                    |  |   |                  | XC3S1600E | -0.05       | -0.03 | ns    |

**Notes:**

1. The numbers in this table are tested using the methodology presented in [Table 95](#) and are based on the operating conditions set forth in [Table 77](#) and [Table 80](#).
2. This setup time requires adjustment whenever a signal standard other than LVCMS25 is assigned to the Global Clock Input or the data Input. If this is true of the Global Clock Input, subtract the appropriate adjustment from [Table 91](#). If this is true of the data Input, add the appropriate Input adjustment from the same table.
3. DCM output jitter is included in all measurements.
4. This hold time requires adjustment whenever a signal standard other than LVCMS25 is assigned to the Global Clock Input or the data Input. If this is true of the Global Clock Input, add the appropriate Input adjustment from [Table 91](#). If this is true of the data Input, subtract the appropriate Input adjustment from the same table. When the hold time is negative, it is possible to change the data before the clock's active edge.

Table 88: Setup and Hold Times for the IOB Input Path

| Symbol                       | Description   | Conditions   | IFD_DELAY_VALUE= | Device     | Speed Grade |       | Units |
|------------------------------|---|--|------------------|------------|-------------|-------|-------|
|                              |   |  |                  |            | -5          | -4    |       |
|                              |   |  |                  |            | Min         | Min   |       |
| <b>Setup Times</b>           |   |  |                  |            |             |       |       |
| T <sub>IOPICK</sub>          | Time from the setup of data at the Input pin to the active transition at the ICLK input of the Input Flip-Flop (IFF). No Input Delay is programmed. | LVCMOS25 <sup>(2)</sup> , IFD_DELAY_VALUE = 0                        | 0                | All        | 1.84        | 2.12  | ns    |
| T <sub>IOPICKD</sub>         | Time from the setup of data at the Input pin to the active transition at the IFF's ICLK input. The Input Delay is programmed.                       | LVCMOS25 <sup>(2)</sup> , IFD_DELAY_VALUE = default software setting | 2                | XC3S100E   | 6.12        | 7.01  | ns    |
|                              |   |  | 3                | All Others | 6.76        | 7.72  |       |
| <b>Hold Times</b>            |   |  |                  |            |             |       |       |
| T <sub>IOICKP</sub>          | Time from the active transition at the IFF's ICLK input to the point where data must be held at the Input pin. No Input Delay is programmed.        | LVCMOS25 <sup>(3)</sup> , IFD_DELAY_VALUE = 0                        | 0                | All        | -0.76       | -0.76 | ns    |
| T <sub>IOICKPD</sub>         | Time from the active transition at the IFF's ICLK input to the point where data must be held at the Input pin. The Input Delay is programmed.       | LVCMOS25 <sup>(3)</sup> , IFD_DELAY_VALUE = default software setting | 2                | XC3S100E   | -3.93       | -3.93 | ns    |
|                              |   |  | 3                | All Others | -3.50       | -3.50 |       |
| <b>Set/Reset Pulse Width</b> |   |  |                  |            |             |       |       |
| T <sub>RPW_IOB</sub>         | Minimum pulse width to SR control input on IOB  |  |                  | All        | 1.57        | 1.80  | ns    |

**Notes:**

1. The numbers in this table are tested using the methodology presented in [Table 95](#) and are based on the operating conditions set forth in [Table 77](#) and [Table 80](#).
2. This setup time requires adjustment whenever a signal standard other than LVCMOS25 is assigned to the data Input. If this is true, add the appropriate Input adjustment from [Table 91](#).
3. These hold times require adjustment whenever a signal standard other than LVCMOS25 is assigned to the data Input. If this is true, subtract the appropriate Input adjustment from [Table 91](#). When the hold time is negative, it is possible to change the data before the clock's active edge.

Table 89: Sample Window (Source Synchronous)

| Symbol            | Description   | Max   | Units |
|-------------------|---|---|-------|
| T <sub>SAMP</sub> | Setup and hold capture window of an IOB input flip-flop | The input capture sample window value is highly specific to a particular application, device, package, I/O standard, I/O placement, DCM usage, and clock buffer. Please consult the appropriate Xilinx application note for application-specific values.<br>• <a href="#">XAPP485: 1:7 Deserialization in Spartan-3E FPGAs at Speeds Up to 666 Mbps</a> | ps    |

Table 90: Propagation Times for the IOB Input Path

| Symbol                   | Description   | Conditions   | IFD_DELAY_VALUE= | Device     | Speed Grade |      | Units |
|--------------------------|---|--|------------------|------------|-------------|------|-------|
|                          |   |  |                  |            | -5          | -4   |       |
|                          |   |  |                  |            | Min         | Min  |       |
| <b>Propagation Times</b> |   |  |                  |            |             |      |       |
| T <sub>IOPLI</sub>       | The time it takes for data to travel from the Input pin through the IFF latch to the I output with no input delay programmed  | LVCMOS25 <sup>(2)</sup> , IFD_DELAY_VALUE = 0                        | 0                | All        | 1.96        | 2.25 | ns    |
| T <sub>IOPLID</sub>      | The time it takes for data to travel from the Input pin through the IFF latch to the I output with the input delay programmed | LVCMOS25 <sup>(2)</sup> , IFD_DELAY_VALUE = default software setting | 2                | XC3S100E   | 5.40        | 5.97 | ns    |
|                          |   |  | 3                | All Others | 6.30        | 7.20 |       |

**Notes:**

1. The numbers in this table are tested using the methodology presented in [Table 95](#) and are based on the operating conditions set forth in [Table 77](#) and [Table 80](#).
2. This propagation time requires adjustment whenever a signal standard other than LVCMOS25 is assigned to the data Input. When this is true, add the appropriate Input adjustment from [Table 91](#).

Table 91: Input Timing Adjustments by IOSTANDARD

| Convert Input Time from LVCMOS25 to the Following Signal Standard (IOSTANDARD) | Add the Adjustment Below |      | Units |  |
|--|--------------------------|------|-------|--|
|  | Speed Grade              |      |       |  |
|  | -5                       | -4   |       |  |
| <b>Single-Ended Standards</b>  |                          |      |       |  |
| LVTTL  | 0.42                     | 0.43 | ns    |  |
| LVCMOS33   | 0.42                     | 0.43 | ns    |  |
| LVCMOS25   | 0                        | 0    | ns    |  |
| LVCMOS18   | 0.96                     | 0.98 | ns    |  |
| LVCMOS15   | 0.62                     | 0.63 | ns    |  |
| LVCMOS12   | 0.26                     | 0.27 | ns    |  |
| PCI33_3  | 0.41                     | 0.42 | ns    |  |
| PCI66_3  | 0.41                     | 0.42 | ns    |  |
| HSTL_I_18  | 0.12                     | 0.12 | ns    |  |
| HSTL_III_18  | 0.17                     | 0.17 | ns    |  |
| SSTL18_I   | 0.30                     | 0.30 | ns    |  |
| SSTL2_I  | 0.15                     | 0.15 | ns    |  |

Table 91: Input Timing Adjustments by IOSTANDARD (Cont'd)

| Convert Input Time from LVCMOS25 to the Following Signal Standard (IOSTANDARD) | Add the Adjustment Below |      | Units |  |
|--|--------------------------|------|-------|--|
|  | Speed Grade              |      |       |  |
|  | -5                       | -4   |       |  |
| <b>Differential Standards</b>  |                          |      |       |  |
| LVDS_25  | 0.48                     | 0.49 | ns    |  |
| BLVDS_25   | 0.39                     | 0.39 | ns    |  |
| MINI_LVDS_25   | 0.48                     | 0.49 | ns    |  |
| LVPECL_25  | 0.27                     | 0.27 | ns    |  |
| RSDS_25  | 0.48                     | 0.49 | ns    |  |
| DIFF_HSTL_I_18   | 0.48                     | 0.49 | ns    |  |
| DIFF_HSTL_III_18   | 0.48                     | 0.49 | ns    |  |
| DIFF_SSTL18_I  | 0.30                     | 0.30 | ns    |  |
| DIFF_SSTL2_I   | 0.32                     | 0.32 | ns    |  |

**Notes:**

1. The numbers in this table are tested using the methodology presented in [Table 95](#) and are based on the operating conditions set forth in [Table 77](#), [Table 80](#), and [Table 82](#).
2. These adjustments are used to convert input path times originally specified for the LVCMOS25 standard to times that correspond to other signal standards.

Table 92: Timing for the IOB Output Path

| Symbol                       | Description   | Conditions  | Device | Speed Grade |      | Units |
|------------------------------|---|---|--------|-------------|------|-------|
|                              |   |   |        | -5          | -4   |       |
|                              |   |   |        | Min         | Min  |       |
| <b>Clock-to-Output Times</b> |   |   |        |             |      |       |
| T <sub>IOCKP</sub>           | When reading from the Output Flip-Flop (OFF), the time from the active transition at the OCLK input to data appearing at the Output pin | LVC MOS25 <sup>(2)</sup> , 12 mA output drive, Fast slew rate | All    | 2.18        | 2.50 | ns    |
| <b>Propagation Times</b>     |   |   |        |             |      |       |
| T <sub>IOOP</sub>            | The time it takes for data to travel from the IOB's O input to the Output pin   | LVC MOS25 <sup>(2)</sup> , 12 mA output drive, Fast slew rate | All    | 2.24        | 2.58 | ns    |
| T <sub>IOOLP</sub>           | The time it takes for data to travel from the O input through the OFF latch to the Output pin   | LVC MOS25 <sup>(2)</sup> , 12 mA output drive, Fast slew rate | All    | 2.32        | 2.67 | ns    |
| <b>Set/Reset Times</b>       |   |   |        |             |      |       |
| T <sub>IOSRP</sub>           | Time from asserting the OFF's SR input to setting/resetting data at the Output pin  | LVC MOS25 <sup>(2)</sup> , 12 mA output drive, Fast slew rate | All    | 3.27        | 3.76 | ns    |
| T <sub>IOGSRQ</sub>          | Time from asserting the Global Set Reset (GSR) input on the STARTUP_SPARTAN3E primitive to setting/resetting data at the Output pin     |   |        | 8.40        | 9.65 | ns    |

**Notes:**

1. The numbers in this table are tested using the methodology presented in [Table 95](#) and are based on the operating conditions set forth in [Table 77](#) and [Table 80](#).
2. This time requires adjustment whenever a signal standard other than LVC MOS25 with 12 mA drive and Fast slew rate is assigned to the data Output. When this is true, *add* the appropriate Output adjustment from [Table 94](#).
3. For minimum delays use the values reported by the Timing Analyzer.

Table 93: Timing for the IOB Three-State Path

| Symbol  | Description  | Conditions                                  | Device | Speed Grade |      | Units |
|---|--|---|--------|-------------|------|-------|
|   |  |   |        | -5          | -4   |       |
|   |  |   |        | Max         | Max  |       |
| <b>Synchronous Output Enable/Disable Times</b>  |  |   |        |             |      |       |
| T <sub>LOCKHZ</sub>                             | Time from the active transition at the OTCLK input of the Three-state Flip-Flop (TFF) to when the Output pin enters the high-impedance state     | LVCMS25, 12 mA output drive, Fast slew rate | All    | 1.49        | 1.71 | ns    |
| T <sub>LOCKON</sub> <sup>(2)</sup>              | Time from the active transition at TFF's OTCLK input to when the Output pin drives valid data  |   | All    | 2.70        | 3.10 | ns    |
| <b>Asynchronous Output Enable/Disable Times</b> |  |   |        |             |      |       |
| T <sub>GTS</sub>                                | Time from asserting the Global Three State (GTS) input on the STARTUP_SPARTAN3E primitive to when the Output pin enters the high-impedance state | LVCMS25, 12 mA output drive, Fast slew rate | All    | 8.52        | 9.79 | ns    |
| <b>Set/Reset Times</b>                          |  |   |        |             |      |       |
| T <sub>IOSRHZ</sub>                             | Time from asserting TFF's SR input to when the Output pin enters a high-impedance state  | LVCMS25, 12 mA output drive, Fast slew rate | All    | 2.11        | 2.43 | ns    |
| T <sub>IOSRON</sub> <sup>(2)</sup>              | Time from asserting TFF's SR input at TFF to when the Output pin drives valid data   |   | All    | 3.32        | 3.82 | ns    |

**Notes:**

1. The numbers in this table are tested using the methodology presented in [Table 95](#) and are based on the operating conditions set forth in [Table 77](#) and [Table 80](#).
2. This time requires adjustment whenever a signal standard other than LVCMS25 with 12 mA drive and Fast slew rate is assigned to the data Output. When this is true, add the appropriate Output adjustment from [Table 94](#).
3. For minimum delays use the values reported by the Timing Analyzer.

Table 94: Output Timing Adjustments for IOB

| Convert Output Time from LVC MOS25 with 12mA Drive and Fast Slew Rate to the Following Signal Standard (IOSTANDARD) |      | Add the Adjustment Below |      | Units |    |
|---|------|--------------------------|------|-------|----|
|   |      | Speed Grade              |      |       |    |
|   |      | -5                       | -4   |       |    |
| <b>Single-Ended Standards</b>   |      |                          |      |       |    |
| LVTTL   | Slow | 2 mA                     | 5.20 | 5.41  | ns |
|   |      | 4 mA                     | 2.32 | 2.41  | ns |
|   |      | 6 mA                     | 1.83 | 1.90  | ns |
|   |      | 8 mA                     | 0.64 | 0.67  | ns |
|   |      | 12 mA                    | 0.68 | 0.70  | ns |
|   |      | 16 mA                    | 0.41 | 0.43  | ns |
|   | Fast | 2 mA                     | 4.80 | 5.00  | ns |
|   |      | 4 mA                     | 1.88 | 1.96  | ns |
|   |      | 6 mA                     | 1.39 | 1.45  | ns |
|   |      | 8 mA                     | 0.32 | 0.34  | ns |
|   |      | 12 mA                    | 0.28 | 0.30  | ns |
|   |      | 16 mA                    | 0.28 | 0.30  | ns |
| LVC MOS33   | Slow | 2 mA                     | 5.08 | 5.29  | ns |
|   |      | 4 mA                     | 1.82 | 1.89  | ns |
|   |      | 6 mA                     | 1.00 | 1.04  | ns |
|   |      | 8 mA                     | 0.66 | 0.69  | ns |
|   |      | 12 mA                    | 0.40 | 0.42  | ns |
|   |      | 16 mA                    | 0.41 | 0.43  | ns |
|   | Fast | 2 mA                     | 4.68 | 4.87  | ns |
|   |      | 4 mA                     | 1.46 | 1.52  | ns |
|   |      | 6 mA                     | 0.38 | 0.39  | ns |
|   |      | 8 mA                     | 0.33 | 0.34  | ns |
|   |      | 12 mA                    | 0.28 | 0.30  | ns |
|   |      | 16 mA                    | 0.28 | 0.30  | ns |
| LVC MOS25   | Slow | 2 mA                     | 4.04 | 4.21  | ns |
|   |      | 4 mA                     | 2.17 | 2.26  | ns |
|   |      | 6 mA                     | 1.46 | 1.52  | ns |
|   |      | 8 mA                     | 1.04 | 1.08  | ns |
|   |      | 12 mA                    | 0.65 | 0.68  | ns |
|   |      | 2 mA                     | 3.53 | 3.67  | ns |
|   | Fast | 4 mA                     | 1.65 | 1.72  | ns |
|   |      | 6 mA                     | 0.44 | 0.46  | ns |
|   |      | 8 mA                     | 0.20 | 0.21  | ns |
|   |      | 12 mA                    | 0    | 0     | ns |

Table 94: Output Timing Adjustments for IOB (Cont'd)

| Convert Output Time from LVC MOS25 with 12mA Drive and Fast Slew Rate to the Following Signal Standard (IOSTANDARD) |      | Add the Adjustment Below |            | Units |  |
|---|------|--------------------------|------------|-------|--|
|   |      | Speed Grade              |            |       |  |
|   |      | -5                       | -4         |       |  |
| LVC MOS18   | Slow | 2 mA                     | 5.03       | 5.24  |  |
|   |      | 4 mA                     | 3.08       | 3.21  |  |
|   |      | 6 mA                     | 2.39       | 2.49  |  |
|   |      | 8 mA                     | 1.83       | 1.90  |  |
|   | Fast | 2 mA                     | 3.98       | 4.15  |  |
|   |      | 4 mA                     | 2.04       | 2.13  |  |
|   |      | 6 mA                     | 1.09       | 1.14  |  |
|   |      | 8 mA                     | 0.72       | 0.75  |  |
| LVC MOS15   | Slow | 2 mA                     | 4.49       | 4.68  |  |
|   |      | 4 mA                     | 3.81       | 3.97  |  |
|   |      | 6 mA                     | 2.99       | 3.11  |  |
|   | Fast | 2 mA                     | 3.25       | 3.38  |  |
|   |      | 4 mA                     | 2.59       | 2.70  |  |
|   |      | 6 mA                     | 1.47       | 1.53  |  |
| LVC MOS12   | Slow | 2 mA                     | 6.36       | 6.63  |  |
|   | Fast | 2 mA                     | 4.26       | 4.44  |  |
| HSTL_I_18   |      |                          | 0.33       | 0.34  |  |
| HSTL_III_18   |      |                          | 0.53       | 0.55  |  |
| PCI33_3   |      |                          | 0.44       | 0.46  |  |
| PCI66_3   |      |                          | 0.44       | 0.46  |  |
| SSTL18_I  |      |                          | 0.24       | 0.25  |  |
| SSTL2_I   |      |                          | -0.20      | -0.20 |  |
| <b>Differential Standards</b>   |      |                          |            |       |  |
| LVDS_25   |      |                          | -0.55      | -0.55 |  |
| BLVDS_25  |      |                          | 0.04       | 0.04  |  |
| MINI_LVDS_25  |      |                          | -0.56      | -0.56 |  |
| LVPECL_25   |      |                          | Input Only |       |  |
| RSDS_25   |      |                          | -0.48      | -0.48 |  |
| DIFF_HSTL_I_18  |      |                          | 0.42       | 0.42  |  |
| DIFF_HSTL_III_18  |      |                          | 0.53       | 0.55  |  |
| DIFF_SSTL18_I   |      |                          | 0.40       | 0.40  |  |
| DIFF_SSTL2_I  |      |                          | 0.44       | 0.44  |  |

**Notes:**

1. The numbers in this table are tested using the methodology presented in Table 95 and are based on the operating conditions set forth in Table 77, Table 80, and Table 82.
2. These adjustments are used to convert output- and three-state-path times originally specified for the LVC MOS25 standard with 12 mA drive and Fast slew rate to times that correspond to other signal standards. Do not adjust times that measure when outputs go into a high-impedance state.

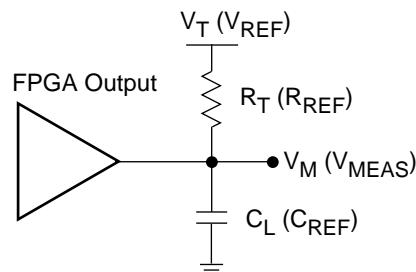
## Timing Measurement Methodology

When measuring timing parameters at the programmable I/Os, different signal standards call for different test conditions. [Table 95](#) lists the conditions to use for each standard.

The method for measuring Input timing is as follows: A signal that swings between a Low logic level of  $V_L$  and a High logic level of  $V_H$  is applied to the Input under test. Some standards also require the application of a bias voltage to the  $V_{REF}$  pins of a given bank to properly set the input-switching threshold. The measurement point of the Input signal ( $V_M$ ) is commonly located halfway between  $V_L$  and  $V_H$ .

The Output test setup is shown in [Figure 72](#). A termination voltage  $V_T$  is applied to the termination resistor  $R_T$ , the other end of which is connected to the Output. For each standard,  $R_T$  and  $V_T$  generally take on the standard values recommended for minimizing signal reflections. If the standard does not ordinarily use terminations (e.g.,

LVC MOS, LV TTL), then  $R_T$  is set to  $1M\Omega$  to indicate an open connection, and  $V_T$  is set to zero. The same measurement point ( $V_M$ ) that was used at the Input is also used at the Output.



ds312-3\_04\_090105

### Notes:

1. The names shown in parentheses are used in the IBIS file.

[Figure 72: Output Test Setup](#)

[Table 95: Test Methods for Timing Measurement at I/Os](#)

| Signal Standard<br>(IOSTANDARD) | Inputs        |                   |                   | Outputs            |           | Inputs and<br>Outputs |      |
|---------------------------------|---------------|-------------------|-------------------|--------------------|-----------|-----------------------|------|
|                                 | $V_{REF}$ (V) | $V_L$ (V)         | $V_H$ (V)         | $R_T$ ( $\Omega$ ) | $V_T$ (V) | $V_M$ (V)             |      |
| <b>Single-Ended</b>             |               |                   |                   |                    |           |                       |      |
| LV TTL                          | -             | 0                 | 3.3               | 1M                 | 0         | 1.4                   |      |
| LVC MOS33                       | -             | 0                 | 3.3               | 1M                 | 0         | 1.65                  |      |
| LVC MOS25                       | -             | 0                 | 2.5               | 1M                 | 0         | 1.25                  |      |
| LVC MOS18                       | -             | 0                 | 1.8               | 1M                 | 0         | 0.9                   |      |
| LVC MOS15                       | -             | 0                 | 1.5               | 1M                 | 0         | 0.75                  |      |
| LVC MOS12                       | -             | 0                 | 1.2               | 1M                 | 0         | 0.6                   |      |
| PCI33_3                         | Rising        | -                 | Note 3            | Note 3             | 25        | 0                     | 0.94 |
|                                 | Falling       |                   |                   |                    | 25        | 3.3                   | 2.03 |
| PCI66_3                         | Rising        | -                 | Note 3            | Note 3             | 25        | 0                     | 0.94 |
|                                 | Falling       |                   |                   |                    | 25        | 3.3                   | 2.03 |
| HSTL_I_18                       | 0.9           | $V_{REF} - 0.5$   | $V_{REF} + 0.5$   | 50                 | 0.9       | $V_{REF}$             |      |
| HSTL_III_18                     | 1.1           | $V_{REF} - 0.5$   | $V_{REF} + 0.5$   | 50                 | 1.8       | $V_{REF}$             |      |
| SSTL18_I                        | 0.9           | $V_{REF} - 0.5$   | $V_{REF} + 0.5$   | 50                 | 0.9       | $V_{REF}$             |      |
| SSTL2_I                         | 1.25          | $V_{REF} - 0.75$  | $V_{REF} + 0.75$  | 50                 | 1.25      | $V_{REF}$             |      |
| <b>Differential</b>             |               |                   |                   |                    |           |                       |      |
| LVDS_25                         | -             | $V_{ICM} - 0.125$ | $V_{ICM} + 0.125$ | 50                 | 1.2       | $V_{ICM}$             |      |
| BLVDS_25                        | -             | $V_{ICM} - 0.125$ | $V_{ICM} + 0.125$ | 1M                 | 0         | $V_{ICM}$             |      |
| MINI_LVDS_25                    | -             | $V_{ICM} - 0.125$ | $V_{ICM} + 0.125$ | 50                 | 1.2       | $V_{ICM}$             |      |
| LVPECL_25                       | -             | $V_{ICM} - 0.3$   | $V_{ICM} + 0.3$   | 1M                 | 0         | $V_{ICM}$             |      |
| RSDS_25                         | -             | $V_{ICM} - 0.1$   | $V_{ICM} + 0.1$   | 50                 | 1.2       | $V_{ICM}$             |      |

Table 95: Test Methods for Timing Measurement at I/Os (Cont'd)

| Signal Standard<br>(IOSTANDARD) | Inputs               |                        |                        | Outputs            |                    | Inputs and<br>Outputs<br>V <sub>M</sub> (V) |
|---------------------------------|----------------------|------------------------|------------------------|--------------------|--------------------|---|
|                                 | V <sub>REF</sub> (V) | V <sub>L</sub> (V)     | V <sub>H</sub> (V)     | R <sub>T</sub> (Ω) | V <sub>T</sub> (V) |   |
| DIFF_HSTL_I_18                  | -                    | V <sub>REF</sub> - 0.5 | V <sub>REF</sub> + 0.5 | 50                 | 0.9                | V <sub>ICM</sub>                            |
| DIFF_HSTL_III_18                | -                    | V <sub>REF</sub> - 0.5 | V <sub>REF</sub> + 0.5 | 50                 | 1.8                | V <sub>ICM</sub>                            |
| DIFF_SSTL18_I                   | -                    | V <sub>REF</sub> - 0.5 | V <sub>REF</sub> + 0.5 | 50                 | 0.9                | V <sub>ICM</sub>                            |
| DIFF_SSTL2_I                    | -                    | V <sub>REF</sub> - 0.5 | V <sub>REF</sub> + 0.5 | 50                 | 1.25               | V <sub>ICM</sub>                            |

**Notes:**

1. Descriptions of the relevant symbols are as follows:
  - V<sub>REF</sub> – The reference voltage for setting the input switching threshold
  - V<sub>ICM</sub> – The common mode input voltage
  - V<sub>M</sub> – Voltage of measurement point on signal transition
  - V<sub>L</sub> – Low-level test voltage at Input pin
  - V<sub>H</sub> – High-level test voltage at Input pin
  - R<sub>T</sub> – Effective termination resistance, which takes on a value of 1MΩ when no parallel termination is required
  - V<sub>T</sub> – Termination voltage
2. The load capacitance (C<sub>L</sub>) at the Output pin is 0 pF for all signal standards.
3. According to the PCI specification.

The capacitive load (C<sub>L</sub>) is connected between the output and GND. *The Output timing for all standards, as published in the speed files and the data sheet, is always based on a C<sub>L</sub> value of zero.* High-impedance probes (less than 1 pF) are used for all measurements. Any delay that the test fixture might contribute to test measurements is subtracted from those measurements to produce the final timing numbers as published in the speed files and data sheet.

## Using IBIS Models to Simulate Load Conditions in Application

IBIS models permit the most accurate prediction of timing delays for a given application. The parameters found in the IBIS model (V<sub>REF</sub>, R<sub>REF</sub>, and V<sub>MEAS</sub>) correspond directly with the parameters used in Table 95 (V<sub>T</sub>, R<sub>T</sub>, and V<sub>M</sub>). Do not confuse V<sub>REF</sub> (the termination voltage) from the IBIS model with V<sub>REF</sub> (the input-switching threshold) from the table. A fourth parameter, C<sub>REF</sub>, is always zero. The four parameters describe all relevant output test conditions. IBIS models are found in the Xilinx development software as well as at the following link:

<http://www.xilinx.com/support/download/index.htm>

Delays for a given application are simulated according to its specific load conditions as follows:

1. Simulate the desired signal standard with the output driver connected to the test setup shown in Figure 72. Use parameter values V<sub>T</sub>, R<sub>T</sub>, and V<sub>M</sub> from Table 95. C<sub>REF</sub> is zero.
2. Record the time to V<sub>M</sub>.
3. Simulate the same signal standard with the output driver connected to the PCB trace with load. Use the appropriate IBIS model (including V<sub>REF</sub>, R<sub>REF</sub>, C<sub>REF</sub>, and V<sub>MEAS</sub> values) or capacitive value to represent the load.
4. Record the time to V<sub>MEAS</sub>.
5. Compare the results of steps 2 and 4. Add (or subtract) the increase (or decrease) in delay to (or from) the appropriate Output standard adjustment (Table 94) to yield the worst-case delay of the PCB trace.

## Simultaneously Switching Output Guidelines

This section provides guidelines for the recommended maximum allowable number of Simultaneous Switching Outputs (SSOs). These guidelines describe the maximum number of user I/O pins of a given output signal standard that should simultaneously switch in the same direction, while maintaining a safe level of switching noise. Meeting these guidelines for the stated test conditions ensures that the FPGA operates free from the adverse effects of ground and power bounce.

Ground or power bounce occurs when a large number of outputs simultaneously switch in the same direction. The output drive transistors all conduct current to a common voltage rail. Low-to-High transitions conduct to the  $V_{CCO}$  rail; High-to-Low transitions conduct to the GND rail. The resulting cumulative current transient induces a voltage difference across the inductance that exists between the die pad and the power supply or ground return. The inductance is associated with bonding wires, the package lead frame, and any other signal routing inside the package. Other variables contribute to SSO noise levels, including stray inductance on the PCB as well as capacitive loading at receivers. Any SSO-induced voltage consequently affects internal switching noise margins and ultimately signal quality.

[Table 96](#) and [Table 97](#) provide the essential SSO guidelines. For each device/package combination, [Table 96](#) provides the number of equivalent  $V_{CCO}$ /GND pairs. The

equivalent number of pairs is based on characterization and might not match the physical number of pairs. For each output signal standard and drive strength, [Table 97](#) recommends the maximum number of SSOs, switching in the same direction, allowed per  $V_{CCO}$ /GND pair within an I/O bank. The guidelines in [Table 97](#) are categorized by package style. Multiply the appropriate numbers from [Table 96](#) and [Table 97](#) to calculate the maximum number of SSOs allowed within an I/O bank. Exceeding these SSO guidelines might result in increased power or ground bounce, degraded signal integrity, or increased system jitter.

$$SSO_{MAX}/IO\ Bank = Table\ 96 \times Table\ 97$$

The recommended maximum SSO values assumes that the FPGA is soldered on the printed circuit board and that the board uses sound design practices. The SSO values do not apply for FPGAs mounted in sockets, due to the lead inductance introduced by the socket.

The number of SSOs allowed for quad-flat packages (VQ, TQ, PQ) is lower than for ball grid array packages (FG) due to the larger lead inductance of the quad-flat packages. The results for chip-scale packaging (CP132) are better than quad-flat packaging but not as high as for ball grid array packaging. Ball grid array packages are recommended for applications with a large number of simultaneously switching outputs.

*Table 96: Equivalent  $V_{CCO}$ /GND Pairs per Bank*

| Device    | Package Style (including Pb-free) |       |       |       |       |       |       |       |
|-----------|-----------------------------------|-------|-------|-------|-------|-------|-------|-------|
|           | VQ100                             | CP132 | TQ144 | PQ208 | FT256 | FG320 | FG400 | FG484 |
| XC3S100E  | 2                                 | 2     | 2     | -     | -     | -     | -     | -     |
| XC3S250E  | 2                                 | 2     | 2     | 3     | 4     | -     | -     | -     |
| XC3S500E  | 2                                 | 2     | -     | 3     | 4     | 5     | -     | -     |
| XC3S1200E | -                                 | -     | -     | -     | 4     | 5     | 6     | -     |
| XC3S1600E | -                                 | -     | -     | -     | -     | 5     | 6     | 7     |

Table 97: Recommended Number of Simultaneously Switching Outputs per V<sub>CCO</sub>/GND Pair

| Signal Standard (IOSTANDARD)  |      | Package Type |        |        |        |                                  |    |
|-------------------------------|------|--------------|--------|--------|--------|----------------------------------|----|
|                               |      | VQ 100       | TQ 144 | PQ 208 | CP 132 | FT256<br>FG320<br>FG400<br>FG484 |    |
| <b>Single-Ended Standards</b> |      |              |        |        |        |                                  |    |
| LV TTL                        | Slow | 2            | 34     | 20     | 19     | 52                               | 60 |
|                               |      | 4            | 17     | 10     | 10     | 26                               | 41 |
|                               |      | 6            | 17     | 10     | 7      | 26                               | 29 |
|                               |      | 8            | 8      | 6      | 6      | 13                               | 22 |
|                               |      | 12           | 8      | 6      | 5      | 13                               | 13 |
|                               |      | 16           | 5      | 5      | 5      | 6                                | 11 |
|                               | Fast | 2            | 17     | 17     | 17     | 26                               | 34 |
|                               |      | 4            | 9      | 9      | 9      | 13                               | 20 |
|                               |      | 6            | 7      | 7      | 7      | 13                               | 15 |
|                               |      | 8            | 6      | 6      | 6      | 6                                | 12 |
|                               |      | 12           | 5      | 5      | 5      | 6                                | 10 |
|                               |      | 16           | 5      | 5      | 5      | 5                                | 9  |
| LVCMOS33                      | Slow | 2            | 34     | 20     | 20     | 52                               | 76 |
|                               |      | 4            | 17     | 10     | 10     | 26                               | 46 |
|                               |      | 6            | 17     | 10     | 7      | 26                               | 27 |
|                               |      | 8            | 8      | 6      | 6      | 13                               | 20 |
|                               |      | 12           | 8      | 6      | 5      | 13                               | 13 |
|                               |      | 16           | 5      | 5      | 5      | 6                                | 10 |
|                               | Fast | 2            | 17     | 17     | 17     | 26                               | 44 |
|                               |      | 4            | 8      | 8      | 8      | 13                               | 26 |
|                               |      | 6            | 8      | 6      | 6      | 13                               | 16 |
|                               |      | 8            | 6      | 6      | 6      | 6                                | 12 |
|                               |      | 12           | 5      | 5      | 5      | 6                                | 10 |
|                               |      | 16           | 8      | 8      | 5      | 5                                | 8  |
| LVCMOS25                      | Slow | 2            | 28     | 16     | 16     | 42                               | 76 |
|                               |      | 4            | 13     | 10     | 10     | 19                               | 46 |
|                               |      | 6            | 13     | 7      | 7      | 19                               | 33 |
|                               |      | 8            | 6      | 6      | 6      | 9                                | 24 |
|                               |      | 12           | 6      | 6      | 6      | 9                                | 18 |
|                               |      | 2            | 17     | 16     | 16     | 26                               | 42 |
|                               | Fast | 4            | 9      | 9      | 9      | 13                               | 20 |
|                               |      | 6            | 9      | 7      | 7      | 13                               | 15 |
|                               |      | 8            | 6      | 6      | 6      | 6                                | 13 |
|                               |      | 12           | 5      | 5      | 5      | 6                                | 11 |
|                               |      | 2            | 13     | 8      | 8      | 19                               | 36 |
|                               |      | 4            | 8      | 5      | 5      | 13                               | 21 |
| LVCMOS18                      | Slow | 6            | 4      | 4      | 4      | 9                                | 18 |
|                               |      | 8            | 6      | 4      | 4      | 9                                | 18 |
|                               |      | 2            | 13     | 8      | 8      | 19                               | 36 |
|                               |      | 4            | 8      | 5      | 5      | 13                               | 21 |
|                               | Fast | 6            | 4      | 4      | 4      | 6                                | 13 |
|                               |      | 8            | 4      | 4      | 4      | 6                                | 10 |

Table 97: Recommended Number of Simultaneously Switching Outputs per V<sub>CCO</sub>/GND Pair (Cont'd)

| Signal Standard (IOSTANDARD)                                    |      | Package Type |            |        |        |                                  |
|---|------|--------------|------------|--------|--------|----------------------------------|
|   |      | VQ 100       | TQ 144     | PQ 208 | CP 132 | FT256<br>FG320<br>FG400<br>FG484 |
| LVCMOS15  | Slow | 2            | 16         | 10     | 10     | 55                               |
|   |      | 4            | 8          | 7      | 7      | 31                               |
|   |      | 6            | 6          | 5      | 5      | 18                               |
|   | Fast | 2            | 9          | 9      | 9      | 25                               |
|   |      | 4            | 7          | 7      | 7      | 16                               |
|   |      | 6            | 5          | 5      | 5      | 13                               |
| LVCMOS12  | Slow | 2            | 17         | 11     | 11     | 55                               |
|   | Fast | 2            | 10         | 10     | 10     | 31                               |
| PCI33_3   |      |              | 8          | 8      | 8      | 16                               |
| PCI66_3   |      |              | 8          | 8      | 8      | 13                               |
| PCIX  |      |              | 7          | 7      | 7      | 11                               |
| HSTL_I_18   |      |              | 10         | 10     | 10     | 17                               |
| HSTL_III_18   |      |              | 10         | 10     | 10     | 16                               |
| SSTL18_I  |      |              | 9          | 9      | 9      | 15                               |
| SSTL2_I   |      |              | 12         | 12     | 12     | 18                               |
| <b>Differential Standards (Number of I/O Pairs or Channels)</b> |      |              |            |        |        |                                  |
| LVDS_25   |      |              | 6          | 6      | 6      | 20                               |
| BLVDS_25  |      |              | 4          | 4      | 4      | 4                                |
| MINI_LVDS_25  |      |              | 6          | 6      | 6      | 20                               |
| LVPECL_25   |      |              | Input Only |        |        |                                  |
| RSDS_25   |      |              | 6          | 6      | 6      | 20                               |
| DIFF_HSTL_I_18  |      |              | 5          | 5      | 5      | 8                                |
| DIFF_HSTL_III_18  |      |              | 5          | 5      | 5      | 8                                |
| DIFF_SSTL18_I   |      |              | 4          | 4      | 4      | 7                                |
| DIFF_SSTL2_I  |      |              | 6          | 6      | 6      | 8                                |

**Notes:**

1. The numbers in this table are recommendations that assume sound board layout practice. This table assumes the following parasitic factors: combined PCB trace and land inductance per V<sub>CCO</sub> and GND pin of 1.0 nH, receiver capacitive load of 15 pF. Test limits are the V<sub>IL</sub>/V<sub>IH</sub> voltage limits for the respective I/O standard.
2. The PQ208 results are based on physical measurements of a PQ208 package soldered to a typical printed circuit board. All other results are based on worst-case simulation and an interpolation of the PQ208 physical results.
3. If more than one signal standard is assigned to the I/Os of a given bank, refer to [XAPP689: Managing Ground Bounce in Large FPGAs](#) for information on how to perform weighted average SSO calculations.

## Configurable Logic Block (CLB) Timing

Table 98: CLB (SLICEM) Timing

| Symbol                       | Description   | Speed Grade |      |      |      | Units |  |
|------------------------------|---|-------------|------|------|------|-------|--|
|                              |   | -5          |      | -4   |      |       |  |
|                              |   | Min         | Max  | Min  | Max  |       |  |
| <b>Clock-to-Output Times</b> |   |             |      |      |      |       |  |
| T <sub>CKO</sub>             | When reading from the FFX (FFY) Flip-Flop, the time from the active transition at the CLK input to data appearing at the XQ (YQ) output | -           | 0.52 | -    | 0.60 | ns    |  |
| <b>Setup Times</b>           |   |             |      |      |      |       |  |
| T <sub>AS</sub>              | Time from the setup of data at the F or G input to the active transition at the CLK input of the CLB                                    | 0.46        | -    | 0.52 | -    | ns    |  |
| T <sub>DICK</sub>            | Time from the setup of data at the BX or BY input to the active transition at the CLK input of the CLB                                  | 1.58        | -    | 1.81 | -    | ns    |  |
| <b>Hold Times</b>            |   |             |      |      |      |       |  |
| T <sub>AH</sub>              | Time from the active transition at the CLK input to the point where data is last held at the F or G input                               | 0           | -    | 0    | -    | ns    |  |
| T <sub>CKDI</sub>            | Time from the active transition at the CLK input to the point where data is last held at the BX or BY input                             | 0           | -    | 0    | -    | ns    |  |
| <b>Clock Timing</b>          |   |             |      |      |      |       |  |
| T <sub>CH</sub>              | The High pulse width of the CLB's CLK signal  | 0.70        | -    | 0.80 | -    | ns    |  |
| T <sub>CL</sub>              | The Low pulse width of the CLK signal   | 0.70        | -    | 0.80 | -    | ns    |  |
| F <sub>TOG</sub>             | Toggle frequency (for export control)   | 0           | 657  | 0    | 572  | MHz   |  |
| <b>Propagation Times</b>     |   |             |      |      |      |       |  |
| T <sub>ILO</sub>             | The time it takes for data to travel from the CLB's F (G) input to the X (Y) output   | -           | 0.66 | -    | 0.76 | ns    |  |
| <b>Set/Reset Pulse Width</b> |   |             |      |      |      |       |  |
| T <sub>RPW_CLB</sub>         | The minimum allowable pulse width, High or Low, to the CLB's SR input   | 1.57        | -    | 1.80 | -    | ns    |  |

### Notes:

1. The numbers in this table are based on the operating conditions set forth in Table 77.

Table 99: CLB Distributed RAM Switching Characteristics

| Symbol                       | Description   | -5   |      | -4   |      | Units |
|------------------------------|---|------|------|------|------|-------|
|                              |   | Min  | Max  | Min  | Max  |       |
| <b>Clock-to-Output Times</b> |   |      |      |      |      |       |
| $T_{SHCKO}$                  | Time from the active edge at the CLK input to data appearing on the distributed RAM output  | -    | 2.05 | -    | 2.35 | ns    |
| <b>Setup Times</b>           |   |      |      |      |      |       |
| $T_{DS}$                     | Setup time of data at the BX or BY input before the active transition at the CLK input of the distributed RAM                     | 0.40 | -    | 0.46 | -    | ns    |
| $T_{AS}$                     | Setup time of the F/G address inputs before the active transition at the CLK input of the distributed RAM                         | 0.46 | -    | 0.52 | -    | ns    |
| $T_{WS}$                     | Setup time of the write enable input before the active transition at the CLK input of the distributed RAM                         | 0.34 | -    | 0.40 | -    | ns    |
| <b>Hold Times</b>            |   |      |      |      |      |       |
| $T_{DH}$                     | Hold time of the BX, BY data inputs after the active transition at the CLK input of the distributed RAM                           | 0.13 | -    | 0.15 | -    | ns    |
| $T_{AH}, T_{WH}$             | Hold time of the F/G address inputs or the write enable input after the active transition at the CLK input of the distributed RAM | 0    | -    | 0    | -    | ns    |
| <b>Clock Pulse Width</b>     |   |      |      |      |      |       |
| $T_{WPH}, T_{WPL}$           | Minimum High or Low pulse width at CLK input  | 0.88 | -    | 1.01 | -    | ns    |

Table 100: CLB Shift Register Switching Characteristics

| Symbol                       | Description  | -5   |      | -4   |      | Units |
|------------------------------|--|------|------|------|------|-------|
|                              |  | Min  | Max  | Min  | Max  |       |
| <b>Clock-to-Output Times</b> |  |      |      |      |      |       |
| $T_{REG}$                    | Time from the active edge at the CLK input to data appearing on the shift register output                    | -    | 3.62 | -    | 4.16 | ns    |
| <b>Setup Times</b>           |  |      |      |      |      |       |
| $T_{SRLDS}$                  | Setup time of data at the BX or BY input before the active transition at the CLK input of the shift register | 0.41 | -    | 0.46 | -    | ns    |
| <b>Hold Times</b>            |  |      |      |      |      |       |
| $T_{SRLDH}$                  | Hold time of the BX or BY data input after the active transition at the CLK input of the shift register      | 0.14 | -    | 0.16 | -    | ns    |
| <b>Clock Pulse Width</b>     |  |      |      |      |      |       |
| $T_{WPH}, T_{WPL}$           | Minimum High or Low pulse width at CLK input   | 0.88 | -    | 1.01 | -    | ns    |

## Clock Buffer/Multiplexer Switching Characteristics

Table 101: Clock Distribution Switching Characteristics

| Description   | Symbol     | Maximum     |      | Units |  |
|---|------------|-------------|------|-------|--|
|   |            | Speed Grade |      |       |  |
|   |            | -5          | -4   |       |  |
| Global clock buffer (BUFG, BUFGMUX, BUFGCE) I input to O-output delay                                       | $T_{GIO}$  | 1.46        | 1.46 | ns    |  |
| Global clock multiplexer (BUFGMUX) select S-input setup to I0 and I1 inputs. Same as BUFGCE enable CE-input | $T_{GSI}$  | 0.55        | 0.63 | ns    |  |
| Frequency of signals distributed on global buffers (all sides)  | $F_{BUFG}$ | 333         | 311  | MHz   |  |

## 18 x 18 Embedded Multiplier Timing

Table 102: 18 x 18 Embedded Multiplier Timing

| Symbol                                       | Description  | Speed Grade |                     |       |                     | Units |  |
|--|--|-------------|---------------------|-------|---------------------|-------|--|
|  |  | -5          |                     | -4    |                     |       |  |
|  |  | Min         | Max                 | Min   | Max                 |       |  |
| <b>Combinatorial Delay</b>                   |  |             |                     |       |                     |       |  |
| T <sub>MULT</sub>                            | Combinatorial multiplier propagation delay from the A and B inputs to the P outputs, assuming 18-bit inputs and a 36-bit product (AREG, BREG, and PREG registers unused) | -           | 4.34 <sup>(1)</sup> | -     | 4.88 <sup>(1)</sup> | ns    |  |
| <b>Clock-to-Output Times</b>                 |  |             |                     |       |                     |       |  |
| T <sub>MSCKP_P</sub>                         | Clock-to-output delay from the active transition of the CLK input to valid data appearing on the P outputs when using the PREG register <sup>(2)</sup>                   | -           | 0.98                | -     | 1.10                | ns    |  |
| T <sub>MSCKP_A</sub><br>T <sub>MSCKP_B</sub> | Clock-to-output delay from the active transition of the CLK input to valid data appearing on the P outputs when using either the AREG or BREG register <sup>(3)</sup>    | -           | 4.42                | -     | 4.97                | ns    |  |
| <b>Setup Times</b>                           |  |             |                     |       |                     |       |  |
| T <sub>MSDCK_P</sub>                         | Data setup time at the A or B input before the active transition at the CLK when using only the PREG output register (AREG, BREG registers unused) <sup>(2)</sup>        | 3.54        | -                   | 3.98  | -                   | ns    |  |
| T <sub>MSDCK_A</sub>                         | Data setup time at the A input before the active transition at the CLK when using the AREG input register <sup>(3)</sup>   | 0.20        | -                   | 0.23  | -                   | ns    |  |
| T <sub>MSDCK_B</sub>                         | Data setup time at the B input before the active transition at the CLK when using the BREG input register <sup>(3)</sup>   | 0.35        | -                   | 0.39  | -                   | ns    |  |
| <b>Hold Times</b>                            |  |             |                     |       |                     |       |  |
| T <sub>MSCKD_P</sub>                         | Data hold time at the A or B input after the active transition at the CLK when using only the PREG output register (AREG, BREG registers unused) <sup>(2)</sup>          | -0.97       | -                   | -0.97 | -                   | ns    |  |
| T <sub>MSCKD_A</sub>                         | Data hold time at the A input after the active transition at the CLK when using the AREG input register <sup>(3)</sup>   | 0.03        | -                   | 0.04  | -                   | ns    |  |
| T <sub>MSCKD_B</sub>                         | Data hold time at the B input after the active transition at the CLK when using the BREG input register <sup>(3)</sup>   | 0.04        | -                   | 0.05  | -                   | ns    |  |
| <b>Clock Frequency</b>                       |  |             |                     |       |                     |       |  |
| F <sub>MULT</sub>                            | Internal operating frequency for a two-stage 18x18 multiplier using the AREG and BREG input registers and the PREG output register <sup>(1)</sup>                        | 0           | 270                 | 0     | 240                 | MHz   |  |

### Notes:

1. Combinatorial delay is less and pipelined performance is higher when multiplying input data with less than 18 bits.
2. The PREG register is typically used in both single-stage and two-stage pipelined multiplier implementations.
3. Input registers AREG or BREG are typically used when inferring a two-stage multiplier.

## Block RAM Timing

Table 103: Block RAM Timing

| Symbol                       | Description  | Speed Grade |      |      |      | Units |  |
|------------------------------|--|-------------|------|------|------|-------|--|
|                              |  | -5          |      | -4   |      |       |  |
|                              |  | Min         | Max  | Min  | Max  |       |  |
| <b>Clock-to-Output Times</b> |  |             |      |      |      |       |  |
| T <sub>BCKO</sub>            | When reading from block RAM, the delay from the active transition at the CLK input to data appearing at the DOUT output  | -           | 2.45 | -    | 2.82 | ns    |  |
| <b>Setup Times</b>           |  |             |      |      |      |       |  |
| T <sub>BACK</sub>            | Setup time for the ADDR inputs before the active transition at the CLK input of the block RAM  | 0.33        | -    | 0.38 | -    | ns    |  |
| T <sub>BDCK</sub>            | Setup time for data at the DIN inputs before the active transition at the CLK input of the block RAM   | 0.23        | -    | 0.23 | -    | ns    |  |
| T <sub>BECK</sub>            | Setup time for the EN input before the active transition at the CLK input of the block RAM   | 0.67        | -    | 0.77 | -    | ns    |  |
| T <sub>BWCK</sub>            | Setup time for the WE input before the active transition at the CLK input of the block RAM   | 1.09        | -    | 1.26 | -    | ns    |  |
| <b>Hold Times</b>            |  |             |      |      |      |       |  |
| T <sub>BCKA</sub>            | Hold time on the ADDR inputs after the active transition at the CLK input  | 0.12        | -    | 0.14 | -    | ns    |  |
| T <sub>BCKD</sub>            | Hold time on the DIN inputs after the active transition at the CLK input   | 0.12        | -    | 0.13 | -    | ns    |  |
| T <sub>BCKE</sub>            | Hold time on the EN input after the active transition at the CLK input   | 0           | -    | 0    | -    | ns    |  |
| T <sub>BCKW</sub>            | Hold time on the WE input after the active transition at the CLK input   | 0           | -    | 0    | -    | ns    |  |
| <b>Clock Timing</b>          |  |             |      |      |      |       |  |
| T <sub>BPWH</sub>            | High pulse width of the CLK signal   | 1.39        | -    | 1.59 | -    | ns    |  |
| T <sub>BPWL</sub>            | Low pulse width of the CLK signal  | 1.39        | -    | 1.59 | -    | ns    |  |
| <b>Clock Frequency</b>       |  |             |      |      |      |       |  |
| F <sub>BRAM</sub>            | Block RAM clock frequency. RAM read output value written back into RAM, for shift-registers and circular buffers. Write-only or read-only performance is faster. | 0           | 270  | 0    | 230  | MHz   |  |

### Notes:

1. The numbers in this table are based on the operating conditions set forth in Table 77.

## Digital Clock Manager (DCM) Timing

For specification purposes, the DCM consists of three key components: the Delay-Locked Loop (DLL), the Digital Frequency Synthesizer (DFS), and the Phase Shifter (PS).

Aspects of DLL operation play a role in all DCM applications. All such applications inevitably use the CLKIN and the CLKFB inputs connected to either the CLK0 or the CLK2X feedback, respectively. Thus, specifications in the DLL tables (Table 104 and Table 105) apply to any application that only employs the DLL component. When the DFS and/or the PS components are used together with the DLL, then the specifications listed in the DFS and PS tables (Table 106 through Table 109) supersede any corresponding ones in the DLL tables. DLL specifications that do not change with the addition of DFS or PS functions are presented in Table 104 and Table 105.

Period jitter and cycle-cycle jitter are two of many different ways of specifying clock jitter. Both specifications describe statistical variation from a mean value.

### Delay-Locked Loop (DLL)

Table 104: Recommended Operating Conditions for the DLL

| Symbol   | Description   | Speed Grade                        |            |          |                  | Units              |                  |                    |     |
|--|---|------------------------------------|------------|----------|------------------|--------------------|------------------|--------------------|-----|
|  |   | -5                                 |            | -4       |                  |                    |                  |                    |     |
|  |   | Min                                | Max        | Min      | Max              |                    |                  |                    |     |
| <b>Input Frequency Ranges</b>  |   |                                    |            |          |                  |                    |                  |                    |     |
| F <sub>CLKIN</sub>   | CLKIN_FREQ_DLL  | Frequency of the CLKIN clock input | Stepping 0 | XC3S100E | N/A              | N/A                | 5 <sup>(2)</sup> | 90 <sup>(3)</sup>  | MHz |
|  |   |                                    |            | XC3S250E |                  |                    |                  | 200 <sup>(3)</sup> | MHz |
|  |   |                                    |            | XC3S500E |                  |                    |                  | 240 <sup>(3)</sup> | MHz |
|  |   |                                    | Stepping 1 | All      | 5 <sup>(2)</sup> | 275 <sup>(3)</sup> |                  |                    | MHz |
| <b>Input Pulse Requirements</b>  |   |                                    |            |          |                  |                    |                  |                    |     |
| CLKIN_PULSE  | CLKIN pulse width as a percentage of the CLKIN period                                 | F <sub>CLKIN</sub> ≤ 150 MHz       | 40%        | 60%      | 40%              | 60%                | -                |                    |     |
|  |   |                                    | 45%        | 55%      | 45%              | 55%                | -                |                    |     |
| <b>Input Clock Jitter Tolerance and Delay Path Variation<sup>(4)</sup></b> |   |                                    |            |          |                  |                    |                  |                    |     |
| CLKIN_CYC_JITT_DLL_LF  | Cycle-to-cycle jitter at the CLKIN input  | F <sub>CLKIN</sub> ≤ 150 MHz       | -          | ±300     | -                | ±300               | ps               |                    |     |
| CLKIN_CYC_JITT_DLL_HF  |   | F <sub>CLKIN</sub> > 150 MHz       | -          | ±150     | -                | ±150               | ps               |                    |     |
| CLKIN_PER_JITT_DLL   | Period jitter at the CLKIN input  |                                    |            | -        | ±1               | -                  | ±1               | ns                 |     |
| CLKFB_DELAY_VAR_EXT  | Allowable variation of off-chip feedback delay from the DCM output to the CLKFB input |                                    |            | -        | ±1               | -                  | ±1               | ns                 |     |

#### Notes:

1. DLL specifications apply when any of the DLL outputs (CLK0, CLK90, CLK180, CLK270, CLK2X, CLK2X180, or CLKDV) are in use.
2. The DFS, when operating independently of the DLL, supports lower FCLKIN frequencies. See Table 106.
3. To support double the maximum effective FCLKIN limit, set the CLKIN\_DIVIDE\_BY\_2 attribute to TRUE. This attribute divides the incoming clock frequency by two as it enters the DCM. The CLK2X output reproduces the clock frequency provided on the CLKIN input.
4. CLKIN input jitter beyond these limits might cause the DCM to lose lock.

Period jitter is the worst-case deviation from the ideal clock period over a collection of millions of samples. In a histogram of period jitter, the mean value is the clock period.

Cycle-cycle jitter is the worst-case difference in clock period between adjacent clock cycles in the collection of clock periods sampled. In a histogram of cycle-cycle jitter, the mean value is zero.

### Spread Spectrum

DCMs accept typical spread spectrum clocks as long as they meet the input requirements. The DLL will track the frequency changes created by the spread spectrum clock to drive the global clocks to the FPGA logic. See [XAPP469, Spread-Spectrum Clocking Reception for Displays](#) for details.

Table 105: Switching Characteristics for the DLL

| Symbol                                       | Description  | Device     | Speed Grade                                   |                             |     |                             | Units |     |
|--|--|------------|---|-----------------------------|-----|-----------------------------|-------|-----|
|  |  |            | -5  |                             | -4  |                             |       |     |
|  |  |            | Min   | Max                         | Min | Max                         |       |     |
| <b>Output Frequency Ranges</b>               |  |            |   |                             |     |                             |       |     |
| CLKOUT_FREQ_CLK0                             | Frequency for the CLK0 and CLK180 outputs  | Stepping 0 | XC3S100E<br>XC3S250E<br>XC3S500E<br>XC3S1600E | N/A                         | N/A | 5                           | 90    | MHz |
|  |  |            | XC3S1200E                                     |                             |     |                             | 200   | MHz |
|  |  | Stepping 1 | All   | 5                           | 275 |                             | 240   | MHz |
| CLKOUT_FREQ_CLK90                            | Frequency for the CLK90 and CLK270 outputs   | Stepping 0 | XC3S100E<br>XC3S250E<br>XC3S500E<br>XC3S1600E | N/A                         | N/A | 5                           | 90    | MHz |
|  |  |            | XC3S1200E                                     |                             |     |                             | 167   | MHz |
|  |  | Stepping 1 | All   | 5                           | 200 |                             | 200   | MHz |
| CLKOUT_FREQ_2X                               | Frequency for the CLK2X and CLK2X180 outputs   | Stepping 0 | XC3S100E<br>XC3S250E<br>XC3S500E<br>XC3S1600E | N/A                         | N/A | 10                          | 180   | MHz |
|  |  |            | XC3S1200E                                     |                             |     |                             | 311   | MHz |
|  |  | Stepping 1 | All   | 10                          | 333 |                             | 311   | MHz |
| CLKOUT_FREQ_DV                               | Frequency for the CLKDV output   | Stepping 0 | XC3S100E<br>XC3S250E<br>XC3S500E<br>XC3S1600E | N/A                         | N/A | 0.3125                      | 60    | MHz |
|  |  |            | XC3S1200E                                     |                             |     |                             | 133   | MHz |
|  |  | Stepping 1 | All   | 0.3125                      | 183 |                             | 160   | MHz |
| <b>Output Clock Jitter<sup>(2,3,4)</sup></b> |  |            |   |                             |     |                             |       |     |
| CLKOUT_PER_JITT_0                            | Period jitter at the CLK0 output   | All        | -   | ±100                        | -   | ±100                        | ps    |     |
| CLKOUT_PER_JITT_90                           | Period jitter at the CLK90 output  |            | -   | ±150                        | -   | ±150                        | ps    |     |
| CLKOUT_PER_JITT_180                          | Period jitter at the CLK180 output   |            | -   | ±150                        | -   | ±150                        | ps    |     |
| CLKOUT_PER_JITT_270                          | Period jitter at the CLK270 output   |            | -   | ±150                        | -   | ±150                        | ps    |     |
| CLKOUT_PER_JITT_2X                           | Period jitter at the CLK2X and CLK2X180 outputs  |            | -   | ±[1% of CLKIN period + 150] | -   | ±[1% of CLKIN period + 150] | ps    |     |
| CLKOUT_PER_JITT_DV1                          | Period jitter at the CLKDV output when performing integer division   |            | -   | ±150                        | -   | ±150                        | ps    |     |
| CLKOUT_PER_JITT_DV2                          | Period jitter at the CLKDV output when performing non-integer division   |            | -   | ±[1% of CLKIN period + 200] | -   | ±[1% of CLKIN period + 200] | ps    |     |
| <b>Duty Cycle<sup>(4)</sup></b>              |  |            |   |                             |     |                             |       |     |
| CLKOUT_DUTY_CYCLE_DLL                        | Duty cycle variation for the CLK0, CLK90, CLK180, CLK270, CLK2X, CLK2X180, and CLKDV outputs, including the BUFGMUX and clock tree duty-cycle distortion | All        | -   | ±[1% of CLKIN period + 400] | -   | ±[1% of CLKIN period + 400] | ps    |     |

Table 105: Switching Characteristics for the DLL (Cont'd)

| Symbol                               | Description  | Device                              | Speed Grade |                             |     |                             | Units  |  |
|--------------------------------------|--|-------------------------------------|-------------|-----------------------------|-----|-----------------------------|--------|--|
|                                      |  |                                     | -5          |                             | -4  |                             |        |  |
|                                      |  |                                     | Min         | Max                         | Min | Max                         |        |  |
| <b>Phase Alignment<sup>(4)</sup></b> |  |                                     |             |                             |     |                             |        |  |
| CLKIN_CLKFB_PHASE                    | Phase offset between the CLKIN and CLKFB inputs  | All                                 | -           | ±200                        | -   | ±200                        | ps     |  |
| CLKOUT_PHASE_DLL                     | Phase offset between DLL outputs   | All others                          | -           | ±[1% of CLKIN period + 100] | -   | ±[1% of CLKIN period + 100] | ps     |  |
|                                      |  |                                     | -           | ±[1% of CLKIN period + 200] | -   | ±[1% of CLKIN period + 200] | ps     |  |
| <b>Lock Time</b>                     |  |                                     |             |                             |     |                             |        |  |
| LOCK_DLL <sup>(3)</sup>              | When using the DLL alone: The time from deassertion at the DCM's Reset input to the rising transition at its LOCKED output. When the DCM is locked, the CLKIN and CLKFB signals are in phase | 5 MHz ≤ F <sub>CLKIN</sub> ≤ 15 MHz | All         | -                           | 5   | -                           | 5 ms   |  |
|                                      |  | F <sub>CLKIN</sub> > 15 MHz         |             | -                           | 600 | -                           | 600 μs |  |
| <b>Delay Lines</b>                   |  |                                     |             |                             |     |                             |        |  |
| DCM_DELAY_STEP                       | Finest delay resolution  | All                                 | 20          | 40                          | 20  | 40                          | ps     |  |

**Notes:**

- The numbers in this table are based on the operating conditions set forth in Table 77 and Table 104.
- Indicates the maximum amount of output jitter that the DCM adds to the jitter on the CLKIN input.
- For optimal jitter tolerance and faster lock time, use the CLKIN\_PERIOD attribute.
- Some jitter and duty-cycle specifications include 1% of input clock period or 0.01 UI.

**Example:** The data sheet specifies a maximum jitter of ±[1% of CLKIN period + 150]. Assume the CLKIN frequency is 100 MHz. The equivalent CLKIN period is 10 ns and 1% of 10 ns is 0.1 ns or 100 ps. According to the data sheet, the maximum jitter is ±[100 ps + 150 ps] = ±250 ps.

## Digital Frequency Synthesizer (DFS)

Table 106: Recommended Operating Conditions for the DFS

| Symbol  | Description   | Speed Grade                   |       |                    |       | Units                  |  |
|---|---|-------------------------------|-------|--------------------|-------|------------------------|--|
|   |   | -5                            |       | -4                 |       |                        |  |
|   |   | Min                           | Max   | Min                | Max   |                        |  |
| <b>Input Frequency Ranges<sup>(2)</sup></b>       |   |                               |       |                    |       |                        |  |
| F <sub>CLKIN</sub>                                | CLKIN_FREQ_FX   | Frequency for the CLKIN input | 0.200 | 333 <sup>(4)</sup> | 0.200 | 333 <sup>(4)</sup> MHz |  |
| <b>Input Clock Jitter Tolerance<sup>(3)</sup></b> |   |                               |       |                    |       |                        |  |
| CLKIN_CYC_JITT_FX_LF                              | Cycle-to-cycle jitter at the CLKIN input, based on CLKFX output frequency | F <sub>CLKFX</sub> ≤ 150 MHz  | -     | ±300               | -     | ±300 ps                |  |
| CLKIN_CYC_JITT_FX_HF                              |   | F <sub>CLKFX</sub> > 150 MHz  | -     | ±150               | -     | ±150 ps                |  |
| CLKIN_PER_JITT_FX                                 | Period jitter at the CLKIN input  | -                             | ±1    | -                  | ±1    | ns                     |  |

**Notes:**

- DFS specifications apply when either of the DFS outputs (CLKFX or CLKFX180) are used.
- If both DFS and DLL outputs are used on the same DCM, follow the more restrictive CLKIN\_FREQ\_DLL specifications in Table 104.
- CLKIN input jitter beyond these limits may cause the DCM to lose lock.
- To support double the maximum effective FCLKIN limit, set the CLKIN\_DIVIDE\_BY\_2 attribute to TRUE. This attribute divides the incoming clock frequency by two as it enters the DCM.

Table 107: Switching Characteristics for the DFS

| Symbol                                     | Description   | Device   | Speed Grade                                   |                             |                             |                             | Units                       |                             |
|--|---|--|---|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
|  |   |  | -5  |                             | -4                          |                             |                             |                             |
|  |   |  | Min   | Max                         | Min                         | Max                         |                             |                             |
| <b>Output Frequency Ranges</b>             |   |  |   |                             |                             |                             |                             |                             |
| CLKOUT_FREQ_FX_LF                          | Frequency for the CLKFX and CLKFX180 outputs, low frequencies   | Stepping 0   | XC3S100E<br>XC3S250E<br>XC3S500E<br>XC3S1600E | N/A                         | N/A                         | 5                           | 90                          | MHz                         |
| CLKOUT_FREQ_FX_HF                          | Frequency for the CLKFX and CLKFX180 outputs, high frequencies  |  |   |                             |                             | 220                         | 307                         | MHz                         |
| CLKOUT_FREQ_FX                             | Frequency for the CLKFX and CLKFX180 outputs  |  |   |                             |                             | 5                           | 307                         | MHz                         |
|  |   |  | Stepping 1                                    | All                         | 5                           | 333                         |                             | 311 MHz                     |
| <b>Output Clock Jitter<sup>(2,3)</sup></b> |   |  |   |                             |                             |                             |                             |                             |
| CLKOUT_PER_JITT_FX                         | Period jitter at the CLKFX and CLKFX180 outputs.  |  | All   | Typ                         | Max                         | Typ                         | Max                         | ps                          |
|  |   |  |   |                             |                             | Note 6                      |                             |                             |
|  |   |  |   |                             |                             | ±[1% of CLKFX period + 100] | ±[1% of CLKFX period + 200] | ±[1% of CLKFX period + 100] |
| <b>Duty Cycle<sup>(4,5)</sup></b>          |   |  |   |                             |                             |                             |                             |                             |
| CLKOUT_DUTY_CYCLE_FX                       | Duty cycle precision for the CLKFX and CLKFX180 outputs, including the BUFGMUX and clock tree duty-cycle distortion   | All  | -   | -                           | ±[1% of CLKFX period + 400] | -                           | ±[1% of CLKFX period + 400] | ps                          |
| <b>Phase Alignment<sup>(5)</sup></b>       |   |  |   |                             |                             |                             |                             |                             |
| CLKOUT_PHASE_FX                            | Phase offset between the DFS CLKFX output and the DLL CLK0 output when both the DFS and DLL are used  | All  | -   | ±200                        | -                           | ±200                        | ps                          |                             |
| CLKOUT_PHASE_FX180                         | Phase offset between the DFS CLKFX180 output and the DLL CLK0 output when both the DFS and DLL are used   | All  | -   | ±[1% of CLKFX period + 300] | -                           | ±[1% of CLKFX period + 300] | ps                          |                             |
| <b>Lock Time</b>                           |   |  |   |                             |                             |                             |                             |                             |
| LOCK_FX <sup>(2)</sup>                     | The time from deassertion at the DCM's Reset input to the rising transition at its LOCKED output. The DFS asserts LOCKED when the CLKFX and CLKFX180 signals are valid. If using both the DLL and the DFS, use the longer locking time. | 5 MHz ≤ F <sub>CLKIN</sub> ≤ 15 MHz<br>F <sub>CLKIN</sub> > 15 MHz | All   | -                           | 5                           | -                           | 5                           | ms                          |
|  |   |  |   | -                           | 450                         | -                           | 450                         | μs                          |

**Notes:**

- The numbers in this table are based on the operating conditions set forth in Table 77 and Table 106.
- For optimal jitter tolerance and faster lock time, use the CLKIN\_PERIOD attribute.
- Maximum output jitter is characterized within a reasonable noise environment (150 ps input period jitter, 40 SSOs and 25% CLB switching). Output jitter strongly depends on the environment, including the number of SSOs, the output drive strength, CLB utilization, CLB switching activities, switching frequency, power supply and PCB design. The actual maximum output jitter depends on the system application.
- The CLKFX and CLKFX180 outputs always have an approximate 50% duty cycle.
- Some duty-cycle and alignment specifications include 1% of the CLKFX output period or 0.01 UI.

**Example:** The data sheet specifies a maximum jitter of ±[1% of CLKFX period + 300]. Assume the CLKFX output frequency is 100 MHz. The equivalent CLKFX period is 10 ns and 1% of 10 ns is 0.1 ns or 100 ps. According to the data sheet, the maximum jitter is ±[100 ps + 300 ps] = ±400 ps.

- Use the Spartan-3A Jitter Calculator ([www.xilinx.com/support/documentation/data\\_sheets/s3a\\_jitter\\_calc.zip](http://www.xilinx.com/support/documentation/data_sheets/s3a_jitter_calc.zip)) to estimate DFS output jitter. Use the Clocking Wizard to determine jitter for a specific design.

## Phase Shifter (PS)

Table 108: Recommended Operating Conditions for the PS in Variable Phase Mode

| Symbol                            | Description   | Speed Grade |     |     |     | Units |  |
|-----------------------------------|---|-------------|-----|-----|-----|-------|--|
|                                   |   | -5          |     | -4  |     |       |  |
|                                   |   | Min         | Max | Min | Max |       |  |
| <b>Operating Frequency Ranges</b> |   |             |     |     |     |       |  |
| PSCLK_FREQ<br>( $F_{PSCLK}$ )     | Frequency for the PSCLK input                         | 1           | 167 | 1   | 167 | MHz   |  |
| <b>Input Pulse Requirements</b>   |   |             |     |     |     |       |  |
| PSCLK_PULSE                       | PSCLK pulse width as a percentage of the PSCLK period | 40%         | 60% | 40% | 60% | -     |  |

Table 109: Switching Characteristics for the PS in Variable Phase Mode

| Symbol                      | Description   | Equation   |  | Units |
|-----------------------------|---|--|--|-------|
| <b>Phase Shifting Range</b> |   |  |  |       |
| MAX_STEPS <sup>(2)</sup>    | Maximum allowed number of DCM_DELAY_STEP steps for a given CLKIN clock period, where $T = CLKIN$ clock period in ns. If using CLKIN_DIVIDE_BY_2 = TRUE, double the effective clock period. <sup>(3)</sup> | CLKIN < 60 MHz                                       | $\pm[\text{INTEGER}(10 \cdot (T_{CLKIN} - 3 \text{ ns}))]$ | steps |
|                             |   | CLKIN $\geq$ 60 MHz                                  | $\pm[\text{INTEGER}(15 \cdot (T_{CLKIN} - 3 \text{ ns}))]$ | steps |
| FINE_SHIFT_RANGE_MIN        | Minimum guaranteed delay for variable phase shifting  | $\pm[\text{MAX\_STEPS} \cdot DCM\_DELAY\_STEP\_MIN]$ |  | ns    |
| FINE_SHIFT_RANGE_MAX        | Maximum guaranteed delay for variable phase shifting  | $\pm[\text{MAX\_STEPS} \cdot DCM\_DELAY\_STEP\_MAX]$ |  | ns    |

### Notes:

1. The numbers in this table are based on the operating conditions set forth in Table 77 and Table 108.
2. The maximum variable phase shift range, MAX\_STEPS, is only valid when the DCM has no initial fixed phase shifting, i.e., the PHASE\_SHIFT attribute is set to 0.
3. The DCM\_DELAY\_STEP values are provided at the bottom of Table 105.

## Miscellaneous DCM Timing

Table 110: Miscellaneous DCM Timing

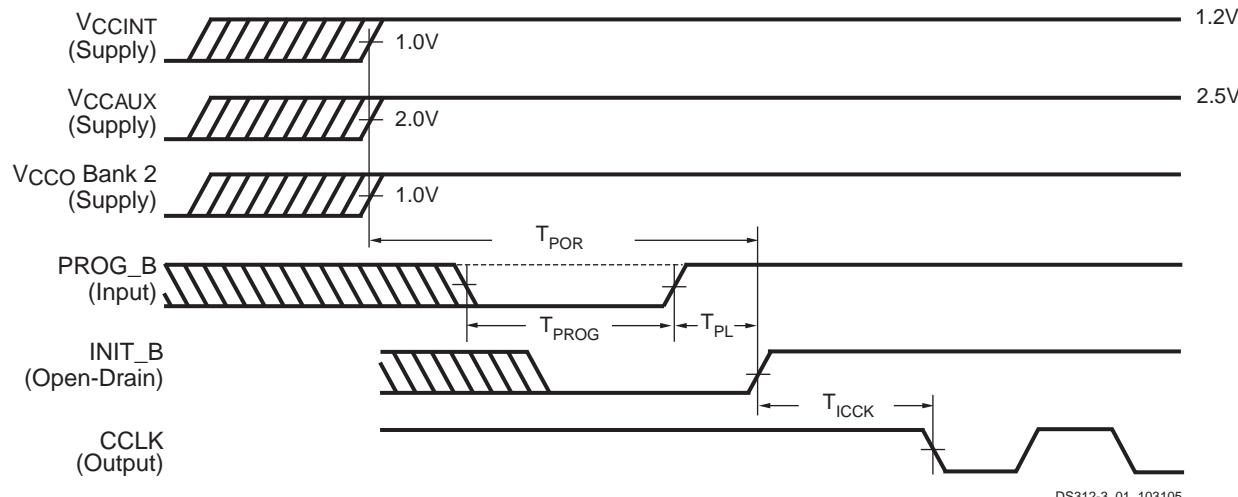
| Symbol                             | Description   | Min | Max | Units        |
|------------------------------------|---|-----|-----|--------------|
| DCM_RST_PW_MIN <sup>(1)</sup>      | Minimum duration of a RST pulse width   | 3   | -   | CLKIN cycles |
| DCM_RST_PW_MAX <sup>(2)</sup>      | Maximum duration of a RST pulse width   | N/A | N/A | seconds      |
| DCM_CONFIG_LAG_TIME <sup>(3)</sup> | Maximum duration from $V_{CCINT}$ applied to FPGA configuration successfully completed (DONE pin goes High) and clocks applied to DCM DLL | N/A | N/A | minutes      |

### Notes:

1. This limit only applies to applications that use the DCM DLL outputs (CLK0, CLK90, CLK180, CLK270, CLK2X, CLK2X180, and CLKDV). The DCM DFS outputs (CLKFX, CLKFX180) are unaffected.
2. This specification is equivalent to the Virtex-4 DCM\_RESET specification. This specification does not apply for Spartan-3E FPGAs.
3. This specification is equivalent to the Virtex-4 TCONFIG specification. This specification does not apply for Spartan-3E FPGAs.

## Configuration and JTAG Timing

### General Configuration Power-On/Reconfigure Timing



#### Notes:

1. The  $V_{CCINT}$ ,  $V_{CCAUX}$ , and  $V_{CCO}$  supplies may be applied in any order.
2. The Low-going pulse on  $PROG_B$  is optional after power-on but necessary for reconfiguration without a power cycle.
3. The rising edge of  $INIT_B$  samples the voltage levels applied to the mode pins (M0 - M2).

Figure 73: Waveforms for Power-On and the Beginning of Configuration

Table 111: Power-On Timing and the Beginning of Configuration

| Symbol           | Description   | Device    | All Speed Grades |     | Units   |
|------------------|---|-----------|------------------|-----|---------|
|                  |   |           | Min              | Max |         |
| $T_{POR}^{(2)}$  | The time from the application of $V_{CCINT}$ , $V_{CCAUX}$ , and $V_{CCO}$ Bank 2 supply voltage ramps (whichever occurs last) to the rising transition of the $INIT_B$ pin | XC3S100E  | -                | 5   | ms      |
|                  |   | XC3S250E  | -                | 5   | ms      |
|                  |   | XC3S500E  | -                | 5   | ms      |
|                  |   | XC3S1200E | -                | 5   | ms      |
|                  |   | XC3S1600E | -                | 7   | ms      |
| $T_{PROG}$       | The width of the low-going pulse on the $PROG_B$ pin  | All       | 0.5              | -   | $\mu$ s |
| $T_{PL}^{(2)}$   | The time from the rising edge of the $PROG_B$ pin to the rising transition on the $INIT_B$ pin  | XC3S100E  | -                | 0.5 | ms      |
|                  |   | XC3S250E  | -                | 0.5 | ms      |
|                  |   | XC3S500E  | -                | 1   | ms      |
|                  |   | XC3S1200E | -                | 2   | ms      |
|                  |   | XC3S1600E | -                | 2   | ms      |
| $T_{INIT}$       | Minimum Low pulse width on $INIT_B$ output  | All       | 250              | -   | ns      |
| $T_{ICCK}^{(3)}$ | The time from the rising edge of the $INIT_B$ pin to the generation of the configuration clock signal at the $CCLK$ output pin  | All       | 0.5              | 4.0 | $\mu$ s |

#### Notes:

1. The numbers in this table are based on the operating conditions set forth in Table 77. This means power must be applied to all  $V_{CCINT}$ ,  $V_{CCO}$ , and  $V_{CCAUX}$  lines.
2. Power-on reset and the clearing of configuration memory occurs during this period.
3. This specification applies only to the Master Serial, SPI, BPI-Up, and BPI-Down modes.

## Configuration Clock (CCLK) Characteristics

Table 112: Master Mode CCLK Output Period by **ConfigRate** Option Setting

| Symbol              | Description                                    | ConfigRate Setting                      | Temperature Range | Minimum | Maximum | Units |
|---------------------|--|---|-------------------|---------|---------|-------|
| T <sub>CCLK1</sub>  | CCLK clock period by <b>ConfigRate</b> setting | 1<br>(power-on value and default value) | Commercial        | 570     | 1,250   | ns    |
| T <sub>CCLK3</sub>  |  |   | Industrial        | 485     |         | ns    |
| T <sub>CCLK6</sub>  |  | 3                                       | Commercial        | 285     | 625     | ns    |
| T <sub>CCLK12</sub> |  |   | Industrial        | 242     |         | ns    |
| T <sub>CCLK25</sub> |  | 6                                       | Commercial        | 142     | 313     | ns    |
| T <sub>CCLK50</sub> |  |   | Industrial        | 121     |         | ns    |
|                     |  | 12                                      | Commercial        | 71.2    | 157     | ns    |
|                     |  |   | Industrial        | 60.6    |         | ns    |
|                     |  | 25                                      | Commercial        | 35.5    | 78.2    | ns    |
|                     |  |   | Industrial        | 30.3    |         | ns    |
|                     |  | 50                                      | Commercial        | 17.8    | 39.1    | ns    |
|                     |  |   | Industrial        | 15.1    |         | ns    |

### Notes:

- Set the **ConfigRate** option value when generating a configuration bitstream. See [Bitstream Generator \(BitGen\) Options](#) in Module 2.

Table 113: Master Mode CCLK Output Frequency by **ConfigRate** Option Setting

| Symbol              | Description  | ConfigRate Setting                      | Temperature Range | Minimum | Maximum | Units |
|---------------------|--|---|-------------------|---------|---------|-------|
| F <sub>CCLK1</sub>  | Equivalent CCLK clock frequency by <b>ConfigRate</b> setting | 1<br>(power-on value and default value) | Commercial        | 0.8     | 1.8     | MHz   |
| F <sub>CCLK3</sub>  |  |   | Industrial        |         | 2.1     | MHz   |
| F <sub>CCLK6</sub>  |  | 3                                       | Commercial        | 1.6     | 3.6     | MHz   |
| F <sub>CCLK12</sub> |  |   | Industrial        |         | 4.2     | MHz   |
| F <sub>CCLK25</sub> |  | 6                                       | Commercial        | 3.2     | 7.1     | MHz   |
| F <sub>CCLK50</sub> |  |   | Industrial        |         | 8.3     | MHz   |
|                     |  | 12                                      | Commercial        | 6.4     | 14.1    | MHz   |
|                     |  |   | Industrial        |         | 16.5    | MHz   |
|                     |  | 25                                      | Commercial        | 12.8    | 28.1    | MHz   |
|                     |  |   | Industrial        |         | 33.0    | MHz   |
|                     |  | 50                                      | Commercial        | 25.6    | 56.2    | MHz   |
|                     |  |   | Industrial        |         | 66.0    | MHz   |

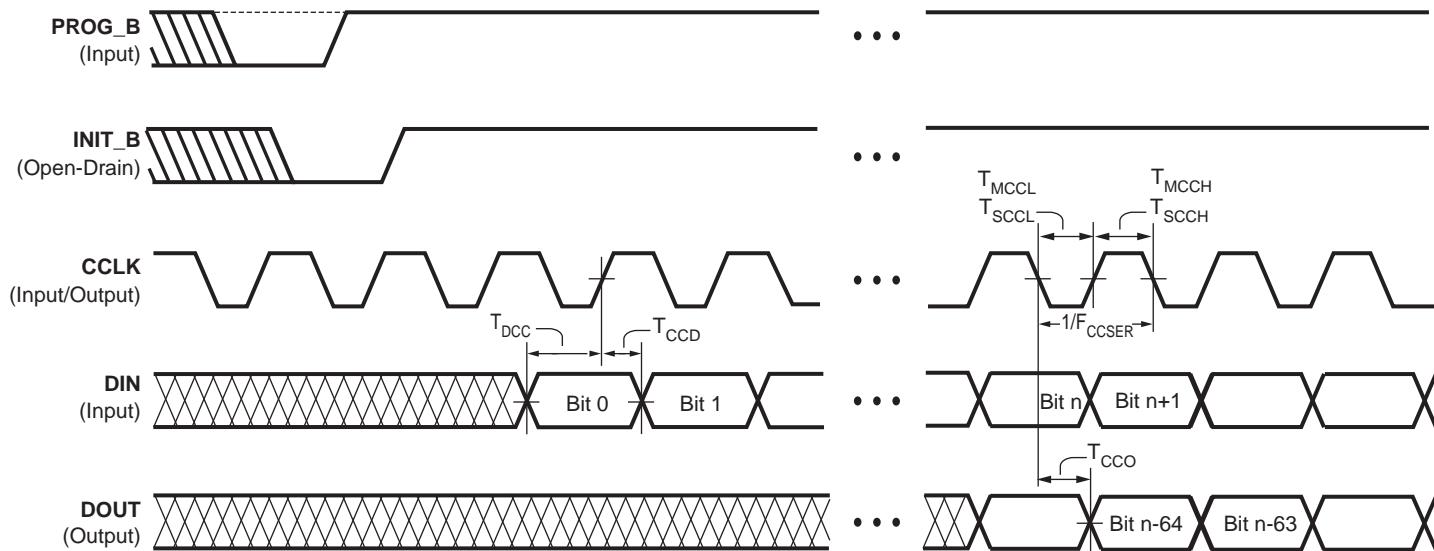
Table 114: Master Mode CCLK Output Minimum Low and High Time

| Symbol                                   | Description                                | ConfigRate Setting |     |     |    |      |      | Units |    |
|--|--|--------------------|-----|-----|----|------|------|-------|----|
|  |  | 1                  | 3   | 6   | 12 | 25   | 50   |       |    |
| T <sub>MCCL</sub> ,<br>T <sub>MCCH</sub> | Master mode CCLK minimum Low and High time | Commercial         | 276 | 138 | 69 | 34.5 | 17.1 | 8.5   | ns |
|  |  | Industrial         | 235 | 117 | 58 | 29.3 | 14.5 | 7.3   | ns |

Table 115: Slave Mode CCLK Input Low and High Time

| Symbol                                   | Description            | Min | Max      | Units |
|--|------------------------|-----|----------|-------|
| T <sub>SCCL</sub> ,<br>T <sub>SCCH</sub> | CCLK Low and High time | 5   | $\infty$ | ns    |

## Master Serial and Slave Serial Mode Timing



DS312-3\_05\_103105

Figure 74: Waveforms for Master Serial and Slave Serial Configuration

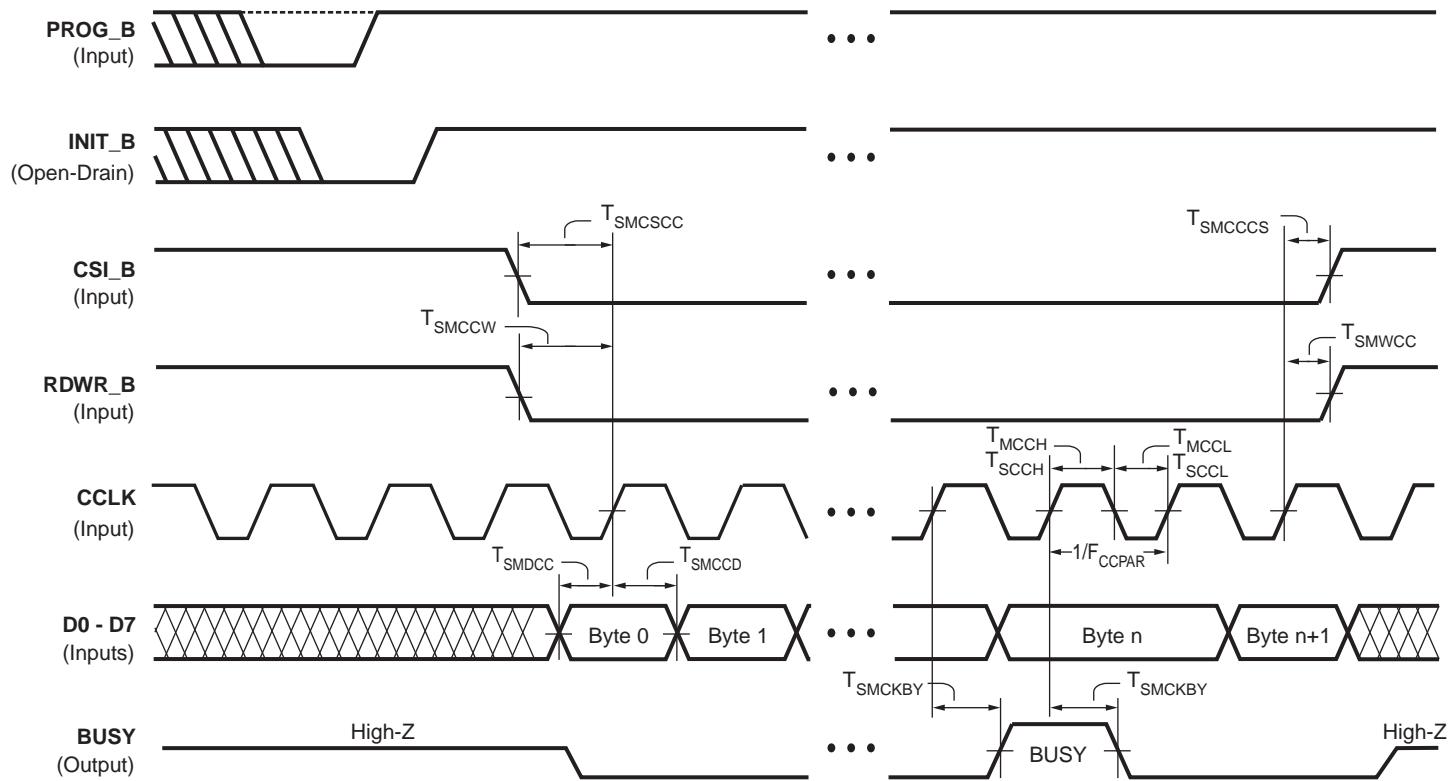
Table 116: Timing for the Master Serial and Slave Serial Configuration Modes

| Symbol                       | Description  | Slave/<br>Master | All Speed Grades |                   | Units |
|------------------------------|--|------------------|------------------|-------------------|-------|
|                              |  |                  | Min              | Max               |       |
| <b>Clock-to-Output Times</b> |  |                  |                  |                   |       |
| T <sub>CCO</sub>             | The time from the falling transition on the CCLK pin to data appearing at the DOUT pin           | Both             | 1.5              | 10.0              | ns    |
| <b>Setup Times</b>           |  |                  |                  |                   |       |
| T <sub>DCC</sub>             | The time from the setup of data at the DIN pin to the active edge of the CCLK pin                | Both             | 11.0             | -                 | ns    |
| <b>Hold Times</b>            |  |                  |                  |                   |       |
| T <sub>CCD</sub>             | The time from the active edge of the CCLK pin to the point when data is last held at the DIN pin | Both             | 0                | -                 | ns    |
| <b>Clock Timing</b>          |  |                  |                  |                   |       |
| T <sub>CCH</sub>             | High pulse width at the CCLK input pin   | Master           | See Table 114    |                   |       |
|                              |  | Slave            | See Table 115    |                   |       |
| T <sub>CCL</sub>             | Low pulse width at the CCLK input pin  | Master           | See Table 114    |                   |       |
|                              |  | Slave            | See Table 115    |                   |       |
| F <sub>CCSER</sub>           | Frequency of the clock signal at the CCLK input pin  | Slave            | 0                | 66 <sup>(2)</sup> | MHz   |
|                              |  |                  | 0                | 20                | MHz   |

### Notes:

1. The numbers in this table are based on the operating conditions set forth in Table 77.
2. For serial configuration with a daisy-chain of multiple FPGAs, the maximum limit is 25 MHz.

## Slave Parallel Mode Timing



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## Notes:

1. It is possible to abort configuration by pulling CSI\_B Low in a given CCLK cycle, then switching RDWR\_B Low or High in any subsequent cycle for which CSI\_B remains Low. The RDWR\_B pin asynchronously controls the driver impedance of the D0 - D7 bus. When RDWR\_B switches High, be careful to avoid contention on the D0 - D7 bus.

Figure 75: Waveforms for Slave Parallel Configuration

Table 117: Timing for the Slave Parallel Configuration Mode

| Symbol                       | Description  | All Speed Grades |      | Units |
|------------------------------|--|------------------|------|-------|
|                              |  | Min              | Max  |       |
| <b>Clock-to-Output Times</b> |  |                  |      |       |
| $T_{SMCKBY}$                 | The time from the rising transition on the CCLK pin to a signal transition at the BUSY pin                   | -                | 12.0 | ns    |
| <b>Setup Times</b>           |  |                  |      |       |
| $T_{SMDCC}$                  | The time from the setup of data at the D0-D7 pins to the active edge the CCLK pin                            | 11.0             | -    | ns    |
| $T_{SMCSCC}$                 | Setup time on the CSI_B pin before the active edge of the CCLK pin   | 10.0             | -    | ns    |
| $T_{SMCCW}^{(2)}$            | Setup time on the RDWR_B pin before active edge of the CCLK pin  | 23.0             | -    | ns    |
| <b>Hold Times</b>            |  |                  |      |       |
| $T_{SMCCD}$                  | The time from the active edge of the CCLK pin to the point when data is last held at the D0-D7 pins          | 1.0              | -    | ns    |
| $T_{SMCCCS}$                 | The time from the active edge of the CCLK pin to the point when a logic level is last held at the CSO_B pin  | 0                | -    | ns    |
| $T_{SMWCC}$                  | The time from the active edge of the CCLK pin to the point when a logic level is last held at the RDWR_B pin | 0                | -    | ns    |

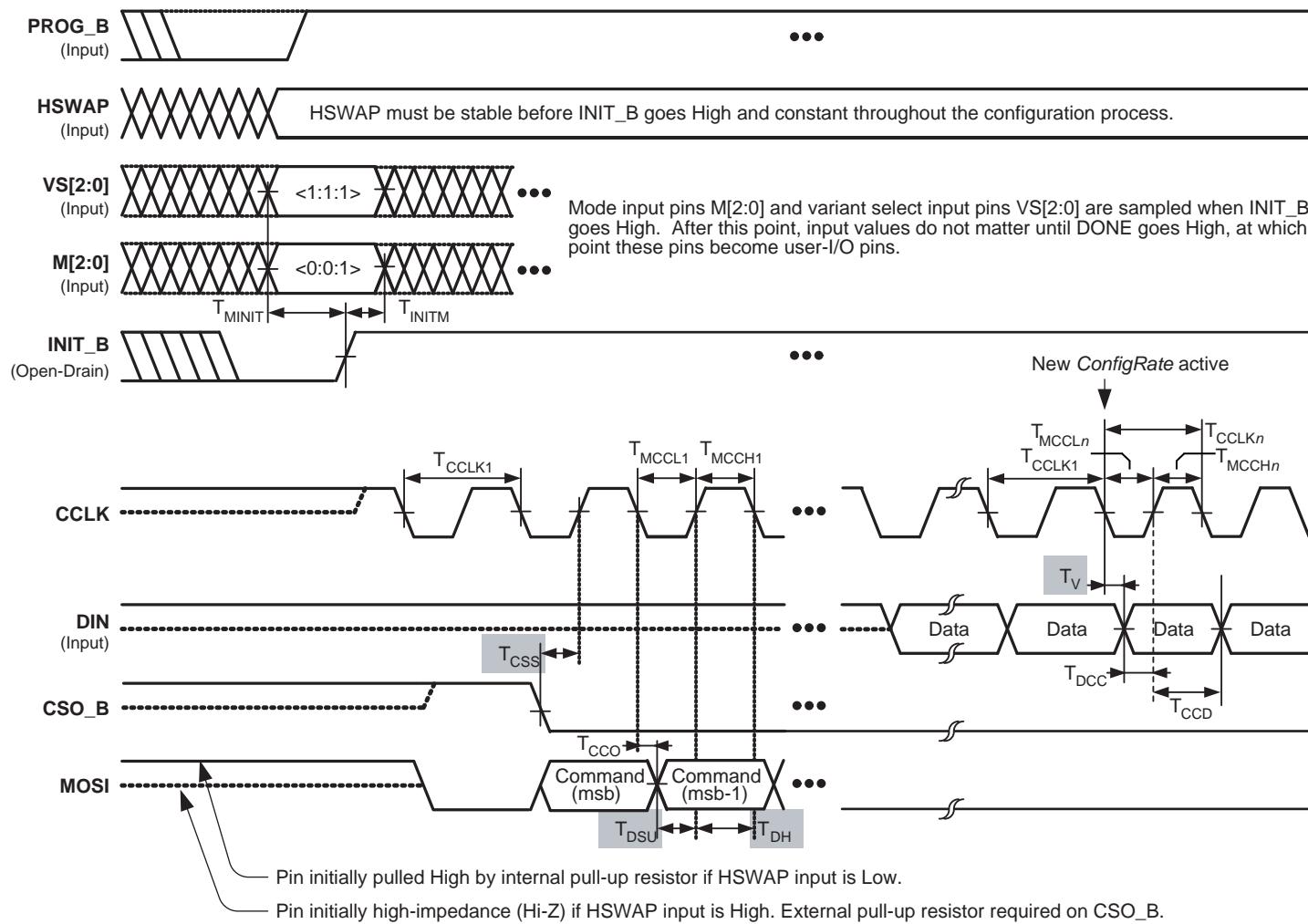
Table 117: Timing for the Slave Parallel Configuration Mode (Cont'd)

| Symbol              | Description   | All Speed Grades           |                                       | Units |
|---------------------|---|----------------------------|---------------------------------------|-------|
|                     |   | Min                        | Max                                   |       |
| <b>Clock Timing</b> |   |                            |                                       |       |
| T <sub>CCH</sub>    | The High pulse width at the CCLK input pin          | 5                          | -                                     | ns    |
| T <sub>CCL</sub>    | The Low pulse width at the CCLK input pin           | 5                          | -                                     | ns    |
| F <sub>CCPAR</sub>  | Frequency of the clock signal at the CCLK input pin | No bitstream compression   | Not using the BUSY pin <sup>(2)</sup> | 0     |
|                     |   |                            | Using the BUSY pin                    | 0     |
|                     |   | With bitstream compression |                                       | 0     |
|                     |   |                            | 50                                    | MHz   |
|                     |   |                            | 66                                    | MHz   |
|                     |   |                            | 20                                    | MHz   |

**Notes:**

1. The numbers in this table are based on the operating conditions set forth in [Table 77](#).
2. In the Slave Parallel mode, it is necessary to use the BUSY pin when the CCLK frequency exceeds this maximum specification.
3. Some Xilinx documents refer to Parallel modes as "SelectMAP" modes.

## Serial Peripheral Interface (SPI) Configuration Timing



Shaded values indicate specifications on attached SPI Flash PROM.

ds312-3\_06\_110206

Figure 76: Waveforms for Serial Peripheral Interface (SPI) Configuration

Table 118: Timing for Serial Peripheral Interface (SPI) Configuration Mode

| Symbol             | Description   | Minimum       | Maximum | Units |
|--------------------|---|---------------|---------|-------|
| T <sub>CCLK1</sub> | Initial CCLK clock period   | See Table 112 |         |       |
| T <sub>CCLKn</sub> | CCLK clock period after FPGA loads ConfigRate setting                       | See Table 112 |         |       |
| T <sub>MINIT</sub> | Setup time on VS[2:0] and M[2:0] mode pins before the rising edge of INIT_B | 50            | -       | ns    |
| T <sub>INITM</sub> | Hold time on VS[2:0] and M[2:0] mode pins after the rising edge of INIT_B   | 0             | -       | ns    |
| T <sub>CCO</sub>   | MOSI output valid after CCLK edge   | See Table 116 |         |       |
| T <sub>DCC</sub>   | Setup time on DIN data input before CCLK edge                               | See Table 116 |         |       |
| T <sub>CCD</sub>   | Hold time on DIN data input after CCLK edge                                 | See Table 116 |         |       |

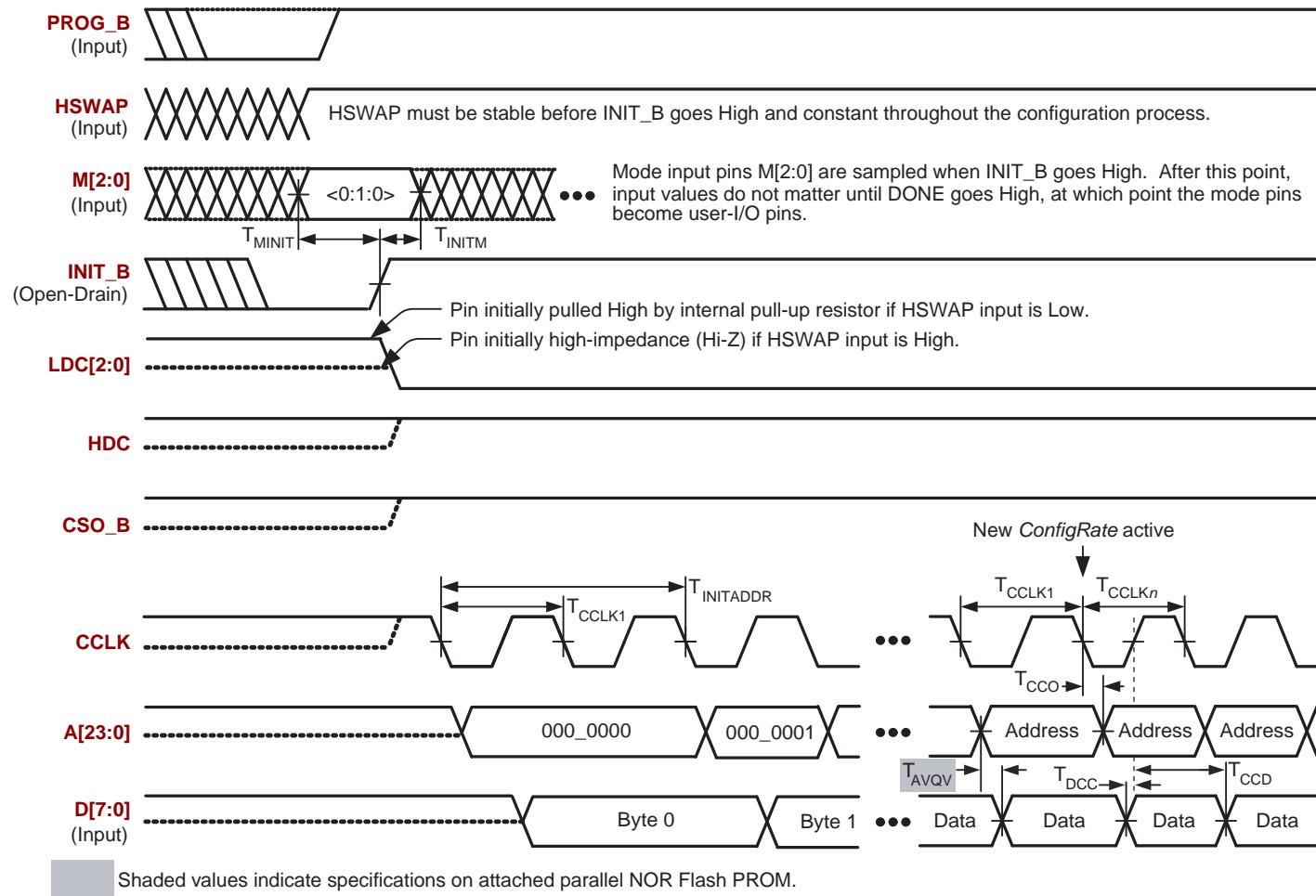
Table 119: Configuration Timing Requirements for Attached SPI Serial Flash

| Symbol         | Description  | Requirement                         | Units |
|----------------|--|-------------------------------------|-------|
| $T_{CCS}$      | SPI serial Flash PROM chip-select time   | $T_{CCS} \leq T_{MCCL1} - T_{CCO}$  | ns    |
| $T_{DSU}$      | SPI serial Flash PROM data input setup time  | $T_{DSU} \leq T_{MCCL1} - T_{CCO}$  | ns    |
| $T_{DH}$       | SPI serial Flash PROM data input hold time   | $T_{DH} \leq T_{MCCH1}$             | ns    |
| $T_V$          | SPI serial Flash PROM data clock-to-output time  | $T_V \leq T_{MCCLn} - T_{DCC}$      | ns    |
| $f_C$ or $f_R$ | Maximum SPI serial Flash PROM clock frequency (also depends on specific read command used) | $f_C \geq \frac{1}{T_{CCLKn(min)}}$ | MHz   |

**Notes:**

1. These requirements are for successful FPGA configuration in SPI mode, where the FPGA provides the CCLK frequency. The post configuration timing can be different to support the specific needs of the application loaded into the FPGA and the resulting clock source.
2. Subtract additional printed circuit board routing delay as required by the application.

## Byte Peripheral Interface (BPI) Configuration Timing



DS312-3\_08\_032409

Figure 77: Waveforms for Byte-wide Peripheral Interface (BPI) Configuration (BPI-DN mode shown)

Table 120: Timing for Byte-wide Peripheral Interface (BPI) Configuration Mode

| Symbol                | Description  | Minimum  | Maximum | Units         |                              |
|-----------------------|--|--|---------|---------------|------------------------------|
| T <sub>CCLK1</sub>    | Initial CCLK clock period  |  |         | See Table 112 |                              |
| T <sub>CCLKn</sub>    | CCLK clock period after FPGA loads ConfigRate setting                                    |  |         | See Table 112 |                              |
| T <sub>MINIT</sub>    | Setup time on CSI_B, RDWR_B, and M[2:0] mode pins before the rising edge of INIT_B       | 50   | -       | ns            |                              |
| T <sub>INITIM</sub>   | Hold time on CSI_B, RDWR_B, and M[2:0] mode pins after the rising edge of INIT_B         | 0  | -       | ns            |                              |
| T <sub>INITADDR</sub> | Minimum period of initial A[23:0] address cycle; LDC[2:0] and HDC are asserted and valid | BPI-UP:<br>(M[2:0] = <0:1:0>)<br><br>BPI-DN:<br>(M[2:0] = <0:1:1>) | 5       | 5             | T <sub>CCLK1</sub><br>cycles |
| T <sub>CCO</sub>      | Address A[23:0] outputs valid after CCLK falling edge                                    |  | 2       |               |                              |
| T <sub>DCC</sub>      | Setup time on D[7:0] data inputs before CCLK rising edge                                 |  |         | See Table 116 |                              |
| T <sub>CCD</sub>      | Hold time on D[7:0] data inputs after CCLK rising edge                                   |  |         | See Table 116 |                              |

Table 121: Configuration Timing Requirements for Attached Parallel NOR Flash

| Symbol                                 | Description  | Requirement   | Units |
|--|--|---|-------|
| $T_{CE}$ ( $t_{ELQV}$ )                | Parallel NOR Flash PROM chip-select time                         | $T_{CE} \leq T_{INITADDR}$                                  | ns    |
| $T_{OE}$ ( $t_{GLQV}$ )                | Parallel NOR Flash PROM output-enable time                       | $T_{OE} \leq T_{INITADDR}$                                  | ns    |
| $T_{ACC}$ ( $t_{AVQV}$ )               | Parallel NOR Flash PROM read access time                         | $T_{ACC} \leq 0.5 T_{CCLKn(min)} - T_{CCO} - T_{DCC} - PCB$ | ns    |
| $T_{BYTE}$ ( $t_{FLQV}$ , $t_{FHQV}$ ) | For x8/x16 PROMs only: BYTE# to output valid time <sup>(3)</sup> | $T_{BYTE} \leq T_{INITADDR}$                                | ns    |

**Notes:**

1. These requirements are for successful FPGA configuration in BPI mode, where the FPGA provides the CCLK frequency. The post configuration timing can be different to support the specific needs of the application loaded into the FPGA and the resulting clock source.
2. Subtract additional printed circuit board routing delay as required by the application.
3. The initial BYTE# timing can be extended using an external, appropriately sized pull-down resistor on the FPGA's LDC2 pin. The resistor value also depends on whether the FPGA's HSWAP pin is High or Low.

Table 122: MultiBoot Trigger (MBT) Timing

| Symbol    | Description  | Minimum | Maximum  | Units |
|-----------|--|---------|----------|-------|
| $T_{MBT}$ | MultiBoot Trigger (MBT) Low pulse width required to initiate MultiBoot reconfiguration | 300     | $\infty$ | ns    |

**Notes:**

1. MultiBoot re-configuration starts on the rising edge after MBT is Low for at least the prescribed minimum period.

## IEEE 1149.1/1532 JTAG Test Access Port Timing

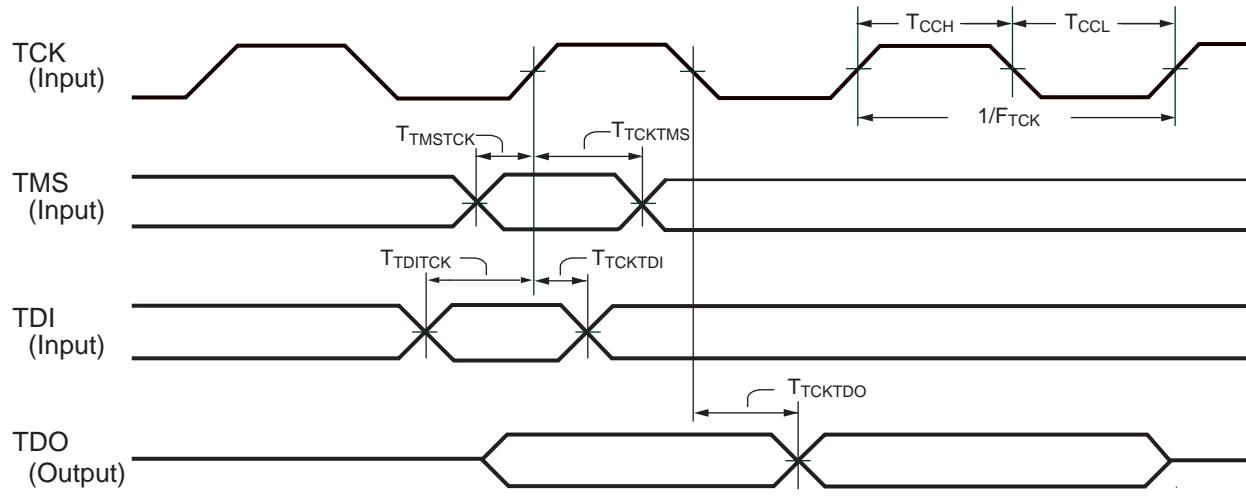


Figure 78: JTAG Waveforms

Table 123: Timing for the JTAG Test Access Port

| Symbol                       | Description  | All Speed Grades |      | Units |
|------------------------------|--|------------------|------|-------|
|                              |  | Min              | Max  |       |
| <b>Clock-to-Output Times</b> |  |                  |      |       |
| $T_{TCKTDO}$                 | The time from the falling transition on the TCK pin to data appearing at the TDO pin                           | 1.0              | 11.0 | ns    |
| <b>Setup Times</b>           |  |                  |      |       |
| $T_{TDITCK}$                 | The time from the setup of data at the TDI pin to the rising transition at the TCK pin                         | 7.0              | -    | ns    |
| $T_{TMSTCK}$                 | The time from the setup of a logic level at the TMS pin to the rising transition at the TCK pin                | 7.0              | -    | ns    |
| <b>Hold Times</b>            |  |                  |      |       |
| $T_{TCKTDI}$                 | The time from the rising transition at the TCK pin to the point when data is last held at the TDI pin          | 0                | -    | ns    |
| $T_{TCKTMS}$                 | The time from the rising transition at the TCK pin to the point when a logic level is last held at the TMS pin | 0                | -    | ns    |
| <b>Clock Timing</b>          |  |                  |      |       |
| $T_{CCH}$                    | The High pulse width at the TCK pin  | 5                | -    | ns    |
| $T_{CCL}$                    | The Low pulse width at the TCK pin   | 5                | -    | ns    |
| $F_{TCK}$                    | Frequency of the TCK signal  | -                | 30   | MHz   |

**Notes:**

1. The numbers in this table are based on the operating conditions set forth in Table 77.

## Revision History

The following table shows the revision history for this document.

| Date       | Version | Revision  |
|------------|---------|---|
| 03/01/2005 | 1.0     | Initial Xilinx release.   |
| 11/23/2005 | 2.0     | Added AC timing information and additional DC specifications.   |
| 03/22/2006 | 3.0     | Upgraded data sheet status to Preliminary. Finalized production timing parameters. All speed grades for all Spartan-3E FPGAs are now Production status using the v1.21 speed files, as shown in <a href="#">Table 84</a> . Expanded description in Note 2, <a href="#">Table 78</a> . Updated pin-to-pin and clock-to-output timing based on final characterization, shown in <a href="#">Table 86</a> . Updated system-synchronous input setup and hold times based on final characterization, shown in <a href="#">Table 87</a> and <a href="#">Table 88</a> . Updated other I/O timing in <a href="#">Table 90</a> . Provided input and output adjustments for LVPECL_25, DIFF_SSTL and DIFF_HSTL I/O standards that supersede the v1.21 speed file values, in <a href="#">Table 91</a> and <a href="#">Table 94</a> . Reduced I/O three-state and set/reset delays in <a href="#">Table 93</a> . Added XC3S100E FPGA in CP132 package to <a href="#">Table 96</a> . Increased $T_{AS}$ slice flip-flop timing by 100 ps in <a href="#">Table 98</a> . Updated distributed RAM timing in <a href="#">Table 99</a> and SRL16 timing in <a href="#">Table 100</a> . Updated global clock timing, removed left/right clock buffer limits in <a href="#">Table 101</a> . Updated block RAM timing in <a href="#">Table 103</a> . Added DCM parameters for remainder of Step 0 device; added improved Step 1 DCM performance to <a href="#">Table 104</a> , <a href="#">Table 105</a> , <a href="#">Table 106</a> , and <a href="#">Table 107</a> . Added minimum INIT_B pulse width specification, $T_{INIT}$ , in <a href="#">Table 111</a> . Increased data hold time for Slave Parallel mode to 1.0 ns ( $T_{SMCCD}$ ) in <a href="#">Table 117</a> . Improved the DCM performance for the XC3S1200E, Stepping 0 in <a href="#">Table 104</a> , <a href="#">Table 105</a> , <a href="#">Table 106</a> , and <a href="#">Table 107</a> . Corrected links in <a href="#">Table 118</a> and <a href="#">Table 120</a> . Added MultiBoot timing specifications to <a href="#">Table 122</a> . |
| 04/07/2006 | 3.1     | Improved SSO limits for LVDS_25, MINI_LVDS_25, and RSDS_25 I/O standards in the QFP packages ( <a href="#">Table 97</a> ). Removed potentially confusing Note 2 from <a href="#">Table 78</a> .   |
| 05/19/2006 | 3.2     | Clarified that 100 mV of hysteresis applies to LVCMOS33 and LVCMOS25 I/O standards (Note 4, <a href="#">Table 80</a> ). Other minor edits.  |
| 05/30/2006 | 3.2.1   | Corrected various typos and incorrect links.  |
| 11/09/2006 | 3.4     | Improved absolute maximum voltage specifications in <a href="#">Table 73</a> , providing additional overshoot allowance. Widened the recommended voltage range for PCI and PCI-X standards in <a href="#">Table 80</a> . Clarified Note 2, <a href="#">Table 83</a> . Improved various timing specifications for v1.26 speed file. Added <a href="#">Table 85</a> to summarize the history of speed file releases after which time all devices became Production status. Added absolute minimum values for <a href="#">Table 86</a> , <a href="#">Table 92</a> , and <a href="#">Table 93</a> . Updated pin-to-pin setup and hold timing based on default IFD_DELAY_VALUE settings in <a href="#">Table 87</a> , <a href="#">Table 88</a> , and <a href="#">Table 90</a> . Added <a href="#">Table 89</a> about source-synchronous input capture sample window. Promoted Module 3 to Production status. Synchronized all modules to v3.4.   |
| 03/16/2007 | 3.5     | Based on extensive 90 nm production data, improved (reduced) the maximum quiescent current limits for the $I_{CCINTQ}$ , $I_{CCAUXQ}$ , and $I_{CCOQ}$ specifications in <a href="#">Table 79</a> by an average of 50%.   |
| 05/29/2007 | 3.6     | Added note to <a href="#">Table 74</a> and <a href="#">Table 75</a> regarding HSWAP in step 0 devices. Updated $t_{RPW\_CLB}$ in <a href="#">Table 98</a> to match value in speed file. Improved CLKOUT_FREQ_CLK90 to 200 MHz for Stepping 1 in <a href="#">Table 105</a> .   |
| 04/18/2008 | 3.7     | Clarified that Stepping 0 was offered only for -4C and removed Stepping 0 -5 specifications. Added reference to XAPP459 in <a href="#">Table 73</a> and <a href="#">Table 77</a> . Improved recommended max $V_{CCO}$ to 3.465V (3.3V + 5%) in <a href="#">Table 77</a> . Removed minimum input capacitance from <a href="#">Table 78</a> . Updated Recommended Operating Conditions for LVCMOS and PCI I/O standards in <a href="#">Table 80</a> . Removed Absolute Minimums from <a href="#">Table 86</a> , <a href="#">Table 92</a> and <a href="#">Table 93</a> and added footnote recommending use of Timing Analyzer for minimum values. Updated $T_{PSFD}$ and $T_{PHFD}$ in <a href="#">Table 87</a> to match current speed file. Update $T_{RPW\_IOB}$ in <a href="#">Table 88</a> to match current speed file and CLB equivalent spec. Added XC3S500E VQG100 to <a href="#">Table 96</a> . Replaced $T_{MULCKID}$ with $T_{MSCKD}$ for A, B, and P registers in <a href="#">Table 102</a> . Updated CLKOUT_PER_JITT_FX in <a href="#">Table 107</a> . Updated MAX_STEPS equation in <a href="#">Table 109</a> . Updated <a href="#">Figure 77</a> and <a href="#">Table 120</a> to correct CCLK active edge. Updated links.   |
| 08/26/2009 | 3.8     | Added reference to XAPP459 in <a href="#">Table 73</a> note 2. Updated BPI timing in <a href="#">Figure 77</a> , <a href="#">Table 119</a> , and <a href="#">Table 120</a> . Removed $V_{REF}$ requirements for differential HSTL and differential SSTL in <a href="#">Table 95</a> . Added Spread Spectrum paragraph. Revised hold times for $T_{IOICKPD}$ in <a href="#">Table 88</a> and setup times for $T_{DICK}$ in <a href="#">Table 98</a> . Added note 4 to <a href="#">Table 106</a> and note 3 to <a href="#">Table 107</a> , and updated note 6 for <a href="#">Table 107</a> to add input jitter.  |

| Date       | Version | Revision   |
|------------|---------|--|
| 10/29/2012 | 4.0     | Added <a href="#">Notice of Disclaimer</a> . This product is not recommended for new designs.<br>Revised note 2 in <a href="#">Table 73</a> . Revised note 2 and $V_{IN}$ description in <a href="#">Table 77</a> , and added note 5. Added note 3 to <a href="#">Table 78</a> . |
| 07/19/2013 | 4.1     | Removed banner. This product IS recommended for new designs.   |
| 12/14/2018 | 4.2     | Updated for <i>Lead-Frame Plating Composition Change For Legacy Eutectic Products</i> ( <a href="#">XCN18024</a> ).  |

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## Introduction

This section describes the various pins on a Spartan®-3E FPGA and how they connect within the supported component packages.

## Pin Types

Most pins on a Spartan-3E FPGA are general-purpose, user-defined I/O pins. There are, however, up to 11 different functional types of pins on Spartan-3E packages, as outlined in [Table 124](#). In the package footprint drawings that follow, the individual pins are color-coded according to pin type as in the table.

**Table 124: Types of Pins on Spartan-3E FPGAs**

| Type / Color Code | Description  | Pin Name(s) in Type <sup>(1)</sup>   |
|-------------------|--|--|
| I/O               | Unrestricted, general-purpose user-I/O pin. Most pins can be paired together to form differential I/Os.  | IO<br>IO_Lxxxy_#   |
| INPUT             | Unrestricted, general-purpose input-only pin. This pin does not have an output structure, differential termination resistor, or PCI clamp diode.   | IP<br>IP_Lxxxy_#   |
| DUAL              | Dual-purpose pin used in some configuration modes during the configuration process and then usually available as a user I/O after configuration. If the pin is not used during configuration, this pin behaves as an I/O-type pin. Some of the dual-purpose pins are also shared with bottom-edge global (GCLK) or right-half (RHCLK) clock inputs. See the <a href="#">Configuration</a> section in Module 2 for additional information on these signals.   | M[2:0]<br>HSWAP<br>CCLK<br>MOSI/CSI_B<br>D[7:1]<br>D0/DIN<br>CSO_B<br>RDWR_B<br>BUSY/DOUT<br>INIT_B<br>A[23:20]<br>A19/VS2<br>A18/VS1<br>A17/VS0<br>A[16:0]<br>LDC[2:0]<br>HDC |
| VREF              | Dual-purpose pin that is either a user-I/O pin or Input-only pin, or, along with all other VREF pins in the same bank, provides a reference voltage input for certain I/O standards. If used for a reference voltage within a bank, all VREF pins within the bank must be connected.   | IP/VREF_#<br>IP_Lxxxy_#/VREF_#<br>IO/VREF_#<br>IO_Lxxxy_#/VREF_#   |
| CLK               | Either a user-I/O pin or Input-only pin, or an input to a specific clock buffer driver. Every package has 16 global clock inputs that optionally clock the entire device. The RHCLK inputs optionally clock the right-half of the device. The LHCLK inputs optionally clock the left-half of the device. Some of the clock pins are shared with the dual-purpose configuration pins and are considered DUAL-type. See the <a href="#">Clocking Infrastructure</a> section in Module 2 for additional information on these signals. | IO_Lxxxy_#/GCLK[15:10, 7:2]<br>IP_Lxxxy_#/GCLK[9:8, 1:0]<br>IO_Lxxxy_#/LHCLK[7:0]<br>IO_Lxxxy_#/RHCLK[7:0]   |
| CONFIG            | Dedicated configuration pin. Not available as a user-I/O pin. Every package has two dedicated configuration pins. These pins are powered by VCCAUX. See the <a href="#">Configuration</a> section in Module 2 for details.   | DONE, PROG_B   |
| JTAG              | Dedicated JTAG pin. Not available as a user-I/O pin. Every package has four dedicated JTAG pins. These pins are powered by VCCAUX.   | TDI, TMS, TCK, TDO   |
| GND               | Dedicated ground pin. The number of GND pins depends on the package used. All must be connected.   | GND  |

Table 124: Types of Pins on Spartan-3E FPGAs (Cont'd)

| Type / Color Code | Description  | Pin Name(s) in Type <sup>(1)</sup> |
|-------------------|--|------------------------------------|
| VCCAUX            | Dedicated auxiliary power supply pin. The number of VCCAUX pins depends on the package used. All must be connected to +2.5V. See the <a href="#">Powering Spartan-3E FPGAs</a> section in Module 2 for details.  | VCCAUX                             |
| VCCINT            | Dedicated internal core logic power supply pin. The number of VCCINT pins depends on the package used. All must be connected to +1.2V. See the <a href="#">Powering Spartan-3E FPGAs</a> section in Module 2 for details.  | VCCINT                             |
| VCCO              | Along with all the other VCCO pins in the same bank, this pin supplies power to the output buffers within the I/O bank and sets the input threshold voltage for some I/O standards. See the <a href="#">Powering Spartan-3E FPGAs</a> section in Module 2 for details. | VCCO_#                             |
| N.C.              | This package pin is not connected in this specific device/package combination but may be connected in larger devices in the same package.  | N.C.                               |

**Notes:**

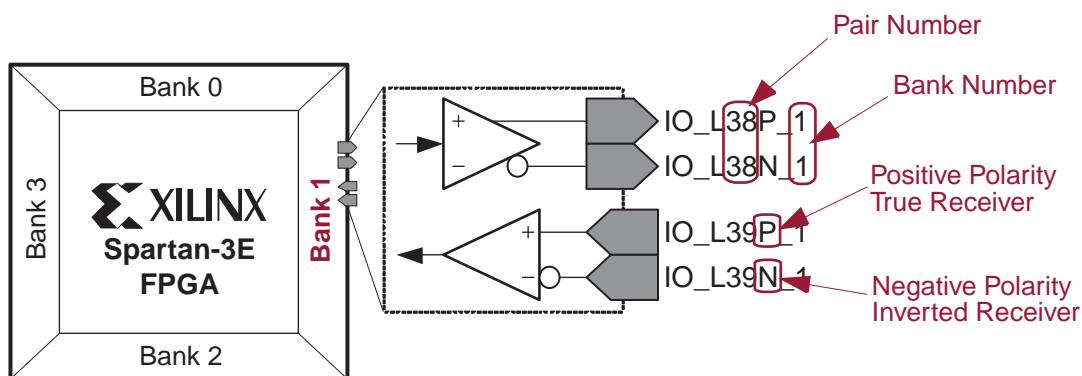
- # = I/O bank number, an integer between 0 and 3.
- IRDY/TRDY designations are for PCI designs; refer to PCI documentation for details.

**Differential Pair Labeling**

I/Os with Lxx\_y\_# are part of a differential pair. 'L' indicates differential capability. The 'xx' field is a two-digit integer, unique to each bank that identifies a differential pin-pair. The 'y' field is either 'P' for the true signal or 'N' for the inverted signal in the differential pair. The '#' field is the I/O bank number.

The pin name suffix has the following significance. [Figure 79](#) provides a specific example showing a differential input to and a differential output from Bank 1.

'L' indicates that the pin is part of a differential pair.  
'xx' is a two-digit integer, unique for each bank, that identifies a differential pin-pair.  
'y' is replaced by 'P' for the true signal or 'N' for the inverted. These two pins form one differential pin-pair.  
'#' is an integer, 0 through 3, indicating the associated I/O bank.



DS312-4\_00\_032409

Figure 79: Differential Pair Labeling

## Package Overview

Table 125 shows the eight low-cost, space-saving production package styles for the Spartan-3E family. Each package style is available as a standard and an environmentally friendly lead-free (Pb-free) option. The Pb-free packages include an extra 'G' in the package style name. For example, the standard "VQ100" package becomes "VQG100" when ordered as the Pb-free option. The mechanical dimensions of the standard and Pb-free packages are similar. Package drawings and package

material declaration data sheets (MDDS) are available on [www.xilinx.com](http://www.xilinx.com).

Not all Spartan-3E densities are available in all packages. For a specific package, however, there is a common footprint that supports all the devices available in that package. See the footprint diagrams that follow.

For additional package information, see [UG112: Device Package User Guide](#).

Table 125: Spartan-3E Family Package Options<sup>(1)</sup>

| Package        | Leads | Type                                    | Maximum I/O | Lead Pitch (mm) | Footprint Area (mm) | Height (mm) |
|----------------|-------|---|-------------|-----------------|---------------------|-------------|
| VQ100 / VQG100 | 100   | Very-thin Quad Flat Pack (VQFP)         | 66          | 0.5             | 16 x 16             | 1.20        |
| CP132 / CPG132 | 132   | Chip-Scale Package (CSP)                | 92          | 0.5             | 8.1 x 8.1           | 1.10        |
| TQ144 / TQG144 | 144   | Thin Quad Flat Pack (TQFP)              | 108         | 0.5             | 22 x 22             | 1.60        |
| PQ208 / PQG208 | 208   | Plastic Quad Flat Pack (PQFP)           | 158         | 0.5             | 30.6 x 30.6         | 4.10        |
| FT256 / FTG256 | 256   | Fine-pitch, Thin Ball Grid Array (FBGA) | 190         | 1.0             | 17 x 17             | 1.55        |
| FG320 / FGG320 | 320   | Fine-pitch Ball Grid Array (FBGA)       | 250         | 1.0             | 19 x 19             | 2.00        |
| FG400 / FGG400 | 400   | Fine-pitch Ball Grid Array (FBGA)       | 304         | 1.0             | 21 x 21             | 2.43        |
| FG484 / FGG484 | 484   | Fine-pitch Ball Grid Array (FBGA)       | 376         | 1.0             | 23 x 23             | 2.60        |

**Notes:**

1. See the package material declaration data sheet for package mass.

## Selecting the Right Package Option

Spartan-3E FPGAs are available in both quad-flat pack (QFP) and ball grid array (BGA) packaging options. While QFP packaging offers the lowest absolute cost, the BGA

packages are superior in almost every other aspect, as summarized in Table 126. Consequently, Xilinx recommends using BGA packaging whenever possible.

Table 126: QFP and BGA Comparison

| Characteristic                              | Quad Flat Pack (QFP) | Ball Grid Array (BGA) |
|---|----------------------|-----------------------|
| Maximum User I/O                            | 158                  | 376                   |
| Packing Density (Logic/Area)                | Good                 | Better                |
| Signal Integrity                            | Fair                 | Better                |
| Simultaneous Switching Output (SSO) Support | Fair                 | Better                |
| Thermal Dissipation                         | Fair                 | Better                |
| Minimum Printed Circuit Board (PCB) Layers  | 4                    | 4-6                   |
| Hand Assembly/Rework                        | Possible             | Difficult             |

## Mechanical Drawings

Package drawings and package material declaration data sheets (MDDS) are available on [www.xilinx.com](http://www.xilinx.com).

## Package Pins by Type

Each package has three separate voltage supply inputs—VCCINT, VCCAUX, and VCCO—and a common ground return, GND. The numbers of pins dedicated to these functions vary by package, as shown in Table 127.

Table 127: Power and Ground Supply Pins by Package

| Package | VCCINT | VCCAUX | VCCO | GND |
|---------|--------|--------|------|-----|
| VQ100   | 4      | 4      | 8    | 12  |
| CP132   | 6      | 4      | 8    | 16  |
| TQ144   | 4      | 4      | 9    | 13  |
| PQ208   | 4      | 8      | 12   | 20  |
| FT256   | 8      | 8      | 16   | 28  |
| FG320   | 8      | 8      | 20   | 28  |
| FG400   | 16     | 8      | 24   | 42  |
| FG484   | 16     | 10     | 28   | 48  |

A majority of package pins are user-defined I/O or input pins. However, the numbers and characteristics of these I/O depend on the device type and the package in which it is available, as shown in Table 128. The table shows the maximum number of single-ended I/O pins available, assuming that all I/O-, INPUT-, DUAL-, VREF-, and CLK-type pins are used as general-purpose I/O. Likewise, the table shows the maximum number of differential pin-pairs available on the package. Finally, the table shows how the total maximum user-I/Os are distributed by pin type, including the number of unconnected—i.e., N.C.—pins on the device.

Table 128: Maximum User I/O by Package

| Device    | Package | Maximum User I/Os and Input-Only | Maximum Input-Only | Maximum Differential Pairs | All Possible I/Os by Type |       |      |                     |                    |      |
|-----------|---------|----------------------------------|--------------------|----------------------------|---------------------------|-------|------|---------------------|--------------------|------|
|           |         |                                  |                    |                            | I/O                       | INPUT | DUAL | VREF <sup>(1)</sup> | CLK <sup>(2)</sup> | N.C. |
| XC3S100E  | VQ100   | 66                               | 7                  | 30                         | 16                        | 1     | 21   | 4                   | 24                 | 0    |
| XC3S250E  |         | 66                               | 7                  | 30                         | 16                        | 1     | 21   | 4                   | 24                 | 0    |
| XC3S500E  |         | 66                               | 7                  | 30                         | 16                        | 1     | 21   | 4                   | 24                 | 0    |
| XC3S100E  | CP132   | 83                               | 11                 | 35                         | 16                        | 2     | 42   | 7                   | 16                 | 9    |
| XC3S250E  |         | 92                               | 7                  | 41                         | 22                        | 0     | 46   | 8                   | 16                 | 0    |
| XC3S500E  |         | 92                               | 7                  | 41                         | 22                        | 0     | 46   | 8                   | 16                 | 0    |
| XC3S100E  | TQ144   | 108                              | 28                 | 40                         | 22                        | 19    | 42   | 9                   | 16                 | 0    |
| XC3S250E  |         | 108                              | 28                 | 40                         | 20                        | 21    | 42   | 9                   | 16                 | 0    |
| XC3S250E  | PQ208   | 158                              | 32                 | 65                         | 58                        | 25    | 46   | 13                  | 16                 | 0    |
| XC3S500E  |         | 158                              | 32                 | 65                         | 58                        | 25    | 46   | 13                  | 16                 | 0    |
| XC3S250E  | FT256   | 172                              | 40                 | 68                         | 62                        | 33    | 46   | 15                  | 16                 | 18   |
| XC3S500E  |         | 190                              | 41                 | 77                         | 76                        | 33    | 46   | 19                  | 16                 | 0    |
| XC3S1200E |         | 190                              | 40                 | 77                         | 78                        | 31    | 46   | 19                  | 16                 | 0    |
| XC3S500E  | FG320   | 232                              | 56                 | 92                         | 102                       | 48    | 46   | 20                  | 16                 | 18   |
| XC3S1200E |         | 250                              | 56                 | 99                         | 120                       | 47    | 46   | 21                  | 16                 | 0    |
| XC3S1600E |         | 250                              | 56                 | 99                         | 120                       | 47    | 46   | 21                  | 16                 | 0    |
| XC3S1200E | FG400   | 304                              | 72                 | 124                        | 156                       | 62    | 46   | 24                  | 16                 | 0    |
| XC3S1600E |         | 304                              | 72                 | 124                        | 156                       | 62    | 46   | 24                  | 16                 | 0    |
| XC3S1600E | FG484   | 376                              | 82                 | 156                        | 214                       | 72    | 46   | 28                  | 16                 | 0    |

**Notes:**

1. Some VREF pins are on INPUT pins. See pinout tables for details.
2. All devices have 24 possible global clock and right- and left-half side clock inputs. The right-half and bottom-edge clock pins have shared functionality in some FPGA configuration modes. Consequently, some clock pins are counted in the DUAL column. 4 GCLK pins, including 2 DUAL pins, are on INPUT pins.

Electronic versions of the package pinout tables and footprints are available for download from the Xilinx website.

Download the files from the following location:

[http://www.xilinx.com/support/documentation/data\\_sheets/s3e\\_pin.zip](http://www.xilinx.com/support/documentation/data_sheets/s3e_pin.zip)

Using a spreadsheet program, the data can be sorted and reformatted according to any specific needs. Similarly, the ASCII-text file is easily parsed by most scripting programs.

## Package Thermal Characteristics

The power dissipated by an FPGA application has implications on package selection and system design. The power consumed by a Spartan-3E FPGA is reported using either the [XPower Estimator](#) or the [XPower Analyzer](#) calculator integrated in the Xilinx ISE® development software. [Table 129](#) provides the thermal characteristics for the various Spartan-3E package offerings.

The junction-to-case thermal resistance ( $\theta_{JC}$ ) indicates the difference between the temperature measured on the

package body (case) and the die junction temperature per watt of power consumption. The junction-to-board ( $\theta_{JB}$ ) value similarly reports the difference between the board and junction temperature. The junction-to-ambient ( $\theta_{JA}$ ) value reports the temperature difference per watt between the ambient environment and the junction temperature. The  $\theta_{JA}$  value is reported at different air velocities, measured in linear feet per minute (LFM). The Still Air (0 LFM) column shows the  $\theta_{JA}$  value in a system without a fan. The thermal resistance drops with increasing air flow.

**Table 129: Spartan-3E Package Thermal Characteristics**

| Device    | Package | Junction-to-Case<br>( $\theta_{JC}$ ) | Junction-to-Board<br>( $\theta_{JB}$ ) | Junction-to-Ambient ( $\theta_{JA}$ )<br>at Different Air Flows |         |         |         | Units   |
|-----------|---------|---------------------------------------|--|---|---------|---------|---------|---------|
|           |         |                                       |  | Still Air<br>(0 LFM)  | 250 LFM | 500 LFM | 750 LFM |         |
| XC3S100E  | VQ100   | 13.0                                  | 30.9                                   | 49.0  | 40.7    | 37.9    | 37.0    | °C/Watt |
| XC3S250E  |         | 11.0                                  | 25.9                                   | 43.3  | 36.0    | 33.6    | 32.7    | °C/Watt |
| XC3S500E  |         | 9.8                                   |  | 40.0  | 33.3    | 31.0    | 30.2    | °C/Watt |
| XC3S100E  | CP132   | 19.3                                  | 42.0                                   | 62.1  | 55.3    | 52.8    | 51.2    | °C/Watt |
| XC3S250E  |         | 11.8                                  | 28.1                                   | 48.3  | 41.8    | 39.5    | 38.0    | °C/Watt |
| XC3S500E  |         | 8.5                                   | 21.3                                   | 41.5  | 35.2    | 32.9    | 31.5    | °C/Watt |
| XC3S100E  | TQ144   | 8.2                                   | 31.9                                   | 52.1  | 40.5    | 34.6    | 32.5    | °C/Watt |
| XC3S250E  |         | 7.2                                   | 25.7                                   | 37.6  | 29.2    | 25.0    | 23.4    | °C/Watt |
| XC3S250E  | PQ208   | 9.8                                   | 29.0                                   | 37.0  | 27.3    | 24.1    | 22.4    | °C/Watt |
| XC3S500E  |         | 8.5                                   | 26.8                                   | 36.1  | 26.6    | 23.6    | 21.8    | °C/Watt |
| XC3S250E  | FT256   | 12.4                                  | 27.7                                   | 35.8  | 29.3    | 28.4    | 28.1    | °C/Watt |
| XC3S500E  |         | 9.6                                   | 22.2                                   | 31.1  | 25.0    | 24.0    | 23.6    | °C/Watt |
| XC3S1200E |         | 6.5                                   | 16.4                                   | 26.2  | 20.5    | 19.3    | 18.9    | °C/Watt |
| XC3S500E  | FG320   | 9.8                                   | 15.6                                   | 26.1  | 20.6    | 19.4    | 18.6    | °C/Watt |
| XC3S1200E |         | 8.2                                   | 12.5                                   | 23.0  | 17.7    | 16.4    | 15.7    | °C/Watt |
| XC3S1600E |         | 7.1                                   | 10.6                                   | 21.1  | 15.9    | 14.6    | 13.8    | °C/Watt |
| XC3S1200E | FG400   | 7.5                                   | 12.4                                   | 22.3  | 17.2    | 16.0    | 15.3    | °C/Watt |
| XC3S1600E |         | 6.0                                   | 10.4                                   | 20.3  | 15.2    | 14.0    | 13.3    | °C/Watt |
| XC3S1600E | FG484   | 5.7                                   | 9.4                                    | 18.8  | 12.5    | 11.3    | 10.8    | °C/Watt |

## VQ100: 100-lead Very-thin Quad Flat Package

The XC3S100E, XC3S250E, and the XC3S500E devices are available in the 100-lead very-thin quad flat package, VQ100. All devices share a common footprint for this package as shown in [Table 130](#) and [Figure 80](#).

[Table 130](#) lists all the package pins. They are sorted by bank number and then by pin name. Pins that form a differential I/O pair appear together in the table. The table also shows the pin number for each pin and the pin type, as defined earlier.

The VQ100 package does not support the Byte-wide Peripheral Interface (BPI) configuration mode. Consequently, the VQ100 footprint has fewer DUAL-type pins than other packages.

An electronic version of this package pinout table and footprint diagram is available for download from the Xilinx web site at:

[http://www.xilinx.com/support/documentation/data\\_sheets/s3e\\_pin.zip](http://www.xilinx.com/support/documentation/data_sheets/s3e_pin.zip)

### Pinout Table

[Table 130](#) shows the pinout for production Spartan-3E FPGAs in the VQ100 package.

*Table 130: VQ100 Package Pinout*

| Bank | XC3S100E<br>XC3S250E<br>XC3S500E<br>Pin Name | VQ100<br>Pin<br>Number | Type |
|------|--|------------------------|------|
| 0    | IO   | P92                    | I/O  |
| 0    | IO_L01N_0                                    | P79                    | I/O  |
| 0    | IO_L01P_0                                    | P78                    | I/O  |
| 0    | IO_L02N_0/GCLK5                              | P84                    | GCLK |
| 0    | IO_L02P_0/GCLK4                              | P83                    | GCLK |
| 0    | IO_L03N_0/GCLK7                              | P86                    | GCLK |
| 0    | IO_L03P_0/GCLK6                              | P85                    | GCLK |
| 0    | IO_L05N_0/GCLK11                             | P91                    | GCLK |
| 0    | IO_L05P_0/GCLK10                             | P90                    | GCLK |
| 0    | IO_L06N_0/VREF_0                             | P95                    | VREF |
| 0    | IO_L06P_0                                    | P94                    | I/O  |
| 0    | IO_L07N_0/HSWAP                              | P99                    | DUAL |
| 0    | IO_L07P_0                                    | P98                    | I/O  |
| 0    | IP_L04N_0/GCLK9                              | P89                    | GCLK |
| 0    | IP_L04P_0/GCLK8                              | P88                    | GCLK |
| 0    | VCCO_0                                       | P82                    | VCCO |
| 0    | VCCO_0                                       | P97                    | VCCO |
| 1    | IO_L01N_1                                    | P54                    | I/O  |
| 1    | IO_L01P_1                                    | P53                    | I/O  |
| 1    | IO_L02N_1                                    | P58                    | I/O  |

*Table 130: VQ100 Package Pinout (Cont'd)*

| Bank | XC3S100E<br>XC3S250E<br>XC3S500E<br>Pin Name | VQ100<br>Pin<br>Number | Type      |
|------|--|------------------------|-----------|
| 1    | IO_L02P_1                                    | P57                    | I/O       |
| 1    | IO_L03N_1/RHCLK1                             | P61                    | RHCLK     |
| 1    | IO_L03P_1/RHCLK0                             | P60                    | RHCLK     |
| 1    | IO_L04N_1/RHCLK3                             | P63                    | RHCLK     |
| 1    | IO_L04P_1/RHCLK2                             | P62                    | RHCLK     |
| 1    | IO_L05N_1/RHCLK5                             | P66                    | RHCLK     |
| 1    | IO_L05P_1/RHCLK4                             | P65                    | RHCLK     |
| 1    | IO_L06N_1/RHCLK7                             | P68                    | RHCLK     |
| 1    | IO_L06P_1/RHCLK6                             | P67                    | RHCLK     |
| 1    | IO_L07N_1                                    | P71                    | I/O       |
| 1    | IO_L07P_1                                    | P70                    | I/O       |
| 1    | IP/VREF_1                                    | P69                    | VREF      |
| 1    | VCCO_1                                       | P55                    | VCCO      |
| 1    | VCCO_1                                       | P73                    | VCCO      |
| 2    | IO/D5  | P34                    | DUAL      |
| 2    | IO/M1  | P42                    | DUAL      |
| 2    | IO_L01N_2/INIT_B                             | P25                    | DUAL      |
| 2    | IO_L01P_2/CSO_B                              | P24                    | DUAL      |
| 2    | IO_L02N_2/MOSI/CSI_B                         | P27                    | DUAL      |
| 2    | IO_L02P_2/DOUT/BUSY                          | P26                    | DUAL      |
| 2    | IO_L03N_2/D6/GCLK13                          | P33                    | DUAL/GCLK |
| 2    | IO_L03P_2/D7/GCLK12                          | P32                    | DUAL/GCLK |
| 2    | IO_L04N_2/D3/GCLK15                          | P36                    | DUAL/GCLK |
| 2    | IO_L04P_2/D4/GCLK14                          | P35                    | DUAL/GCLK |
| 2    | IO_L06N_2/D1/GCLK3                           | P41                    | DUAL/GCLK |
| 2    | IO_L06P_2/D2/GCLK2                           | P40                    | DUAL/GCLK |
| 2    | IO_L07N_2/DIN/D0                             | P44                    | DUAL      |
| 2    | IO_L07P_2/M0                                 | P43                    | DUAL      |
| 2    | IO_L08N_2/VS1                                | P48                    | DUAL      |
| 2    | IO_L08P_2/VS2                                | P47                    | DUAL      |
| 2    | IO_L09N_2/CCLK                               | P50                    | DUAL      |
| 2    | IO_L09P_2/VS0                                | P49                    | DUAL      |
| 2    | IP/VREF_2                                    | P30                    | VREF      |
| 2    | IP_L05N_2/M2/GCLK1                           | P39                    | DUAL/GCLK |
| 2    | IP_L05P_2/RDWR_B/<br>GCLK0                   | P38                    | DUAL/GCLK |
| 2    | VCCO_2                                       | P31                    | VCCO      |
| 2    | VCCO_2                                       | P45                    | VCCO      |
| 3    | IO_L01N_3                                    | P3                     | I/O       |
| 3    | IO_L01P_3                                    | P2                     | I/O       |
| 3    | IO_L02N_3/VREF_3                             | P5                     | VREF      |

Table 130: VQ100 Package Pinout (Cont'd)

| Bank   | XC3S100E<br>XC3S250E<br>XC3S500E<br>Pin Name | VQ100<br>Pin<br>Number | Type   |
|--------|--|------------------------|--------|
| 3      | IO_L02P_3                                    | P4                     | I/O    |
| 3      | IO_L03N_3/LHCLK1                             | P10                    | LHCLK  |
| 3      | IO_L03P_3/LHCLK0                             | P9                     | LHCLK  |
| 3      | IO_L04N_3/LHCLK3                             | P12                    | LHCLK  |
| 3      | IO_L04P_3/LHCLK2                             | P11                    | LHCLK  |
| 3      | IO_L05N_3/LHCLK5                             | P16                    | LHCLK  |
| 3      | IO_L05P_3/LHCLK4                             | P15                    | LHCLK  |
| 3      | IO_L06N_3/LHCLK7                             | P18                    | LHCLK  |
| 3      | IO_L06P_3/LHCLK6                             | P17                    | LHCLK  |
| 3      | IO_L07N_3                                    | P23                    | I/O    |
| 3      | IO_L07P_3                                    | P22                    | I/O    |
| 3      | IP   | P13                    | INPUT  |
| 3      | VCCO_3                                       | P8                     | VCCO   |
| 3      | VCCO_3                                       | P20                    | VCCO   |
| GND    | GND  | P7                     | GND    |
| GND    | GND  | P14                    | GND    |
| GND    | GND  | P19                    | GND    |
| GND    | GND  | P29                    | GND    |
| GND    | GND  | P37                    | GND    |
| GND    | GND  | P52                    | GND    |
| GND    | GND  | P59                    | GND    |
| GND    | GND  | P64                    | GND    |
| GND    | GND  | P72                    | GND    |
| GND    | GND  | P81                    | GND    |
| GND    | GND  | P87                    | GND    |
| GND    | GND  | P93                    | GND    |
| VCCAUX | DONE   | P51                    | CONFIG |
| VCCAUX | PROG_B                                       | P1                     | CONFIG |
| VCCAUX | TCK  | P77                    | JTAG   |
| VCCAUX | TDI  | P100                   | JTAG   |
| VCCAUX | TDO  | P76                    | JTAG   |
| VCCAUX | TMS  | P75                    | JTAG   |
| VCCAUX | VCCAUX                                       | P21                    | VCCAUX |
| VCCAUX | VCCAUX                                       | P46                    | VCCAUX |
| VCCAUX | VCCAUX                                       | P74                    | VCCAUX |
| VCCAUX | VCCAUX                                       | P96                    | VCCAUX |
| VCCINT | VCCINT                                       | P6                     | VCCINT |
| VCCINT | VCCINT                                       | P28                    | VCCINT |
| VCCINT | VCCINT                                       | P56                    | VCCINT |
| VCCINT | VCCINT                                       | P80                    | VCCINT |

## User I/Os by Bank

Table 131 indicates how the 66 available user-I/O pins are distributed between the four I/O banks on the VQ100 package.

Table 131: User I/Os Per Bank for XC3S100E, XC3S250E, and XC3S500E in the VQ100 Package

| Package Edge | I/O Bank | Maximum I/O | All Possible I/O Pins by Type |          |           |                     |                    |
|--------------|----------|-------------|-------------------------------|----------|-----------|---------------------|--------------------|
|              |          |             | I/O                           | INPUT    | DUAL      | VREF <sup>(1)</sup> | CLK <sup>(2)</sup> |
| Top          | 0        | 15          | 5                             | 0        | 1         | 1                   | 8                  |
| Right        | 1        | 15          | 6                             | 0        | 0         | 1                   | 8                  |
| Bottom       | 2        | 19          | 0                             | 0        | 18        | 1                   | 0 <sup>(2)</sup>   |
| Left         | 3        | 17          | 5                             | 1        | 2         | 1                   | 8                  |
| <b>TOTAL</b> |          | <b>66</b>   | <b>16</b>                     | <b>1</b> | <b>21</b> | <b>4</b>            | <b>24</b>          |

**Notes:**

1. Some VREF and CLK pins are on INPUT pins.
2. The eight global clock pins in this bank have optional functionality during configuration and are counted in the DUAL column.

## Footprint Migration Differences

The production XC3S100E, XC3S250E, and XC3S500E FPGAs have identical footprints in the VQ100 package. Designs can migrate between the devices without further consideration.

## VQ100 Footprint

In Figure 80, note pin 1 indicator in top-left corner and logo orientation.

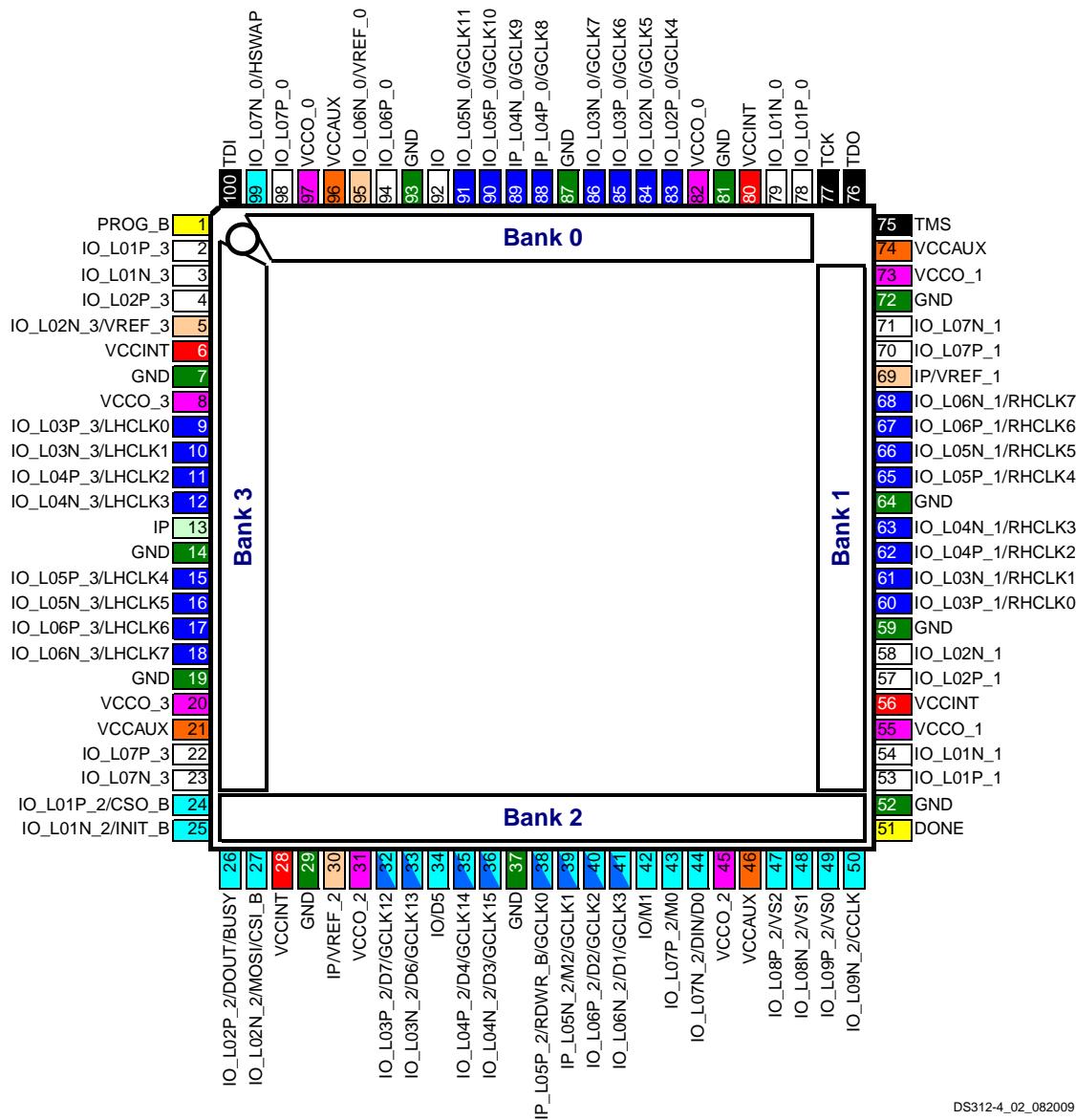


Figure 80: VQ100 Package Footprint (top view)

|    |  |    |   |   |  |
|----|--|----|---|---|--|
| 16 | IO: Unrestricted, general-purpose user I/O     | 21 | DUAL: Configuration pin, then possible user-I/O | 4 | VREF: User I/O or input voltage reference for bank |
| 1  | INPUT: Unrestricted, general-purpose input pin | 24 | CLK: User I/O, input, or global buffer input    | 8 | VCCO: Output voltage supply for bank               |
| 2  | CONFIG: Dedicated configuration pins           | 4  | JTAG: Dedicated JTAG port pins                  | 4 | VCCINT: Internal core supply voltage (+1.2V)       |
| 0  | N.C.: Not connected                            | 12 | GND: Ground                                     | 4 | VCCAUX: Auxiliary supply voltage (+2.5V)           |

## CP132: 132-ball Chip-scale Package

The XC3S100E, XC3S250E and the XC3S500E FPGAs are available in the 132-ball chip-scale package, CP132. The devices share a common footprint for this package as shown in [Table 132](#) and [Figure 81](#).

[Table 132](#) lists all the CP132 package pins. They are sorted by bank number and then by pin name. Pins that form a differential I/O pair appear together in the table. The table also shows the pin number for each pin and the pin type, as defined earlier.

Physically, the D14 and K2 balls on the XC3S100E and XC3S250E FPGAs are not connected but should be connected to VCCINT to maintain density migration compatibility.

Similarly, the A4, C1, and P10 balls on the XC3S100E FPGA are not connected but should be connected to GND to maintain density migration compatibility.

The XC3S100E FPGA has four fewer BPI address pins, A[19:0], whereas the XC3S250E and XC3S500E support A[23:0].

An electronic version of this package pinout table and footprint diagram is available for download from the Xilinx web site at:

[http://www.xilinx.com/support/documentation/data\\_sheets/s3e\\_pin.zip](http://www.xilinx.com/support/documentation/data_sheets/s3e_pin.zip)

## Pinout Table

*Table 132: CP132 Package Pinout*

| Bank | XC3S100E<br>Pin Name | XC3S250E<br>XC3S500E<br>Pin Name | CP132 Ball | Type   |
|------|----------------------|----------------------------------|------------|--|
| 0    | IO_L01N_0            | IO_L01N_0                        | C12        | I/O  |
| 0    | IO_L01P_0            | IO_L01P_0                        | A13        | I/O  |
| 0    | N.C. (◆)             | IO_L02N_0                        | A12        | <b>100E:</b> N.C.<br><b>Others:</b> I/O        |
| 0    | N.C. (◆)             | IO_L02P_0                        | B12        | <b>100E:</b> N.C.<br><b>Others:</b> I/O        |
| 0    | N.C. (◆)             | IO_L03N_0/VREF_0                 | B11        | <b>100E:</b> N.C.<br><b>Others:</b> VREF (I/O) |
| 0    | IP                   | IO_L03P_0                        | C11        | <b>100E:</b> INPUT<br><b>Others:</b> I/O       |
| 0    | IO_L04N_0/GCLK5      | IO_L04N_0/GCLK5                  | C9         | GCLK   |
| 0    | IO_L04P_0/GCLK4      | IO_L04P_0/GCLK4                  | A10        | GCLK   |
| 0    | IO_L05N_0/GCLK7      | IO_L05N_0/GCLK7                  | A9         | GCLK   |
| 0    | IO_L05P_0/GCLK6      | IO_L05P_0/GCLK6                  | B9         | GCLK   |
| 0    | IO_L07N_0/GCLK11     | IO_L07N_0/GCLK11                 | B7         | GCLK   |
| 0    | IO_L07P_0/GCLK10     | IO_L07P_0/GCLK10                 | A7         | GCLK   |
| 0    | IO_L08N_0/VREF_0     | IO_L08N_0/VREF_0                 | C6         | VREF   |
| 0    | IO_L08P_0            | IO_L08P_0                        | B6         | I/O  |
| 0    | IO_L09N_0            | IO_L09N_0                        | C5         | I/O  |
| 0    | IO_L09P_0            | IO_L09P_0                        | B5         | I/O  |
| 0    | N.C. (◆)             | IO_L10N_0                        | C4         | <b>100E:</b> N.C.<br><b>Others:</b> I/O        |
| 0    | IP                   | IO_L10P_0                        | B4         | <b>100E:</b> INPUT<br><b>Others:</b> I/O       |
| 0    | IO_L11N_0/HSWAP      | IO_L11N_0/HSWAP                  | B3         | DUAL   |
| 0    | IO_L11P_0            | IO_L11P_0                        | A3         | I/O  |
| 0    | IP_L06N_0/GCLK9      | IP_L06N_0/GCLK9                  | C8         | GCLK   |
| 0    | IP_L06P_0/GCLK8      | IP_L06P_0/GCLK8                  | B8         | GCLK   |
| 0    | VCCO_0               | VCCO_0                           | A6         | VCCO   |

Table 132: CP132 Package Pinout (Cont'd)

| Bank | XC3S100E<br>Pin Name      | XC3S250E<br>XC3S500E<br>Pin Name | CP132 Ball | Type   |
|------|---------------------------|----------------------------------|------------|--|
| 0    | VCCO_0                    | VCCO_0                           | B10        | VCCO   |
| 1    | IO/A0                     | IO/A0                            | F12        | DUAL   |
| 1    | IO/VREF_1                 | IO/VREF_1                        | K13        | VREF   |
| 1    | IO_L01N_1/A15             | IO_L01N_1/A15                    | N14        | DUAL   |
| 1    | IO_L01P_1/A16             | IO_L01P_1/A16                    | N13        | DUAL   |
| 1    | IO_L02N_1/A13             | IO_L02N_1/A13                    | M13        | DUAL   |
| 1    | IO_L02P_1/A14             | IO_L02P_1/A14                    | M12        | DUAL   |
| 1    | IO_L03N_1/A11             | IO_L03N_1/A11                    | L14        | DUAL   |
| 1    | IO_L03P_1/A12             | IO_L03P_1/A12                    | L13        | DUAL   |
| 1    | IO_L04N_1/A9/RHCLK1       | IO_L04N_1/A9/RHCLK1              | J12        | RHCLK/DUAL   |
| 1    | IO_L04P_1/A10/RHCLK0      | IO_L04P_1/A10/RHCLK0             | K14        | RHCLK/DUAL   |
| 1    | IO_L05N_1/A7/RHCLK3/TRDY1 | IO_L05N_1/A7/RHCLK3/TRDY1        | J14        | RHCLK/DUAL   |
| 1    | IO_L05P_1/A8/RHCLK2       | IO_L05P_1/A8/RHCLK2              | J13        | RHCLK/DUAL   |
| 1    | IO_L06N_1/A5/RHCLK5       | IO_L06N_1/A5/RHCLK5              | H12        | RHCLK/DUAL   |
| 1    | IO_L06P_1/A6/RHCLK4/IRDY1 | IO_L06P_1/A6/RHCLK4/IRDY1        | H13        | RHCLK/DUAL   |
| 1    | IO_L07N_1/A3/RHCLK7       | IO_L07N_1/A3/RHCLK7              | G13        | RHCLK/DUAL   |
| 1    | IO_L07P_1/A4/RHCLK6       | IO_L07P_1/A4/RHCLK6              | G14        | RHCLK/DUAL   |
| 1    | IO_L08N_1/A1              | IO_L08N_1/A1                     | F13        | DUAL   |
| 1    | IO_L08P_1/A2              | IO_L08P_1/A2                     | F14        | DUAL   |
| 1    | IO_L09N_1/LDC0            | IO_L09N_1/LDC0                   | D12        | DUAL   |
| 1    | IO_L09P_1/HDC             | IO_L09P_1/HDC                    | D13        | DUAL   |
| 1    | IO_L10N_1/LDC2            | IO_L10N_1/LDC2                   | C13        | DUAL   |
| 1    | IO_L10P_1/LDC1            | IO_L10P_1/LDC1                   | C14        | DUAL   |
| 1    | IP/VREF_1                 | IP/VREF_1                        | G12        | VREF   |
| 1    | VCCO_1                    | VCCO_1                           | E13        | VCCO   |
| 1    | VCCO_1                    | VCCO_1                           | M14        | VCCO   |
| 2    | IO/D5                     | IO/D5                            | P4         | DUAL   |
| 2    | IO/M1                     | IO/M1                            | N7         | DUAL   |
| 2    | IP/VREF_2                 | IO/VREF_2                        | P11        | <b>100E:</b> VREF(INPUT)<br><b>Others:</b> VREF(I/O) |
| 2    | IO_L01N_2/INIT_B          | IO_L01N_2/INIT_B                 | N1         | DUAL   |
| 2    | IO_L01P_2/CSO_B           | IO_L01P_2/CSO_B                  | M2         | DUAL   |
| 2    | IO_L02N_2/MOSI/CSI_B      | IO_L02N_2/MOSI/CSI_B             | N2         | DUAL   |
| 2    | IO_L02P_2/DOUT/BUSY       | IO_L02P_2/DOUT/BUSY              | P1         | DUAL   |
| 2    | IO_L03N_2/D6/GCLK13       | IO_L03N_2/D6/GCLK13              | N4         | DUAL/GCLK  |
| 2    | IO_L03P_2/D7/GCLK12       | IO_L03P_2/D7/GCLK12              | M4         | DUAL/GCLK  |
| 2    | IO_L04N_2/D3/GCLK15       | IO_L04N_2/D3/GCLK15              | N5         | DUAL/GCLK  |
| 2    | IO_L04P_2/D4/GCLK14       | IO_L04P_2/D4/GCLK14              | M5         | DUAL/GCLK  |
| 2    | IO_L06N_2/D1/GCLK3        | IO_L06N_2/D1/GCLK3               | P7         | DUAL/GCLK  |
| 2    | IO_L06P_2/D2/GCLK2        | IO_L06P_2/D2/GCLK2               | P6         | DUAL/GCLK  |
| 2    | IO_L07N_2/DIN/D0          | IO_L07N_2/DIN/D0                 | N8         | DUAL   |
| 2    | IO_L07P_2/M0              | IO_L07P_2/M0                     | P8         | DUAL   |
| 2    | N.C. (◆)                  | IO_L08N_2/A22                    | M9         | <b>100E:</b> N.C.<br><b>Others:</b> DUAL             |

Table 132: CP132 Package Pinout (Cont'd)

| Bank | XC3S100E<br>Pin Name   | XC3S250E<br>XC3S500E<br>Pin Name | CP132 Ball | Type   |
|------|------------------------|----------------------------------|------------|--|
| 2    | N.C. (◆)               | IO_L08P_2/A23                    | N9         | <b>100E:</b> N.C.<br><b>Others:</b> DUAL             |
| 2    | N.C. (◆)               | IO_L09N_2/A20                    | M10        | <b>100E:</b> N.C.<br><b>Others:</b> DUAL             |
| 2    | N.C. (◆)               | IO_L09P_2/A21                    | N10        | <b>100E:</b> N.C.<br><b>Others:</b> DUAL             |
| 2    | IO_L10N_2/VS1/A18      | IO_L10N_2/VS1/A18                | M11        | DUAL   |
| 2    | IO_L10P_2/VS2/A19      | IO_L10P_2/VS2/A19                | N11        | DUAL   |
| 2    | IO_L11N_2/CCLK         | IO_L11N_2/CCLK                   | N12        | DUAL   |
| 2    | IO_L11P_2/VS0/A17      | IO_L11P_2/VS0/A17                | P12        | DUAL   |
| 2    | IP/VREF_2              | IP/VREF_2                        | N3         | VREF   |
| 2    | IP_L05N_2/M2/GCLK1     | IP_L05N_2/M2/GCLK1               | N6         | DUAL/GCLK  |
| 2    | IP_L05P_2/RDWR_B/GCLK0 | IP_L05P_2/RDWR_B/GCLK0           | M6         | DUAL/GCLK  |
| 2    | VCCO_2                 | VCCO_2                           | M8         | VCCO   |
| 2    | VCCO_2                 | VCCO_2                           | P3         | VCCO   |
| 3    | IO                     | IO                               | J3         | I/O  |
| 3    | IP/VREF_3              | IO/VREF_3                        | K3         | <b>100E:</b> VREF(INPUT)<br><b>Others:</b> VREF(I/O) |
| 3    | IO_L01N_3              | IO_L01N_3                        | B1         | I/O  |
| 3    | IO_L01P_3              | IO_L01P_3                        | B2         | I/O  |
| 3    | IO_L02N_3              | IO_L02N_3                        | C2         | I/O  |
| 3    | IO_L02P_3              | IO_L02P_3                        | C3         | I/O  |
| 3    | N.C. (◆)               | IO_L03N_3                        | D1         | <b>100E:</b> N.C.<br><b>Others:</b> I/O              |
| 3    | IO                     | IO_L03P_3                        | D2         | I/O  |
| 3    | IO_L04N_3/LHCLK1       | IO_L04N_3/LHCLK1                 | F2         | LHCLK  |
| 3    | IO_L04P_3/LHCLK0       | IO_L04P_3/LHCLK0                 | F3         | LHCLK  |
| 3    | IO_L05N_3/LHCLK3/IRDY2 | IO_L05N_3/LHCLK3/IRDY2           | G1         | LHCLK  |
| 3    | IO_L05P_3/LHCLK2       | IO_L05P_3/LHCLK2                 | F1         | LHCLK  |
| 3    | IO_L06N_3/LHCLK5       | IO_L06N_3/LHCLK5                 | H1         | LHCLK  |
| 3    | IO_L06P_3/LHCLK4/TRDY2 | IO_L06P_3/LHCLK4/TRDY2           | G3         | LHCLK  |
| 3    | IO_L07N_3/LHCLK7       | IO_L07N_3/LHCLK7                 | H3         | LHCLK  |
| 3    | IO_L07P_3/LHCLK6       | IO_L07P_3/LHCLK6                 | H2         | LHCLK  |
| 3    | IO_L08N_3              | IO_L08N_3                        | L2         | I/O  |
| 3    | IO_L08P_3              | IO_L08P_3                        | L1         | I/O  |
| 3    | IO_L09N_3              | IO_L09N_3                        | M1         | I/O  |
| 3    | IO_L09P_3              | IO_L09P_3                        | L3         | I/O  |
| 3    | IP/VREF_3              | IP/VREF_3                        | E2         | VREF   |
| 3    | VCCO_3                 | VCCO_3                           | E1         | VCCO   |
| 3    | VCCO_3                 | VCCO_3                           | J2         | VCCO   |
| GND  | N.C. (GND)             | GND                              | A4         | GND  |
| GND  | GND                    | GND                              | A8         | GND  |
| GND  | N.C. (GND)             | GND                              | C1         | GND  |
| GND  | GND                    | GND                              | C7         | GND  |

Table 132: CP132 Package Pinout (Cont'd)

| Bank   | XC3S100E<br>Pin Name | XC3S250E<br>XC3S500E<br>Pin Name | CP132 Ball | Type   |
|--------|----------------------|----------------------------------|------------|--------|
| GND    | GND                  | GND                              | C10        | GND    |
| GND    | GND                  | GND                              | E3         | GND    |
| GND    | GND                  | GND                              | E14        | GND    |
| GND    | GND                  | GND                              | G2         | GND    |
| GND    | GND                  | GND                              | H14        | GND    |
| GND    | GND                  | GND                              | J1         | GND    |
| GND    | GND                  | GND                              | K12        | GND    |
| GND    | GND                  | GND                              | M3         | GND    |
| GND    | GND                  | GND                              | M7         | GND    |
| GND    | GND                  | GND                              | P5         | GND    |
| GND    | N.C. (GND)           | GND                              | P10        | GND    |
| GND    | GND                  | GND                              | P14        | GND    |
| VCCAUX | DONE                 | DONE                             | P13        | CONFIG |
| VCCAUX | PROG_B               | PROG_B                           | A1         | CONFIG |
| VCCAUX | TCK                  | TCK                              | B13        | JTAG   |
| VCCAUX | TDI                  | TDI                              | A2         | JTAG   |
| VCCAUX | TDO                  | TDO                              | A14        | JTAG   |
| VCCAUX | TMS                  | TMS                              | B14        | JTAG   |
| VCCAUX | VCCAUX               | VCCAUX                           | A5         | VCCAUX |
| VCCAUX | VCCAUX               | VCCAUX                           | E12        | VCCAUX |
| VCCAUX | VCCAUX               | VCCAUX                           | K1         | VCCAUX |
| VCCAUX | VCCAUX               | VCCAUX                           | P9         | VCCAUX |
| VCCINT | VCCINT               | VCCINT                           | A11        | VCCINT |
| VCCINT | VCCINT               | VCCINT                           | D3         | VCCINT |
| VCCINT | N.C. (VCCINT)        | VCCINT                           | D14        | VCCINT |
| VCCINT | N.C. (VCCINT)        | VCCINT                           | K2         | VCCINT |
| VCCINT | VCCINT               | VCCINT                           | L12        | VCCINT |
| VCCINT | VCCINT               | VCCINT                           | P2         | VCCINT |

## User I/Os by Bank

Table 133 shows how the 83 available user-I/O pins are distributed on the XC3S100E FPGA packaged in the CP132 package. Table 134 indicates how the 92 available user-I/O

pins are distributed on the XC3S250E and the XC3S500E FPGAs in the CP132 package.

Table 133: User I/Os Per Bank for the XC3S100E in the CP132 Package

| Package Edge | I/O Bank | Maximum I/O | All Possible I/O Pins by Type |          |           |                     |                    |
|--------------|----------|-------------|-------------------------------|----------|-----------|---------------------|--------------------|
|              |          |             | I/O                           | INPUT    | DUAL      | VREF <sup>(1)</sup> | CLK <sup>(2)</sup> |
| Top          | 0        | 18          | 6                             | 2        | 1         | 1                   | 8                  |
| Right        | 1        | 23          | 0                             | 0        | 21        | 2                   | 0 <sup>(2)</sup>   |
| Bottom       | 2        | 22          | 0                             | 0        | 20        | 2                   | 0 <sup>(2)</sup>   |
| Left         | 3        | 20          | 10                            | 0        | 0         | 2                   | 8                  |
| <b>TOTAL</b> |          | <b>83</b>   | <b>16</b>                     | <b>2</b> | <b>42</b> | <b>7</b>            | <b>16</b>          |

**Notes:**

1. Some VREF and CLK pins are on INPUT pins.
2. The eight global clock pins in this bank have optional functionality during configuration and are counted in the DUAL column.

Table 134: User I/Os Per Bank for the XC3S250E and XC3S500E in the CP132 Package

| Package Edge | I/O Bank | Maximum I/O | All Possible I/O Pins by Type |          |           |                     |                    |
|--------------|----------|-------------|-------------------------------|----------|-----------|---------------------|--------------------|
|              |          |             | I/O                           | INPUT    | DUAL      | VREF <sup>(1)</sup> | CLK <sup>(2)</sup> |
| Top          | 0        | 22          | 11                            | 0        | 1         | 2                   | 8                  |
| Right        | 1        | 23          | 0                             | 0        | 21        | 2                   | 0 <sup>(2)</sup>   |
| Bottom       | 2        | 26          | 0                             | 0        | 24        | 2                   | 0 <sup>(2)</sup>   |
| Left         | 3        | 21          | 11                            | 0        | 0         | 2                   | 8                  |
| <b>TOTAL</b> |          | <b>92</b>   | <b>22</b>                     | <b>0</b> | <b>46</b> | <b>8</b>            | <b>16</b>          |

**Notes:**

1. Some VREF and CLK pins are on INPUT pins.
2. The eight global clock pins in this bank have optional functionality during configuration and are counted in the DUAL column.

## Footprint Migration Differences

Table 135 summarizes any footprint and functionality differences between the XC3S100E, the XC3S250E, and the XC3S500E FPGAs that may affect easy migration between devices in the CP132 package. There are 14 such balls. All other pins not listed in Table 135 unconditionally migrate between Spartan-3E devices available in the CP132 package.

The XC3S100E is duplicated on both the left and right sides of the table to show migrations to and from the XC3S250E and the XC3S500E. The arrows indicate the direction for easy migration. A double-ended arrow ( $\leftrightarrow$ ) indicates that

the two pins have identical functionality. A left-facing arrow ( $\leftarrow$ ) indicates that the pin on the device on the right unconditionally migrates to the pin on the device on the left. It may be possible to migrate the opposite direction depending on the I/O configuration. For example, an I/O pin (Type = I/O) can migrate to an input-only pin (Type = INPUT) if the I/O pin is configured as an input.

The XC3S100E FPGA in the CP132 package has four fewer BPI-mode address lines than the XC3S250E and XC3S500E.

Table 135: CP132 Footprint Migration Differences

| CP132 Ball         | Bank | XC3S100E Type | Migration     | XC3S250E Type | Migration         | XC3S500E Type | Migration    | XC3S100E Type |
|--------------------|------|---------------|---------------|---------------|-------------------|---------------|--------------|---------------|
| A12                | 0    | N.C.          | $\rightarrow$ | I/O           | $\leftrightarrow$ | I/O           | $\leftarrow$ | N.C.          |
| B4                 | 0    | INPUT         | $\rightarrow$ | I/O           | $\leftrightarrow$ | I/O           | $\leftarrow$ | INPUT         |
| B11                | 0    | N.C.          | $\rightarrow$ | I/O           | $\leftrightarrow$ | I/O           | $\leftarrow$ | N.C.          |
| B12                | 0    | N.C.          | $\rightarrow$ | I/O           | $\leftrightarrow$ | I/O           | $\leftarrow$ | N.C.          |
| C4                 | 0    | N.C.          | $\rightarrow$ | I/O           | $\leftrightarrow$ | I/O           | $\leftarrow$ | N.C.          |
| C11                | 0    | INPUT         | $\rightarrow$ | I/O           | $\leftrightarrow$ | I/O           | $\leftarrow$ | INPUT         |
| D1                 | 3    | N.C.          | $\rightarrow$ | I/O           | $\leftrightarrow$ | I/O           | $\leftarrow$ | N.C.          |
| D2                 | 3    | I/O           | $\rightarrow$ | I/O (Diff)    | $\leftrightarrow$ | I/O (Diff)    | $\leftarrow$ | I/O           |
| K3                 | 3    | VREF(INPUT)   | $\rightarrow$ | VREF(I/O)     | $\leftrightarrow$ | VREF(I/O)     | $\leftarrow$ | VREF(INPUT)   |
| M9                 | 2    | N.C.          | $\rightarrow$ | DUAL          | $\leftrightarrow$ | DUAL          | $\leftarrow$ | N.C.          |
| M10                | 2    | N.C.          | $\rightarrow$ | DUAL          | $\leftrightarrow$ | DUAL          | $\leftarrow$ | N.C.          |
| N9                 | 2    | N.C.          | $\rightarrow$ | DUAL          | $\leftrightarrow$ | DUAL          | $\leftarrow$ | N.C.          |
| N10                | 2    | N.C.          | $\rightarrow$ | DUAL          | $\leftrightarrow$ | DUAL          | $\leftarrow$ | N.C.          |
| P11                | 2    | VREF(INPUT)   | $\rightarrow$ | VREF(I/O)     | $\leftrightarrow$ | VREF(I/O)     | $\leftarrow$ | VREF(INPUT)   |
| <b>DIFFERENCES</b> |      |               | <b>14</b>     |               | <b>0</b>          |               | <b>14</b>    |               |

Legend:

- $\leftrightarrow$  This pin is identical on the device on the left and the right.
- $\rightarrow$  This pin can unconditionally migrate from the device on the left to the device on the right. Migration in the other direction may be possible depending on how the pin is configured for the device on the right.
- $\leftarrow$  This pin can unconditionally migrate from the device on the right to the device on the left. Migration in the other direction may be possible depending on how the pin is configured for the device on the left.

## CP132 Footprint

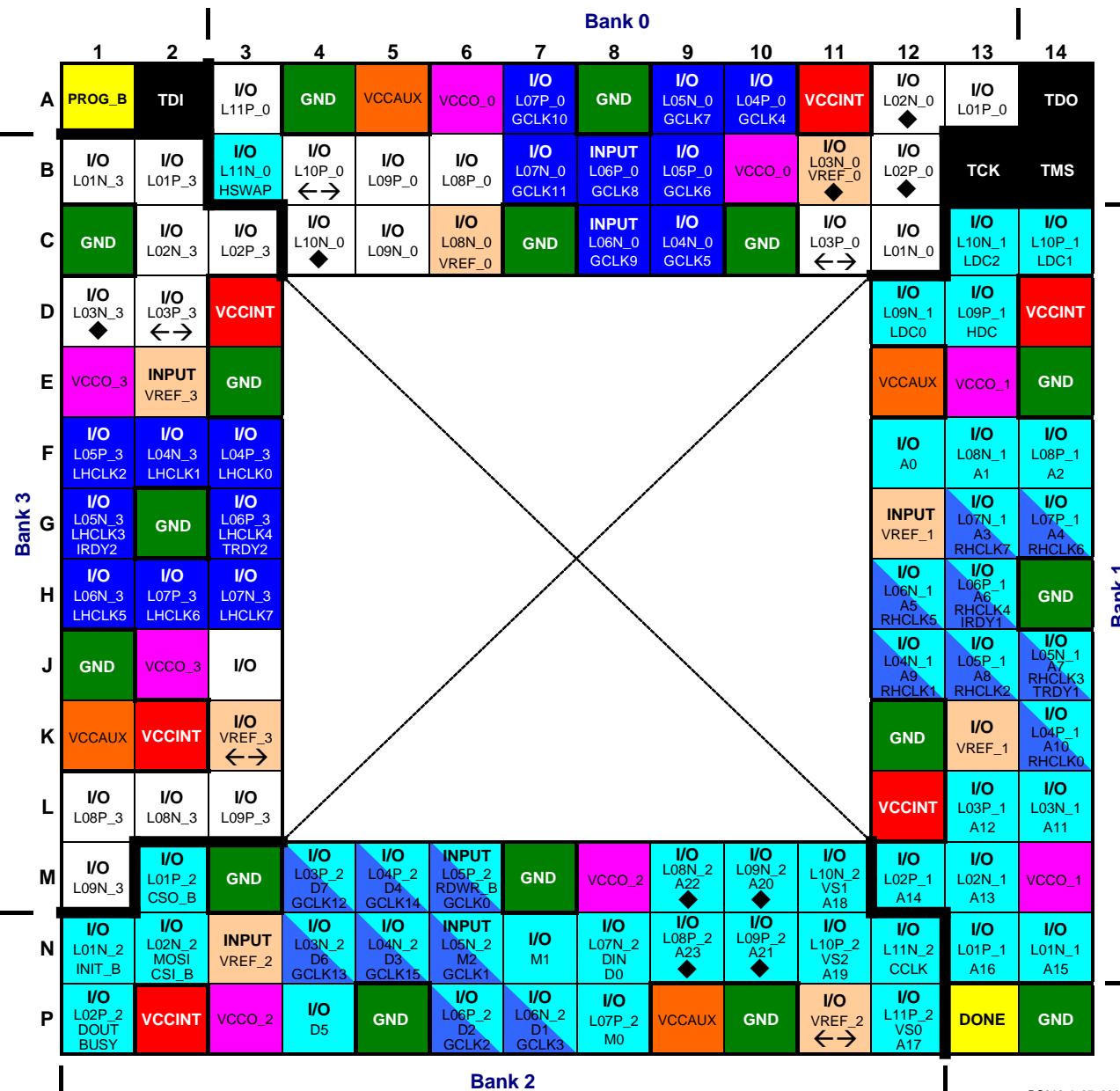


Figure 81: CP132 Package Footprint (top view)

|       |   |       |  |     |   |
|-------|---|-------|--|-----|---|
| 16-22 | <b>I/O:</b> Unrestricted, general-purpose user I/O      | 42-46 | <b>DUAL:</b> Configuration pin, then possible user I/O | 7-8 | <b>VREF:</b> User I/O or input voltage reference for bank |
| 0-2   | <b>INPUT:</b> Unrestricted, general-purpose input pin   | 16    | <b>CLK:</b> User I/O, input, or global buffer input    | 8   | <b>VCCO:</b> Output voltage supply for bank               |
| 2     | <b>CONFIG:</b> Dedicated configuration pins             | 4     | <b>JTAG:</b> Dedicated JTAG port pins                  | 6   | <b>VCCINT:</b> Internal core supply voltage (+1.2V)       |
| 9     | <b>N.C.:</b> Unconnected balls on the XC3S100E FPGA (◆) | 16    | <b>GND:</b> Ground                                     | 4   | <b>VCCAUX:</b> Auxiliary supply voltage (+2.5V)           |

## TQ144: 144-lead Thin Quad Flat Package

The XC3S100E and the XC3S250E FPGAs are available in the 144-lead thin quad flat package, TQ144. Both devices share a common footprint for this package as shown in [Table 136](#) and [Figure 82](#).

[Table 136](#) lists all the package pins. They are sorted by bank number and then by pin name of the largest device. Pins that form a differential I/O pair appear together in the table. The table also shows the pin number for each pin and the pin type, as defined earlier.

The TQ144 package only supports 20 address output pins in the Byte-wide Peripheral Interface (BPI) configuration mode. In larger packages, there are 24 BPI address outputs.

An electronic version of this package pinout table and footprint diagram is available for download from the Xilinx web site at:

[http://www.xilinx.com/support/documentation/data\\_sheets/s3e\\_pin.zip](http://www.xilinx.com/support/documentation/data_sheets/s3e_pin.zip)

### Pinout Table

*Table 136: TQ144 Package Pinout*

| Bank | XC3S100E Pin Name | XC3S250E Pin Name | TQ144 Pin | Type  |
|------|-------------------|-------------------|-----------|-------|
| 0    | IO                | IO                | P132      | I/O   |
| 0    | IO/VREF_0         | IO/VREF_0         | P124      | VREF  |
| 0    | IO_L01N_0         | IO_L01N_0         | P113      | I/O   |
| 0    | IO_L01P_0         | IO_L01P_0         | P112      | I/O   |
| 0    | IO_L02N_0         | IO_L02N_0         | P117      | I/O   |
| 0    | IO_L02P_0         | IO_L02P_0         | P116      | I/O   |
| 0    | IO_L04N_0/GCLK5   | IO_L04N_0/GCLK5   | P123      | GCLK  |
| 0    | IO_L04P_0/GCLK4   | IO_L04P_0/GCLK4   | P122      | GCLK  |
| 0    | IO_L05N_0/GCLK7   | IO_L05N_0/GCLK7   | P126      | GCLK  |
| 0    | IO_L05P_0/GCLK6   | IO_L05P_0/GCLK6   | P125      | GCLK  |
| 0    | IO_L07N_0/GCLK11  | IO_L07N_0/GCLK11  | P131      | GCLK  |
| 0    | IO_L07P_0/GCLK10  | IO_L07P_0/GCLK10  | P130      | GCLK  |
| 0    | IO_L08N_0/VREF_0  | IO_L08N_0/VREF_0  | P135      | VREF  |
| 0    | IO_L08P_0         | IO_L08P_0         | P134      | I/O   |
| 0    | IO_L09N_0         | IO_L09N_0         | P140      | I/O   |
| 0    | IO_L09P_0         | IO_L09P_0         | P139      | I/O   |
| 0    | IO_L10N_0/HSWAP   | IO_L10N_0/HSWAP   | P143      | DUAL  |
| 0    | IO_L10P_0         | IO_L10P_0         | P142      | I/O   |
| 0    | IP                | IP                | P111      | INPUT |
| 0    | IP                | IP                | P114      | INPUT |
| 0    | IP                | IP                | P136      | INPUT |
| 0    | IP                | IP                | P141      | INPUT |
| 0    | IP_L03N_0         | IP_L03N_0         | P120      | INPUT |
| 0    | IP_L03P_0         | IP_L03P_0         | P119      | INPUT |
| 0    | IP_L06N_0/GCLK9   | IP_L06N_0/GCLK9   | P129      | GCLK  |
| 0    | IP_L06P_0/GCLK8   | IP_L06P_0/GCLK8   | P128      | GCLK  |
| 0    | VCCO_0            | VCCO_0            | P121      | VCCO  |
| 0    | VCCO_0            | VCCO_0            | P138      | VCCO  |
| 1    | IO/A0             | IO/A0             | P98       | DUAL  |
| 1    | IO/VREF_1         | IO/VREF_1         | P83       | VREF  |
| 1    | IO_L01N_1/A15     | IO_L01N_1/A15     | P75       | DUAL  |
| 1    | IO_L01P_1/A16     | IO_L01P_1/A16     | P74       | DUAL  |
| 1    | IO_L02N_1/A13     | IO_L02N_1/A13     | P77       | DUAL  |

Table 136: TQ144 Package Pinout (Cont'd)

| Bank | XC3S100E Pin Name         | XC3S250E Pin Name    | TQ144 Pin | Type                                 |
|------|---------------------------|----------------------|-----------|--------------------------------------|
| 1    | IO_L02P_1/A14             | IO_L02P_1/A14        | P76       | DUAL                                 |
| 1    | IO_L03N_1/A11             | IO_L03N_1/A11        | P82       | DUAL                                 |
| 1    | IO_L03P_1/A12             | IO_L03P_1/A12        | P81       | DUAL                                 |
| 1    | IO_L04N_1/A9/RHCLK1       | IO_L04N_1/A9/RHCLK1  | P86       | RHCLK/DUAL                           |
| 1    | IO_L04P_1/A10/RHCLK0      | IO_L04P_1/A10/RHCLK0 | P85       | RHCLK/DUAL                           |
| 1    | IO_L05N_1/A7/RHCLK3/TRDY1 | IO_L05N_1/A7/RHCLK3  | P88       | RHCLK/DUAL                           |
| 1    | IO_L05P_1/A8/RHCLK2       | IO_L05P_1/A8/RHCLK2  | P87       | RHCLK/DUAL                           |
| 1    | IO_L06N_1/A5/RHCLK5       | IO_L06N_1/A5/RHCLK5  | P92       | RHCLK/DUAL                           |
| 1    | IO_L06P_1/A6/RHCLK4/IRDY1 | IO_L06P_1/A6/RHCLK4  | P91       | RHCLK/DUAL                           |
| 1    | IO_L07N_1/A3/RHCLK7       | IO_L07N_1/A3/RHCLK7  | P94       | RHCLK/DUAL                           |
| 1    | IO_L07P_1/A4/RHCLK6       | IO_L07P_1/A4/RHCLK6  | P93       | RHCLK/DUAL                           |
| 1    | IO_L08N_1/A1              | IO_L08N_1/A1         | P97       | DUAL                                 |
| 1    | IO_L08P_1/A2              | IO_L08P_1/A2         | P96       | DUAL                                 |
| 1    | IO_L09N_1/LDC0            | IO_L09N_1/LDC0       | P104      | DUAL                                 |
| 1    | IO_L09P_1/HDC             | IO_L09P_1/HDC        | P103      | DUAL                                 |
| 1    | IO_L10N_1/LDC2            | IO_L10N_1/LDC2       | P106      | DUAL                                 |
| 1    | IO_L10P_1/LDC1            | IO_L10P_1/LDC1       | P105      | DUAL                                 |
| 1    | IP                        | IP                   | P78       | INPUT                                |
| 1    | IP                        | IP                   | P84       | INPUT                                |
| 1    | IP                        | IP                   | P89       | INPUT                                |
| 1    | IP                        | IP                   | P101      | INPUT                                |
| 1    | IP                        | IP                   | P107      | INPUT                                |
| 1    | IP/VREF_1                 | IP/VREF_1            | P95       | VREF                                 |
| 1    | VCCO_1                    | VCCO_1               | P79       | VCCO                                 |
| 1    | VCCO_1                    | VCCO_1               | P100      | VCCO                                 |
| 2    | IO/D5                     | IO/D5                | P52       | DUAL                                 |
| 2    | IO/M1                     | IO/M1                | P60       | DUAL                                 |
| 2    | IP/VREF_2                 | IO/VREF_2            | P66       | 100E: VREF(INPUT)<br>250E: VREF(I/O) |
| 2    | IO_L01N_2/INIT_B          | IO_L01N_2/INIT_B     | P40       | DUAL                                 |
| 2    | IO_L01P_2/CSO_B           | IO_L01P_2/CSO_B      | P39       | DUAL                                 |
| 2    | IO_L02N_2/MOSI/CSI_B      | IO_L02N_2/MOSI/CSI_B | P44       | DUAL                                 |
| 2    | IO_L02P_2/DOUT/BUSY       | IO_L02P_2/DOUT/BUSY  | P43       | DUAL                                 |
| 2    | IO_L04N_2/D6/GCLK13       | IO_L04N_2/D6/GCLK13  | P51       | DUAL/GCLK                            |
| 2    | IO_L04P_2/D7/GCLK12       | IO_L04P_2/D7/GCLK12  | P50       | DUAL/GCLK                            |
| 2    | IO_L05N_2/D3/GCLK15       | IO_L05N_2/D3/GCLK15  | P54       | DUAL/GCLK                            |
| 2    | IO_L05P_2/D4/GCLK14       | IO_L05P_2/D4/GCLK14  | P53       | DUAL/GCLK                            |
| 2    | IO_L07N_2/D1/GCLK3        | IO_L07N_2/D1/GCLK3   | P59       | DUAL/GCLK                            |
| 2    | IO_L07P_2/D2/GCLK2        | IO_L07P_2/D2/GCLK2   | P58       | DUAL/GCLK                            |
| 2    | IO_L08N_2/DIN/D0          | IO_L08N_2/DIN/D0     | P63       | DUAL                                 |
| 2    | IO_L08P_2/M0              | IO_L08P_2/M0         | P62       | DUAL                                 |
| 2    | IO_L09N_2/VS1/A18         | IO_L09N_2/VS1/A18    | P68       | DUAL                                 |
| 2    | IO_L09P_2/VS2/A19         | IO_L09P_2/VS2/A19    | P67       | DUAL                                 |
| 2    | IO_L10N_2/CCLK            | IO_L10N_2/CCLK       | P71       | DUAL                                 |
| 2    | IO_L10P_2/VS0/A17         | IO_L10P_2/VS0/A17    | P70       | DUAL                                 |

Table 136: TQ144 Package Pinout (Cont'd)

| Bank | XC3S100E Pin Name      | XC3S250E Pin Name      | TQ144 Pin | Type   |
|------|------------------------|------------------------|-----------|--|
| 2    | IP                     | IP                     | P38       | INPUT  |
| 2    | IP                     | IP                     | P41       | INPUT  |
| 2    | IP                     | IP                     | P69       | INPUT  |
| 2    | IP_L03N_2/VREF_2       | IP_L03N_2/VREF_2       | P48       | VREF   |
| 2    | IP_L03P_2              | IP_L03P_2              | P47       | INPUT  |
| 2    | IP_L06N_2/M2/GCLK1     | IP_L06N_2/M2/GCLK1     | P57       | DUAL/GCLK  |
| 2    | IP_L06P_2/RDWR_B/GCLK0 | IP_L06P_2/RDWR_B/GCLK0 | P56       | DUAL/GCLK  |
| 2    | VCCO_2                 | VCCO_2                 | P42       | VCCO   |
| 2    | VCCO_2                 | VCCO_2                 | P49       | VCCO   |
| 2    | VCCO_2                 | VCCO_2                 | P64       | VCCO   |
| 3    | IP/VREF_3              | IO/VREF_3              | P31       | <b>100E:</b> VREF(INPUT)<br><b>250E:</b> VREF(I/O) |
| 3    | IO_L01N_3              | IO_L01N_3              | P3        | I/O  |
| 3    | IO_L01P_3              | IO_L01P_3              | P2        | I/O  |
| 3    | IO_L02N_3/VREF_3       | IO_L02N_3/VREF_3       | P5        | VREF   |
| 3    | IO_L02P_3              | IO_L02P_3              | P4        | I/O  |
| 3    | IO_L03N_3              | IO_L03N_3              | P8        | I/O  |
| 3    | IO_L03P_3              | IO_L03P_3              | P7        | I/O  |
| 3    | IO_L04N_3/LHCLK1       | IO_L04N_3/LHCLK1       | P15       | LHCLK  |
| 3    | IO_L04P_3/LHCLK0       | IO_L04P_3/LHCLK0       | P14       | LHCLK  |
| 3    | IO_L05N_3/LHCLK3/IRDY2 | IO_L05N_3/LHCLK3       | P17       | LHCLK  |
| 3    | IO_L05P_3/LHCLK2       | IO_L05P_3/LHCLK2       | P16       | LHCLK  |
| 3    | IO_L06N_3/LHCLK5       | IO_L06N_3/LHCLK5       | P21       | LHCLK  |
| 3    | IO_L06P_3/LHCLK4/TRDY2 | IO_L06P_3/LHCLK4       | P20       | LHCLK  |
| 3    | IO_L07N_3/LHCLK7       | IO_L07N_3/LHCLK7       | P23       | LHCLK  |
| 3    | IO_L07P_3/LHCLK6       | IO_L07P_3/LHCLK6       | P22       | LHCLK  |
| 3    | IO_L08N_3              | IO_L08N_3              | P26       | I/O  |
| 3    | IO_L08P_3              | IO_L08P_3              | P25       | I/O  |
| 3    | IO_L09N_3              | IO_L09N_3              | P33       | I/O  |
| 3    | IO_L09P_3              | IO_L09P_3              | P32       | I/O  |
| 3    | IO_L10N_3              | IO_L10N_3              | P35       | I/O  |
| 3    | IO_L10P_3              | IO_L10P_3              | P34       | I/O  |
| 3    | IP                     | IP                     | P6        | INPUT  |
| 3    | IO                     | IP                     | P10       | <b>100E:</b> I/O<br><b>250E:</b> INPUT             |
| 3    | IP                     | IP                     | P18       | INPUT  |
| 3    | IP                     | IP                     | P24       | INPUT  |
| 3    | IO                     | IP                     | P29       | <b>100E:</b> I/O<br><b>250E:</b> INPUT             |
| 3    | IP                     | IP                     | P36       | INPUT  |
| 3    | IP/VREF_3              | IP/VREF_3              | P12       | VREF   |
| 3    | VCCO_3                 | VCCO_3                 | P13       | VCCO   |
| 3    | VCCO_3                 | VCCO_3                 | P28       | VCCO   |
| GND  | GND                    | GND                    | P11       | GND  |
| GND  | GND                    | GND                    | P19       | GND  |

Table 136: TQ144 Package Pinout (Cont'd)

| Bank   | XC3S100E Pin Name | XC3S250E Pin Name | TQ144 Pin | Type   |
|--------|-------------------|-------------------|-----------|--------|
| GND    | GND               | GND               | P27       | GND    |
| GND    | GND               | GND               | P37       | GND    |
| GND    | GND               | GND               | P46       | GND    |
| GND    | GND               | GND               | P55       | GND    |
| GND    | GND               | GND               | P61       | GND    |
| GND    | GND               | GND               | P73       | GND    |
| GND    | GND               | GND               | P90       | GND    |
| GND    | GND               | GND               | P99       | GND    |
| GND    | GND               | GND               | P118      | GND    |
| GND    | GND               | GND               | P127      | GND    |
| GND    | GND               | GND               | P133      | GND    |
| VCCAUX | DONE              | DONE              | P72       | CONFIG |
| VCCAUX | PROG_B            | PROG_B            | P1        | CONFIG |
| VCCAUX | TCK               | TCK               | P110      | JTAG   |
| VCCAUX | TDI               | TDI               | P144      | JTAG   |
| VCCAUX | TDO               | TDO               | P109      | JTAG   |
| VCCAUX | TMS               | TMS               | P108      | JTAG   |
| VCCAUX | VCCAUX            | VCCAUX            | P30       | VCCAUX |
| VCCAUX | VCCAUX            | VCCAUX            | P65       | VCCAUX |
| VCCAUX | VCCAUX            | VCCAUX            | P102      | VCCAUX |
| VCCAUX | VCCAUX            | VCCAUX            | P137      | VCCAUX |
| VCCINT | VCCINT            | VCCINT            | P9        | VCCINT |
| VCCINT | VCCINT            | VCCINT            | P45       | VCCINT |
| VCCINT | VCCINT            | VCCINT            | P80       | VCCINT |
| VCCINT | VCCINT            | VCCINT            | P115      | VCCINT |

## User I/Os by Bank

Table 137 and Table 138 indicate how the 108 available user-I/O pins are distributed between the four I/O banks on the TQ144 package.

Table 137: User I/Os Per Bank for the XC3S100E in the TQ144 Package

| Package Edge | I/O Bank | Maximum I/O | All Possible I/O Pins by Type |           |           |                     |                    |
|--------------|----------|-------------|-------------------------------|-----------|-----------|---------------------|--------------------|
|              |          |             | I/O                           | INPUT     | DUAL      | VREF <sup>(1)</sup> | CLK <sup>(2)</sup> |
| Top          | 0        | 26          | 9                             | 6         | 1         | 2                   | 8                  |
| Right        | 1        | 28          | 0                             | 5         | 21        | 2                   | 0 <sup>(2)</sup>   |
| Bottom       | 2        | 26          | 0                             | 4         | 20        | 2                   | 0 <sup>(2)</sup>   |
| Left         | 3        | 28          | 13                            | 4         | 0         | 3                   | 8                  |
| <b>TOTAL</b> |          | <b>108</b>  | <b>22</b>                     | <b>19</b> | <b>42</b> | <b>9</b>            | <b>16</b>          |

**Notes:**

1. Some VREF and CLK pins are on INPUT pins.
2. The eight global clock pins in this bank have optional functionality during configuration and are counted in the DUAL column.

Table 138: User I/Os Per Bank for the XC3S250E in TQ144 Package

| Package Edge | I/O Bank | Maximum I/O | All Possible I/O Pins by Type |           |           |                     |                    |
|--------------|----------|-------------|-------------------------------|-----------|-----------|---------------------|--------------------|
|              |          |             | I/O                           | INPUT     | DUAL      | VREF <sup>(1)</sup> | CLK <sup>(2)</sup> |
| Top          | 0        | 26          | 9                             | 6         | 1         | 2                   | 8                  |
| Right        | 1        | 28          | 0                             | 5         | 21        | 2                   | 0 <sup>(2)</sup>   |
| Bottom       | 2        | 26          | 0                             | 4         | 20        | 2                   | 0 <sup>(2)</sup>   |
| Left         | 3        | 28          | 11                            | 6         | 0         | 3                   | 8                  |
| <b>TOTAL</b> |          | <b>108</b>  | <b>20</b>                     | <b>21</b> | <b>42</b> | <b>9</b>            | <b>16</b>          |

**Notes:**

1. Some VREF and CLK pins are on INPUT pins.
2. The eight global clock pins in this bank have optional functionality during configuration and are counted in the DUAL column.

## Footprint Migration Differences

Table 139 summarizes any footprint and functionality differences between the XC3S100E and the XC3S250E FPGAs that may affect easy migration between devices. There are four such pins. All other pins not listed in Table 139 unconditionally migrate between Spartan-3E devices available in the TQ144 package.

The arrows indicate the direction for easy migration. For example, a left-facing arrow indicates that the pin on the XC3S250E unconditionally migrates to the pin on the XC3S100E. It may be possible to migrate the opposite direction depending on the I/O configuration. For example, an I/O pin (Type = I/O) can migrate to an input-only pin (Type = INPUT) if the I/O pin is configured as an input.

Table 139: TQ144 Footprint Migration Differences

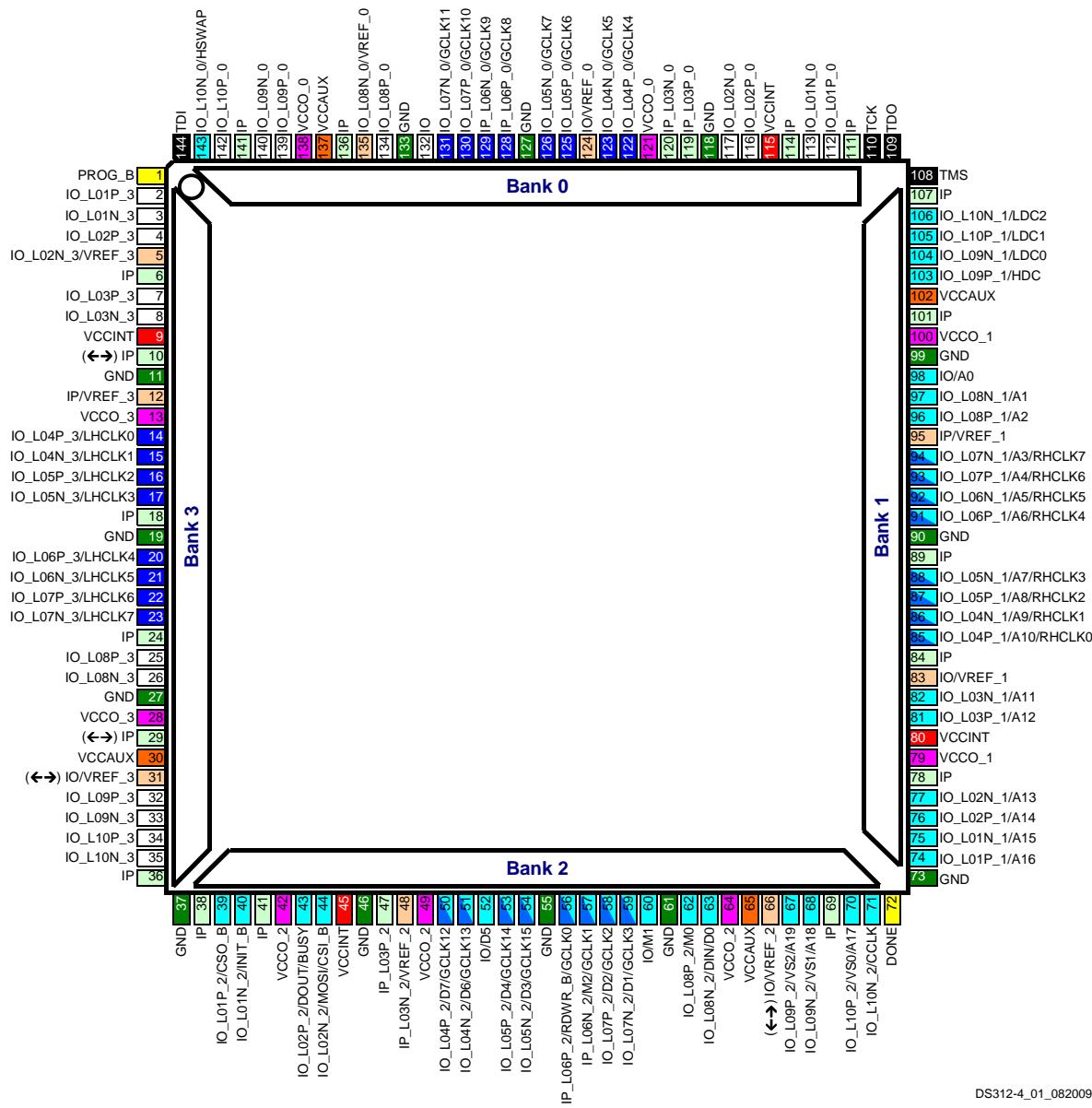
| TQ144 Pin          | Bank | XC3S100E Type | Migration | XC3S250E Type |
|--------------------|------|---------------|-----------|---------------|
| P10                | 3    | I/O           | ←         | INPUT         |
| P29                | 3    | I/O           | ←         | INPUT         |
| P31                | 3    | VREF(INPUT)   | →         | VREF(I/O)     |
| P66                | 2    | VREF(INPUT)   | →         | VREF(I/O)     |
| <b>DIFFERENCES</b> |      |               | <b>4</b>  |               |

Legend:

- This pin can unconditionally migrate from the device on the left to the device on the right. Migration in the other direction may be possible depending on how the pin is configured for the device on the right.
- ← This pin can unconditionally migrate from the device on the right to the device on the left. Migration in the other direction may be possible depending on how the pin is configured for the device on the left.

## TQ144 Footprint

Note pin 1 indicator in top-left corner and logo orientation.  
 Double arrows ( $\leftrightarrow$ ) indicates a pinout migration difference  
 between the XC3S100E and XC3S250E.



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Figure 82: TQ144 Package Footprint (top view)

|    |  |    |   |   |  |
|----|--|----|---|---|--|
| 20 | I/O: Unrestricted, general-purpose user I/O    | 42 | DUAL: Configuration pin, then possible user I/O | 9 | VREF: User I/O or input voltage reference for bank |
| 21 | INPUT: Unrestricted, general-purpose input pin | 16 | CLK: User I/O, input, or global buffer input    | 9 | VCCO: Output voltage supply for bank               |
| 2  | CONFIG: Dedicated configuration pins           | 4  | JTAG: Dedicated JTAG port pins                  | 4 | VCCINT: Internal core supply voltage (+1.2V)       |
| 0  | N.C.: Not connected                            | 13 | GND: Ground                                     | 4 | VCCAUX: Auxiliary supply voltage (+2.5V)           |

## PQ208: 208-pin Plastic Quad Flat Package

The 208-pin plastic quad flat package, PQ208, supports two different Spartan-3E FPGAs, including the XC3S250E and the XC3S500E.

Table 140 lists all the PQ208 package pins. They are sorted by bank number and then by pin name. Pairs of pins that form a differential I/O pair appear together in the table. The table also shows the pin number for each pin and the pin type, as defined earlier.

An electronic version of this package pinout table and footprint diagram is available for download from the Xilinx website at:

[http://www.xilinx.com/support/documentation/data\\_sheets/s3e\\_pin.zip](http://www.xilinx.com/support/documentation/data_sheets/s3e_pin.zip)

### Pinout Table

Table 140: PQ208 Package Pinout

| Bank | XC3S250E<br>XC3S500E<br>Pin Name | PQ208<br>Pin | Type |
|------|----------------------------------|--------------|------|
| 0    | IO                               | P187         | I/O  |
| 0    | IO/VREF_0                        | P179         | VREF |
| 0    | IO_L01N_0                        | P161         | I/O  |
| 0    | IO_L01P_0                        | P160         | I/O  |
| 0    | IO_L02N_0/VREF_0                 | P163         | VREF |
| 0    | IO_L02P_0                        | P162         | I/O  |
| 0    | IO_L03N_0                        | P165         | I/O  |
| 0    | IO_L03P_0                        | P164         | I/O  |
| 0    | IO_L04N_0/VREF_0                 | P168         | VREF |
| 0    | IO_L04P_0                        | P167         | I/O  |
| 0    | IO_L05N_0                        | P172         | I/O  |
| 0    | IO_L05P_0                        | P171         | I/O  |
| 0    | IO_L07N_0/GCLK5                  | P178         | GCLK |
| 0    | IO_L07P_0/GCLK4                  | P177         | GCLK |
| 0    | IO_L08N_0/GCLK7                  | P181         | GCLK |
| 0    | IO_L08P_0/GCLK6                  | P180         | GCLK |
| 0    | IO_L10N_0/GCLK11                 | P186         | GCLK |
| 0    | IO_L10P_0/GCLK10                 | P185         | GCLK |
| 0    | IO_L11N_0                        | P190         | I/O  |
| 0    | IO_L11P_0                        | P189         | I/O  |
| 0    | IO_L12N_0/VREF_0                 | P193         | VREF |
| 0    | IO_L12P_0                        | P192         | I/O  |
| 0    | IO_L13N_0                        | P197         | I/O  |
| 0    | IO_L13P_0                        | P196         | I/O  |
| 0    | IO_L14N_0/VREF_0                 | P200         | VREF |
| 0    | IO_L14P_0                        | P199         | I/O  |
| 0    | IO_L15N_0                        | P203         | I/O  |

Table 140: PQ208 Package Pinout (Cont'd)

| Bank | XC3S250E<br>XC3S500E<br>Pin Name | PQ208<br>Pin | Type       |
|------|----------------------------------|--------------|------------|
| 0    | IO_L15P_0                        | P202         | I/O        |
| 0    | IO_L16N_0/HSWAP                  | P206         | DUAL       |
| 0    | IO_L16P_0                        | P205         | I/O        |
| 0    | IP                               | P159         | INPUT      |
| 0    | IP                               | P169         | INPUT      |
| 0    | IP                               | P194         | INPUT      |
| 0    | IP                               | P204         | INPUT      |
| 0    | IP_L06N_0                        | P175         | INPUT      |
| 0    | IP_L06P_0                        | P174         | INPUT      |
| 0    | IP_L09N_0/GCLK9                  | P184         | GCLK       |
| 0    | IP_L09P_0/GCLK8                  | P183         | GCLK       |
| 0    | VCCO_0                           | P176         | VCCO       |
| 0    | VCCO_0                           | P191         | VCCO       |
| 0    | VCCO_0                           | P201         | VCCO       |
| 1    | IO_L01N_1/A15                    | P107         | DUAL       |
| 1    | IO_L01P_1/A16                    | P106         | DUAL       |
| 1    | IO_L02N_1/A13                    | P109         | DUAL       |
| 1    | IO_L02P_1/A14                    | P108         | DUAL       |
| 1    | IO_L03N_1/VREF_1                 | P113         | VREF       |
| 1    | IO_L03P_1                        | P112         | I/O        |
| 1    | IO_L04N_1                        | P116         | I/O        |
| 1    | IO_L04P_1                        | P115         | I/O        |
| 1    | IO_L05N_1/A11                    | P120         | DUAL       |
| 1    | IO_L05P_1/A12                    | P119         | DUAL       |
| 1    | IO_L06N_1/VREF_1                 | P123         | VREF       |
| 1    | IO_L06P_1                        | P122         | I/O        |
| 1    | IO_L07N_1/A9/RHCLK1              | P127         | RHCLK/DUAL |
| 1    | IO_L07P_1/A10/RHCLK0             | P126         | RHCLK/DUAL |
| 1    | IO_L08N_1/A7/RHCLK3              | P129         | RHCLK/DUAL |
| 1    | IO_L08P_1/A8/RHCLK2              | P128         | RHCLK/DUAL |
| 1    | IO_L09N_1/A5/RHCLK5              | P133         | RHCLK/DUAL |
| 1    | IO_L09P_1/A6/RHCLK4              | P132         | RHCLK/DUAL |
| 1    | IO_L10N_1/A3/RHCLK7              | P135         | RHCLK/DUAL |
| 1    | IO_L10P_1/A4/RHCLK6              | P134         | RHCLK/DUAL |
| 1    | IO_L11N_1/A1                     | P138         | DUAL       |
| 1    | IO_L11P_1/A2                     | P137         | DUAL       |
| 1    | IO_L12N_1/A0                     | P140         | DUAL       |
| 1    | IO_L12P_1                        | P139         | I/O        |
| 1    | IO_L13N_1                        | P145         | I/O        |
| 1    | IO_L13P_1                        | P144         | I/O        |
| 1    | IO_L14N_1                        | P147         | I/O        |
| 1    | IO_L14P_1                        | P146         | I/O        |

Table 140: PQ208 Package Pinout (Cont'd)

| Bank | XC3S250E<br>XC3S500E<br>Pin Name | PQ208<br>Pin | Type      |
|------|----------------------------------|--------------|-----------|
| 1    | IO_L15N_1/LDC0                   | P151         | DUAL      |
| 1    | IO_L15P_1/HDC                    | P150         | DUAL      |
| 1    | IO_L16N_1/LDC2                   | P153         | DUAL      |
| 1    | IO_L16P_1/LDC1                   | P152         | DUAL      |
| 1    | IP                               | P110         | INPUT     |
| 1    | IP                               | P118         | INPUT     |
| 1    | IP                               | P124         | INPUT     |
| 1    | IP                               | P130         | INPUT     |
| 1    | IP                               | P142         | INPUT     |
| 1    | IP                               | P148         | INPUT     |
| 1    | IP                               | P154         | INPUT     |
| 1    | IP/VREF_1                        | P136         | VREF      |
| 1    | VCCO_1                           | P114         | VCCO      |
| 1    | VCCO_1                           | P125         | VCCO      |
| 1    | VCCO_1                           | P143         | VCCO      |
| 2    | IO/D5                            | P76          | DUAL      |
| 2    | IO/M1                            | P84          | DUAL      |
| 2    | IO/VREF_2                        | P98          | VREF      |
| 2    | IO_L01N_2/INIT_B                 | P56          | DUAL      |
| 2    | IO_L01P_2/CSO_B                  | P55          | DUAL      |
| 2    | IO_L03N_2/MOSI/CSI_B             | P61          | DUAL      |
| 2    | IO_L03P_2/DOUT/BUSY              | P60          | DUAL      |
| 2    | IO_L04N_2                        | P63          | I/O       |
| 2    | IO_L04P_2                        | P62          | I/O       |
| 2    | IO_L05N_2                        | P65          | I/O       |
| 2    | IO_L05P_2                        | P64          | I/O       |
| 2    | IO_L06N_2                        | P69          | I/O       |
| 2    | IO_L06P_2                        | P68          | I/O       |
| 2    | IO_L08N_2/D6/GCLK13              | P75          | DUAL/GCLK |
| 2    | IO_L08P_2/D7/GCLK12              | P74          | DUAL/GCLK |
| 2    | IO_L09N_2/D3/GCLK15              | P78          | DUAL/GCLK |
| 2    | IO_L09P_2/D4/GCLK14              | P77          | DUAL/GCLK |
| 2    | IO_L11N_2/D1/GCLK3               | P83          | DUAL/GCLK |
| 2    | IO_L11P_2/D2/GCLK2               | P82          | DUAL/GCLK |
| 2    | IO_L12N_2/DIN/D0                 | P87          | DUAL      |
| 2    | IO_L12P_2/M0                     | P86          | DUAL      |
| 2    | IO_L13N_2                        | P90          | I/O       |
| 2    | IO_L13P_2                        | P89          | I/O       |
| 2    | IO_L14N_2/A22                    | P94          | DUAL      |
| 2    | IO_L14P_2/A23                    | P93          | DUAL      |
| 2    | IO_L15N_2/A20                    | P97          | DUAL      |
| 2    | IO_L15P_2/A21                    | P96          | DUAL      |
| 2    | IO_L16N_2/VS1/A18                | P100         | DUAL      |

Table 140: PQ208 Package Pinout (Cont'd)

| Bank | XC3S250E<br>XC3S500E<br>Pin Name | PQ208<br>Pin | Type      |
|------|----------------------------------|--------------|-----------|
| 2    | IO_L16P_2/VS2/A19                | P99          | DUAL      |
| 2    | IO_L17N_2/CCLK                   | P103         | DUAL      |
| 2    | IO_L17P_2/VS0/A17                | P102         | DUAL      |
| 2    | IP                               | P54          | INPUT     |
| 2    | IP                               | P91          | INPUT     |
| 2    | IP                               | P101         | INPUT     |
| 2    | IP_L02N_2                        | P58          | INPUT     |
| 2    | IP_L02P_2                        | P57          | INPUT     |
| 2    | IP_L07N_2/VREF_2                 | P72          | VREF      |
| 2    | IP_L07P_2                        | P71          | INPUT     |
| 2    | IP_L10N_2/M2/GCLK1               | P81          | DUAL/GCLK |
| 2    | IP_L10P_2/RDWR_B/<br>GCLK0       | P80          | DUAL/GCLK |
| 2    | VCCO_2                           | P59          | VCCO      |
| 2    | VCCO_2                           | P73          | VCCO      |
| 2    | VCCO_2                           | P88          | VCCO      |
| 3    | IO/VREF_3                        | P45          | VREF      |
| 3    | IO_L01N_3                        | P3           | I/O       |
| 3    | IO_L01P_3                        | P2           | I/O       |
| 3    | IO_L02N_3/VREF_3                 | P5           | VREF      |
| 3    | IO_L02P_3                        | P4           | I/O       |
| 3    | IO_L03N_3                        | P9           | I/O       |
| 3    | IO_L03P_3                        | P8           | I/O       |
| 3    | IO_L04N_3                        | P12          | I/O       |
| 3    | IO_L04P_3                        | P11          | I/O       |
| 3    | IO_L05N_3                        | P16          | I/O       |
| 3    | IO_L05P_3                        | P15          | I/O       |
| 3    | IO_L06N_3                        | P19          | I/O       |
| 3    | IO_L06P_3                        | P18          | I/O       |
| 3    | IO_L07N_3/LHCLK1                 | P23          | LHCLK     |
| 3    | IO_L07P_3/LHCLK0                 | P22          | LHCLK     |
| 3    | IO_L08N_3/LHCLK3                 | P25          | LHCLK     |
| 3    | IO_L08P_3/LHCLK2                 | P24          | LHCLK     |
| 3    | IO_L09N_3/LHCLK5                 | P29          | LHCLK     |
| 3    | IO_L09P_3/LHCLK4                 | P28          | LHCLK     |
| 3    | IO_L10N_3/LHCLK7                 | P31          | LHCLK     |
| 3    | IO_L10P_3/LHCLK6                 | P30          | LHCLK     |
| 3    | IO_L11N_3                        | P34          | I/O       |
| 3    | IO_L11P_3                        | P33          | I/O       |
| 3    | IO_L12N_3                        | P36          | I/O       |
| 3    | IO_L12P_3                        | P35          | I/O       |
| 3    | IO_L13N_3                        | P40          | I/O       |
| 3    | IO_L13P_3                        | P39          | I/O       |
| 3    | IO_L14N_3                        | P42          | I/O       |

Table 140: PQ208 Package Pinout (Cont'd)

| Bank   | XC3S250E<br>XC3S500E<br>Pin Name | PQ208<br>Pin | Type   |
|--------|----------------------------------|--------------|--------|
| 3      | IO_L14P_3                        | P41          | I/O    |
| 3      | IO_L15N_3                        | P48          | I/O    |
| 3      | IO_L15P_3                        | P47          | I/O    |
| 3      | IO_L16N_3                        | P50          | I/O    |
| 3      | IO_L16P_3                        | P49          | I/O    |
| 3      | IP                               | P6           | INPUT  |
| 3      | IP                               | P14          | INPUT  |
| 3      | IP                               | P26          | INPUT  |
| 3      | IP                               | P32          | INPUT  |
| 3      | IP                               | P43          | INPUT  |
| 3      | IP                               | P51          | INPUT  |
| 3      | IP/VREF_3                        | P20          | VREF   |
| 3      | VCCO_3                           | P21          | VCCO   |
| 3      | VCCO_3                           | P38          | VCCO   |
| 3      | VCCO_3                           | P46          | VCCO   |
| GND    | GND                              | P10          | GND    |
| GND    | GND                              | P17          | GND    |
| GND    | GND                              | P27          | GND    |
| GND    | GND                              | P37          | GND    |
| GND    | GND                              | P52          | GND    |
| GND    | GND                              | P53          | GND    |
| GND    | GND                              | P70          | GND    |
| GND    | GND                              | P79          | GND    |
| GND    | GND                              | P85          | GND    |
| GND    | GND                              | P95          | GND    |
| GND    | GND                              | P105         | GND    |
| GND    | GND                              | P121         | GND    |
| GND    | GND                              | P131         | GND    |
| GND    | GND                              | P141         | GND    |
| GND    | GND                              | P156         | GND    |
| GND    | GND                              | P173         | GND    |
| GND    | GND                              | P182         | GND    |
| GND    | GND                              | P188         | GND    |
| GND    | GND                              | P198         | GND    |
| GND    | GND                              | P208         | GND    |
| VCCAUX | DONE                             | P104         | CONFIG |
| VCCAUX | PROG_B                           | P1           | CONFIG |
| VCCAUX | TCK                              | P158         | JTAG   |
| VCCAUX | TDI                              | P207         | JTAG   |
| VCCAUX | TDO                              | P157         | JTAG   |
| VCCAUX | TMS                              | P155         | JTAG   |
| VCCAUX | VCCAUX                           | P7           | VCCAUX |
| VCCAUX | VCCAUX                           | P44          | VCCAUX |

Table 140: PQ208 Package Pinout (Cont'd)

| Bank   | XC3S250E<br>XC3S500E<br>Pin Name | PQ208<br>Pin | Type   |
|--------|----------------------------------|--------------|--------|
| VCCAUX | VCCAUX                           | P66          | VCCAUX |
| VCCAUX | VCCAUX                           | P92          | VCCAUX |
| VCCAUX | VCCAUX                           | P111         | VCCAUX |
| VCCAUX | VCCAUX                           | P149         | VCCAUX |
| VCCAUX | VCCAUX                           | P166         | VCCAUX |
| VCCAUX | VCCAUX                           | P195         | VCCAUX |
| VCCINT | VCCINT                           | P13          | VCCINT |
| VCCINT | VCCINT                           | P67          | VCCINT |
| VCCINT | VCCINT                           | P117         | VCCINT |
| VCCINT | VCCINT                           | P170         | VCCINT |

## User I/Os by Bank

Table 141 indicates how the 158 available user-I/O pins are distributed between the four I/O banks on the PQ208 package.

## Footprint Migration Differences

The XC3S250E and XC3S500E FPGAs have identical footprints in the PQ208 package. Designs can migrate between the XC3S250E and XC3S500E without further consideration.

Table 141: User I/Os Per Bank for the XC3S250E and XC3S500E in the PQ208 Package

| Package Edge | I/O Bank | Maximum I/O | All Possible I/O Pins by Type |           |           |                     |                    |
|--------------|----------|-------------|-------------------------------|-----------|-----------|---------------------|--------------------|
|              |          |             | I/O                           | INPUT     | DUAL      | VREF <sup>(1)</sup> | CLK <sup>(2)</sup> |
| Top          | 0        | 38          | 18                            | 6         | 1         | 5                   | 8                  |
| Right        | 1        | 40          | 9                             | 7         | 21        | 3                   | 0 <sup>(2)</sup>   |
| Bottom       | 2        | 40          | 8                             | 6         | 24        | 2                   | 0 <sup>(2)</sup>   |
| Left         | 3        | 40          | 23                            | 6         | 0         | 3                   | 8                  |
| <b>TOTAL</b> |          | <b>158</b>  | <b>58</b>                     | <b>25</b> | <b>46</b> | <b>13</b>           | <b>16</b>          |

### Notes:

1. Some VREF and CLK pins are on INPUT pins.
2. The eight global clock pins in this bank have optional functionality during configuration and are counted in the DUAL column.

## PQ208 Footprint (Left)

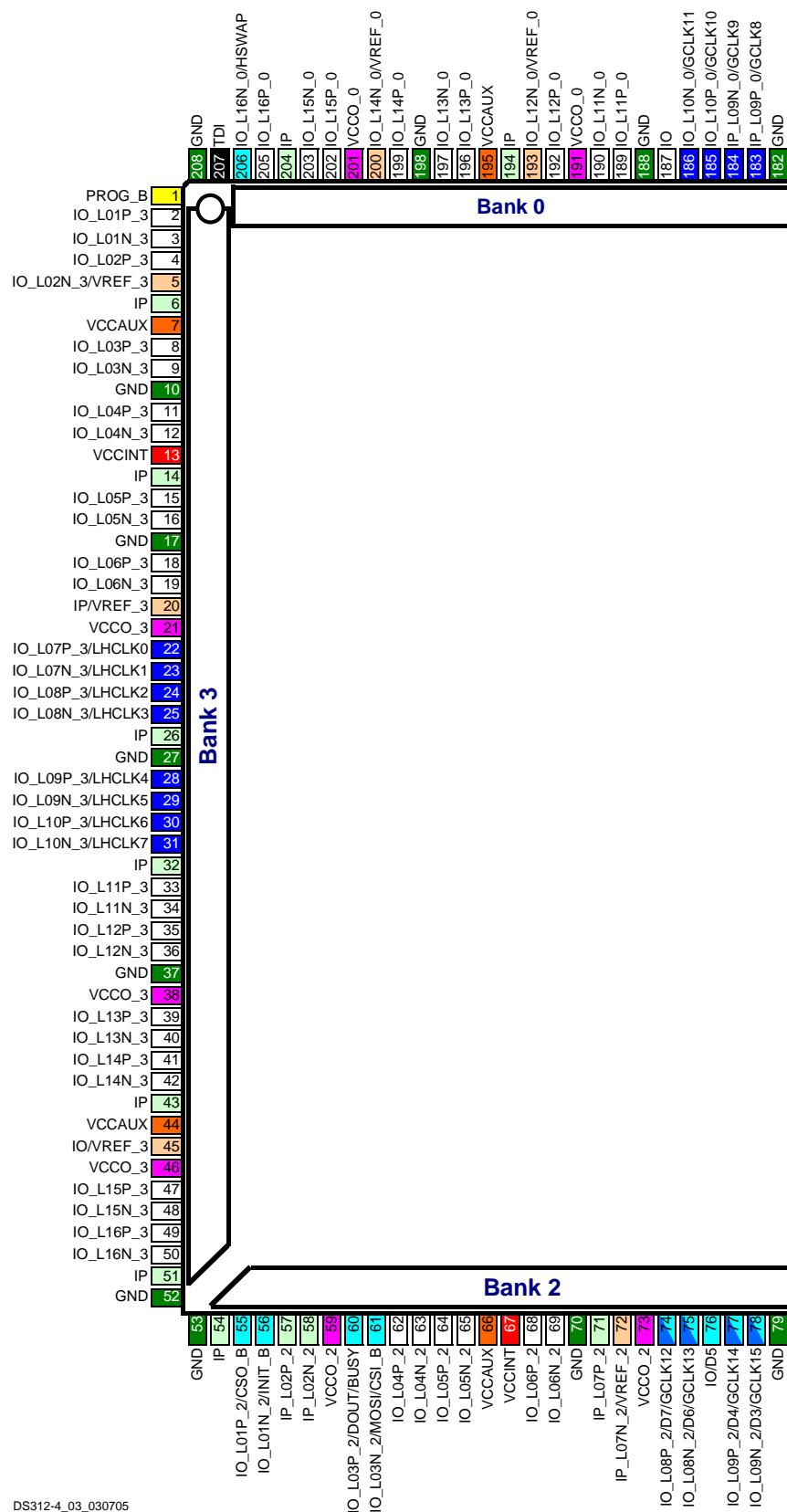
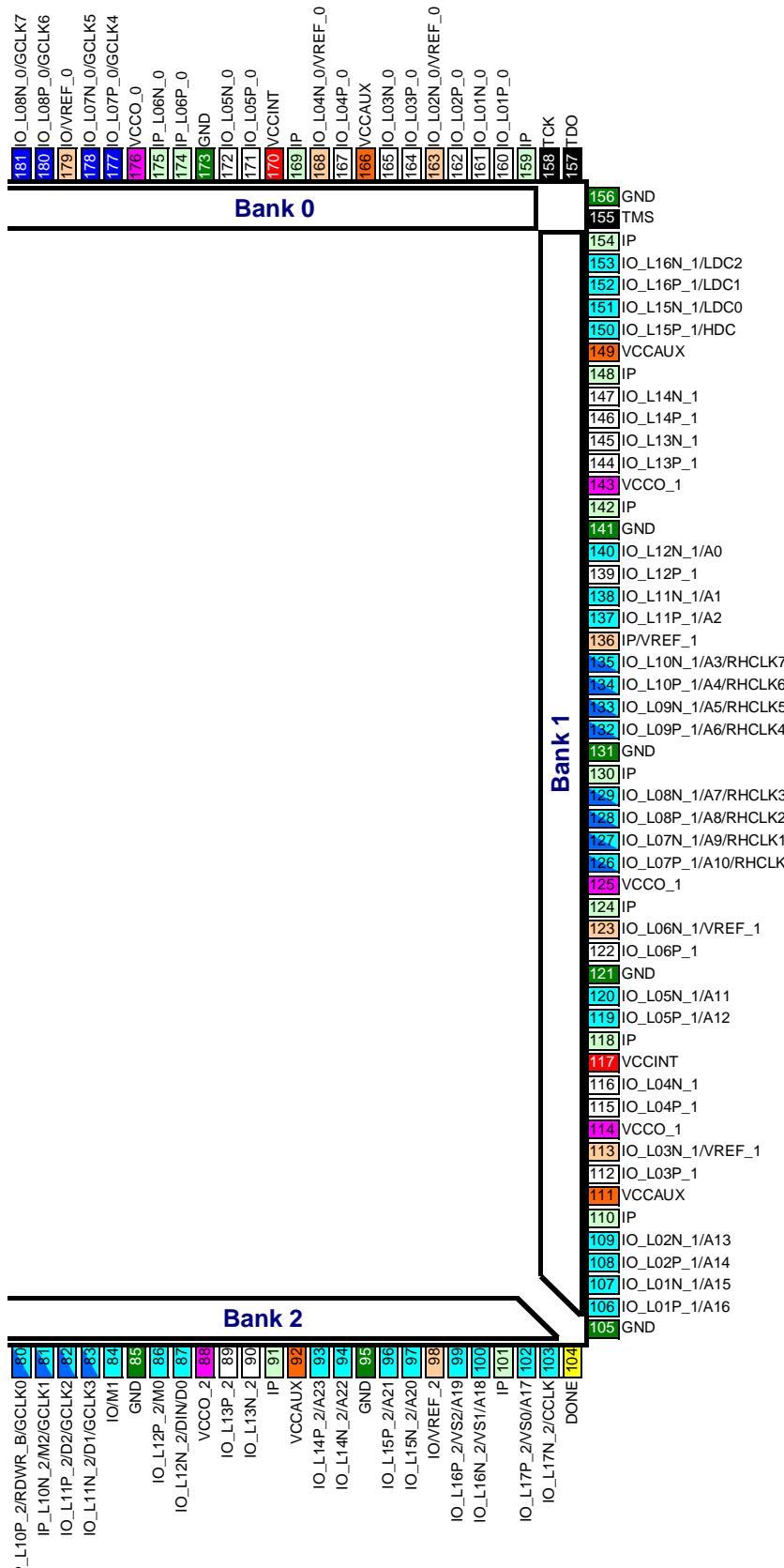


Figure 83: PQ208 Footprint (Left)

## PQ208 Footprint (Right)



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Figure 84: PQ208 Footprint (Right)

## FT256: 256-ball Fine-pitch, Thin Ball Grid Array

The 256-ball fine-pitch, thin ball grid array package, FT256, supports three different Spartan-3E FPGAs, including the XC3S250E, the XC3S500E, and the XC3S1200E.

**Table 142** lists all the package pins. They are sorted by bank number and then by pin name of the largest device. Pins that form a differential I/O pair appear together in the table. The table also shows the pin number for each pin and the pin type, as defined earlier.

The highlighted rows indicate pinout differences between the XC3S250E, the XC3S500E, and the XC3S1200E FPGAs. The XC3S250E has 18 unconnected balls, indicated as N.C. (No Connection) in **Table 142** and with the black diamond character (◆) in **Table 142** and **Figure 83**.

If the table row is highlighted in tan, then this is an instance where an unconnected pin on the XC3S250E FPGA maps

to a VREF pin on the XC3S500E and XC3S1200E FPGA. If the FPGA application uses an I/O standard that requires a VREF voltage reference, connect the highlighted pin to the VREF voltage supply, even though this does not actually connect to the XC3S250E FPGA. This VREF connection on the board allows future migration to the larger devices without modifying the printed-circuit board.

All other balls have nearly identical functionality on all three devices. **Table 146** summarizes the Spartan-3E footprint migration differences for the FT256 package.

An electronic version of this package pinout table and footprint diagram is available for download from the Xilinx web site at:

[http://www.xilinx.com/support/documentation/data\\_sheets/s3e\\_pin.zip](http://www.xilinx.com/support/documentation/data_sheets/s3e_pin.zip)

### Pinout Table

**Table 142: FT256 Package Pinout**

| Bank | XC3S250E Pin Name | XC3S500E Pin Name | XC3S1200E Pin Name | FT256 Ball | Type  |
|------|-------------------|-------------------|--------------------|------------|---|
| 0    | IO                | IO                | IO                 | A7         | I/O   |
| 0    | IO                | IO                | IO                 | A12        | I/O   |
| 0    | IO                | IO                | IO                 | B4         | I/O   |
| 0    | IP                | IP                | IO                 | B6         | <b>250E: INPUT<br/>500E: INPUT<br/>1200E: I/O</b> |
| 0    | IP                | IP                | IO                 | B10        | <b>250E: INPUT<br/>500E: INPUT<br/>1200E: I/O</b> |
| 0    | IO/VREF_0         | IO/VREF_0         | IO/VREF_0          | D9         | VREF  |
| 0    | IO_L01N_0         | IO_L01N_0         | IO_L01N_0          | A14        | I/O   |
| 0    | IO_L01P_0         | IO_L01P_0         | IO_L01P_0          | B14        | I/O   |
| 0    | IO_L03N_0/VREF_0  | IO_L03N_0/VREF_0  | IO_L03N_0/VREF_0   | A13        | VREF  |
| 0    | IO_L03P_0         | IO_L03P_0         | IO_L03P_0          | B13        | I/O   |
| 0    | IO_L04N_0         | IO_L04N_0         | IO_L04N_0          | E11        | I/O   |
| 0    | IO_L04P_0         | IO_L04P_0         | IO_L04P_0          | D11        | I/O   |
| 0    | IO_L05N_0/VREF_0  | IO_L05N_0/VREF_0  | IO_L05N_0/VREF_0   | B11        | VREF  |
| 0    | IO_L05P_0         | IO_L05P_0         | IO_L05P_0          | C11        | I/O   |
| 0    | IO_L06N_0         | IO_L06N_0         | IO_L06N_0          | E10        | I/O   |
| 0    | IO_L06P_0         | IO_L06P_0         | IO_L06P_0          | D10        | I/O   |
| 0    | IO_L08N_0/GCLK5   | IO_L08N_0/GCLK5   | IO_L08N_0/GCLK5    | F9         | GCLK  |
| 0    | IO_L08P_0/GCLK4   | IO_L08P_0/GCLK4   | IO_L08P_0/GCLK4    | E9         | GCLK  |
| 0    | IO_L09N_0/GCLK7   | IO_L09N_0/GCLK7   | IO_L09N_0/GCLK7    | A9         | GCLK  |
| 0    | IO_L09P_0/GCLK6   | IO_L09P_0/GCLK6   | IO_L09P_0/GCLK6    | A10        | GCLK  |
| 0    | IO_L11N_0/GCLK11  | IO_L11N_0/GCLK11  | IO_L11N_0/GCLK11   | D8         | GCLK  |
| 0    | IO_L11P_0/GCLK10  | IO_L11P_0/GCLK10  | IO_L11P_0/GCLK10   | C8         | GCLK  |
| 0    | IO_L12N_0         | IO_L12N_0         | IO_L12N_0          | F8         | I/O   |

Table 142: FT256 Package Pinout (Cont'd)

| Bank | XC3S250E Pin Name | XC3S500E Pin Name | XC3S1200E Pin Name | FT256 Ball | Type   |
|------|-------------------|-------------------|--------------------|------------|--|
| 0    | IO_L12P_0         | IO_L12P_0         | IO_L12P_0          | E8         | I/O  |
| 0    | N.C. (◆)          | IO_L13N_0         | IO_L13N_0          | C7         | <b>250E:</b> N.C.<br><b>500E:</b> I/O<br><b>1200E:</b> I/O   |
| 0    | N.C. (◆)          | IO_L13P_0         | IO_L13P_0          | B7         | <b>250E:</b> N.C.<br><b>500E:</b> I/O<br><b>1200E:</b> I/O   |
| 0    | IO_L14N_0/VREF_0  | IO_L14N_0/VREF_0  | IO_L14N_0/VREF_0   | D7         | VREF   |
| 0    | IO_L14P_0         | IO_L14P_0         | IO_L14P_0          | E7         | I/O  |
| 0    | IO_L15N_0         | IO_L15N_0         | IO_L15N_0          | D6         | I/O  |
| 0    | IO_L15P_0         | IO_L15P_0         | IO_L15P_0          | C6         | I/O  |
| 0    | IO_L17N_0/VREF_0  | IO_L17N_0/VREF_0  | IO_L17N_0/VREF_0   | A4         | VREF   |
| 0    | IO_L17P_0         | IO_L17P_0         | IO_L17P_0          | A5         | I/O  |
| 0    | IO_L18N_0         | IO_L18N_0         | IO_L18N_0          | C4         | I/O  |
| 0    | IO_L18P_0         | IO_L18P_0         | IO_L18P_0          | C5         | I/O  |
| 0    | IO_L19N_0/HSWAP   | IO_L19N_0/HSWAP   | IO_L19N_0/HSWAP    | B3         | DUAL   |
| 0    | IO_L19P_0         | IO_L19P_0         | IO_L19P_0          | C3         | I/O  |
| 0    | IP                | IP                | IP                 | A3         | INPUT  |
| 0    | IP                | IP                | IP                 | C13        | INPUT  |
| 0    | IP_L02N_0         | IP_L02N_0         | IP_L02N_0          | C12        | INPUT  |
| 0    | IP_L02P_0         | IP_L02P_0         | IP_L02P_0          | D12        | INPUT  |
| 0    | IP_L07N_0         | IP_L07N_0         | IP_L07N_0          | C9         | INPUT  |
| 0    | IP_L07P_0         | IP_L07P_0         | IP_L07P_0          | C10        | INPUT  |
| 0    | IP_L10N_0/GCLK9   | IP_L10N_0/GCLK9   | IP_L10N_0/GCLK9    | B8         | GCLK   |
| 0    | IP_L10P_0/GCLK8   | IP_L10P_0/GCLK8   | IP_L10P_0/GCLK8    | A8         | GCLK   |
| 0    | IP_L16N_0         | IP_L16N_0         | IP_L16N_0          | E6         | INPUT  |
| 0    | IP_L16P_0         | IP_L16P_0         | IP_L16P_0          | D5         | INPUT  |
| 0    | VCCO_0            | VCCO_0            | VCCO_0             | B5         | VCCO   |
| 0    | VCCO_0            | VCCO_0            | VCCO_0             | B12        | VCCO   |
| 0    | VCCO_0            | VCCO_0            | VCCO_0             | F7         | VCCO   |
| 0    | VCCO_0            | VCCO_0            | VCCO_0             | F10        | VCCO   |
| 1    | IO_L01N_1/A15     | IO_L01N_1/A15     | IO_L01N_1/A15      | R15        | DUAL   |
| 1    | IO_L01P_1/A16     | IO_L01P_1/A16     | IO_L01P_1/A16      | R16        | DUAL   |
| 1    | IO_L02N_1/A13     | IO_L02N_1/A13     | IO_L02N_1/A13      | P15        | DUAL   |
| 1    | IO_L02P_1/A14     | IO_L02P_1/A14     | IO_L02P_1/A14      | P16        | DUAL   |
| 1    | N.C. (◆)          | IO_L03N_1/VREF_1  | IO_L03N_1/VREF_1   | N15        | <b>250E:</b> N.C.<br><b>500E:</b> VREF<br><b>1200E:</b> VREF |
| 1    | N.C. (◆)          | IO_L03P_1         | IO_L03P_1          | N14        | <b>250E:</b> N.C.<br><b>500E:</b> I/O<br><b>1200E:</b> I/O   |
| 1    | IO_L04N_1/VREF_1  | IO_L04N_1/VREF_1  | IO_L04N_1/VREF_1   | M16        | VREF   |
| 1    | IO_L04P_1         | IO_L04P_1         | IO_L04P_1          | N16        | I/O  |
| 1    | N.C. (◆)          | IO_L05N_1         | IO_L05N_1          | L13        | <b>250E:</b> N.C.<br><b>500E:</b> I/O<br><b>1200E:</b> I/O   |

Table 142: FT256 Package Pinout (Cont'd)

| Bank | XC3S250E Pin Name         | XC3S500E Pin Name         | XC3S1200E Pin Name        | FT256 Ball | Type   |
|------|---------------------------|---------------------------|---------------------------|------------|--|
| 1    | N.C. (◆)                  | IO_L05P_1                 | IO_L05P_1                 | L12        | <b>250E:</b> N.C.<br><b>500E:</b> I/O<br><b>1200E:</b> I/O |
| 1    | IO_L06N_1                 | IO_L06N_1                 | IO_L06N_1                 | L15        | I/O  |
| 1    | IO_L06P_1                 | IO_L06P_1                 | IO_L06P_1                 | L14        | I/O  |
| 1    | IO_L07N_1/A11             | IO_L07N_1/A11             | IO_L07N_1/A11             | K12        | DUAL   |
| 1    | IO_L07P_1/A12             | IO_L07P_1/A12             | IO_L07P_1/A12             | K13        | DUAL   |
| 1    | IO_L08N_1/VREF_1          | IO_L08N_1/VREF_1          | IO_L08N_1/VREF_1          | K14        | VREF   |
| 1    | IO_L08P_1                 | IO_L08P_1                 | IO_L08P_1                 | K15        | I/O  |
| 1    | IO_L09N_1/A9/RHCLK1       | IO_L09N_1/A9/RHCLK1       | IO_L09N_1/A9/RHCLK1       | J16        | RHCLK/DUAL   |
| 1    | IO_L09P_1/A10/RHCLK0      | IO_L09P_1/A10/RHCLK0      | IO_L09P_1/A10/RHCLK0      | K16        | RHCLK/DUAL   |
| 1    | IO_L10N_1/A7/RHCLK3/TRDY1 | IO_L10N_1/A7/RHCLK3/TRDY1 | IO_L10N_1/A7/RHCLK3/TRDY1 | J13        | RHCLK/DUAL   |
| 1    | IO_L10P_1/A8/RHCLK2       | IO_L10P_1/A8/RHCLK2       | IO_L10P_1/A8/RHCLK2       | J14        | RHCLK/DUAL   |
| 1    | IO_L11N_1/A5/RHCLK5       | IO_L11N_1/A5/RHCLK5       | IO_L11N_1/A5/RHCLK5       | H14        | RHCLK/DUAL   |
| 1    | IO_L11P_1/A6/RHCLK4/IRDY1 | IO_L11P_1/A6/RHCLK4/IRDY1 | IO_L11P_1/A6/RHCLK4/IRDY1 | H15        | RHCLK/DUAL   |
| 1    | IO_L12N_1/A3/RHCLK7       | IO_L12N_1/A3/RHCLK7       | IO_L12N_1/A3/RHCLK7       | H11        | RHCLK/DUAL   |
| 1    | IO_L12P_1/A4/RHCLK6       | IO_L12P_1/A4/RHCLK6       | IO_L12P_1/A4/RHCLK6       | H12        | RHCLK/DUAL   |
| 1    | IO_L13N_1/A1              | IO_L13N_1/A1              | IO_L13N_1/A1              | G16        | DUAL   |
| 1    | IO_L13P_1/A2              | IO_L13P_1/A2              | IO_L13P_1/A2              | G15        | DUAL   |
| 1    | IO_L14N_1/A0              | IO_L14N_1/A0              | IO_L14N_1/A0              | G14        | DUAL   |
| 1    | IO_L14P_1                 | IO_L14P_1                 | IO_L14P_1                 | G13        | I/O  |
| 1    | IO_L15N_1                 | IO_L15N_1                 | IO_L15N_1                 | F15        | I/O  |
| 1    | IO_L15P_1                 | IO_L15P_1                 | IO_L15P_1                 | F14        | I/O  |
| 1    | IO_L16N_1                 | IO_L16N_1                 | IO_L16N_1                 | F12        | I/O  |
| 1    | IO_L16P_1                 | IO_L16P_1                 | IO_L16P_1                 | F13        | I/O  |
| 1    | N.C. (◆)                  | IO_L17N_1                 | IO_L17N_1                 | E16        | <b>250E:</b> N.C.<br><b>500E:</b> I/O<br><b>1200E:</b> I/O |
| 1    | N.C. (◆)                  | IO_L17P_1                 | IO_L17P_1                 | E13        | <b>250E:</b> N.C.<br><b>500E:</b> I/O<br><b>1200E:</b> I/O |
| 1    | IO_L18N_1/LDC0            | IO_L18N_1/LDC0            | IO_L18N_1/LDC0            | D14        | DUAL   |
| 1    | IO_L18P_1/HDC             | IO_L18P_1/HDC             | IO_L18P_1/HDC             | D15        | DUAL   |
| 1    | IO_L19N_1/LDC2            | IO_L19N_1/LDC2            | IO_L19N_1/LDC2            | C15        | DUAL   |
| 1    | IO_L19P_1/LDC1            | IO_L19P_1/LDC1            | IO_L19P_1/LDC1            | C16        | DUAL   |
| 1    | IP                        | IP                        | IP                        | B16        | INPUT  |
| 1    | IP                        | IP                        | IP                        | E14        | INPUT  |
| 1    | IP                        | IP                        | IP                        | G12        | INPUT  |
| 1    | IP                        | IP                        | IP                        | H16        | INPUT  |
| 1    | IP                        | IP                        | IP                        | J11        | INPUT  |
| 1    | IP                        | IP                        | IP                        | J12        | INPUT  |
| 1    | IP                        | IP                        | IP                        | M13        | INPUT  |

Table 142: FT256 Package Pinout (Cont'd)

| Bank | XC3S250E Pin Name    | XC3S500E Pin Name    | XC3S1200E Pin Name   | FT256 Ball | Type  |
|------|----------------------|----------------------|----------------------|------------|---|
| 1    | IO                   | IO                   | IP                   | M14        | <b>250E:</b> I/O<br><b>500E:</b> I/O<br><b>1200E:</b> INPUT                     |
| 1    | IO/VREF_1            | IP/VREF_1            | IP/VREF_1            | D16        | <b>250E:</b> VREF(I/O)<br><b>500E:</b> VREF(INPUT)<br><b>1200E:</b> VREF(INPUT) |
| 1    | IP/VREF_1            | IP/VREF_1            | IP/VREF_1            | H13        | VREF  |
| 1    | VCCO_1               | VCCO_1               | VCCO_1               | E15        | VCCO  |
| 1    | VCCO_1               | VCCO_1               | VCCO_1               | G11        | VCCO  |
| 1    | VCCO_1               | VCCO_1               | VCCO_1               | K11        | VCCO  |
| 1    | VCCO_1               | VCCO_1               | VCCO_1               | M15        | VCCO  |
| 2    | IP                   | IP                   | IO                   | M7         | <b>250E:</b> INPUT<br><b>500E:</b> INPUT<br><b>1200E:</b> I/O                   |
| 2    | IP                   | IP                   | IO                   | T12        | <b>250E:</b> INPUT<br><b>500E:</b> INPUT<br><b>1200E:</b> I/O                   |
| 2    | IO/D5                | IO/D5                | IO/D5                | T8         | DUAL  |
| 2    | IO/M1                | IO/M1                | IO/M1                | T10        | DUAL  |
| 2    | IO/VREF_2            | IO/VREF_2            | IO/VREF_2            | P13        | VREF  |
| 2    | IO/VREF_2            | IO/VREF_2            | IO/VREF_2            | R4         | VREF  |
| 2    | IO_L01N_2/INIT_B     | IO_L01N_2/INIT_B     | IO_L01N_2/INIT_B     | P4         | DUAL  |
| 2    | IO_L01P_2/CSO_B      | IO_L01P_2/CSO_B      | IO_L01P_2/CSO_B      | P3         | DUAL  |
| 2    | IO_L03N_2/MOSI/CSI_B | IO_L03N_2/MOSI/CSI_B | IO_L03N_2/MOSI/CSI_B | N5         | DUAL  |
| 2    | IO_L03P_2/DOUT/BUSY  | IO_L03P_2/DOUT/BUSY  | IO_L03P_2/DOUT/BUSY  | P5         | DUAL  |
| 2    | IO_L04N_2            | IO_L04N_2            | IO_L04N_2            | T5         | I/O   |
| 2    | IO_L04P_2            | IO_L04P_2            | IO_L04P_2            | T4         | I/O   |
| 2    | IO_L05N_2            | IO_L05N_2            | IO_L05N_2            | N6         | I/O   |
| 2    | IO_L05P_2            | IO_L05P_2            | IO_L05P_2            | M6         | I/O   |
| 2    | IO_L06N_2            | IO_L06N_2            | IO_L06N_2            | P6         | I/O   |
| 2    | IO_L06P_2            | IO_L06P_2            | IO_L06P_2            | R6         | I/O   |
| 2    | N.C. (◆)             | IO_L07N_2            | IO_L07N_2            | P7         | <b>250E:</b> N.C.<br><b>500E:</b> I/O<br><b>1200E:</b> I/O                      |
| 2    | N.C. (◆)             | IO_L07P_2            | IO_L07P_2            | N7         | <b>250E:</b> N.C.<br><b>500E:</b> I/O<br><b>1200E:</b> I/O                      |
| 2    | IO_L09N_2/D6/GCLK13  | IO_L09N_2/D6/GCLK13  | IO_L09N_2/D6/GCLK13  | L8         | DUAL/GCLK   |
| 2    | IO_L09P_2/D7/GCLK12  | IO_L09P_2/D7/GCLK12  | IO_L09P_2/D7/GCLK12  | M8         | DUAL/GCLK   |
| 2    | IO_L10N_2/D3/GCLK15  | IO_L10N_2/D3/GCLK15  | IO_L10N_2/D3/GCLK15  | P8         | DUAL/GCLK   |
| 2    | IO_L10P_2/D4/GCLK14  | IO_L10P_2/D4/GCLK14  | IO_L10P_2/D4/GCLK14  | N8         | DUAL/GCLK   |
| 2    | IO_L12N_2/D1/GCLK3   | IO_L12N_2/D1/GCLK3   | IO_L12N_2/D1/GCLK3   | N9         | DUAL/GCLK   |
| 2    | IO_L12P_2/D2/GCLK2   | IO_L12P_2/D2/GCLK2   | IO_L12P_2/D2/GCLK2   | P9         | DUAL/GCLK   |
| 2    | IO_L13N_2/DIN/D0     | IO_L13N_2/DIN/D0     | IO_L13N_2/DIN/D0     | M9         | DUAL  |
| 2    | IO_L13P_2/M0         | IO_L13P_2/M0         | IO_L13P_2/M0         | L9         | DUAL  |

Table 142: FT256 Package Pinout (Cont'd)

| Bank | XC3S250E Pin Name          | XC3S500E Pin Name          | XC3S1200E Pin Name         | FT256 Ball | Type  |
|------|----------------------------|----------------------------|----------------------------|------------|---|
| 2    | N.C. (◆)                   | IO_L14N_2/VREF_2           | IO_L14N_2/VREF_2           | R10        | <b>250E</b> : N.C.<br><b>500E</b> : VREF<br><b>1200E</b> : VREF |
| 2    | N.C. (◆)                   | IO_L14P_2                  | IO_L14P_2                  | P10        | <b>250E</b> : N.C.<br><b>500E</b> : I/O<br><b>1200E</b> : I/O   |
| 2    | IO_L15N_2                  | IO_L15N_2                  | IO_L15N_2                  | M10        | I/O   |
| 2    | IO_L15P_2                  | IO_L15P_2                  | IO_L15P_2                  | N10        | I/O   |
| 2    | IO_L16N_2/A22              | IO_L16N_2/A22              | IO_L16N_2/A22              | P11        | DUAL  |
| 2    | IO_L16P_2/A23              | IO_L16P_2/A23              | IO_L16P_2/A23              | R11        | DUAL  |
| 2    | IO_L18N_2/A20              | IO_L18N_2/A20              | IO_L18N_2/A20              | N12        | DUAL  |
| 2    | IO_L18P_2/A21              | IO_L18P_2/A21              | IO_L18P_2/A21              | P12        | DUAL  |
| 2    | IO_L19N_2/VS1/A18          | IO_L19N_2/VS1/A18          | IO_L19N_2/VS1/A18          | R13        | DUAL  |
| 2    | IO_L19P_2/VS2/A19          | IO_L19P_2/VS2/A19          | IO_L19P_2/VS2/A19          | T13        | DUAL  |
| 2    | IO_L20N_2/CCLK             | IO_L20N_2/CCLK             | IO_L20N_2/CCLK             | R14        | DUAL  |
| 2    | IO_L20P_2/VS0/A17          | IO_L20P_2/VS0/A17          | IO_L20P_2/VS0/A17          | P14        | DUAL  |
| 2    | IP                         | IP                         | IP                         | T2         | INPUT   |
| 2    | IP                         | IP                         | IP                         | T14        | INPUT   |
| 2    | IP_L02N_2                  | IP_L02N_2                  | IP_L02N_2                  | R3         | INPUT   |
| 2    | IP_L02P_2                  | IP_L02P_2                  | IP_L02P_2                  | T3         | INPUT   |
| 2    | IP_L08N_2/VREF_2           | IP_L08N_2/VREF_2           | IP_L08N_2/VREF_2           | T7         | VREF  |
| 2    | IP_L08P_2                  | IP_L08P_2                  | IP_L08P_2                  | R7         | INPUT   |
| 2    | IP_L11N_2/M2/GCLK1         | IP_L11N_2/M2/GCLK1         | IP_L11N_2/M2/GCLK1         | R9         | DUAL/GCLK   |
| 2    | IP_L11P_2/RDWR_B/<br>GCLK0 | IP_L11P_2/RDWR_B/<br>GCLK0 | IP_L11P_2/RDWR_B/<br>GCLK0 | T9         | DUAL/GCLK   |
| 2    | IP_L17N_2                  | IP_L17N_2                  | IP_L17N_2                  | M11        | INPUT   |
| 2    | IP_L17P_2                  | IP_L17P_2                  | IP_L17P_2                  | N11        | INPUT   |
| 2    | VCCO_2                     | VCCO_2                     | VCCO_2                     | L7         | VCCO  |
| 2    | VCCO_2                     | VCCO_2                     | VCCO_2                     | L10        | VCCO  |
| 2    | VCCO_2                     | VCCO_2                     | VCCO_2                     | R5         | VCCO  |
| 2    | VCCO_2                     | VCCO_2                     | VCCO_2                     | R12        | VCCO  |
| 3    | IO_L01N_3                  | IO_L01N_3                  | IO_L01N_3                  | B2         | I/O   |
| 3    | IO_L01P_3                  | IO_L01P_3                  | IO_L01P_3                  | B1         | I/O   |
| 3    | IO_L02N_3/VREF_3           | IO_L02N_3/VREF_3           | IO_L02N_3/VREF_3           | C2         | VREF  |
| 3    | IO_L02P_3                  | IO_L02P_3                  | IO_L02P_3                  | C1         | I/O   |
| 3    | IO_L03N_3                  | IO_L03N_3                  | IO_L03N_3                  | E4         | I/O   |
| 3    | IO_L03P_3                  | IO_L03P_3                  | IO_L03P_3                  | E3         | I/O   |
| 3    | N.C. (◆)                   | IO_L04N_3/VREF_3           | IO_L04N_3/VREF_3           | F4         | <b>250E</b> : N.C.<br><b>500E</b> : VREF<br><b>1200E</b> : VREF |
| 3    | N.C. (◆)                   | IO_L04P_3                  | IO_L04P_3                  | F3         | <b>250E</b> : N.C.<br><b>500E</b> : I/O<br><b>1200E</b> : I/O   |
| 3    | IO_L05N_3                  | IO_L05N_3                  | IO_L05N_3                  | E1         | I/O   |
| 3    | IO_L05P_3                  | IO_L05P_3                  | IO_L05P_3                  | D1         | I/O   |
| 3    | IO_L06N_3                  | IO_L06N_3                  | IO_L06N_3                  | G4         | I/O   |

Table 142: FT256 Package Pinout (Cont'd)

| Bank | XC3S250E Pin Name      | XC3S500E Pin Name      | XC3S1200E Pin Name     | FT256 Ball | Type   |
|------|------------------------|------------------------|------------------------|------------|--|
| 3    | IO_L06P_3              | IO_L06P_3              | IO_L06P_3              | G5         | I/O  |
| 3    | IO_L07N_3              | IO_L07N_3              | IO_L07N_3              | G2         | I/O  |
| 3    | IO_L07P_3              | IO_L07P_3              | IO_L07P_3              | G3         | I/O  |
| 3    | IO_L08N_3/LHCLK1       | IO_L08N_3/LHCLK1       | IO_L08N_3/LHCLK1       | H6         | LHCLK  |
| 3    | IO_L08P_3/LHCLK0       | IO_L08P_3/LHCLK0       | IO_L08P_3/LHCLK0       | H5         | LHCLK  |
| 3    | IO_L09N_3/LHCLK3/IRDY2 | IO_L09N_3/LHCLK3/IRDY2 | IO_L09N_3/LHCLK3/IRDY2 | H4         | LHCLK  |
| 3    | IO_L09P_3/LHCLK2       | IO_L09P_3/LHCLK2       | IO_L09P_3/LHCLK2       | H3         | LHCLK  |
| 3    | IO_L10N_3/LHCLK5       | IO_L10N_3/LHCLK5       | IO_L10N_3/LHCLK5       | J3         | LHCLK  |
| 3    | IO_L10P_3/LHCLK4/IRDY2 | IO_L10P_3/LHCLK4/IRDY2 | IO_L10P_3/LHCLK4/IRDY2 | J2         | LHCLK  |
| 3    | IO_L11N_3/LHCLK7       | IO_L11N_3/LHCLK7       | IO_L11N_3/LHCLK7       | J4         | LHCLK  |
| 3    | IO_L11P_3/LHCLK6       | IO_L11P_3/LHCLK6       | IO_L11P_3/LHCLK6       | J5         | LHCLK  |
| 3    | IO_L12N_3              | IO_L12N_3              | IO_L12N_3              | K1         | I/O  |
| 3    | IO_L12P_3              | IO_L12P_3              | IO_L12P_3              | J1         | I/O  |
| 3    | IO_L13N_3              | IO_L13N_3              | IO_L13N_3              | K3         | I/O  |
| 3    | IO_L13P_3              | IO_L13P_3              | IO_L13P_3              | K2         | I/O  |
| 3    | N.C. (◆)               | IO_L14N_3/VREF_3       | IO_L14N_3/VREF_3       | L2         | <b>250E: N.C.</b><br><b>500E: VREF</b><br><b>1200E: VREF</b> |
| 3    | N.C. (◆)               | IO_L14P_3              | IO_L14P_3              | L3         | <b>250E: N.C.</b><br><b>500E: I/O</b><br><b>1200E: I/O</b>   |
| 3    | IO_L15N_3              | IO_L15N_3              | IO_L15N_3              | L5         | I/O  |
| 3    | IO_L15P_3              | IO_L15P_3              | IO_L15P_3              | K5         | I/O  |
| 3    | IO_L16N_3              | IO_L16N_3              | IO_L16N_3              | N1         | I/O  |
| 3    | IO_L16P_3              | IO_L16P_3              | IO_L16P_3              | M1         | I/O  |
| 3    | N.C. (◆)               | IO_L17N_3              | IO_L17N_3              | L4         | <b>250E: N.C.</b><br><b>500E: I/O</b><br><b>1200E: I/O</b>   |
| 3    | N.C. (◆)               | IO_L17P_3              | IO_L17P_3              | M4         | <b>250E: N.C.</b><br><b>500E: I/O</b><br><b>1200E: I/O</b>   |
| 3    | IO_L18N_3              | IO_L18N_3              | IO_L18N_3              | P1         | I/O  |
| 3    | IO_L18P_3              | IO_L18P_3              | IO_L18P_3              | P2         | I/O  |
| 3    | IO_L19N_3              | IO_L19N_3              | IO_L19N_3              | R1         | I/O  |
| 3    | IO_L19P_3              | IO_L19P_3              | IO_L19P_3              | R2         | I/O  |
| 3    | IP                     | IP                     | IP                     | D2         | INPUT  |
| 3    | IP                     | IP                     | IP                     | F2         | INPUT  |
| 3    | IO                     | IO                     | IP                     | F5         | <b>250E: I/O</b><br><b>500E: I/O</b><br><b>1200E: INPUT</b>  |
| 3    | IP                     | IP                     | IP                     | H1         | INPUT  |
| 3    | IP                     | IP                     | IP                     | J6         | INPUT  |
| 3    | IP                     | IP                     | IP                     | K4         | INPUT  |
| 3    | IP                     | IP                     | IP                     | M3         | INPUT  |

Table 142: FT256 Package Pinout (Cont'd)

| Bank   | XC3S250E Pin Name | XC3S500E Pin Name | XC3S1200E Pin Name | FT256 Ball | Type   |
|--------|-------------------|-------------------|--------------------|------------|--|
| 3      | IP                | IP                | IP                 | N3         | INPUT  |
| 3      | IP/VREF_3         | IP/VREF_3         | IP/VREF_3          | G1         | VREF   |
| 3      | IO/VREF_3         | IO/VREF_3         | IP/VREF_3          | N2         | <b>250E</b> : VREF(I/O)<br><b>500E</b> : VREF(I/O)<br><b>1200E</b> : VREF(INPUT) |
| 3      | VCCO_3            | VCCO_3            | VCCO_3             | E2         | VCCO   |
| 3      | VCCO_3            | VCCO_3            | VCCO_3             | G6         | VCCO   |
| 3      | VCCO_3            | VCCO_3            | VCCO_3             | K6         | VCCO   |
| 3      | VCCO_3            | VCCO_3            | VCCO_3             | M2         | VCCO   |
| GND    | GND               | GND               | GND                | A1         | GND  |
| GND    | GND               | GND               | GND                | A16        | GND  |
| GND    | GND               | GND               | GND                | B9         | GND  |
| GND    | GND               | GND               | GND                | F6         | GND  |
| GND    | GND               | GND               | GND                | F11        | GND  |
| GND    | GND               | GND               | GND                | G7         | GND  |
| GND    | GND               | GND               | GND                | G8         | GND  |
| GND    | GND               | GND               | GND                | G9         | GND  |
| GND    | GND               | GND               | GND                | G10        | GND  |
| GND    | GND               | GND               | GND                | H2         | GND  |
| GND    | GND               | GND               | GND                | H7         | GND  |
| GND    | GND               | GND               | GND                | H8         | GND  |
| GND    | GND               | GND               | GND                | H9         | GND  |
| GND    | GND               | GND               | GND                | H10        | GND  |
| GND    | GND               | GND               | GND                | J7         | GND  |
| GND    | GND               | GND               | GND                | J8         | GND  |
| GND    | GND               | GND               | GND                | J9         | GND  |
| GND    | GND               | GND               | GND                | J10        | GND  |
| GND    | GND               | GND               | GND                | J15        | GND  |
| GND    | GND               | GND               | GND                | K7         | GND  |
| GND    | GND               | GND               | GND                | K8         | GND  |
| GND    | GND               | GND               | GND                | K9         | GND  |
| GND    | GND               | GND               | GND                | K10        | GND  |
| GND    | GND               | GND               | GND                | L6         | GND  |
| GND    | GND               | GND               | GND                | L11        | GND  |
| GND    | GND               | GND               | GND                | R8         | GND  |
| GND    | GND               | GND               | GND                | T1         | GND  |
| GND    | GND               | GND               | GND                | T16        | GND  |
| VCCAUX | DONE              | DONE              | DONE               | T15        | CONFIG   |
| VCCAUX | PROG_B            | PROG_B            | PROG_B             | D3         | CONFIG   |
| VCCAUX | TCK               | TCK               | TCK                | A15        | JTAG   |
| VCCAUX | TDI               | TDI               | TDI                | A2         | JTAG   |
| VCCAUX | TDO               | TDO               | TDO                | C14        | JTAG   |
| VCCAUX | TMS               | TMS               | TMS                | B15        | JTAG   |
| VCCAUX | VCCAUX            | VCCAUX            | VCCAUX             | A6         | VCCAUX   |

Table 142: FT256 Package Pinout (Cont'd)

| Bank   | XC3S250E Pin Name | XC3S500E Pin Name | XC3S1200E Pin Name | FT256 Ball | Type   |
|--------|-------------------|-------------------|--------------------|------------|--------|
| VCCAUX | VCCAUX            | VCCAUX            | VCCAUX             | A11        | VCCAUX |
| VCCAUX | VCCAUX            | VCCAUX            | VCCAUX             | F1         | VCCAUX |
| VCCAUX | VCCAUX            | VCCAUX            | VCCAUX             | F16        | VCCAUX |
| VCCAUX | VCCAUX            | VCCAUX            | VCCAUX             | L1         | VCCAUX |
| VCCAUX | VCCAUX            | VCCAUX            | VCCAUX             | L16        | VCCAUX |
| VCCAUX | VCCAUX            | VCCAUX            | VCCAUX             | T6         | VCCAUX |
| VCCAUX | VCCAUX            | VCCAUX            | VCCAUX             | T11        | VCCAUX |
| VCCINT | VCCINT            | VCCINT            | VCCINT             | D4         | VCCINT |
| VCCINT | VCCINT            | VCCINT            | VCCINT             | D13        | VCCINT |
| VCCINT | VCCINT            | VCCINT            | VCCINT             | E5         | VCCINT |
| VCCINT | VCCINT            | VCCINT            | VCCINT             | E12        | VCCINT |
| VCCINT | VCCINT            | VCCINT            | VCCINT             | M5         | VCCINT |
| VCCINT | VCCINT            | VCCINT            | VCCINT             | M12        | VCCINT |
| VCCINT | VCCINT            | VCCINT            | VCCINT             | N4         | VCCINT |
| VCCINT | VCCINT            | VCCINT            | VCCINT             | N13        | VCCINT |

## User I/Os by Bank

Table 143, Table 144, and Table 145 indicate how the available user-I/O pins are distributed between the four I/O banks on the FT256 package.

The XC3S250E FPGA in the FT256 package has 18 unconnected balls, labeled with an “N.C.” type. These pins are also indicated with the black diamond (◆) symbol in Figure 85.

Table 143: User I/Os Per Bank on XC3S250E in the FT256 Package

| Package Edge | I/O Bank | Maximum I/O | All Possible I/O Pins by Type |           |           |                     |                    |
|--------------|----------|-------------|-------------------------------|-----------|-----------|---------------------|--------------------|
|              |          |             | I/O                           | INPUT     | DUAL      | VREF <sup>(1)</sup> | CLK <sup>(2)</sup> |
| Top          | 0        | 44          | 20                            | 10        | 1         | 5                   | 8                  |
| Right        | 1        | 42          | 10                            | 7         | 21        | 4                   | 0 <sup>(2)</sup>   |
| Bottom       | 2        | 44          | 8                             | 9         | 24        | 3                   | 0 <sup>(2)</sup>   |
| Left         | 3        | 42          | 24                            | 7         | 0         | 3                   | 8                  |
| <b>TOTAL</b> |          | <b>172</b>  | <b>62</b>                     | <b>33</b> | <b>46</b> | <b>15</b>           | <b>16</b>          |

**Notes:**

1. Some VREF and CLK pins are on INPUT pins.
2. The eight global clock pins in this bank have optional functionality during configuration and are counted in the DUAL column.

Table 144: User I/Os Per Bank on XC3S500E in the FT256 Package

| Package Edge | I/O Bank | Maximum I/O | All Possible I/O Pins by Type |           |           |                     |                    |
|--------------|----------|-------------|-------------------------------|-----------|-----------|---------------------|--------------------|
|              |          |             | I/O                           | INPUT     | DUAL      | VREF <sup>(1)</sup> | CLK <sup>(2)</sup> |
| Top          | 0        | 46          | 22                            | 10        | 1         | 5                   | 8                  |
| Right        | 1        | 48          | 15                            | 7         | 21        | 5                   | 0 <sup>(2)</sup>   |
| Bottom       | 2        | 48          | 11                            | 9         | 24        | 4                   | 0 <sup>(2)</sup>   |
| Left         | 3        | 48          | 28                            | 7         | 0         | 5                   | 8                  |
| <b>TOTAL</b> |          | <b>190</b>  | <b>76</b>                     | <b>33</b> | <b>46</b> | <b>19</b>           | <b>16</b>          |

**Notes:**

1. Some VREF and CLK pins are on INPUT pins.
2. The eight global clock pins in this bank have optional functionality during configuration and are counted in the DUAL column.

Table 145: User I/Os Per Bank on XC3S1200E in the FT256 Package

| Package Edge | I/O Bank | Maximum I/O | All Possible I/O Pins by Type |           |           |                     |                    |
|--------------|----------|-------------|-------------------------------|-----------|-----------|---------------------|--------------------|
|              |          |             | I/O                           | INPUT     | DUAL      | VREF <sup>(1)</sup> | CLK <sup>(2)</sup> |
| Top          | 0        | 46          | 24                            | 8         | 1         | 5                   | 8                  |
| Right        | 1        | 48          | 14                            | 8         | 21        | 5                   | 0 <sup>(2)</sup>   |
| Bottom       | 2        | 48          | 13                            | 7         | 24        | 4                   | 0 <sup>(2)</sup>   |
| Left         | 3        | 48          | 27                            | 8         | 0         | 5                   | 8                  |
| <b>TOTAL</b> |          | <b>190</b>  | <b>78</b>                     | <b>31</b> | <b>46</b> | <b>19</b>           | <b>16</b>          |

**Notes:**

1. Some VREF and CLK pins are on INPUT pins.
2. The eight global clock pins in this bank have optional functionality during configuration and are counted in the DUAL column.

## Footprint Migration Differences

Table 146 summarizes any footprint and functionality differences between the XC3S250E, the XC3S500E, and the XC3S1200E FPGAs that may affect easy migration between devices in the FG256 package. There are 26 such balls. All other pins not listed in Table 146 unconditionally migrate between Spartan-3E devices available in the FT256 package.

The XC3S250E is duplicated on both the left and right sides of the table to show migrations to and from the XC3S500E

and the XC3S1200E. The arrows indicate the direction for easy migration. A double-ended arrow ( $\leftrightarrow$ ) indicates that the two pins have identical functionality. A left-facing arrow ( $\leftarrow$ ) indicates that the pin on the device on the right unconditionally migrates to the pin on the device on the left. It may be possible to migrate the opposite direction depending on the I/O configuration. For example, an I/O pin (Type = I/O) can migrate to an input-only pin (Type = INPUT) if the I/O pin is configured as an input.

Table 146: FT256 Footprint Migration Differences

| FT256 Ball         | Bank | XC3S250E Type | Migration         | XC3S500E Type | Migration         | XC3S1200E Type | Migration     | XC3S250E Type |
|--------------------|------|---------------|-------------------|---------------|-------------------|----------------|---------------|---------------|
| B6                 | 0    | INPUT         | $\leftrightarrow$ | INPUT         | $\rightarrow$     | I/O            | $\leftarrow$  | INPUT         |
| B7                 | 0    | N.C.          | $\rightarrow$     | I/O           | $\leftrightarrow$ | I/O            | $\leftarrow$  | N.C.          |
| B10                | 0    | INPUT         | $\leftrightarrow$ | INPUT         | $\rightarrow$     | I/O            | $\leftarrow$  | INPUT         |
| C7                 | 0    | N.C.          | $\rightarrow$     | I/O           | $\leftrightarrow$ | I/O            | $\leftarrow$  | N.C.          |
| D16                | 1    | VREF(I/O)     | $\leftarrow$      | VREF(INPUT)   | $\leftrightarrow$ | VREF(INPUT)    | $\rightarrow$ | VREF(I/O)     |
| E13                | 1    | N.C.          | $\rightarrow$     | I/O           | $\leftrightarrow$ | I/O            | $\leftarrow$  | N.C.          |
| E16                | 1    | N.C.          | $\rightarrow$     | I/O           | $\leftrightarrow$ | I/O            | $\leftarrow$  | N.C.          |
| F3                 | 3    | N.C.          | $\rightarrow$     | I/O           | $\leftrightarrow$ | I/O            | $\leftarrow$  | N.C.          |
| F4                 | 3    | N.C.          | $\rightarrow$     | VREF          | $\leftrightarrow$ | VREF           | $\leftarrow$  | N.C.          |
| F5                 | 3    | I/O           | $\leftrightarrow$ | I/O           | $\leftarrow$      | INPUT          | $\rightarrow$ | I/O           |
| L2                 | 3    | N.C.          | $\rightarrow$     | VREF          | $\leftrightarrow$ | VREF           | $\leftarrow$  | N.C.          |
| L3                 | 3    | N.C.          | $\rightarrow$     | I/O           | $\leftrightarrow$ | I/O            | $\leftarrow$  | N.C.          |
| L4                 | 3    | N.C.          | $\rightarrow$     | I/O           | $\leftrightarrow$ | I/O            | $\leftarrow$  | N.C.          |
| L12                | 1    | N.C.          | $\rightarrow$     | I/O           | $\leftrightarrow$ | I/O            | $\leftarrow$  | N.C.          |
| L13                | 1    | N.C.          | $\rightarrow$     | I/O           | $\leftrightarrow$ | I/O            | $\leftarrow$  | N.C.          |
| M4                 | 3    | N.C.          | $\rightarrow$     | I/O           | $\leftrightarrow$ | I/O            | $\leftarrow$  | N.C.          |
| M7                 | 2    | INPUT         | $\leftrightarrow$ | INPUT         | $\rightarrow$     | I/O            | $\leftarrow$  | INPUT         |
| M14                | 1    | I/O           | $\leftrightarrow$ | I/O           | $\leftarrow$      | INPUT          | $\rightarrow$ | I/O           |
| N2                 | 3    | VREF(I/O)     | $\leftrightarrow$ | VREF(I/O)     | $\leftarrow$      | VREF(INPUT)    | $\rightarrow$ | VREF(I/O)     |
| N7                 | 2    | N.C.          | $\rightarrow$     | I/O           | $\leftrightarrow$ | I/O            | $\leftarrow$  | N.C.          |
| N14                | 1    | N.C.          | $\rightarrow$     | I/O           | $\leftrightarrow$ | I/O            | $\leftarrow$  | N.C.          |
| N15                | 1    | N.C.          | $\rightarrow$     | VREF          | $\leftrightarrow$ | VREF           | $\leftarrow$  | N.C.          |
| P7                 | 2    | N.C.          | $\rightarrow$     | I/O           | $\leftrightarrow$ | I/O            | $\leftarrow$  | N.C.          |
| P10                | 2    | N.C.          | $\rightarrow$     | I/O           | $\leftrightarrow$ | I/O            | $\leftarrow$  | N.C.          |
| R10                | 2    | N.C.          | $\rightarrow$     | VREF          | $\leftrightarrow$ | VREF           | $\leftarrow$  | N.C.          |
| T12                | 2    | INPUT         | $\leftrightarrow$ | INPUT         | $\rightarrow$     | I/O            | $\leftarrow$  | INPUT         |
| <b>DIFFERENCES</b> |      | <b>19</b>     |                   | <b>7</b>      |                   |                | <b>26</b>     |               |

Legend:

- $\leftrightarrow$  This pin is identical on the device on the left and the right.
- $\rightarrow$  This pin can unconditionally migrate from the device on the left to the device on the right. Migration in the other direction may be possible depending on how the pin is configured for the device on the right.
- $\leftarrow$  This pin can unconditionally migrate from the device on the right to the device on the left. Migration in the other direction may be possible depending on how the pin is configured for the device on the left.

## FT256 Footprint

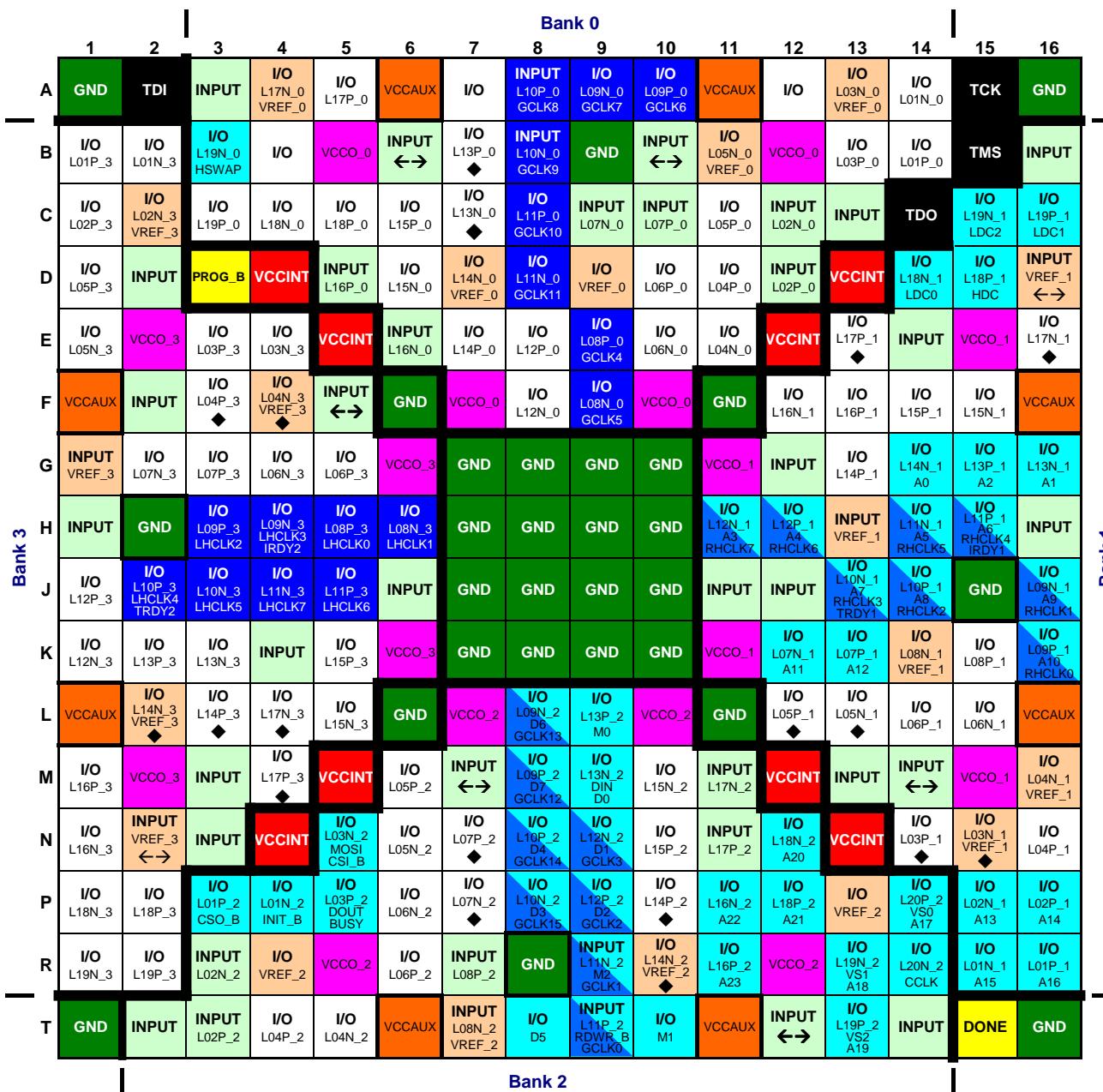


Figure 85: FT256 Package Footprint (top view)

|        |   |           |                                      |   |  |
|--------|---|-----------|--------------------------------------|---|--|
| 2      | CONFIG: Dedicated configuration pins  | 4         | JTAG: Dedicated JTAG port pins       | 8 | VCCINT: Internal core supply voltage (+1.2V) |
| 28     | GND: Ground   | 16        | VCCO: Output voltage supply for bank | 8 | VCCAUX: Auxiliary supply voltage (+2.5V)     |
| 6<br>↔ | Migration Difference: For flexible package migration, use these pins as inputs. | 18<br>(◆) | Unconnected pins on XC3S250E         |   |  |

## FG320: 320-ball Fine-pitch Ball Grid Array

The 320-ball fine-pitch ball grid array package, FG320, supports three different Spartan-3E FPGAs, including the XC3S500E, the XC3S1200E, and the XC3S1600E, as shown in [Table 147](#) and [Figure 86](#).

The FG320 package is an 18 x 18 array of solder balls minus the four center balls.

[Table 147](#) lists all the package pins. They are sorted by bank number and then by pin name of the largest device. Pins that form a differential I/O pair appear together in the table. The table also shows the pin number for each pin and the pin type, as defined earlier.

The highlighted rows indicate pinout differences between the XC3S500E, the XC3S1200E, and the XC3S1600E FPGAs. The XC3S500E has 18 unconnected balls, indicated as N.C. (No Connection) in [Table 147](#) and with the black diamond character (◆) in [Table 147](#) and [Figure 86](#).

If the table row is highlighted in tan, then this is an instance where an unconnected pin on the XC3S500E FPGA maps to a VREF pin on the XC3S1200E and XC3S1600E FPGA. If the FPGA application uses an I/O standard that requires a VREF voltage reference, connect the highlighted pin to the VREF voltage supply, even though this does not actually connect to the XC3S500E FPGA. This VREF connection on the board allows future migration to the larger devices without modifying the printed-circuit board.

All other balls have nearly identical functionality on all three devices. [Table 146](#) summarizes the Spartan-3E footprint migration differences for the FG320 package.

An electronic version of this package pinout table and footprint diagram is available for download from the Xilinx web site at:

[http://www.xilinx.com/support/documentation/data\\_sheets/s3e\\_pin.zip](http://www.xilinx.com/support/documentation/data_sheets/s3e_pin.zip)

## Pinout Table

Table 147: FG320 Package Pinout

| Bank | XC3S500E Pin Name | XC3S1200E Pin Name | XC3S1600E Pin Name | FG320 Ball | Type   |
|------|-------------------|--------------------|--------------------|------------|--|
| 0    | IP                | IO                 | IO                 | A7         | <b>500E: INPUT<br/>1200E: I/O<br/>1600E: I/O</b> |
| 0    | IO                | IO                 | IO                 | A8         | I/O  |
| 0    | IO                | IO                 | IO                 | A11        | I/O  |
| 0    | N.C. (◆)          | IO                 | IO                 | A12        | <b>500E: N.C.<br/>1200E: I/O<br/>1600E: I/O</b>  |
| 0    | IO                | IO                 | IO                 | C4         | I/O  |
| 0    | IP                | IO                 | IO                 | D13        | <b>500E: INPUT<br/>1200E: I/O<br/>1600E: I/O</b> |
| 0    | IO                | IO                 | IO                 | E13        | I/O  |
| 0    | IO                | IO                 | IO                 | G9         | I/O  |
| 0    | IO/VREF_0         | IO/VREF_0          | IO/VREF_0          | B11        | VREF   |
| 0    | IO_L01N_0         | IO_L01N_0          | IO_L01N_0          | A16        | I/O  |
| 0    | IO_L01P_0         | IO_L01P_0          | IO_L01P_0          | B16        | I/O  |
| 0    | IO_L03N_0/VREF_0  | IO_L03N_0/VREF_0   | IO_L03N_0/VREF_0   | C14        | VREF   |
| 0    | IO_L03P_0         | IO_L03P_0          | IO_L03P_0          | D14        | I/O  |
| 0    | IO_L04N_0         | IO_L04N_0          | IO_L04N_0          | A14        | I/O  |
| 0    | IO_L04P_0         | IO_L04P_0          | IO_L04P_0          | B14        | I/O  |
| 0    | IO_L05N_0/VREF_0  | IO_L05N_0/VREF_0   | IO_L05N_0/VREF_0   | B13        | VREF   |
| 0    | IO_L05P_0         | IO_L05P_0          | IO_L05P_0          | A13        | I/O  |
| 0    | IO_L06N_0         | IO_L06N_0          | IO_L06N_0          | E12        | I/O  |
| 0    | IO_L06P_0         | IO_L06P_0          | IO_L06P_0          | F12        | I/O  |
| 0    | IO_L08N_0         | IO_L08N_0          | IO_L08N_0          | F11        | I/O  |

Table 147: FG320 Package Pinout (Cont'd)

| Bank | XC3S500E Pin Name | XC3S1200E Pin Name | XC3S1600E Pin Name | FG320 Ball | Type   |
|------|-------------------|--------------------|--------------------|------------|--|
| 0    | IO_L08P_0         | IO_L08P_0          | IO_L08P_0          | E11        | I/O  |
| 0    | IO_L09N_0         | IO_L09N_0          | IO_L09N_0          | D11        | I/O  |
| 0    | IO_L09P_0         | IO_L09P_0          | IO_L09P_0          | C11        | I/O  |
| 0    | IO_L11N_0/GCLK5   | IO_L11N_0/GCLK5    | IO_L11N_0/GCLK5    | E10        | GCLK   |
| 0    | IO_L11P_0/GCLK4   | IO_L11P_0/GCLK4    | IO_L11P_0/GCLK4    | D10        | GCLK   |
| 0    | IO_L12N_0/GCLK7   | IO_L12N_0/GCLK7    | IO_L12N_0/GCLK7    | A10        | GCLK   |
| 0    | IO_L12P_0/GCLK6   | IO_L12P_0/GCLK6    | IO_L12P_0/GCLK6    | B10        | GCLK   |
| 0    | IO_L14N_0/GCLK11  | IO_L14N_0/GCLK11   | IO_L14N_0/GCLK11   | D9         | GCLK   |
| 0    | IO_L14P_0/GCLK10  | IO_L14P_0/GCLK10   | IO_L14P_0/GCLK10   | C9         | GCLK   |
| 0    | IO_L15N_0         | IO_L15N_0          | IO_L15N_0          | F9         | I/O  |
| 0    | IO_L15P_0         | IO_L15P_0          | IO_L15P_0          | E9         | I/O  |
| 0    | IO_L17N_0         | IO_L17N_0          | IO_L17N_0          | F8         | I/O  |
| 0    | IO_L17P_0         | IO_L17P_0          | IO_L17P_0          | E8         | I/O  |
| 0    | IO_L18N_0/VREF_0  | IO_L18N_0/VREF_0   | IO_L18N_0/VREF_0   | D7         | VREF   |
| 0    | IO_L18P_0         | IO_L18P_0          | IO_L18P_0          | C7         | I/O  |
| 0    | IO_L19N_0/VREF_0  | IO_L19N_0/VREF_0   | IO_L19N_0/VREF_0   | E7         | VREF   |
| 0    | IO_L19P_0         | IO_L19P_0          | IO_L19P_0          | F7         | I/O  |
| 0    | IO_L20N_0         | IO_L20N_0          | IO_L20N_0          | A6         | I/O  |
| 0    | IO_L20P_0         | IO_L20P_0          | IO_L20P_0          | B6         | I/O  |
| 0    | N.C. (◆)          | IO_L21N_0          | IO_L21N_0          | E6         | <b>500E</b> : N.C.<br><b>1200E</b> : I/O<br><b>1600E</b> : I/O |
| 0    | N.C. (◆)          | IO_L21P_0          | IO_L21P_0          | D6         | <b>500E</b> : N.C.<br><b>1200E</b> : I/O<br><b>1600E</b> : I/O |
| 0    | IO_L23N_0/VREF_0  | IO_L23N_0/VREF_0   | IO_L23N_0/VREF_0   | D5         | VREF   |
| 0    | IO_L23P_0         | IO_L23P_0          | IO_L23P_0          | C5         | I/O  |
| 0    | IO_L24N_0         | IO_L24N_0          | IO_L24N_0          | B4         | I/O  |
| 0    | IO_L24P_0         | IO_L24P_0          | IO_L24P_0          | A4         | I/O  |
| 0    | IO_L25N_0/HSWAP   | IO_L25N_0/HSWAP    | IO_L25N_0/HSWAP    | B3         | DUAL   |
| 0    | IO_L25P_0         | IO_L25P_0          | IO_L25P_0          | C3         | I/O  |
| 0    | IP                | IP                 | IP                 | A3         | INPUT  |
| 0    | IP                | IP                 | IP                 | C15        | INPUT  |
| 0    | IP_L02N_0         | IP_L02N_0          | IP_L02N_0          | A15        | INPUT  |
| 0    | IP_L02P_0         | IP_L02P_0          | IP_L02P_0          | B15        | INPUT  |
| 0    | IP_L07N_0         | IP_L07N_0          | IP_L07N_0          | D12        | INPUT  |
| 0    | IP_L07P_0         | IP_L07P_0          | IP_L07P_0          | C12        | INPUT  |
| 0    | IP_L10N_0         | IP_L10N_0          | IP_L10N_0          | G10        | INPUT  |
| 0    | IP_L10P_0         | IP_L10P_0          | IP_L10P_0          | F10        | INPUT  |
| 0    | IP_L13N_0/GCLK9   | IP_L13N_0/GCLK9    | IP_L13N_0/GCLK9    | B9         | GCLK   |
| 0    | IP_L13P_0/GCLK8   | IP_L13P_0/GCLK8    | IP_L13P_0/GCLK8    | B8         | GCLK   |
| 0    | IP_L16N_0         | IP_L16N_0          | IP_L16N_0          | D8         | INPUT  |
| 0    | IP_L16P_0         | IP_L16P_0          | IP_L16P_0          | C8         | INPUT  |
| 0    | IP_L22N_0         | IP_L22N_0          | IP_L22N_0          | B5         | INPUT  |
| 0    | IP_L22P_0         | IP_L22P_0          | IP_L22P_0          | A5         | INPUT  |

Table 147: FG320 Package Pinout (Cont'd)

| Bank | XC3S500E Pin Name         | XC3S1200E Pin Name        | XC3S1600E Pin Name        | FG320 Ball | Type   |
|------|---------------------------|---------------------------|---------------------------|------------|--|
| 0    | VCCO_0                    | VCCO_0                    | VCCO_0                    | A9         | VCCO   |
| 0    | VCCO_0                    | VCCO_0                    | VCCO_0                    | C6         | VCCO   |
| 0    | VCCO_0                    | VCCO_0                    | VCCO_0                    | C13        | VCCO   |
| 0    | VCCO_0                    | VCCO_0                    | VCCO_0                    | G8         | VCCO   |
| 0    | VCCO_0                    | VCCO_0                    | VCCO_0                    | G11        | VCCO   |
| 1    | N.C. (◆)                  | IO                        | IO                        | P16        | <b>500E</b> : N.C.<br><b>1200E</b> : I/O<br><b>1600E</b> : I/O |
| 1    | IO_L01N_1/A15             | IO_L01N_1/A15             | IO_L01N_1/A15             | T17        | DUAL   |
| 1    | IO_L01P_1/A16             | IO_L01P_1/A16             | IO_L01P_1/A16             | U18        | DUAL   |
| 1    | IO_L02N_1/A13             | IO_L02N_1/A13             | IO_L02N_1/A13             | T18        | DUAL   |
| 1    | IO_L02P_1/A14             | IO_L02P_1/A14             | IO_L02P_1/A14             | R18        | DUAL   |
| 1    | IO_L03N_1/VREF_1          | IO_L03N_1/VREF_1          | IO_L03N_1/VREF_1          | R16        | VREF   |
| 1    | IO_L03P_1                 | IO_L03P_1                 | IO_L03P_1                 | R15        | I/O  |
| 1    | N.C. (◆)                  | IO_L04N_1                 | IO_L04N_1                 | N14        | <b>500E</b> : N.C.<br><b>1200E</b> : I/O<br><b>1600E</b> : I/O |
| 1    | N.C. (◆)                  | IO_L04P_1                 | IO_L04P_1                 | N15        | <b>500E</b> : N.C.<br><b>1200E</b> : I/O<br><b>1600E</b> : I/O |
| 1    | IO_L05N_1/VREF_1          | IO_L05N_1/VREF_1          | IO_L05N_1/VREF_1          | M13        | VREF   |
| 1    | IO_L05P_1                 | IO_L05P_1                 | IO_L05P_1                 | M14        | I/O  |
| 1    | IO_L06N_1                 | IO_L06N_1                 | IO_L06N_1                 | P18        | I/O  |
| 1    | IO_L06P_1                 | IO_L06P_1                 | IO_L06P_1                 | P17        | I/O  |
| 1    | IO_L07N_1                 | IO_L07N_1                 | IO_L07N_1                 | M16        | I/O  |
| 1    | IO_L07P_1                 | IO_L07P_1                 | IO_L07P_1                 | M15        | I/O  |
| 1    | IO_L08N_1                 | IO_L08N_1                 | IO_L08N_1                 | M18        | I/O  |
| 1    | IO_L08P_1                 | IO_L08P_1                 | IO_L08P_1                 | N18        | I/O  |
| 1    | IO_L09N_1/A11             | IO_L09N_1/A11             | IO_L09N_1/A11             | L15        | DUAL   |
| 1    | IO_L09P_1/A12             | IO_L09P_1/A12             | IO_L09P_1/A12             | L16        | DUAL   |
| 1    | IO_L10N_1/VREF_1          | IO_L10N_1/VREF_1          | IO_L10N_1/VREF_1          | L17        | VREF   |
| 1    | IO_L10P_1                 | IO_L10P_1                 | IO_L10P_1                 | L18        | I/O  |
| 1    | IO_L11N_1/A9/RHCLK1       | IO_L11N_1/A9/RHCLK1       | IO_L11N_1/A9/RHCLK1       | K12        | RHCLK/DUAL   |
| 1    | IO_L11P_1/A10/RHCLK0      | IO_L11P_1/A10/RHCLK0      | IO_L11P_1/A10/RHCLK0      | K13        | RHCLK/DUAL   |
| 1    | IO_L12N_1/A7/RHCLK3/TRDY1 | IO_L12N_1/A7/RHCLK3/TRDY1 | IO_L12N_1/A7/RHCLK3/TRDY1 | K14        | RHCLK/DUAL   |
| 1    | IO_L12P_1/A8/RHCLK2       | IO_L12P_1/A8/RHCLK2       | IO_L12P_1/A8/RHCLK2       | K15        | RHCLK/DUAL   |
| 1    | IO_L13N_1/A5/RHCLK5       | IO_L13N_1/A5/RHCLK5       | IO_L13N_1/A5/RHCLK5       | J16        | RHCLK/DUAL   |
| 1    | IO_L13P_1/A6/RHCLK4/IRDY1 | IO_L13P_1/A6/RHCLK4/IRDY1 | IO_L13P_1/A6/RHCLK4/IRDY1 | J17        | RHCLK/DUAL   |
| 1    | IO_L14N_1/A3/RHCLK7       | IO_L14N_1/A3/RHCLK7       | IO_L14N_1/A3/RHCLK7       | J14        | RHCLK/DUAL   |
| 1    | IO_L14P_1/A4/RHCLK6       | IO_L14P_1/A4/RHCLK6       | IO_L14P_1/A4/RHCLK6       | J15        | RHCLK/DUAL   |
| 1    | IO_L15N_1/A1              | IO_L15N_1/A1              | IO_L15N_1/A1              | J13        | DUAL   |
| 1    | IO_L15P_1/A2              | IO_L15P_1/A2              | IO_L15P_1/A2              | J12        | DUAL   |
| 1    | IO_L16N_1/A0              | IO_L16N_1/A0              | IO_L16N_1/A0              | H17        | DUAL   |
| 1    | IO_L16P_1                 | IO_L16P_1                 | IO_L16P_1                 | H16        | I/O  |

Table 147: FG320 Package Pinout (Cont'd)

| Bank | XC3S500E Pin Name | XC3S1200E Pin Name | XC3S1600E Pin Name | FG320 Ball | Type  |
|------|-------------------|--------------------|--------------------|------------|---|
| 1    | IO_L17N_1         | IO_L17N_1          | IO_L17N_1          | H15        | I/O   |
| 1    | IO_L17P_1         | IO_L17P_1          | IO_L17P_1          | H14        | I/O   |
| 1    | IO_L18N_1         | IO_L18N_1          | IO_L18N_1          | G16        | I/O   |
| 1    | IO_L18P_1         | IO_L18P_1          | IO_L18P_1          | G15        | I/O   |
| 1    | IO_L19N_1         | IO_L19N_1          | IO_L19N_1          | F17        | I/O   |
| 1    | IO_L19P_1         | IO_L19P_1          | IO_L19P_1          | F18        | I/O   |
| 1    | IO_L20N_1         | IO_L20N_1          | IO_L20N_1          | G13        | I/O   |
| 1    | IO_L20P_1         | IO_L20P_1          | IO_L20P_1          | G14        | I/O   |
| 1    | IO_L21N_1         | IO_L21N_1          | IO_L21N_1          | F14        | I/O   |
| 1    | IO_L21P_1         | IO_L21P_1          | IO_L21P_1          | F15        | I/O   |
| 1    | N.C. (◆)          | IO_L22N_1          | IO_L22N_1          | E16        | <b>500E</b> : N.C.<br><b>1200E</b> : I/O<br><b>1600E</b> : I/O    |
| 1    | N.C. (◆)          | IO_L22P_1          | IO_L22P_1          | E15        | <b>500E</b> : N.C.<br><b>1200E</b> : I/O<br><b>1600E</b> : I/O    |
| 1    | IO_L23N_1/LDC0    | IO_L23N_1/LDC0     | IO_L23N_1/LDC0     | D16        | DUAL  |
| 1    | IO_L23P_1/HDC     | IO_L23P_1/HDC      | IO_L23P_1/HDC      | D17        | DUAL  |
| 1    | IO_L24N_1/LDC2    | IO_L24N_1/LDC2     | IO_L24N_1/LDC2     | C17        | DUAL  |
| 1    | IO_L24P_1/LDC1    | IO_L24P_1/LDC1     | IO_L24P_1/LDC1     | C18        | DUAL  |
| 1    | IP                | IP                 | IP                 | B18        | INPUT   |
| 1    | IO                | IP                 | IP                 | E17        | <b>500E</b> : I/O<br><b>1200E</b> : INPUT<br><b>1600E</b> : INPUT |
| 1    | IP                | IP                 | IP                 | E18        | INPUT   |
| 1    | IP                | IP                 | IP                 | G18        | INPUT   |
| 1    | IP                | IP                 | IP                 | H13        | INPUT   |
| 1    | IP                | IP                 | IP                 | K17        | INPUT   |
| 1    | IP                | IP                 | IP                 | K18        | INPUT   |
| 1    | IP                | IP                 | IP                 | L13        | INPUT   |
| 1    | IP                | IP                 | IP                 | L14        | INPUT   |
| 1    | IP                | IP                 | IP                 | N17        | INPUT   |
| 1    | IO                | IP                 | IP                 | P15        | <b>500E</b> : I/O<br><b>1200E</b> : INPUT<br><b>1600E</b> : INPUT |
| 1    | IP                | IP                 | IP                 | R17        | INPUT   |
| 1    | IP/VREF_1         | IP/VREF_1          | IP/VREF_1          | D18        | VREF  |
| 1    | IP/VREF_1         | IP/VREF_1          | IP/VREF_1          | H18        | VREF  |
| 1    | VCCO_1            | VCCO_1             | VCCO_1             | F16        | VCCO  |
| 1    | VCCO_1            | VCCO_1             | VCCO_1             | H12        | VCCO  |
| 1    | VCCO_1            | VCCO_1             | VCCO_1             | J18        | VCCO  |
| 1    | VCCO_1            | VCCO_1             | VCCO_1             | L12        | VCCO  |
| 1    | VCCO_1            | VCCO_1             | VCCO_1             | N16        | VCCO  |
| 2    | IO                | IO                 | IO                 | P9         | I/O   |
| 2    | IO                | IO                 | IO                 | R11        | I/O   |

Table 147: FG320 Package Pinout (Cont'd)

| Bank | XC3S500E Pin Name    | XC3S1200E Pin Name   | XC3S1600E Pin Name   | FG320 Ball | Type  |
|------|----------------------|----------------------|----------------------|------------|---|
| 2    | IP                   | IO                   | IO                   | U6         | <b>500E:</b> INPUT<br><b>1200E:</b> I/O<br><b>1600E:</b> I/O  |
| 2    | IP                   | IO                   | IO                   | U13        | <b>500E:</b> INPUT<br><b>1200E:</b> I/O<br><b>1600E:</b> I/O  |
| 2    | N.C. (◆)             | IO                   | IO                   | V7         | <b>500E:</b> N.C.<br><b>1200E:</b> I/O<br><b>1600E:</b> I/O   |
| 2    | IO/D5                | IO/D5                | IO/D5                | R9         | DUAL  |
| 2    | IO/M1                | IO/M1                | IO/M1                | V11        | DUAL  |
| 2    | IO/VREF_2            | IO/VREF_2            | IO/VREF_2            | T15        | VREF  |
| 2    | IO/VREF_2            | IO/VREF_2            | IO/VREF_2            | U5         | VREF  |
| 2    | IO_L01N_2/INIT_B     | IO_L01N_2/INIT_B     | IO_L01N_2/INIT_B     | T3         | DUAL  |
| 2    | IO_L01P_2/CSO_B      | IO_L01P_2/CSO_B      | IO_L01P_2/CSO_B      | U3         | DUAL  |
| 2    | IO_L03N_2/MOSI/CSI_B | IO_L03N_2/MOSI/CSI_B | IO_L03N_2/MOSI/CSI_B | T4         | DUAL  |
| 2    | IO_L03P_2/DOUT/BUSY  | IO_L03P_2/DOUT/BUSY  | IO_L03P_2/DOUT/BUSY  | U4         | DUAL  |
| 2    | IO_L04N_2            | IO_L04N_2            | IO_L04N_2            | T5         | I/O   |
| 2    | IO_L04P_2            | IO_L04P_2            | IO_L04P_2            | R5         | I/O   |
| 2    | IO_L05N_2            | IO_L05N_2            | IO_L05N_2            | P6         | I/O   |
| 2    | IO_L05P_2            | IO_L05P_2            | IO_L05P_2            | R6         | I/O   |
| 2    | N.C. (◆)             | IO_L06N_2/VREF_2     | IO_L06N_2/VREF_2     | V6         | <b>500E:</b> N.C.<br><b>1200E:</b> VREF<br><b>1600E:</b> VREF |
| 2    | N.C. (◆)             | IO_L06P_2            | IO_L06P_2            | V5         | <b>500E:</b> N.C.<br><b>1200E:</b> I/O<br><b>1600E:</b> I/O   |
| 2    | IO_L07N_2            | IO_L07N_2            | IO_L07N_2            | P7         | I/O   |
| 2    | IO_L07P_2            | IO_L07P_2            | IO_L07P_2            | N7         | I/O   |
| 2    | IO_L09N_2            | IO_L09N_2            | IO_L09N_2            | N8         | I/O   |
| 2    | IO_L09P_2            | IO_L09P_2            | IO_L09P_2            | P8         | I/O   |
| 2    | IO_L10N_2            | IO_L10N_2            | IO_L10N_2            | T8         | I/O   |
| 2    | IO_L10P_2            | IO_L10P_2            | IO_L10P_2            | R8         | I/O   |
| 2    | IO_L12N_2/D6/GCLK13  | IO_L12N_2/D6/GCLK13  | IO_L12N_2/D6/GCLK13  | M9         | DUAL/GCLK   |
| 2    | IO_L12P_2/D7/GCLK12  | IO_L12P_2/D7/GCLK12  | IO_L12P_2/D7/GCLK12  | N9         | DUAL/GCLK   |
| 2    | IO_L13N_2/D3/GCLK15  | IO_L13N_2/D3/GCLK15  | IO_L13N_2/D3/GCLK15  | V9         | DUAL/GCLK   |
| 2    | IO_L13P_2/D4/GCLK14  | IO_L13P_2/D4/GCLK14  | IO_L13P_2/D4/GCLK14  | U9         | DUAL/GCLK   |
| 2    | IO_L15N_2/D1/GCLK3   | IO_L15N_2/D1/GCLK3   | IO_L15N_2/D1/GCLK3   | P10        | DUAL/GCLK   |
| 2    | IO_L15P_2/D2/GCLK2   | IO_L15P_2/D2/GCLK2   | IO_L15P_2/D2/GCLK2   | R10        | DUAL/GCLK   |
| 2    | IO_L16N_2/DIN/D0     | IO_L16N_2/DIN/D0     | IO_L16N_2/DIN/D0     | N10        | DUAL  |
| 2    | IO_L16P_2/M0         | IO_L16P_2/M0         | IO_L16P_2/M0         | M10        | DUAL  |
| 2    | IO_L18N_2            | IO_L18N_2            | IO_L18N_2            | N11        | I/O   |
| 2    | IO_L18P_2            | IO_L18P_2            | IO_L18P_2            | P11        | I/O   |
| 2    | IO_L19N_2/VREF_2     | IO_L19N_2/VREF_2     | IO_L19N_2/VREF_2     | V13        | VREF  |
| 2    | IO_L19P_2            | IO_L19P_2            | IO_L19P_2            | V12        | I/O   |
| 2    | IO_L20N_2            | IO_L20N_2            | IO_L20N_2            | R12        | I/O   |

Table 147: FG320 Package Pinout (Cont'd)

| Bank | XC3S500E Pin Name          | XC3S1200E Pin Name         | XC3S1600E Pin Name         | FG320 Ball | Type  |
|------|----------------------------|----------------------------|----------------------------|------------|---|
| 2    | IO_L20P_2                  | IO_L20P_2                  | IO_L20P_2                  | T12        | I/O   |
| 2    | N.C. (◆)                   | IO_L21N_2                  | IO_L21N_2                  | P12        | <b>500E:</b> N.C.<br><b>1200E:</b> I/O<br><b>1600E:</b> I/O |
| 2    | N.C. (◆)                   | IO_L21P_2                  | IO_L21P_2                  | N12        | <b>500E:</b> N.C.<br><b>1200E:</b> I/O<br><b>1600E:</b> I/O |
| 2    | IO_L22N_2/A22              | IO_L22N_2/A22              | IO_L22N_2/A22              | R13        | DUAL  |
| 2    | IO_L22P_2/A23              | IO_L22P_2/A23              | IO_L22P_2/A23              | P13        | DUAL  |
| 2    | IO_L24N_2/A20              | IO_L24N_2/A20              | IO_L24N_2/A20              | R14        | DUAL  |
| 2    | IO_L24P_2/A21              | IO_L24P_2/A21              | IO_L24P_2/A21              | T14        | DUAL  |
| 2    | IO_L25N_2/VS1/A18          | IO_L25N_2/VS1/A18          | IO_L25N_2/VS1/A18          | U15        | DUAL  |
| 2    | IO_L25P_2/VS2/A19          | IO_L25P_2/VS2/A19          | IO_L25P_2/VS2/A19          | V15        | DUAL  |
| 2    | IO_L26N_2/CCLK             | IO_L26N_2/CCLK             | IO_L26N_2/CCLK             | U16        | DUAL  |
| 2    | IO_L26P_2/VS0/A17          | IO_L26P_2/VS0/A17          | IO_L26P_2/VS0/A17          | T16        | DUAL  |
| 2    | IP                         | IP                         | IP                         | V2         | INPUT   |
| 2    | IP                         | IP                         | IP                         | V16        | INPUT   |
| 2    | IP_L02N_2                  | IP_L02N_2                  | IP_L02N_2                  | V3         | INPUT   |
| 2    | IP_L02P_2                  | IP_L02P_2                  | IP_L02P_2                  | V4         | INPUT   |
| 2    | IP_L08N_2                  | IP_L08N_2                  | IP_L08N_2                  | R7         | INPUT   |
| 2    | IP_L08P_2                  | IP_L08P_2                  | IP_L08P_2                  | T7         | INPUT   |
| 2    | IP_L11N_2/VREF_2           | IP_L11N_2/VREF_2           | IP_L11N_2/VREF_2           | V8         | VREF  |
| 2    | IP_L11P_2                  | IP_L11P_2                  | IP_L11P_2                  | U8         | INPUT   |
| 2    | IP_L14N_2/M2/GCLK1         | IP_L14N_2/M2/GCLK1         | IP_L14N_2/M2/GCLK1         | T10        | DUAL/GCLK   |
| 2    | IP_L14P_2/RDWR_B/<br>GCLK0 | IP_L14P_2/RDWR_B/<br>GCLK0 | IP_L14P_2/RDWR_B/<br>GCLK0 | U10        | DUAL/GCLK   |
| 2    | IP_L17N_2                  | IP_L17N_2                  | IP_L17N_2                  | U11        | INPUT   |
| 2    | IP_L17P_2                  | IP_L17P_2                  | IP_L17P_2                  | T11        | INPUT   |
| 2    | IP_L23N_2                  | IP_L23N_2                  | IP_L23N_2                  | U14        | INPUT   |
| 2    | IP_L23P_2                  | IP_L23P_2                  | IP_L23P_2                  | V14        | INPUT   |
| 2    | VCCO_2                     | VCCO_2                     | VCCO_2                     | M8         | VCCO  |
| 2    | VCCO_2                     | VCCO_2                     | VCCO_2                     | M11        | VCCO  |
| 2    | VCCO_2                     | VCCO_2                     | VCCO_2                     | T6         | VCCO  |
| 2    | VCCO_2                     | VCCO_2                     | VCCO_2                     | T13        | VCCO  |
| 2    | VCCO_2                     | VCCO_2                     | VCCO_2                     | V10        | VCCO  |
| 3    | N.C. (◆)                   | IO                         | IO                         | D4         | <b>500E:</b> N.C.<br><b>1200E:</b> I/O<br><b>1600E:</b> I/O |
| 3    | IO_L01N_3                  | IO_L01N_3                  | IO_L01N_3                  | C2         | I/O   |
| 3    | IO_L01P_3                  | IO_L01P_3                  | IO_L01P_3                  | C1         | I/O   |
| 3    | IO_L02N_3/VREF_3           | IO_L02N_3/VREF_3           | IO_L02N_3/VREF_3           | D2         | VREF  |
| 3    | IO_L02P_3                  | IO_L02P_3                  | IO_L02P_3                  | D1         | I/O   |
| 3    | IO_L03N_3                  | IO_L03N_3                  | IO_L03N_3                  | E1         | I/O   |
| 3    | IO_L03P_3                  | IO_L03P_3                  | IO_L03P_3                  | E2         | I/O   |

Table 147: FG320 Package Pinout (Cont'd)

| Bank | XC3S500E Pin Name          | XC3S1200E Pin Name         | XC3S1600E Pin Name         | FG320 Ball | Type  |
|------|----------------------------|----------------------------|----------------------------|------------|---|
| 3    | N.C. (◆)                   | IO_L04N_3                  | IO_L04N_3                  | E3         | <b>500E:</b> N.C.<br><b>1200E:</b> I/O<br><b>1600E:</b> I/O |
| 3    | N.C. (◆)                   | IO_L04P_3                  | IO_L04P_3                  | E4         | <b>500E:</b> N.C.<br><b>1200E:</b> I/O<br><b>1600E:</b> I/O |
| 3    | IO_L05N_3                  | IO_L05N_3                  | IO_L05N_3                  | F2         | I/O   |
| 3    | IO_L05P_3                  | IO_L05P_3                  | IO_L05P_3                  | F1         | I/O   |
| 3    | IO_L06N_3/VREF_3           | IO_L06N_3/VREF_3           | IO_L06N_3/VREF_3           | G4         | VREF  |
| 3    | IO_L06P_3                  | IO_L06P_3                  | IO_L06P_3                  | G3         | I/O   |
| 3    | IO_L07N_3                  | IO_L07N_3                  | IO_L07N_3                  | G5         | I/O   |
| 3    | IO_L07P_3                  | IO_L07P_3                  | IO_L07P_3                  | G6         | I/O   |
| 3    | IO_L08N_3                  | IO_L08N_3                  | IO_L08N_3                  | H5         | I/O   |
| 3    | IO_L08P_3                  | IO_L08P_3                  | IO_L08P_3                  | H6         | I/O   |
| 3    | IO_L09N_3                  | IO_L09N_3                  | IO_L09N_3                  | H3         | I/O   |
| 3    | IO_L09P_3                  | IO_L09P_3                  | IO_L09P_3                  | H4         | I/O   |
| 3    | IO_L10N_3                  | IO_L10N_3                  | IO_L10N_3                  | H1         | I/O   |
| 3    | IO_L10P_3                  | IO_L10P_3                  | IO_L10P_3                  | H2         | I/O   |
| 3    | IO_L11N_3/LHCLK1           | IO_L11N_3/LHCLK1           | IO_L11N_3/LHCLK1           | J4         | LHCLK   |
| 3    | IO_L11P_3/LHCLK0           | IO_L11P_3/LHCLK0           | IO_L11P_3/LHCLK0           | J5         | LHCLK   |
| 3    | IO_L12N_3/LHCLK3/<br>IRDY2 | IO_L12N_3/LHCLK3/<br>IRDY2 | IO_L12N_3/LHCLK3/<br>IRDY2 | J2         | LHCLK   |
| 3    | IO_L12P_3/LHCLK2           | IO_L12P_3/LHCLK2           | IO_L12P_3/LHCLK2           | J1         | LHCLK   |
| 3    | IO_L13N_3/LHCLK5           | IO_L13N_3/LHCLK5           | IO_L13N_3/LHCLK5           | K4         | LHCLK   |
| 3    | IO_L13P_3/LHCLK4/<br>TRDY2 | IO_L13P_3/LHCLK4/<br>TRDY2 | IO_L13P_3/LHCLK4/<br>TRDY2 | K3         | LHCLK   |
| 3    | IO_L14N_3/LHCLK7           | IO_L14N_3/LHCLK7           | IO_L14N_3/LHCLK7           | K5         | LHCLK   |
| 3    | IO_L14P_3/LHCLK6           | IO_L14P_3/LHCLK6           | IO_L14P_3/LHCLK6           | K6         | LHCLK   |
| 3    | IO_L15N_3                  | IO_L15N_3                  | IO_L15N_3                  | L2         | I/O   |
| 3    | IO_L15P_3                  | IO_L15P_3                  | IO_L15P_3                  | L1         | I/O   |
| 3    | IO_L16N_3                  | IO_L16N_3                  | IO_L16N_3                  | L4         | I/O   |
| 3    | IO_L16P_3                  | IO_L16P_3                  | IO_L16P_3                  | L3         | I/O   |
| 3    | IO_L17N_3/VREF_3           | IO_L17N_3/VREF_3           | IO_L17N_3/VREF_3           | L5         | VREF  |
| 3    | IO_L17P_3                  | IO_L17P_3                  | IO_L17P_3                  | L6         | I/O   |
| 3    | IO_L18N_3                  | IO_L18N_3                  | IO_L18N_3                  | M3         | I/O   |
| 3    | IO_L18P_3                  | IO_L18P_3                  | IO_L18P_3                  | M4         | I/O   |
| 3    | IO_L19N_3                  | IO_L19N_3                  | IO_L19N_3                  | M6         | I/O   |
| 3    | IO_L19P_3                  | IO_L19P_3                  | IO_L19P_3                  | M5         | I/O   |
| 3    | IO_L20N_3                  | IO_L20N_3                  | IO_L20N_3                  | N5         | I/O   |
| 3    | IO_L20P_3                  | IO_L20P_3                  | IO_L20P_3                  | N4         | I/O   |
| 3    | IO_L21N_3                  | IO_L21N_3                  | IO_L21N_3                  | P1         | I/O   |
| 3    | IO_L21P_3                  | IO_L21P_3                  | IO_L21P_3                  | P2         | I/O   |
| 3    | N.C. (◆)                   | IO_L22N_3                  | IO_L22N_3                  | P4         | <b>500E:</b> N.C.<br><b>1200E:</b> I/O<br><b>1600E:</b> I/O |

Table 147: FG320 Package Pinout (Cont'd)

| Bank | XC3S500E Pin Name | XC3S1200E Pin Name | XC3S1600E Pin Name | FG320 Ball | Type   |
|------|-------------------|--------------------|--------------------|------------|--|
| 3    | N.C. (◆)          | IO_L22P_3          | IO_L22P_3          | P3         | <b>500E:</b> N.C.<br><b>1200E:</b> I/O<br><b>1600E:</b> I/O                      |
| 3    | IO_L23N_3         | IO_L23N_3          | IO_L23N_3          | R2         | I/O  |
| 3    | IO_L23P_3         | IO_L23P_3          | IO_L23P_3          | R3         | I/O  |
| 3    | IO_L24N_3         | IO_L24N_3          | IO_L24N_3          | T1         | I/O  |
| 3    | IO_L24P_3         | IO_L24P_3          | IO_L24P_3          | T2         | I/O  |
| 3    | IP                | IP                 | IP                 | D3         | INPUT  |
| 3    | IO                | IP                 | IP                 | F4         | <b>500E:</b> I/O<br><b>1200E:</b> INPUT<br><b>1600E:</b> INPUT                   |
| 3    | IP                | IP                 | IP                 | F5         | INPUT  |
| 3    | IP                | IP                 | IP                 | G1         | INPUT  |
| 3    | IP                | IP                 | IP                 | J7         | INPUT  |
| 3    | IP                | IP                 | IP                 | K2         | INPUT  |
| 3    | IP                | IP                 | IP                 | K7         | INPUT  |
| 3    | IP                | IP                 | IP                 | M1         | INPUT  |
| 3    | IP                | IP                 | IP                 | N1         | INPUT  |
| 3    | IP                | IP                 | IP                 | N2         | INPUT  |
| 3    | IP                | IP                 | IP                 | R1         | INPUT  |
| 3    | IP                | IP                 | IP                 | U1         | INPUT  |
| 3    | IP/VREF_3         | IP/VREF_3          | IP/VREF_3          | J6         | VREF   |
| 3    | IO/VREF_3         | IP/VREF_3          | IP/VREF_3          | R4         | <b>500E:</b> VREF(I/O)<br><b>1200E:</b> VREF(INPUT)<br><b>1600E:</b> VREF(INPUT) |
| 3    | VCCO_3            | VCCO_3             | VCCO_3             | F3         | VCCO   |
| 3    | VCCO_3            | VCCO_3             | VCCO_3             | H7         | VCCO   |
| 3    | VCCO_3            | VCCO_3             | VCCO_3             | K1         | VCCO   |
| 3    | VCCO_3            | VCCO_3             | VCCO_3             | L7         | VCCO   |
| 3    | VCCO_3            | VCCO_3             | VCCO_3             | N3         | VCCO   |
| GND  | GND               | GND                | GND                | A1         | GND  |
| GND  | GND               | GND                | GND                | A18        | GND  |
| GND  | GND               | GND                | GND                | B2         | GND  |
| GND  | GND               | GND                | GND                | B17        | GND  |
| GND  | GND               | GND                | GND                | C10        | GND  |
| GND  | GND               | GND                | GND                | G7         | GND  |
| GND  | GND               | GND                | GND                | G12        | GND  |
| GND  | GND               | GND                | GND                | H8         | GND  |
| GND  | GND               | GND                | GND                | H9         | GND  |
| GND  | GND               | GND                | GND                | H10        | GND  |
| GND  | GND               | GND                | GND                | H11        | GND  |
| GND  | GND               | GND                | GND                | J3         | GND  |
| GND  | GND               | GND                | GND                | J8         | GND  |
| GND  | GND               | GND                | GND                | J11        | GND  |

Table 147: FG320 Package Pinout (Cont'd)

| Bank   | XC3S500E Pin Name | XC3S1200E Pin Name | XC3S1600E Pin Name | FG320 Ball | Type   |
|--------|-------------------|--------------------|--------------------|------------|--------|
| GND    | GND               | GND                | GND                | K8         | GND    |
| GND    | GND               | GND                | GND                | K11        | GND    |
| GND    | GND               | GND                | GND                | K16        | GND    |
| GND    | GND               | GND                | GND                | L8         | GND    |
| GND    | GND               | GND                | GND                | L9         | GND    |
| GND    | GND               | GND                | GND                | L10        | GND    |
| GND    | GND               | GND                | GND                | L11        | GND    |
| GND    | GND               | GND                | GND                | M7         | GND    |
| GND    | GND               | GND                | GND                | M12        | GND    |
| GND    | GND               | GND                | GND                | T9         | GND    |
| GND    | GND               | GND                | GND                | U2         | GND    |
| GND    | GND               | GND                | GND                | U17        | GND    |
| GND    | GND               | GND                | GND                | V1         | GND    |
| GND    | GND               | GND                | GND                | V18        | GND    |
| VCCAUX | DONE              | DONE               | DONE               | V17        | CONFIG |
| VCCAUX | PROG_B            | PROG_B             | PROG_B             | B1         | CONFIG |
| VCCAUX | TCK               | TCK                | TCK                | A17        | JTAG   |
| VCCAUX | TDI               | TDI                | TDI                | A2         | JTAG   |
| VCCAUX | TDO               | TDO                | TDO                | C16        | JTAG   |
| VCCAUX | TMS               | TMS                | TMS                | D15        | JTAG   |
| VCCAUX | VCCAUX            | VCCAUX             | VCCAUX             | B7         | VCCAUX |
| VCCAUX | VCCAUX            | VCCAUX             | VCCAUX             | B12        | VCCAUX |
| VCCAUX | VCCAUX            | VCCAUX             | VCCAUX             | G2         | VCCAUX |
| VCCAUX | VCCAUX            | VCCAUX             | VCCAUX             | G17        | VCCAUX |
| VCCAUX | VCCAUX            | VCCAUX             | VCCAUX             | M2         | VCCAUX |
| VCCAUX | VCCAUX            | VCCAUX             | VCCAUX             | M17        | VCCAUX |
| VCCAUX | VCCAUX            | VCCAUX             | VCCAUX             | U7         | VCCAUX |
| VCCAUX | VCCAUX            | VCCAUX             | VCCAUX             | U12        | VCCAUX |
| VCCINT | VCCINT            | VCCINT             | VCCINT             | E5         | VCCINT |
| VCCINT | VCCINT            | VCCINT             | VCCINT             | E14        | VCCINT |
| VCCINT | VCCINT            | VCCINT             | VCCINT             | F6         | VCCINT |
| VCCINT | VCCINT            | VCCINT             | VCCINT             | F13        | VCCINT |
| VCCINT | VCCINT            | VCCINT             | VCCINT             | N6         | VCCINT |
| VCCINT | VCCINT            | VCCINT             | VCCINT             | N13        | VCCINT |
| VCCINT | VCCINT            | VCCINT             | VCCINT             | P5         | VCCINT |
| VCCINT | VCCINT            | VCCINT             | VCCINT             | P14        | VCCINT |

## User I/Os by Bank

Table 148 and Table 149 indicate how the available user-I/O pins are distributed between the four I/O banks on the FG320 package.

Table 148: User I/Os Per Bank for XC3S500E in the FG320 Package

| Package Edge | I/O Bank | Maximum I/O | All Possible I/O Pins by Type |           |           |                     |                    |
|--------------|----------|-------------|-------------------------------|-----------|-----------|---------------------|--------------------|
|              |          |             | I/O                           | INPUT     | DUAL      | VREF <sup>(1)</sup> | CLK <sup>(2)</sup> |
| Top          | 0        | 58          | 29                            | 14        | 1         | 6                   | 8                  |
| Right        | 1        | 58          | 22                            | 10        | 21        | 5                   | 0 <sup>(2)</sup>   |
| Bottom       | 2        | 58          | 17                            | 13        | 24        | 4                   | 0 <sup>(2)</sup>   |
| Left         | 3        | 58          | 34                            | 11        | 0         | 5                   | 8                  |
| <b>TOTAL</b> |          | <b>232</b>  | <b>102</b>                    | <b>48</b> | <b>46</b> | <b>20</b>           | <b>16</b>          |

**Notes:**

1. Some VREF and CLK pins are on INPUT pins.
2. The eight global clock pins in this bank have optional functionality during configuration and are counted in the DUAL column.

Table 149: User I/Os Per Bank for XC3S1200E and XC3S1600E in the FG320 Package

| Package Edge | I/O Bank | Maximum I/O | All Possible I/O Pins by Type |           |           |                     |                    |
|--------------|----------|-------------|-------------------------------|-----------|-----------|---------------------|--------------------|
|              |          |             | I/O                           | INPUT     | DUAL      | VREF <sup>(1)</sup> | CLK <sup>(2)</sup> |
| Top          | 0        | 61          | 34                            | 12        | 1         | 6                   | 8                  |
| Right        | 1        | 63          | 25                            | 12        | 21        | 5                   | 0 <sup>(2)</sup>   |
| Bottom       | 2        | 63          | 23                            | 11        | 24        | 5                   | 0 <sup>(2)</sup>   |
| Left         | 3        | 63          | 38                            | 12        | 0         | 5                   | 8                  |
| <b>TOTAL</b> |          | <b>250</b>  | <b>120</b>                    | <b>47</b> | <b>46</b> | <b>21</b>           | <b>16</b>          |

**Notes:**

1. Some VREF and CLK pins are on INPUT pins.
2. The eight global clock pins in this bank have optional functionality during configuration and are counted in the DUAL column.

## Footprint Migration Differences

Table 150 summarizes any footprint and functionality differences between the XC3S500E, the XC3S1200E, and the XC3S1600E FPGAs that may affect easy migration between devices available in the FG320 package. There are 26 such balls. All other pins not listed in Table 150 unconditionally migrate between Spartan-3E devices available in the FG320 package.

The XC3S500E is duplicated on both the left and right sides of the table to show migrations to and from the XC3S1200E

and the XC3S1600E. The arrows indicate the direction for easy migration. A double-ended arrow ( $\leftrightarrow$ ) indicates that the two pins have identical functionality. A left-facing arrow ( $\leftarrow$ ) indicates that the pin on the device on the right unconditionally migrates to the pin on the device on the left. It may be possible to migrate the opposite direction depending on the I/O configuration. For example, an I/O pin (Type = I/O) can migrate to an input-only pin (Type = INPUT) if the I/O pin is configured as an input.

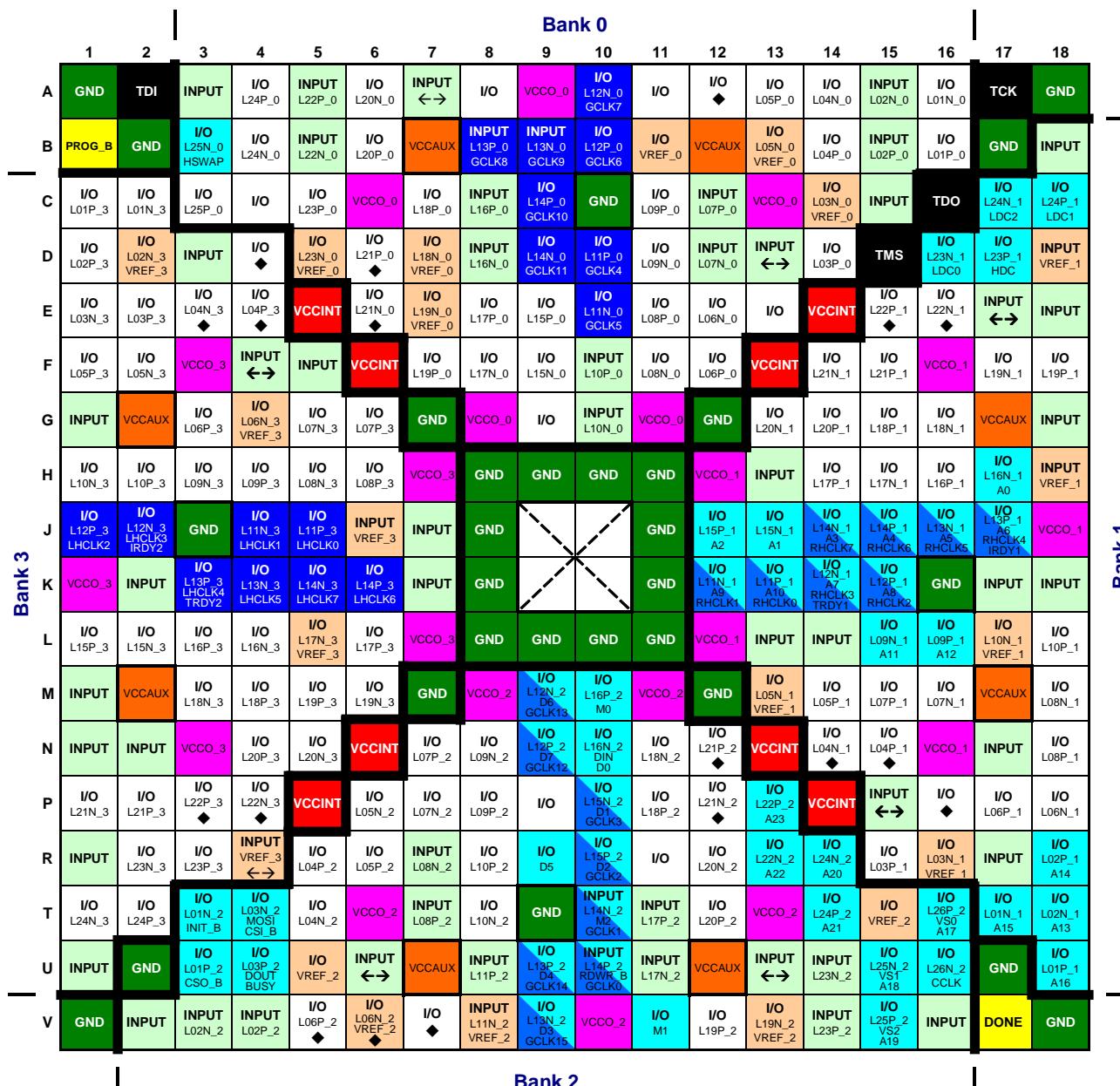
Table 150: FG320 Footprint Migration Differences

| Pin         | Bank | XC3S500E  | Migration     | XC3S1200E   | Migration         | XC3S1600E   | Migration     | XC3S500E  |
|-------------|------|-----------|---------------|-------------|-------------------|-------------|---------------|-----------|
| A7          | 0    | INPUT     | $\rightarrow$ | I/O         | $\leftrightarrow$ | I/O         | $\leftarrow$  | INPUT     |
| A12         | 0    | N.C.      | $\rightarrow$ | I/O         | $\leftrightarrow$ | I/O         | $\leftarrow$  | N.C.      |
| D4          | 3    | N.C.      | $\rightarrow$ | I/O         | $\leftrightarrow$ | I/O         | $\leftarrow$  | N.C.      |
| D6          | 0    | N.C.      | $\rightarrow$ | I/O         | $\leftrightarrow$ | I/O         | $\leftarrow$  | N.C.      |
| D13         | 0    | INPUT     | $\rightarrow$ | I/O         | $\leftrightarrow$ | I/O         | $\leftarrow$  | INPUT     |
| E3          | 3    | N.C.      | $\rightarrow$ | I/O         | $\leftrightarrow$ | I/O         | $\leftarrow$  | N.C.      |
| E4          | 3    | N.C.      | $\rightarrow$ | I/O         | $\leftrightarrow$ | I/O         | $\leftarrow$  | N.C.      |
| E6          | 0    | N.C.      | $\rightarrow$ | I/O         | $\leftrightarrow$ | I/O         | $\leftarrow$  | N.C.      |
| E15         | 1    | N.C.      | $\rightarrow$ | I/O         | $\leftrightarrow$ | I/O         | $\leftarrow$  | N.C.      |
| E16         | 1    | N.C.      | $\rightarrow$ | I/O         | $\leftrightarrow$ | I/O         | $\leftarrow$  | N.C.      |
| E17         | 1    | I/O       | $\leftarrow$  | INPUT       | $\leftrightarrow$ | INPUT       | $\rightarrow$ | I/O       |
| F4          | 3    | I/O       | $\leftarrow$  | INPUT       | $\leftrightarrow$ | INPUT       | $\rightarrow$ | I/O       |
| N12         | 2    | N.C.      | $\rightarrow$ | I/O         | $\leftrightarrow$ | I/O         | $\leftarrow$  | N.C.      |
| N14         | 1    | N.C.      | $\rightarrow$ | I/O         | $\leftrightarrow$ | I/O         | $\leftarrow$  | N.C.      |
| N15         | 1    | N.C.      | $\rightarrow$ | I/O         | $\leftrightarrow$ | I/O         | $\leftarrow$  | N.C.      |
| P3          | 3    | N.C.      | $\rightarrow$ | I/O         | $\leftrightarrow$ | I/O         | $\leftarrow$  | N.C.      |
| P4          | 3    | N.C.      | $\rightarrow$ | I/O         | $\leftrightarrow$ | I/O         | $\leftarrow$  | N.C.      |
| P12         | 2    | N.C.      | $\rightarrow$ | I/O         | $\leftrightarrow$ | I/O         | $\leftarrow$  | N.C.      |
| P15         | 1    | I/O       | $\leftarrow$  | INPUT       | $\leftrightarrow$ | INPUT       | $\rightarrow$ | I/O       |
| P16         | 1    | N.C.      | $\rightarrow$ | I/O         | $\leftrightarrow$ | I/O         | $\leftarrow$  | N.C.      |
| R4          | 3    | VREF(I/O) | $\leftarrow$  | VREF(INPUT) | $\leftrightarrow$ | VREF(INPUT) | $\rightarrow$ | VREF(I/O) |
| U6          | 2    | INPUT     | $\rightarrow$ | I/O         | $\leftrightarrow$ | I/O         | $\leftarrow$  | INPUT     |
| U13         | 2    | INPUT     | $\rightarrow$ | I/O         | $\leftrightarrow$ | I/O         | $\leftarrow$  | INPUT     |
| V5          | 2    | N.C.      | $\rightarrow$ | I/O         | $\leftrightarrow$ | I/O         | $\leftarrow$  | N.C.      |
| V6          | 2    | N.C.      | $\rightarrow$ | VREF        | $\leftrightarrow$ | VREF        | $\leftarrow$  | N.C.      |
| V7          | 2    | N.C.      | $\rightarrow$ | I/O         | $\leftrightarrow$ | I/O         | $\leftarrow$  | N.C.      |
| DIFFERENCES |      | 26        |               | 0           |                   |             | 26            |           |

Legend:

- $\leftrightarrow$  This pin is identical on the device on the left and the right.
- $\rightarrow$  This pin can unconditionally migrate from the device on the left to the device on the right. Migration in the other direction may be possible depending on how the pin is configured for the device on the right.
- $\leftarrow$  This pin can unconditionally migrate from the device on the right to the device on the left. Migration in the other direction may be possible depending on how the pin is configured for the device on the left.

## FG320 Footprint



Bank 2

DS312-4\_06\_022106

Figure 86: FG320 Package Footprint (top view)

|         |  |    |   |       |  |
|---------|--|----|---|-------|--|
| 102-120 | I/O: Unrestricted, general-purpose user I/O                | 46 | DUAL: Configuration pin, then possible user-I/O | 20-21 | VREF: User I/O or input voltage reference for bank |
| 47-48   | INPUT: Unrestricted, general-purpose input pin             | 16 | CLK: User I/O, input, or global buffer input    | 20    | VCCO: Output voltage supply for bank               |
| 2       | CONFIG: Dedicated configuration pins                       | 4  | JTAG: Dedicated JTAG port pins                  | 8     | VCCINT: Internal core supply voltage (+1.2V)       |
| 18      | N.C.: Not connected. Only the XC3S500E has these pins (◆). | 28 | GND: Ground                                     | 8     | VCCAUX: Auxiliary supply voltage (+2.5V)           |

## FG400: 400-ball Fine-pitch Ball Grid Array

The 400-ball fine-pitch ball grid array, FG400, supports two different Spartan-3E FPGAs, including the XC3S1200E and the XC3S1600E. Both devices share a common footprint for this package as shown in [Table 151](#) and [Figure 87](#).

[Table 151](#) lists all the FG400 package pins. They are sorted by bank number and then by pin name. Pairs of pins that form a differential I/O pair appear together in the table. The table also shows the pin number for each pin and the pin type, as defined earlier.

An electronic version of this package pinout table and footprint diagram is available for download from the Xilinx website at:

[http://www.xilinx.com/support/documentation/data\\_sheets/s3e\\_pin.zip](http://www.xilinx.com/support/documentation/data_sheets/s3e_pin.zip)

### Pinout Table

[Table 151: FG400 Package Pinout](#)

| Bank | XC3S1200E<br>XC3S1600E<br>Pin Name | FG400<br>Ball | Type |
|------|------------------------------------|---------------|------|
| 0    | IO                                 | A3            | I/O  |
| 0    | IO                                 | A8            | I/O  |
| 0    | IO                                 | A12           | I/O  |
| 0    | IO                                 | C7            | I/O  |
| 0    | IO                                 | C10           | I/O  |
| 0    | IO                                 | E8            | I/O  |
| 0    | IO                                 | E13           | I/O  |
| 0    | IO                                 | E16           | I/O  |
| 0    | IO                                 | F13           | I/O  |
| 0    | IO                                 | F14           | I/O  |
| 0    | IO                                 | G7            | I/O  |
| 0    | IO/VREF_0                          | C11           | VREF |
| 0    | IO_L01N_0                          | B17           | I/O  |
| 0    | IO_L01P_0                          | C17           | I/O  |
| 0    | IO_L03N_0/VREF_0                   | A18           | VREF |
| 0    | IO_L03P_0                          | A19           | I/O  |
| 0    | IO_L04N_0                          | A17           | I/O  |
| 0    | IO_L04P_0                          | A16           | I/O  |
| 0    | IO_L06N_0                          | A15           | I/O  |
| 0    | IO_L06P_0                          | B15           | I/O  |
| 0    | IO_L07N_0                          | C14           | I/O  |
| 0    | IO_L07P_0                          | D14           | I/O  |
| 0    | IO_L09N_0/VREF_0                   | A13           | VREF |
| 0    | IO_L09P_0                          | A14           | I/O  |
| 0    | IO_L10N_0                          | B13           | I/O  |
| 0    | IO_L10P_0                          | C13           | I/O  |
| 0    | IO_L12N_0                          | C12           | I/O  |

[Table 151: FG400 Package Pinout \(Cont'd\)](#)

| Bank | XC3S1200E<br>XC3S1600E<br>Pin Name | FG400<br>Ball | Type  |
|------|------------------------------------|---------------|-------|
| 0    | IO_L12P_0                          | D12           | I/O   |
| 0    | IO_L13N_0                          | E12           | I/O   |
| 0    | IO_L13P_0                          | F12           | I/O   |
| 0    | IO_L15N_0/GCLK5                    | G11           | GCLK  |
| 0    | IO_L15P_0/GCLK4                    | F11           | GCLK  |
| 0    | IO_L16N_0/GCLK7                    | E10           | GCLK  |
| 0    | IO_L16P_0/GCLK6                    | E11           | GCLK  |
| 0    | IO_L18N_0/GCLK11                   | A9            | GCLK  |
| 0    | IO_L18P_0/GCLK10                   | A10           | GCLK  |
| 0    | IO_L19N_0                          | F9            | I/O   |
| 0    | IO_L19P_0                          | E9            | I/O   |
| 0    | IO_L21N_0                          | C9            | I/O   |
| 0    | IO_L21P_0                          | D9            | I/O   |
| 0    | IO_L22N_0/VREF_0                   | B8            | VREF  |
| 0    | IO_L22P_0                          | B9            | I/O   |
| 0    | IO_L24N_0/VREF_0                   | F7            | VREF  |
| 0    | IO_L24P_0                          | F8            | I/O   |
| 0    | IO_L25N_0                          | A6            | I/O   |
| 0    | IO_L25P_0                          | A7            | I/O   |
| 0    | IO_L27N_0                          | B5            | I/O   |
| 0    | IO_L27P_0                          | B6            | I/O   |
| 0    | IO_L28N_0                          | D6            | I/O   |
| 0    | IO_L28P_0                          | C6            | I/O   |
| 0    | IO_L30N_0/VREF_0                   | C5            | VREF  |
| 0    | IO_L30P_0                          | D5            | I/O   |
| 0    | IO_L31N_0                          | A2            | I/O   |
| 0    | IO_L31P_0                          | B2            | I/O   |
| 0    | IO_L32N_0/HSWAP                    | D4            | DUAL  |
| 0    | IO_L32P_0                          | C4            | I/O   |
| 0    | IP                                 | B18           | INPUT |
| 0    | IP                                 | E5            | INPUT |
| 0    | IP_L02N_0                          | C16           | INPUT |
| 0    | IP_L02P_0                          | D16           | INPUT |
| 0    | IP_L05N_0                          | D15           | INPUT |
| 0    | IP_L05P_0                          | C15           | INPUT |
| 0    | IP_L08N_0                          | E14           | INPUT |
| 0    | IP_L08P_0                          | E15           | INPUT |
| 0    | IP_L11N_0                          | G14           | INPUT |
| 0    | IP_L11P_0                          | G13           | INPUT |
| 0    | IP_L14N_0                          | B11           | INPUT |
| 0    | IP_L14P_0                          | B12           | INPUT |
| 0    | IP_L17N_0/GCLK9                    | G10           | GCLK  |

Table 151: FG400 Package Pinout (Cont'd)

| Bank | XC3S1200E<br>XC3S1600E<br>Pin Name | FG400<br>Ball | Type           |
|------|------------------------------------|---------------|----------------|
| 0    | IP_L17P_0/GCLK8                    | H10           | GCLK           |
| 0    | IP_L20N_0                          | G9            | INPUT          |
| 0    | IP_L20P_0                          | G8            | INPUT          |
| 0    | IP_L23N_0                          | C8            | INPUT          |
| 0    | IP_L23P_0                          | D8            | INPUT          |
| 0    | IP_L26N_0                          | E6            | INPUT          |
| 0    | IP_L26P_0                          | E7            | INPUT          |
| 0    | IP_L29N_0                          | A4            | INPUT          |
| 0    | IP_L29P_0                          | A5            | INPUT          |
| 0    | VCCO_0                             | B4            | VCCO           |
| 0    | VCCO_0                             | B10           | VCCO           |
| 0    | VCCO_0                             | B16           | VCCO           |
| 0    | VCCO_0                             | D7            | VCCO           |
| 0    | VCCO_0                             | D13           | VCCO           |
| 0    | VCCO_0                             | F10           | VCCO           |
| 1    | IO_L01N_1/A15                      | U18           | DUAL           |
| 1    | IO_L01P_1/A16                      | U17           | DUAL           |
| 1    | IO_L02N_1/A13                      | T18           | DUAL           |
| 1    | IO_L02P_1/A14                      | T17           | DUAL           |
| 1    | IO_L03N_1/VREF_1                   | V19           | VREF           |
| 1    | IO_L03P_1                          | U19           | I/O            |
| 1    | IO_L04N_1                          | W20           | I/O            |
| 1    | IO_L04P_1                          | V20           | I/O            |
| 1    | IO_L05N_1                          | R18           | I/O            |
| 1    | IO_L05P_1                          | R17           | I/O            |
| 1    | IO_L06N_1                          | T20           | I/O            |
| 1    | IO_L06P_1                          | U20           | I/O            |
| 1    | IO_L07N_1                          | P18           | I/O            |
| 1    | IO_L07P_1                          | P17           | I/O            |
| 1    | IO_L08N_1/VREF_1                   | P20           | VREF           |
| 1    | IO_L08P_1                          | R20           | I/O            |
| 1    | IO_L09N_1                          | P16           | I/O            |
| 1    | IO_L09P_1                          | N16           | I/O            |
| 1    | IO_L10N_1                          | N19           | I/O            |
| 1    | IO_L10P_1                          | N18           | I/O            |
| 1    | IO_L11N_1                          | N15           | I/O            |
| 1    | IO_L11P_1                          | M15           | I/O            |
| 1    | IO_L12N_1/A11                      | M18           | DUAL           |
| 1    | IO_L12P_1/A12                      | M17           | DUAL           |
| 1    | IO_L13N_1/VREF_1                   | L19           | VREF           |
| 1    | IO_L13P_1                          | M19           | I/O            |
| 1    | IO_L14N_1/A9/RHCLK1                | L16           | RHCLK/<br>DUAL |

Table 151: FG400 Package Pinout (Cont'd)

| Bank | XC3S1200E<br>XC3S1600E<br>Pin Name | FG400<br>Ball | Type           |
|------|------------------------------------|---------------|----------------|
| 1    | IO_L14P_1/A10/RHCLK0               | M16           | RHCLK/<br>DUAL |
| 1    | IO_L15N_1/A7/RHCLK3/<br>TRDY1      | L14           | RHCLK/<br>DUAL |
| 1    | IO_L15P_1/A8/RHCLK2                | L15           | RHCLK/<br>DUAL |
| 1    | IO_L16N_1/A5/RHCLK5                | K14           | RHCLK/<br>DUAL |
| 1    | IO_L16P_1/A6/RHCLK4/<br>IRDY1      | K13           | RHCLK/<br>DUAL |
| 1    | IO_L17N_1/A3/RHCLK7                | J20           | RHCLK/<br>DUAL |
| 1    | IO_L17P_1/A4/RHCLK6                | K20           | RHCLK/<br>DUAL |
| 1    | IO_L18N_1/A1                       | K16           | DUAL           |
| 1    | IO_L18P_1/A2                       | J16           | DUAL           |
| 1    | IO_L19N_1/A0                       | J13           | DUAL           |
| 1    | IO_L19P_1                          | J14           | I/O            |
| 1    | IO_L20N_1                          | J17           | I/O            |
| 1    | IO_L20P_1                          | J18           | I/O            |
| 1    | IO_L21N_1                          | H19           | I/O            |
| 1    | IO_L21P_1                          | J19           | I/O            |
| 1    | IO_L22N_1                          | H15           | I/O            |
| 1    | IO_L22P_1                          | H16           | I/O            |
| 1    | IO_L23N_1                          | H18           | I/O            |
| 1    | IO_L23P_1                          | H17           | I/O            |
| 1    | IO_L24N_1/VREF_1                   | H20           | VREF           |
| 1    | IO_L24P_1                          | G20           | I/O            |
| 1    | IO_L25N_1                          | G16           | I/O            |
| 1    | IO_L25P_1                          | F16           | I/O            |
| 1    | IO_L26N_1                          | F19           | I/O            |
| 1    | IO_L26P_1                          | F20           | I/O            |
| 1    | IO_L27N_1                          | F18           | I/O            |
| 1    | IO_L27P_1                          | F17           | I/O            |
| 1    | IO_L28N_1                          | D20           | I/O            |
| 1    | IO_L28P_1                          | E20           | I/O            |
| 1    | IO_L29N_1/LDC0                     | D18           | DUAL           |
| 1    | IO_L29P_1/HDC                      | E18           | DUAL           |
| 1    | IO_L30N_1/LDC2                     | C19           | DUAL           |
| 1    | IO_L30P_1/LDC1                     | C20           | DUAL           |
| 1    | IP                                 | B20           | INPUT          |
| 1    | IP                                 | G15           | INPUT          |
| 1    | IP                                 | G18           | INPUT          |
| 1    | IP                                 | H14           | INPUT          |
| 1    | IP                                 | J15           | INPUT          |

Table 151: FG400 Package Pinout (Cont'd)

| Bank | XC3S1200E<br>XC3S1600E<br>Pin Name | FG400<br>Ball | Type  |
|------|------------------------------------|---------------|-------|
| 1    | IP                                 | L18           | INPUT |
| 1    | IP                                 | M20           | INPUT |
| 1    | IP                                 | N14           | INPUT |
| 1    | IP                                 | N20           | INPUT |
| 1    | IP                                 | P15           | INPUT |
| 1    | IP                                 | R16           | INPUT |
| 1    | IP                                 | R19           | INPUT |
| 1    | IP/VREF_1                          | E19           | VREF  |
| 1    | IP/VREF_1                          | K18           | VREF  |
| 1    | VCCO_1                             | D19           | VCCO  |
| 1    | VCCO_1                             | G17           | VCCO  |
| 1    | VCCO_1                             | K15           | VCCO  |
| 1    | VCCO_1                             | K19           | VCCO  |
| 1    | VCCO_1                             | N17           | VCCO  |
| 1    | VCCO_1                             | T19           | VCCO  |
| 2    | IO                                 | P8            | I/O   |
| 2    | IO                                 | P13           | I/O   |
| 2    | IO                                 | R9            | I/O   |
| 2    | IO                                 | R13           | I/O   |
| 2    | IO                                 | W15           | I/O   |
| 2    | IO                                 | Y5            | I/O   |
| 2    | IO                                 | Y7            | I/O   |
| 2    | IO                                 | Y13           | I/O   |
| 2    | IO/D5                              | N11           | DUAL  |
| 2    | IO/M1                              | T11           | DUAL  |
| 2    | IO/VREF_2                          | Y3            | VREF  |
| 2    | IO/VREF_2                          | Y17           | VREF  |
| 2    | IO_L01N_2/INIT_B                   | V4            | DUAL  |
| 2    | IO_L01P_2/CSO_B                    | U4            | DUAL  |
| 2    | IO_L03N_2/MOSI/CSI_B               | V5            | DUAL  |
| 2    | IO_L03P_2/DOUT/BUSY                | U5            | DUAL  |
| 2    | IO_L04N_2                          | Y4            | I/O   |
| 2    | IO_L04P_2                          | W4            | I/O   |
| 2    | IO_L06N_2                          | T6            | I/O   |
| 2    | IO_L06P_2                          | T5            | I/O   |
| 2    | IO_L07N_2                          | U7            | I/O   |
| 2    | IO_L07P_2                          | V7            | I/O   |
| 2    | IO_L09N_2/VREF_2                   | R7            | VREF  |
| 2    | IO_L09P_2                          | T7            | I/O   |
| 2    | IO_L10N_2                          | V8            | I/O   |
| 2    | IO_L10P_2                          | W8            | I/O   |
| 2    | IO_L12N_2                          | U9            | I/O   |
| 2    | IO_L12P_2                          | V9            | I/O   |

Table 151: FG400 Package Pinout (Cont'd)

| Bank | XC3S1200E<br>XC3S1600E<br>Pin Name | FG400<br>Ball | Type          |
|------|------------------------------------|---------------|---------------|
| 2    | IO_L13N_2                          | Y8            | I/O           |
| 2    | IO_L13P_2                          | Y9            | I/O           |
| 2    | IO_L15N_2/D6/GCLK13                | W10           | DUAL/<br>GCLK |
| 2    | IO_L15P_2/D7/GCLK12                | W9            | DUAL/<br>GCLK |
| 2    | IO_L16N_2/D3/GCLK15                | P10           | DUAL/<br>GCLK |
| 2    | IO_L16P_2/D4/GCLK14                | R10           | DUAL/<br>GCLK |
| 2    | IO_L18N_2/D1/GCLK3                 | V11           | DUAL/<br>GCLK |
| 2    | IO_L18P_2/D2/GCLK2                 | V10           | DUAL/<br>GCLK |
| 2    | IO_L19N_2/DIN/D0                   | Y12           | DUAL          |
| 2    | IO_L19P_2/M0                       | Y11           | DUAL          |
| 2    | IO_L21N_2                          | U12           | I/O           |
| 2    | IO_L21P_2                          | V12           | I/O           |
| 2    | IO_L22N_2/VREF_2                   | W12           | VREF          |
| 2    | IO_L22P_2                          | W13           | I/O           |
| 2    | IO_L24N_2                          | U13           | I/O           |
| 2    | IO_L24P_2                          | V13           | I/O           |
| 2    | IO_L25N_2                          | P14           | I/O           |
| 2    | IO_L25P_2                          | R14           | I/O           |
| 2    | IO_L27N_2/A22                      | Y14           | DUAL          |
| 2    | IO_L27P_2/A23                      | Y15           | DUAL          |
| 2    | IO_L28N_2                          | T15           | I/O           |
| 2    | IO_L28P_2                          | U15           | I/O           |
| 2    | IO_L30N_2/A20                      | V16           | DUAL          |
| 2    | IO_L30P_2/A21                      | U16           | DUAL          |
| 2    | IO_L31N_2/VS1/A18                  | Y18           | DUAL          |
| 2    | IO_L31P_2/VS2/A19                  | W18           | DUAL          |
| 2    | IO_L32N_2/CCLK                     | W19           | DUAL          |
| 2    | IO_L32P_2/VS0/A17                  | Y19           | DUAL          |
| 2    | IP                                 | T16           | INPUT         |
| 2    | IP                                 | W3            | INPUT         |
| 2    | IP_L02N_2                          | Y2            | INPUT         |
| 2    | IP_L02P_2                          | W2            | INPUT         |
| 2    | IP_L05N_2                          | V6            | INPUT         |
| 2    | IP_L05P_2                          | U6            | INPUT         |
| 2    | IP_L08N_2                          | Y6            | INPUT         |
| 2    | IP_L08P_2                          | W6            | INPUT         |
| 2    | IP_L11N_2                          | R8            | INPUT         |
| 2    | IP_L11P_2                          | T8            | INPUT         |
| 2    | IP_L14N_2/VREF_2                   | T10           | VREF          |

Table 151: FG400 Package Pinout (Cont'd)

| Bank | XC3S1200E<br>XC3S1600E<br>Pin Name | FG400<br>Ball | Type          |
|------|------------------------------------|---------------|---------------|
| 2    | IP_L14P_2                          | T9            | INPUT         |
| 2    | IP_L17N_2/M2/GCLK1                 | P12           | DUAL/<br>GCLK |
| 2    | IP_L17P_2/RDWR_B/<br>GCLK0         | P11           | DUAL/<br>GCLK |
| 2    | IP_L20N_2                          | T12           | INPUT         |
| 2    | IP_L20P_2                          | R12           | INPUT         |
| 2    | IP_L23N_2/VREF_2                   | T13           | VREF          |
| 2    | IP_L23P_2                          | T14           | INPUT         |
| 2    | IP_L26N_2                          | V14           | INPUT         |
| 2    | IP_L26P_2                          | V15           | INPUT         |
| 2    | IP_L29N_2                          | W16           | INPUT         |
| 2    | IP_L29P_2                          | Y16           | INPUT         |
| 2    | VCCO_2                             | R11           | VCCO          |
| 2    | VCCO_2                             | U8            | VCCO          |
| 2    | VCCO_2                             | U14           | VCCO          |
| 2    | VCCO_2                             | W5            | VCCO          |
| 2    | VCCO_2                             | W11           | VCCO          |
| 2    | VCCO_2                             | W17           | VCCO          |
| 3    | IO_L01N_3                          | D2            | I/O           |
| 3    | IO_L01P_3                          | D3            | I/O           |
| 3    | IO_L02N_3/VREF_3                   | E3            | VREF          |
| 3    | IO_L02P_3                          | E4            | I/O           |
| 3    | IO_L03N_3                          | C1            | I/O           |
| 3    | IO_L03P_3                          | B1            | I/O           |
| 3    | IO_L04N_3                          | E1            | I/O           |
| 3    | IO_L04P_3                          | D1            | I/O           |
| 3    | IO_L05N_3                          | F3            | I/O           |
| 3    | IO_L05P_3                          | F4            | I/O           |
| 3    | IO_L06N_3                          | F1            | I/O           |
| 3    | IO_L06P_3                          | F2            | I/O           |
| 3    | IO_L07N_3                          | G4            | I/O           |
| 3    | IO_L07P_3                          | G3            | I/O           |
| 3    | IO_L08N_3                          | G5            | I/O           |
| 3    | IO_L08P_3                          | H5            | I/O           |
| 3    | IO_L09N_3/VREF_3                   | H3            | VREF          |
| 3    | IO_L09P_3                          | H2            | I/O           |
| 3    | IO_L10N_3                          | H7            | I/O           |
| 3    | IO_L10P_3                          | H6            | I/O           |
| 3    | IO_L11N_3                          | J4            | I/O           |
| 3    | IO_L11P_3                          | J3            | I/O           |
| 3    | IO_L12N_3                          | J1            | I/O           |
| 3    | IO_L12P_3                          | J2            | I/O           |
| 3    | IO_L13N_3                          | J6            | I/O           |

Table 151: FG400 Package Pinout (Cont'd)

| Bank | XC3S1200E<br>XC3S1600E<br>Pin Name | FG400<br>Ball | Type  |
|------|------------------------------------|---------------|-------|
| 3    | IO_L13P_3                          | K6            | I/O   |
| 3    | IO_L14N_3/LHCLK1                   | K2            | LHCLK |
| 3    | IO_L14P_3/LHCLK0                   | K3            | LHCLK |
| 3    | IO_L15N_3/LHCLK3/IRDY2             | L7            | LHCLK |
| 3    | IO_L15P_3/LHCLK2                   | K7            | LHCLK |
| 3    | IO_L16N_3/LHCLK5                   | L1            | LHCLK |
| 3    | IO_L16P_3/LHCLK4/TRDY2             | M1            | LHCLK |
| 3    | IO_L17N_3/LHCLK7                   | L3            | LHCLK |
| 3    | IO_L17P_3/LHCLK6                   | M3            | LHCLK |
| 3    | IO_L18N_3                          | M7            | I/O   |
| 3    | IO_L18P_3                          | M8            | I/O   |
| 3    | IO_L19N_3                          | M4            | I/O   |
| 3    | IO_L19P_3                          | M5            | I/O   |
| 3    | IO_L20N_3/VREF_3                   | N6            | VREF  |
| 3    | IO_L20P_3                          | M6            | I/O   |
| 3    | IO_L21N_3                          | N2            | I/O   |
| 3    | IO_L21P_3                          | N1            | I/O   |
| 3    | IO_L22N_3                          | P7            | I/O   |
| 3    | IO_L22P_3                          | N7            | I/O   |
| 3    | IO_L23N_3                          | N4            | I/O   |
| 3    | IO_L23P_3                          | N3            | I/O   |
| 3    | IO_L24N_3                          | R1            | I/O   |
| 3    | IO_L24P_3                          | P1            | I/O   |
| 3    | IO_L25N_3                          | R5            | I/O   |
| 3    | IO_L25P_3                          | P5            | I/O   |
| 3    | IO_L26N_3                          | T2            | I/O   |
| 3    | IO_L26P_3                          | R2            | I/O   |
| 3    | IO_L27N_3                          | R4            | I/O   |
| 3    | IO_L27P_3                          | R3            | I/O   |
| 3    | IO_L28N_3/VREF_3                   | T1            | VREF  |
| 3    | IO_L28P_3                          | U1            | I/O   |
| 3    | IO_L29N_3                          | T3            | I/O   |
| 3    | IO_L29P_3                          | U3            | I/O   |
| 3    | IO_L30N_3                          | V1            | I/O   |
| 3    | IO_L30P_3                          | V2            | I/O   |
| 3    | IP                                 | F5            | INPUT |
| 3    | IP                                 | G1            | INPUT |
| 3    | IP                                 | G6            | INPUT |
| 3    | IP                                 | H1            | INPUT |
| 3    | IP                                 | J5            | INPUT |
| 3    | IP                                 | L5            | INPUT |
| 3    | IP                                 | L8            | INPUT |
| 3    | IP                                 | M2            | INPUT |

Table 151: FG400 Package Pinout (Cont'd)

| Bank | XC3S1200E<br>XC3S1600E<br>Pin Name | FG400<br>Ball | Type  |
|------|------------------------------------|---------------|-------|
| 3    | IP                                 | N5            | INPUT |
| 3    | IP                                 | P3            | INPUT |
| 3    | IP                                 | T4            | INPUT |
| 3    | IP                                 | W1            | INPUT |
| 3    | IP/VREF_3                          | K5            | VREF  |
| 3    | IP/VREF_3                          | P6            | VREF  |
| 3    | VCCO_3                             | E2            | VCCO  |
| 3    | VCCO_3                             | H4            | VCCO  |
| 3    | VCCO_3                             | L2            | VCCO  |
| 3    | VCCO_3                             | L6            | VCCO  |
| 3    | VCCO_3                             | P4            | VCCO  |
| 3    | VCCO_3                             | U2            | VCCO  |
| GND  | GND                                | A1            | GND   |
| GND  | GND                                | A11           | GND   |
| GND  | GND                                | A20           | GND   |
| GND  | GND                                | B7            | GND   |
| GND  | GND                                | B14           | GND   |
| GND  | GND                                | C3            | GND   |
| GND  | GND                                | C18           | GND   |
| GND  | GND                                | D10           | GND   |
| GND  | GND                                | F6            | GND   |
| GND  | GND                                | F15           | GND   |
| GND  | GND                                | G2            | GND   |
| GND  | GND                                | G12           | GND   |
| GND  | GND                                | G19           | GND   |
| GND  | GND                                | H8            | GND   |
| GND  | GND                                | J9            | GND   |
| GND  | GND                                | J11           | GND   |
| GND  | GND                                | K1            | GND   |
| GND  | GND                                | K8            | GND   |
| GND  | GND                                | K10           | GND   |
| GND  | GND                                | K12           | GND   |
| GND  | GND                                | K17           | GND   |
| GND  | GND                                | L4            | GND   |
| GND  | GND                                | L9            | GND   |
| GND  | GND                                | L11           | GND   |
| GND  | GND                                | L13           | GND   |
| GND  | GND                                | L20           | GND   |
| GND  | GND                                | M10           | GND   |
| GND  | GND                                | M12           | GND   |
| GND  | GND                                | N13           | GND   |
| GND  | GND                                | P2            | GND   |
| GND  | GND                                | P9            | GND   |

Table 151: FG400 Package Pinout (Cont'd)

| Bank   | XC3S1200E<br>XC3S1600E<br>Pin Name | FG400<br>Ball | Type   |
|--------|------------------------------------|---------------|--------|
| GND    | GND                                | P19           | GND    |
| GND    | GND                                | R6            | GND    |
| GND    | GND                                | R15           | GND    |
| GND    | GND                                | U11           | GND    |
| GND    | GND                                | V3            | GND    |
| GND    | GND                                | V18           | GND    |
| GND    | GND                                | W7            | GND    |
| GND    | GND                                | W14           | GND    |
| GND    | GND                                | Y1            | GND    |
| GND    | GND                                | Y10           | GND    |
| GND    | GND                                | Y20           | GND    |
| VCCAUX | DONE                               | V17           | CONFIG |
| VCCAUX | PROG_B                             | C2            | CONFIG |
| VCCAUX | TCK                                | D17           | JTAG   |
| VCCAUX | TDI                                | B3            | JTAG   |
| VCCAUX | TDO                                | B19           | JTAG   |
| VCCAUX | TMS                                | E17           | JTAG   |
| VCCAUX | VCCAUX                             | D11           | VCCAUX |
| VCCAUX | VCCAUX                             | H12           | VCCAUX |
| VCCAUX | VCCAUX                             | J7            | VCCAUX |
| VCCAUX | VCCAUX                             | K4            | VCCAUX |
| VCCAUX | VCCAUX                             | L17           | VCCAUX |
| VCCAUX | VCCAUX                             | M14           | VCCAUX |
| VCCAUX | VCCAUX                             | N9            | VCCAUX |
| VCCAUX | VCCAUX                             | U10           | VCCAUX |
| VCCINT | VCCINT                             | H9            | VCCINT |
| VCCINT | VCCINT                             | H11           | VCCINT |
| VCCINT | VCCINT                             | H13           | VCCINT |
| VCCINT | VCCINT                             | J8            | VCCINT |
| VCCINT | VCCINT                             | J10           | VCCINT |
| VCCINT | VCCINT                             | J12           | VCCINT |
| VCCINT | VCCINT                             | K9            | VCCINT |
| VCCINT | VCCINT                             | K11           | VCCINT |
| VCCINT | VCCINT                             | L10           | VCCINT |
| VCCINT | VCCINT                             | L12           | VCCINT |
| VCCINT | VCCINT                             | M9            | VCCINT |
| VCCINT | VCCINT                             | M11           | VCCINT |
| VCCINT | VCCINT                             | M13           | VCCINT |
| VCCINT | VCCINT                             | N8            | VCCINT |
| VCCINT | VCCINT                             | N10           | VCCINT |
| VCCINT | VCCINT                             | N12           | VCCINT |

## User I/Os by Bank

Table 152 indicates how the 304 available user-I/O pins are distributed between the four I/O banks on the FG400 package.

Table 152: User I/Os Per Bank for the XC3S1200E and XC3S1600E in the FG400 Package

| Package Edge | I/O Bank | Maximum I/O | All Possible I/O Pins by Type |           |           |                     |                    |
|--------------|----------|-------------|-------------------------------|-----------|-----------|---------------------|--------------------|
|              |          |             | I/O                           | INPUT     | DUAL      | VREF <sup>(1)</sup> | CLK <sup>(2)</sup> |
| Top          | 0        | 78          | 43                            | 20        | 1         | 6                   | 8                  |
| Right        | 1        | 74          | 35                            | 12        | 21        | 6                   | 0 <sup>(2)</sup>   |
| Bottom       | 2        | 78          | 30                            | 18        | 24        | 6                   | 0 <sup>(2)</sup>   |
| Left         | 3        | 74          | 48                            | 12        | 0         | 6                   | 8                  |
| <b>TOTAL</b> |          | <b>304</b>  | <b>156</b>                    | <b>62</b> | <b>46</b> | <b>24</b>           | <b>16</b>          |

**Notes:**

1. Some VREF and CLK pins are on INPUT pins.
2. The eight global clock pins in this bank have optional functionality during configuration and are counted in the DUAL column.

## Footprint Migration Differences

The XC3S1200E and XC3S1600E FPGAs have identical footprints in the FG400 package. Designs can migrate between the XC3S1200E and XC3S1600E FPGAs without further consideration.

## FG400 Footprint

Left Half of Package  
(top view)

- 156 **I/O:** Unrestricted, general-purpose user I/O
- 62 **INPUT:** Unrestricted, general-purpose input pin
- 46 **DUAL:** Configuration pin, then possible user I/O
- 24 **VREF:** User I/O or input voltage reference for bank
- 16 **CLK:** User I/O, input, or clock buffer input
- 2 **CONFIG:** Dedicated configuration pins
- 4 **JTAG:** Dedicated JTAG port pins
- 42 **GND:** Ground
- 24 **VCCO:** Output voltage supply for bank
- 16 **VCCINT:** Internal core supply voltage (+1.2V)
- 8 **VCCAUX:** Auxiliary supply voltage (+2.5V)
- 0 **N.C.:** Not connected

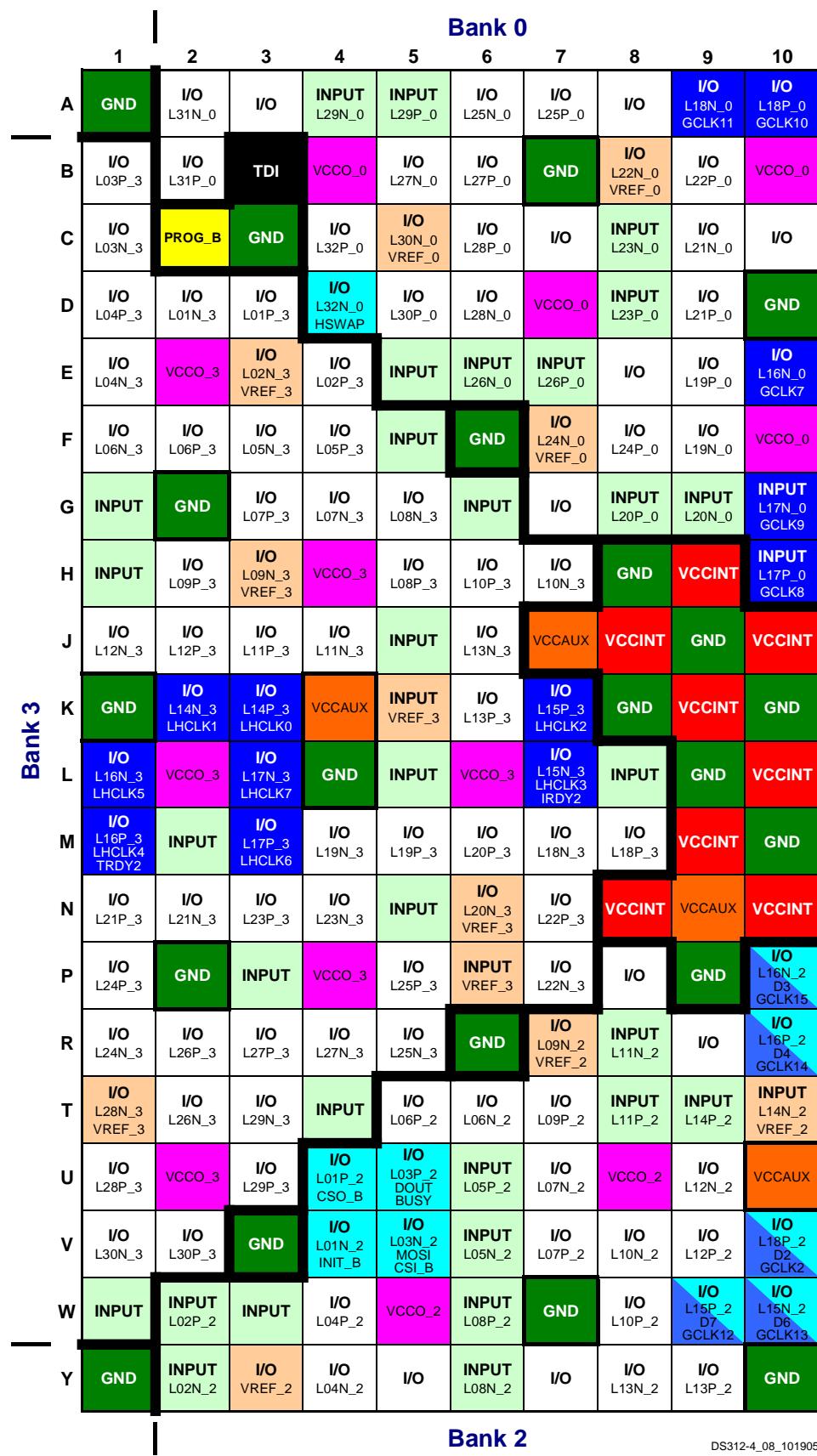
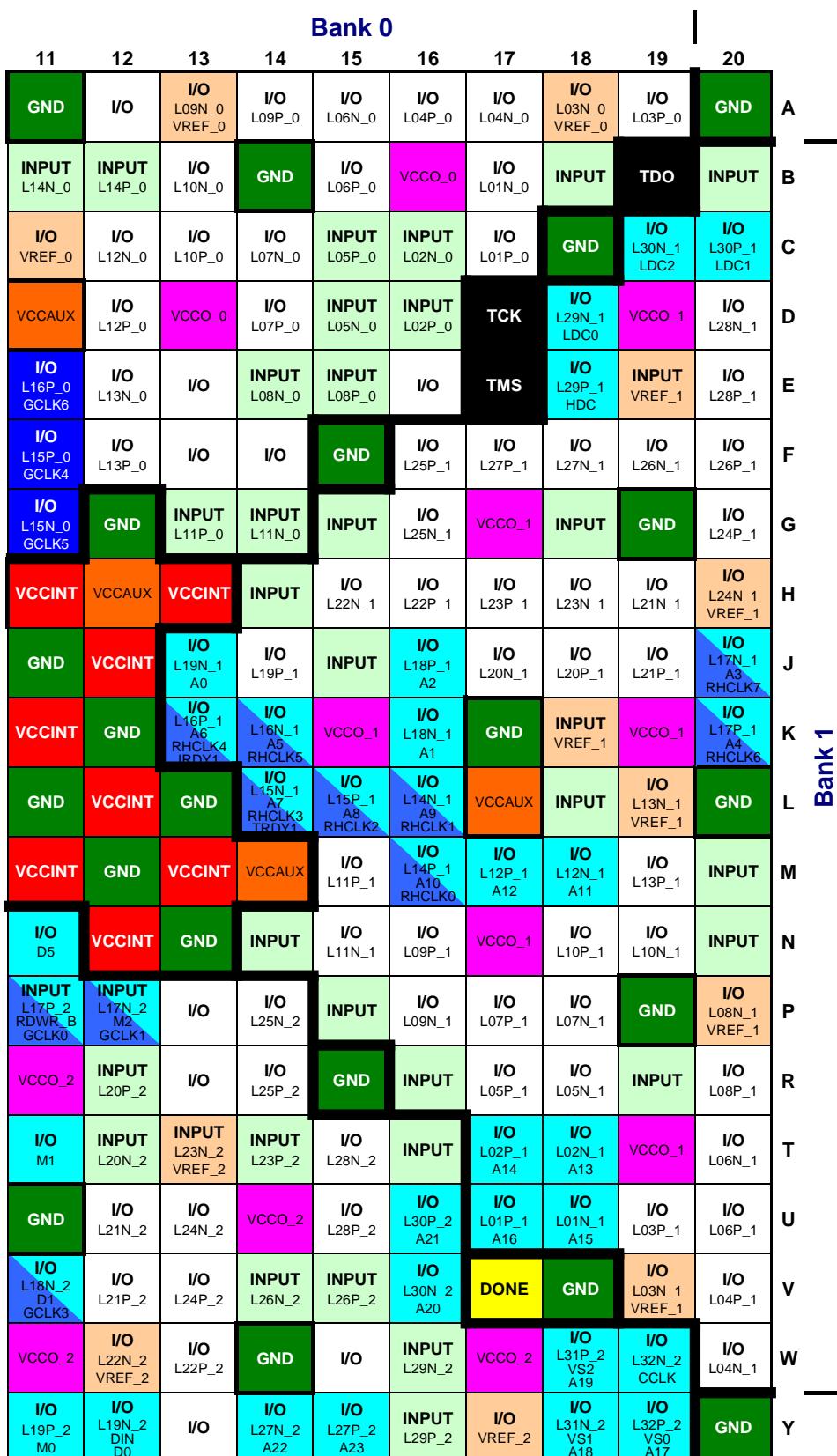


Figure 87: FG400 Package Footprint (top view)

DS312-4\_08\_101905



## FG400 Footprint

Right Half of Package  
(top view)

DS312-4\_09\_101905

## FG484: 484-ball Fine-pitch Ball Grid Array

The 484-ball fine-pitch ball grid array, FG484, supports the XC3S1600E FPGA.

**Table 153** lists all the FG484 package pins. They are sorted by bank number and then by pin name. Pairs of pins that form a differential I/O pair appear together in the table. The table also shows the pin number for each pin and the pin type, as defined earlier.

An electronic version of this package pinout table and footprint diagram is available for download from the Xilinx website at:

[http://www.xilinx.com/support/documentation/data\\_sheets/s3e\\_pin.zip](http://www.xilinx.com/support/documentation/data_sheets/s3e_pin.zip)

### Pinout Table

**Table 153: FG484 Package Pinout**

| Bank | XC3S1600E Pin Name | FG484 Ball | Type |
|------|--------------------|------------|------|
| 0    | IO                 | B6         | I/O  |
| 0    | IO                 | B13        | I/O  |
| 0    | IO                 | C5         | I/O  |
| 0    | IO                 | C14        | I/O  |
| 0    | IO                 | E16        | I/O  |
| 0    | IO                 | F9         | I/O  |
| 0    | IO                 | F16        | I/O  |
| 0    | IO                 | G8         | I/O  |
| 0    | IO                 | H10        | I/O  |
| 0    | IO                 | H15        | I/O  |
| 0    | IO                 | J11        | I/O  |
| 0    | IO/VREF_0          | G12        | VREF |
| 0    | IO_L01N_0          | C18        | I/O  |
| 0    | IO_L01P_0          | C19        | I/O  |
| 0    | IO_L03N_0/VREF_0   | A20        | VREF |
| 0    | IO_L03P_0          | A21        | I/O  |
| 0    | IO_L04N_0          | A19        | I/O  |
| 0    | IO_L04P_0          | A18        | I/O  |
| 0    | IO_L06N_0          | C16        | I/O  |
| 0    | IO_L06P_0          | D16        | I/O  |
| 0    | IO_L07N_0          | A16        | I/O  |
| 0    | IO_L07P_0          | A17        | I/O  |
| 0    | IO_L09N_0/VREF_0   | B15        | VREF |
| 0    | IO_L09P_0          | C15        | I/O  |
| 0    | IO_L10N_0          | G15        | I/O  |
| 0    | IO_L10P_0          | F15        | I/O  |
| 0    | IO_L11N_0          | D14        | I/O  |
| 0    | IO_L11P_0          | E14        | I/O  |
| 0    | IO_L12N_0/VREF_0   | A14        | VREF |

**Table 153: FG484 Package Pinout (Cont'd)**

| Bank | XC3S1600E Pin Name | FG484 Ball | Type  |
|------|--------------------|------------|-------|
| 0    | IO_L12P_0          | A15        | I/O   |
| 0    | IO_L13N_0          | H14        | I/O   |
| 0    | IO_L13P_0          | G14        | I/O   |
| 0    | IO_L15N_0          | G13        | I/O   |
| 0    | IO_L15P_0          | F13        | I/O   |
| 0    | IO_L16N_0          | J13        | I/O   |
| 0    | IO_L16P_0          | H13        | I/O   |
| 0    | IO_L18N_0/GCLK5    | E12        | GCLK  |
| 0    | IO_L18P_0/GCLK4    | F12        | GCLK  |
| 0    | IO_L19N_0/GCLK7    | C12        | GCLK  |
| 0    | IO_L19P_0/GCLK6    | B12        | GCLK  |
| 0    | IO_L21N_0/GCLK11   | B11        | GCLK  |
| 0    | IO_L21P_0/GCLK10   | C11        | GCLK  |
| 0    | IO_L22N_0          | D11        | I/O   |
| 0    | IO_L22P_0          | E11        | I/O   |
| 0    | IO_L24N_0          | A9         | I/O   |
| 0    | IO_L24P_0          | A10        | I/O   |
| 0    | IO_L25N_0/VREF_0   | D10        | VREF  |
| 0    | IO_L25P_0          | C10        | I/O   |
| 0    | IO_L27N_0          | H8         | I/O   |
| 0    | IO_L27P_0          | H9         | I/O   |
| 0    | IO_L28N_0          | C9         | I/O   |
| 0    | IO_L28P_0          | B9         | I/O   |
| 0    | IO_L29N_0          | E9         | I/O   |
| 0    | IO_L29P_0          | D9         | I/O   |
| 0    | IO_L30N_0          | B8         | I/O   |
| 0    | IO_L30P_0          | A8         | I/O   |
| 0    | IO_L32N_0/VREF_0   | F7         | VREF  |
| 0    | IO_L32P_0          | F8         | I/O   |
| 0    | IO_L33N_0          | A6         | I/O   |
| 0    | IO_L33P_0          | A7         | I/O   |
| 0    | IO_L35N_0          | A4         | I/O   |
| 0    | IO_L35P_0          | A5         | I/O   |
| 0    | IO_L36N_0          | E7         | I/O   |
| 0    | IO_L36P_0          | D7         | I/O   |
| 0    | IO_L38N_0/VREF_0   | D6         | VREF  |
| 0    | IO_L38P_0          | D5         | I/O   |
| 0    | IO_L39N_0          | B4         | I/O   |
| 0    | IO_L39P_0          | B3         | I/O   |
| 0    | IO_L40N_0/HSWAP    | D4         | DUAL  |
| 0    | IO_L40P_0          | C4         | I/O   |
| 0    | IP                 | B19        | INPUT |

Table 153: FG484 Package Pinout (Cont'd)

| Bank | XC3S1600E Pin Name | FG484 Ball | Type  |
|------|--------------------|------------|-------|
| 0    | IP                 | E6         | INPUT |
| 0    | IP_L02N_0          | D17        | INPUT |
| 0    | IP_L02P_0          | D18        | INPUT |
| 0    | IP_L05N_0          | C17        | INPUT |
| 0    | IP_L05P_0          | B17        | INPUT |
| 0    | IP_L08N_0          | E15        | INPUT |
| 0    | IP_L08P_0          | D15        | INPUT |
| 0    | IP_L14N_0          | D13        | INPUT |
| 0    | IP_L14P_0          | C13        | INPUT |
| 0    | IP_L17N_0          | A12        | INPUT |
| 0    | IP_L17P_0          | A13        | INPUT |
| 0    | IP_L20N_0/GCLK9    | H11        | GCLK  |
| 0    | IP_L20P_0/GCLK8    | H12        | GCLK  |
| 0    | IP_L23N_0          | F10        | INPUT |
| 0    | IP_L23P_0          | F11        | INPUT |
| 0    | IP_L26N_0          | G9         | INPUT |
| 0    | IP_L26P_0          | G10        | INPUT |
| 0    | IP_L31N_0          | C8         | INPUT |
| 0    | IP_L31P_0          | D8         | INPUT |
| 0    | IP_L34N_0          | C7         | INPUT |
| 0    | IP_L34P_0          | C6         | INPUT |
| 0    | IP_L37N_0          | A3         | INPUT |
| 0    | IP_L37P_0          | A2         | INPUT |
| 0    | VCCO_0             | B5         | VCCO  |
| 0    | VCCO_0             | B10        | VCCO  |
| 0    | VCCO_0             | B14        | VCCO  |
| 0    | VCCO_0             | B18        | VCCO  |
| 0    | VCCO_0             | E8         | VCCO  |
| 0    | VCCO_0             | F14        | VCCO  |
| 0    | VCCO_0             | G11        | VCCO  |
| 1    | IO_L01N_1/A15      | Y22        | DUAL  |
| 1    | IO_L01P_1/A16      | AA22       | DUAL  |
| 1    | IO_L02N_1/A13      | W21        | DUAL  |
| 1    | IO_L02P_1/A14      | Y21        | DUAL  |
| 1    | IO_L03N_1/VREF_1   | W20        | VREF  |
| 1    | IO_L03P_1          | V20        | I/O   |
| 1    | IO_L04N_1          | U19        | I/O   |
| 1    | IO_L04P_1          | V19        | I/O   |
| 1    | IO_L05N_1          | V22        | I/O   |
| 1    | IO_L05P_1          | W22        | I/O   |
| 1    | IO_L06N_1          | T19        | I/O   |
| 1    | IO_L06P_1          | T18        | I/O   |
| 1    | IO_L07N_1/VREF_1   | U20        | VREF  |
| 1    | IO_L07P_1          | U21        | I/O   |

Table 153: FG484 Package Pinout (Cont'd)

| Bank | XC3S1600E Pin Name        | FG484 Ball | Type       |
|------|---------------------------|------------|------------|
| 1    | IO_L08N_1                 | T22        | I/O        |
| 1    | IO_L08P_1                 | U22        | I/O        |
| 1    | IO_L09N_1                 | R19        | I/O        |
| 1    | IO_L09P_1                 | R18        | I/O        |
| 1    | IO_L10N_1                 | R16        | I/O        |
| 1    | IO_L10P_1                 | T16        | I/O        |
| 1    | IO_L11N_1                 | R21        | I/O        |
| 1    | IO_L11P_1                 | R20        | I/O        |
| 1    | IO_L12N_1/VREF_1          | P18        | VREF       |
| 1    | IO_L12P_1                 | P17        | I/O        |
| 1    | IO_L13N_1                 | P22        | I/O        |
| 1    | IO_L13P_1                 | R22        | I/O        |
| 1    | IO_L14N_1                 | P15        | I/O        |
| 1    | IO_L14P_1                 | P16        | I/O        |
| 1    | IO_L15N_1                 | N18        | I/O        |
| 1    | IO_L15P_1                 | N19        | I/O        |
| 1    | IO_L16N_1/A11             | N16        | DUAL       |
| 1    | IO_L16P_1/A12             | N17        | DUAL       |
| 1    | IO_L17N_1/VREF_1          | M20        | VREF       |
| 1    | IO_L17P_1                 | N20        | I/O        |
| 1    | IO_L18N_1/A9/RHCLK1       | M22        | RHCLK/DUAL |
| 1    | IO_L18P_1/A10/RHCLK0      | N22        | RHCLK/DUAL |
| 1    | IO_L19N_1/A7/RHCLK3/TRDY1 | M16        | RHCLK/DUAL |
| 1    | IO_L19P_1/A8/RHCLK2       | M15        | RHCLK/DUAL |
| 1    | IO_L20N_1/A5/RHCLK5       | L21        | RHCLK/DUAL |
| 1    | IO_L20P_1/A6/RHCLK4/IRDY1 | L20        | RHCLK/DUAL |
| 1    | IO_L21N_1/A3/RHCLK7       | L19        | RHCLK/DUAL |
| 1    | IO_L21P_1/A4/RHCLK6       | L18        | RHCLK/DUAL |
| 1    | IO_L22N_1/A1              | K22        | DUAL       |
| 1    | IO_L22P_1/A2              | L22        | DUAL       |
| 1    | IO_L23N_1/A0              | K17        | DUAL       |
| 1    | IO_L23P_1                 | K16        | I/O        |
| 1    | IO_L24N_1                 | K19        | I/O        |
| 1    | IO_L24P_1                 | K18        | I/O        |
| 1    | IO_L25N_1                 | K15        | I/O        |
| 1    | IO_L25P_1                 | J15        | I/O        |
| 1    | IO_L26N_1                 | J20        | I/O        |
| 1    | IO_L26P_1                 | J21        | I/O        |

Table 153: FG484 Package Pinout (Cont'd)

| Bank | XC3S1600E Pin Name | FG484 Ball | Type  |
|------|--------------------|------------|-------|
| 1    | IO_L27N_1          | J17        | I/O   |
| 1    | IO_L27P_1          | J18        | I/O   |
| 1    | IO_L28N_1/VREF_1   | H21        | VREF  |
| 1    | IO_L28P_1          | H22        | I/O   |
| 1    | IO_L29N_1          | H20        | I/O   |
| 1    | IO_L29P_1          | H19        | I/O   |
| 1    | IO_L30N_1          | H17        | I/O   |
| 1    | IO_L30P_1          | G17        | I/O   |
| 1    | IO_L31N_1          | F22        | I/O   |
| 1    | IO_L31P_1          | G22        | I/O   |
| 1    | IO_L32N_1          | F20        | I/O   |
| 1    | IO_L32P_1          | G20        | I/O   |
| 1    | IO_L33N_1          | G18        | I/O   |
| 1    | IO_L33P_1          | G19        | I/O   |
| 1    | IO_L34N_1          | D22        | I/O   |
| 1    | IO_L34P_1          | E22        | I/O   |
| 1    | IO_L35N_1          | F19        | I/O   |
| 1    | IO_L35P_1          | F18        | I/O   |
| 1    | IO_L36N_1          | E20        | I/O   |
| 1    | IO_L36P_1          | E19        | I/O   |
| 1    | IO_L37N_1/LDC0     | C21        | DUAL  |
| 1    | IO_L37P_1/HDC      | C22        | DUAL  |
| 1    | IO_L38N_1/LDC2     | B21        | DUAL  |
| 1    | IO_L38P_1/LDC1     | B22        | DUAL  |
| 1    | IP                 | D20        | INPUT |
| 1    | IP                 | F21        | INPUT |
| 1    | IP                 | G16        | INPUT |
| 1    | IP                 | H16        | INPUT |
| 1    | IP                 | J16        | INPUT |
| 1    | IP                 | J22        | INPUT |
| 1    | IP                 | K20        | INPUT |
| 1    | IP                 | L15        | INPUT |
| 1    | IP                 | M18        | INPUT |
| 1    | IP                 | N15        | INPUT |
| 1    | IP                 | N21        | INPUT |
| 1    | IP                 | P20        | INPUT |
| 1    | IP                 | R15        | INPUT |
| 1    | IP                 | T17        | INPUT |
| 1    | IP                 | T20        | INPUT |
| 1    | IP                 | U18        | INPUT |
| 1    | IP/VREF_1          | D21        | VREF  |
| 1    | IP/VREF_1          | L17        | VREF  |
| 1    | VCCO_1             | E21        | VCCO  |
| 1    | VCCO_1             | H18        | VCCO  |

Table 153: FG484 Package Pinout (Cont'd)

| Bank | XC3S1600E Pin Name   | FG484 Ball | Type |
|------|----------------------|------------|------|
| 1    | VCCO_1               | K21        | VCCO |
| 1    | VCCO_1               | L16        | VCCO |
| 1    | VCCO_1               | P21        | VCCO |
| 1    | VCCO_1               | R17        | VCCO |
| 1    | VCCO_1               | V21        | VCCO |
| 2    | IO                   | Y8         | I/O  |
| 2    | IO                   | Y9         | I/O  |
| 2    | IO                   | AA10       | I/O  |
| 2    | IO                   | AB5        | I/O  |
| 2    | IO                   | AB13       | I/O  |
| 2    | IO                   | AB14       | I/O  |
| 2    | IO                   | AB16       | I/O  |
| 2    | IO                   | AB18       | I/O  |
| 2    | IO/D5                | AB11       | DUAL |
| 2    | IO/M1                | AA12       | DUAL |
| 2    | IO/VREF_2            | AB4        | VREF |
| 2    | IO/VREF_2            | AB21       | VREF |
| 2    | IO_L01N_2/INIT_B     | AB3        | DUAL |
| 2    | IO_L01P_2/CSO_B      | AA3        | DUAL |
| 2    | IO_L03N_2/MOSI/CSI_B | Y5         | DUAL |
| 2    | IO_L03P_2/DOUT/BUSY  | W5         | DUAL |
| 2    | IO_L04N_2            | W6         | I/O  |
| 2    | IO_L04P_2            | V6         | I/O  |
| 2    | IO_L06N_2            | W7         | I/O  |
| 2    | IO_L06P_2            | Y7         | I/O  |
| 2    | IO_L07N_2            | U7         | I/O  |
| 2    | IO_L07P_2            | V7         | I/O  |
| 2    | IO_L09N_2/VREF_2     | V8         | VREF |
| 2    | IO_L09P_2            | W8         | I/O  |
| 2    | IO_L10N_2            | T8         | I/O  |
| 2    | IO_L10P_2            | U8         | I/O  |
| 2    | IO_L11N_2            | AB8        | I/O  |
| 2    | IO_L11P_2            | AA8        | I/O  |
| 2    | IO_L12N_2            | W9         | I/O  |
| 2    | IO_L12P_2            | V9         | I/O  |
| 2    | IO_L13N_2/VREF_2     | R9         | VREF |
| 2    | IO_L13P_2            | T9         | I/O  |
| 2    | IO_L14N_2            | AB9        | I/O  |
| 2    | IO_L14P_2            | AB10       | I/O  |
| 2    | IO_L16N_2            | U10        | I/O  |
| 2    | IO_L16P_2            | T10        | I/O  |
| 2    | IO_L17N_2            | R10        | I/O  |
| 2    | IO_L17P_2            | P10        | I/O  |

Table 153: FG484 Package Pinout (Cont'd)

| Bank | XC3S1600E Pin Name  | FG484 Ball | Type      |
|------|---------------------|------------|-----------|
| 2    | IO_L19N_2/D6/GCLK13 | U11        | DUAL/GCLK |
| 2    | IO_L19P_2/D7/GCLK12 | V11        | DUAL/GCLK |
| 2    | IO_L20N_2/D3/GCLK15 | T11        | DUAL/GCLK |
| 2    | IO_L20P_2/D4/GCLK14 | R11        | DUAL/GCLK |
| 2    | IO_L22N_2/D1/GCLK3  | W12        | DUAL/GCLK |
| 2    | IO_L22P_2/D2/GCLK2  | Y12        | DUAL/GCLK |
| 2    | IO_L23N_2/DIN/D0    | U12        | DUAL      |
| 2    | IO_L23P_2/M0        | V12        | DUAL      |
| 2    | IO_L25N_2           | Y13        | I/O       |
| 2    | IO_L25P_2           | W13        | I/O       |
| 2    | IO_L26N_2/VREF_2    | U14        | VREF      |
| 2    | IO_L26P_2           | U13        | I/O       |
| 2    | IO_L27N_2           | T14        | I/O       |
| 2    | IO_L27P_2           | R14        | I/O       |
| 2    | IO_L28N_2           | Y14        | I/O       |
| 2    | IO_L28P_2           | AA14       | I/O       |
| 2    | IO_L29N_2           | W14        | I/O       |
| 2    | IO_L29P_2           | V14        | I/O       |
| 2    | IO_L30N_2           | AB15       | I/O       |
| 2    | IO_L30P_2           | AA15       | I/O       |
| 2    | IO_L32N_2           | W15        | I/O       |
| 2    | IO_L32P_2           | Y15        | I/O       |
| 2    | IO_L33N_2           | U16        | I/O       |
| 2    | IO_L33P_2           | V16        | I/O       |
| 2    | IO_L35N_2/A22       | AB17       | DUAL      |
| 2    | IO_L35P_2/A23       | AA17       | DUAL      |
| 2    | IO_L36N_2           | W17        | I/O       |
| 2    | IO_L36P_2           | Y17        | I/O       |
| 2    | IO_L38N_2/A20       | Y18        | DUAL      |
| 2    | IO_L38P_2/A21       | W18        | DUAL      |
| 2    | IO_L39N_2/VS1/A18   | AA20       | DUAL      |
| 2    | IO_L39P_2/VS2/A19   | AB20       | DUAL      |
| 2    | IO_L40N_2/CCLK      | W19        | DUAL      |
| 2    | IO_L40P_2/VS0/A17   | Y19        | DUAL      |
| 2    | IP                  | V17        | INPUT     |
| 2    | IP                  | AB2        | INPUT     |
| 2    | IP_L02N_2           | AA4        | INPUT     |
| 2    | IP_L02P_2           | Y4         | INPUT     |
| 2    | IP_L05N_2           | Y6         | INPUT     |
| 2    | IP_L05P_2           | AA6        | INPUT     |

Table 153: FG484 Package Pinout (Cont'd)

| Bank | XC3S1600E Pin Name      | FG484 Ball | Type      |
|------|-------------------------|------------|-----------|
| 2    | IP_L08N_2               | AB7        | INPUT     |
| 2    | IP_L08P_2               | AB6        | INPUT     |
| 2    | IP_L15N_2               | Y10        | INPUT     |
| 2    | IP_L15P_2               | W10        | INPUT     |
| 2    | IP_L18N_2/VREF_2        | AA11       | VREF      |
| 2    | IP_L18P_2               | Y11        | INPUT     |
| 2    | IP_L21N_2/M2/GCLK1      | P12        | DUAL/GCLK |
| 2    | IP_L21P_2/RDWR_B/ GCLK0 | R12        | DUAL/GCLK |
| 2    | IP_L24N_2               | R13        | INPUT     |
| 2    | IP_L24P_2               | T13        | INPUT     |
| 2    | IP_L31N_2/VREF_2        | T15        | VREF      |
| 2    | IP_L31P_2               | U15        | INPUT     |
| 2    | IP_L34N_2               | Y16        | INPUT     |
| 2    | IP_L34P_2               | W16        | INPUT     |
| 2    | IP_L37N_2               | AA19       | INPUT     |
| 2    | IP_L37P_2               | AB19       | INPUT     |
| 2    | VCCO_2                  | T12        | VCCO      |
| 2    | VCCO_2                  | U9         | VCCO      |
| 2    | VCCO_2                  | V15        | VCCO      |
| 2    | VCCO_2                  | AA5        | VCCO      |
| 2    | VCCO_2                  | AA9        | VCCO      |
| 2    | VCCO_2                  | AA13       | VCCO      |
| 2    | VCCO_2                  | AA18       | VCCO      |
| 3    | IO_L01N_3               | C1         | I/O       |
| 3    | IO_L01P_3               | C2         | I/O       |
| 3    | IO_L02N_3/VREF_3        | D2         | VREF      |
| 3    | IO_L02P_3               | D3         | I/O       |
| 3    | IO_L03N_3               | E3         | I/O       |
| 3    | IO_L03P_3               | E4         | I/O       |
| 3    | IO_L04N_3               | E1         | I/O       |
| 3    | IO_L04P_3               | D1         | I/O       |
| 3    | IO_L05N_3               | F4         | I/O       |
| 3    | IO_L05P_3               | F3         | I/O       |
| 3    | IO_L06N_3               | G5         | I/O       |
| 3    | IO_L06P_3               | G4         | I/O       |
| 3    | IO_L07N_3               | F1         | I/O       |
| 3    | IO_L07P_3               | G1         | I/O       |
| 3    | IO_L08N_3/VREF_3        | G6         | VREF      |
| 3    | IO_L08P_3               | G7         | I/O       |
| 3    | IO_L09N_3               | H4         | I/O       |
| 3    | IO_L09P_3               | H5         | I/O       |
| 3    | IO_L10N_3               | H2         | I/O       |
| 3    | IO_L10P_3               | H3         | I/O       |

Table 153: FG484 Package Pinout (Cont'd)

| Bank | XC3S1600E Pin Name     | FG484 Ball | Type  |
|------|------------------------|------------|-------|
| 3    | IO_L11N_3              | H1         | I/O   |
| 3    | IO_L11P_3              | J1         | I/O   |
| 3    | IO_L12N_3              | J6         | I/O   |
| 3    | IO_L12P_3              | J5         | I/O   |
| 3    | IO_L13N_3/VREF_3       | J3         | VREF  |
| 3    | IO_L13P_3              | K3         | I/O   |
| 3    | IO_L14N_3              | J8         | I/O   |
| 3    | IO_L14P_3              | K8         | I/O   |
| 3    | IO_L15N_3              | K4         | I/O   |
| 3    | IO_L15P_3              | K5         | I/O   |
| 3    | IO_L16N_3              | K1         | I/O   |
| 3    | IO_L16P_3              | L1         | I/O   |
| 3    | IO_L17N_3              | L7         | I/O   |
| 3    | IO_L17P_3              | K7         | I/O   |
| 3    | IO_L18N_3/LHCLK1       | L5         | LHCLK |
| 3    | IO_L18P_3/LHCLK0       | M5         | LHCLK |
| 3    | IO_L19N_3/LHCLK3/IRDY2 | M8         | LHCLK |
| 3    | IO_L19P_3/LHCLK2       | L8         | LHCLK |
| 3    | IO_L20N_3/LHCLK5       | N1         | LHCLK |
| 3    | IO_L20P_3/LHCLK4/IRDY2 | M1         | LHCLK |
| 3    | IO_L21N_3/LHCLK7       | M4         | LHCLK |
| 3    | IO_L21P_3/LHCLK6       | M3         | LHCLK |
| 3    | IO_L22N_3              | N6         | I/O   |
| 3    | IO_L22P_3              | N7         | I/O   |
| 3    | IO_L23N_3              | P8         | I/O   |
| 3    | IO_L23P_3              | N8         | I/O   |
| 3    | IO_L24N_3/VREF_3       | N4         | VREF  |
| 3    | IO_L24P_3              | N5         | I/O   |
| 3    | IO_L25N_3              | P2         | I/O   |
| 3    | IO_L25P_3              | P1         | I/O   |
| 3    | IO_L26N_3              | R7         | I/O   |
| 3    | IO_L26P_3              | P7         | I/O   |
| 3    | IO_L27N_3              | P6         | I/O   |
| 3    | IO_L27P_3              | P5         | I/O   |
| 3    | IO_L28N_3              | R2         | I/O   |
| 3    | IO_L28P_3              | R1         | I/O   |
| 3    | IO_L29N_3              | R3         | I/O   |
| 3    | IO_L29P_3              | R4         | I/O   |
| 3    | IO_L30N_3              | T6         | I/O   |
| 3    | IO_L30P_3              | R6         | I/O   |
| 3    | IO_L31N_3              | U2         | I/O   |
| 3    | IO_L31P_3              | U1         | I/O   |
| 3    | IO_L32N_3              | T4         | I/O   |
| 3    | IO_L32P_3              | T5         | I/O   |

Table 153: FG484 Package Pinout (Cont'd)

| Bank | XC3S1600E Pin Name | FG484 Ball | Type  |
|------|--------------------|------------|-------|
| 3    | IO_L33N_3          | W1         | I/O   |
| 3    | IO_L33P_3          | V1         | I/O   |
| 3    | IO_L34N_3          | U4         | I/O   |
| 3    | IO_L34P_3          | U3         | I/O   |
| 3    | IO_L35N_3          | V4         | I/O   |
| 3    | IO_L35P_3          | V3         | I/O   |
| 3    | IO_L36N_3/VREF_3   | W3         | VREF  |
| 3    | IO_L36P_3          | W2         | I/O   |
| 3    | IO_L37N_3          | Y2         | I/O   |
| 3    | IO_L37P_3          | Y1         | I/O   |
| 3    | IO_L38N_3          | AA1        | I/O   |
| 3    | IO_L38P_3          | AA2        | I/O   |
| 3    | IP                 | F2         | INPUT |
| 3    | IP                 | F5         | INPUT |
| 3    | IP                 | G3         | INPUT |
| 3    | IP                 | H7         | INPUT |
| 3    | IP                 | J7         | INPUT |
| 3    | IP                 | K2         | INPUT |
| 3    | IP                 | K6         | INPUT |
| 3    | IP                 | M2         | INPUT |
| 3    | IP                 | M6         | INPUT |
| 3    | IP                 | N3         | INPUT |
| 3    | IP                 | P3         | INPUT |
| 3    | IP                 | R8         | INPUT |
| 3    | IP                 | T1         | INPUT |
| 3    | IP                 | T7         | INPUT |
| 3    | IP                 | U5         | INPUT |
| 3    | IP                 | W4         | INPUT |
| 3    | IP/VREF_3          | L3         | VREF  |
| 3    | IP/VREF_3          | T3         | VREF  |
| 3    | VCCO_3             | E2         | VCCO  |
| 3    | VCCO_3             | H6         | VCCO  |
| 3    | VCCO_3             | J2         | VCCO  |
| 3    | VCCO_3             | M7         | VCCO  |
| 3    | VCCO_3             | N2         | VCCO  |
| 3    | VCCO_3             | R5         | VCCO  |
| 3    | VCCO_3             | V2         | VCCO  |
| GND  | GND                | A1         | GND   |
| GND  | GND                | A11        | GND   |
| GND  | GND                | A22        | GND   |
| GND  | GND                | B7         | GND   |
| GND  | GND                | B16        | GND   |
| GND  | GND                | C3         | GND   |
| GND  | GND                | C20        | GND   |

Table 153: FG484 Package Pinout (Cont'd)

| Bank | XC3S1600E Pin Name | FG484 Ball | Type |
|------|--------------------|------------|------|
| GND  | GND                | E10        | GND  |
| GND  | GND                | E13        | GND  |
| GND  | GND                | F6         | GND  |
| GND  | GND                | F17        | GND  |
| GND  | GND                | G2         | GND  |
| GND  | GND                | G21        | GND  |
| GND  | GND                | J4         | GND  |
| GND  | GND                | J9         | GND  |
| GND  | GND                | J12        | GND  |
| GND  | GND                | J14        | GND  |
| GND  | GND                | J19        | GND  |
| GND  | GND                | K10        | GND  |
| GND  | GND                | K12        | GND  |
| GND  | GND                | L2         | GND  |
| GND  | GND                | L6         | GND  |
| GND  | GND                | L9         | GND  |
| GND  | GND                | L13        | GND  |
| GND  | GND                | M10        | GND  |
| GND  | GND                | M14        | GND  |
| GND  | GND                | M17        | GND  |
| GND  | GND                | M21        | GND  |
| GND  | GND                | N11        | GND  |
| GND  | GND                | N13        | GND  |
| GND  | GND                | P4         | GND  |
| GND  | GND                | P9         | GND  |
| GND  | GND                | P11        | GND  |
| GND  | GND                | P14        | GND  |
| GND  | GND                | P19        | GND  |
| GND  | GND                | T2         | GND  |
| GND  | GND                | T21        | GND  |
| GND  | GND                | U6         | GND  |
| GND  | GND                | U17        | GND  |
| GND  | GND                | V10        | GND  |
| GND  | GND                | V13        | GND  |
| GND  | GND                | Y3         | GND  |
| GND  | GND                | Y20        | GND  |
| GND  | GND                | AA7        | GND  |
| GND  | GND                | AA16       | GND  |

Table 153: FG484 Package Pinout (Cont'd)

| Bank   | XC3S1600E Pin Name | FG484 Ball | Type   |
|--------|--------------------|------------|--------|
| GND    | GND                | AB1        | GND    |
| GND    | GND                | AB12       | GND    |
| GND    | GND                | AB22       | GND    |
| VCCAUX | DONE               | AA21       | CONFIG |
| VCCAUX | PROG_B             | B1         | CONFIG |
| VCCAUX | TCK                | E17        | JTAG   |
| VCCAUX | TDI                | B2         | JTAG   |
| VCCAUX | TDO                | B20        | JTAG   |
| VCCAUX | TMS                | D19        | JTAG   |
| VCCAUX | VCCAUX             | D12        | VCCAUX |
| VCCAUX | VCCAUX             | E5         | VCCAUX |
| VCCAUX | VCCAUX             | E18        | VCCAUX |
| VCCAUX | VCCAUX             | K14        | VCCAUX |
| VCCAUX | VCCAUX             | L4         | VCCAUX |
| VCCAUX | VCCAUX             | M19        | VCCAUX |
| VCCAUX | VCCAUX             | N9         | VCCAUX |
| VCCAUX | VCCAUX             | V5         | VCCAUX |
| VCCAUX | VCCAUX             | V18        | VCCAUX |
| VCCAUX | VCCAUX             | W11        | VCCAUX |
| VCCINT | VCCINT             | J10        | VCCINT |
| VCCINT | VCCINT             | K9         | VCCINT |
| VCCINT | VCCINT             | K11        | VCCINT |
| VCCINT | VCCINT             | K13        | VCCINT |
| VCCINT | VCCINT             | L10        | VCCINT |
| VCCINT | VCCINT             | L11        | VCCINT |
| VCCINT | VCCINT             | L12        | VCCINT |
| VCCINT | VCCINT             | L14        | VCCINT |
| VCCINT | VCCINT             | M9         | VCCINT |
| VCCINT | VCCINT             | M11        | VCCINT |
| VCCINT | VCCINT             | M12        | VCCINT |
| VCCINT | VCCINT             | M13        | VCCINT |
| VCCINT | VCCINT             | N10        | VCCINT |
| VCCINT | VCCINT             | N12        | VCCINT |
| VCCINT | VCCINT             | N14        | VCCINT |
| VCCINT | VCCINT             | P13        | VCCINT |

## User I/Os by Bank

Table 154 indicates how the 304 available user-I/O pins are distributed between the four I/O banks on the FG484 package.

Table 154: User I/Os Per Bank for the XC3S1600E in the FG484 Package

| Package Edge | I/O Bank | Maximum I/O | All Possible I/O Pins by Type |           |           |                     |                    |
|--------------|----------|-------------|-------------------------------|-----------|-----------|---------------------|--------------------|
|              |          |             | I/O                           | INPUT     | DUAL      | VREF <sup>(1)</sup> | CLK <sup>(2)</sup> |
| Top          | 0        | 94          | 56                            | 22        | 1         | 7                   | 8                  |
| Right        | 1        | 94          | 50                            | 16        | 21        | 7                   | 0 <sup>(2)</sup>   |
| Bottom       | 2        | 94          | 45                            | 18        | 24        | 7                   | 0 <sup>(2)</sup>   |
| Left         | 3        | 94          | 63                            | 16        | 0         | 7                   | 8                  |
| <b>TOTAL</b> |          | <b>376</b>  | <b>214</b>                    | <b>72</b> | <b>46</b> | <b>28</b>           | <b>16</b>          |

**Notes:**

1. Some VREF and CLK pins are on INPUT pins.
2. The eight global clock pins in this bank have optional functionality during configuration and are counted in the DUAL column.

**Footprint Migration Differences**

The XC3S1600E FPGA is the only Spartan-3E device offered in the FG484 package.

## FG484 Footprint

Left Half of Package  
(top view)

- 214 **I/O:** Unrestricted, general-purpose user I/O
- 72 **INPUT:** User I/O or reference resistor input for bank
- 46 **DUAL:** Configuration pin, then possible user I/O
- 28 **VREF:** User I/O or input voltage reference for bank
- 16 **CLK:** User I/O, input, or clock buffer input
- 2 **CONFIG:** Dedicated configuration pins
- 4 **JTAG:** Dedicated JTAG port pins
- 48 **GND:** Ground
- 28 **VCCO:** Output voltage supply for bank
- 16 **VCCINT:** Internal core supply voltage (+1.2V)
- 10 **VCCAUX:** Auxiliary supply voltage (+2.5V)
- 0 **N.C.:** Not connected

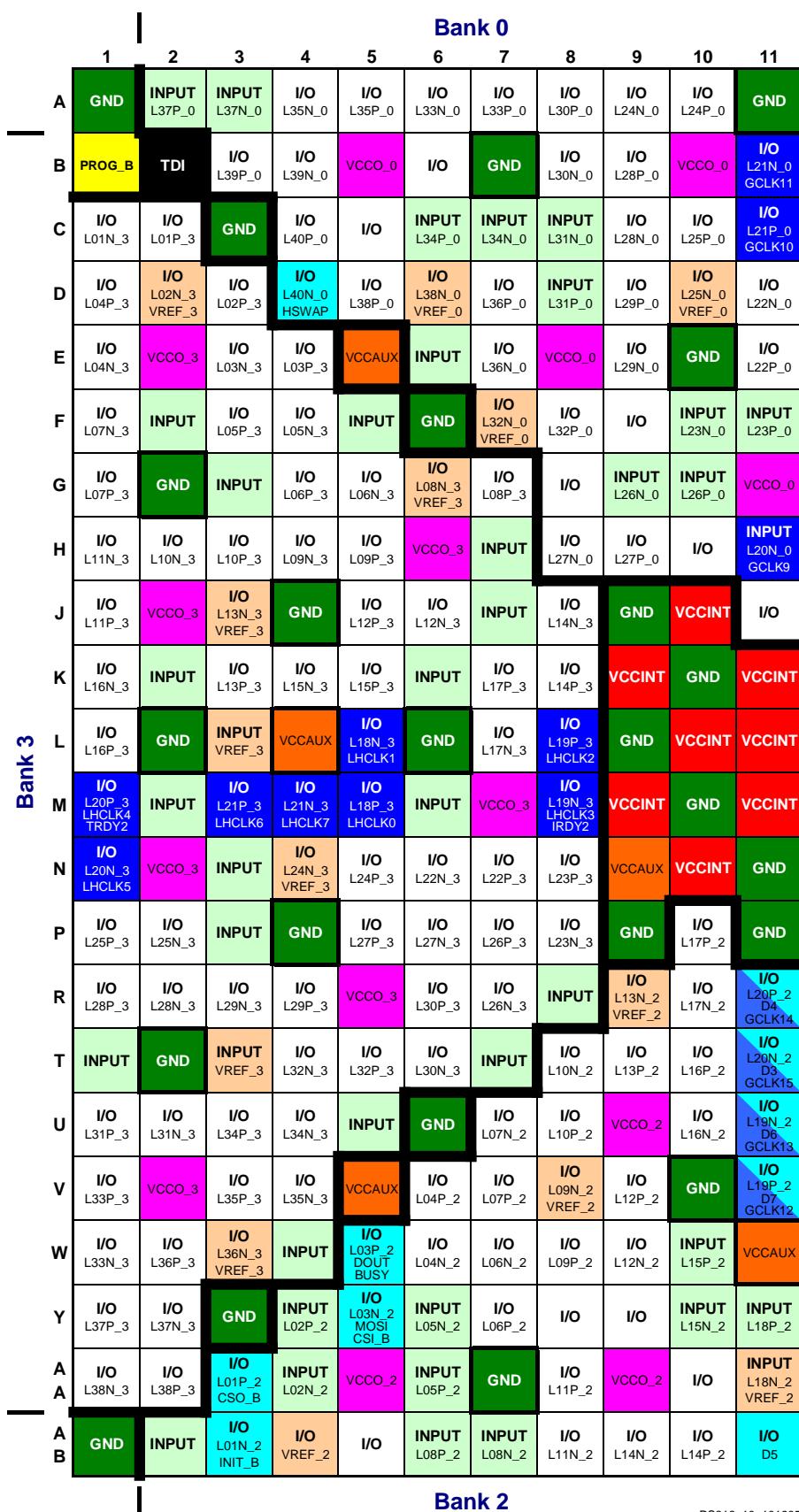
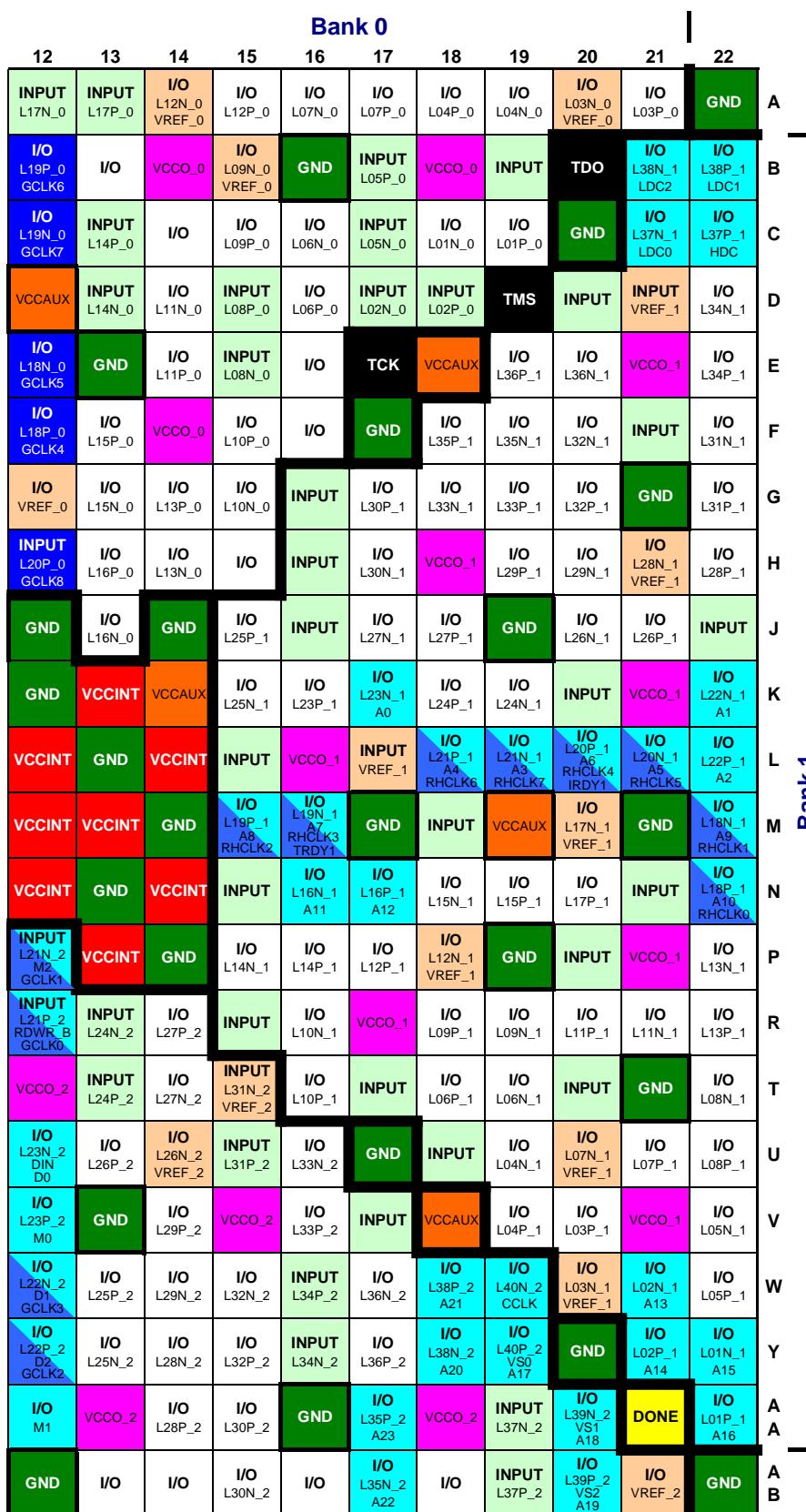


Figure 88: FG484 Package Footprint (top view)

**FG484 Footprint****Right Half of Package  
(top view)**

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## Revision History

The following table shows the revision history for this document.

| Date       | Version | Revision  |
|------------|---------|---|
| 03/01/2005 | 1.0     | Initial Xilinx release.   |
| 03/21/2005 | 1.1     | Added XC3S250E in the CP132 package to <a href="#">Table 128</a> . Corrected number of differential I/O pairs on CP132. Added pinout and footprint information for the CP132, FG400, and FG484 packages. Removed IRDY and TRDY pins from the VQ100, TQ144, and PQ208 packages.  |
| 11/23/2005 | 2.0     | Corrected title of <a href="#">Table 152</a> . Updated differential pair numbering for some pins in Bank 0 of the FG400 package, affecting <a href="#">Table 151</a> and <a href="#">Figure 87</a> . Pin functionality and ball assignment were not affected. Added <a href="#">Package Thermal Characteristics</a> section. Added package mass values to <a href="#">Table 125</a> .   |
| 03/22/2006 | 3.0     | Included I/O pins, not just input-only pins under the VREF description in <a href="#">Table 124</a> . Clarified that some global clock inputs are Input-only pins in <a href="#">Table 124</a> . Added information on the XC3S100E in the CP132 package, affecting <a href="#">Table 128</a> , <a href="#">Table 129</a> , <a href="#">Table 132</a> , <a href="#">Table 133</a> , <a href="#">Table 135</a> , and <a href="#">Figure 81</a> . Ball A12 on the XC3S1600E in the FG320 package a full I/O pin, not an Input-only pin. Corrected the I/O counts for the XC3S1600E in the FG320 package, affecting <a href="#">Table 128</a> , <a href="#">Table 149</a> , <a href="#">Table 150</a> , and <a href="#">Figure 86</a> . Corrected pin type for XC3S1600E balls N14 and N15 in <a href="#">Table 147</a> . |
| 05/19/2006 | 3.1     | Minor text edits.   |
| 11/09/2006 | 3.4     | Added package thermal data for the XC3S100E in the CP132 package to <a href="#">Table 129</a> . Corrected pin migration arrows for balls E17 and F4 between the XC3S500E and XC3S1600E in <a href="#">Table 150</a> . Promoted Module 4 to Production status. Synchronized all modules to v3.4.   |
| 03/16/2007 | 3.5     | Minor formatting changes.   |
| 05/29/2007 | 3.6     | Corrected 'Lxx' to 'Lxx' in <a href="#">Table 124</a> . Noted that some GCLK and VREF pins are on INPUT pins in <a href="#">Table 124</a> and <a href="#">Table 128</a> . Added link before Table 127 to Material Declaration Data Sheets.  |
| 04/18/2008 | 3.7     | Added XC3S500E VQG100 package. Added Material Declaration Data Sheet links in Table 127. Updated Thermal Characteristics in <a href="#">Table 129</a> . Updated links.  |
| 08/26/2009 | 3.8     | Minor typographical updates.  |
| 10/29/2012 | 4.0     | Added <a href="#">Notice of Disclaimer</a> . This product is not recommended for new designs. Updated the XC3S250E-FT256 in <a href="#">Table 128</a> .   |
| 07/19/2013 | 4.1     | Removed banner. This product IS recommended for new designs.  |
| 12/14/2018 | 4.2     | Updated for <a href="#">Lead-Frame Plating Composition Change For Legacy Eutectic Products (XCN18024)</a> . Updated <a href="#">Table 125</a> and <a href="#">Note 1</a> . Updated the <a href="#">Mechanical Drawings</a> section and removed Table 127.   |

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