

# **Cyclone III FPGA Starter Kit**

## **User Guide**



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P25-36228-02

**Document Version:** Document Date:

1.2 July 2010

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Part Number UG-01018-1.2

Altera Corporation July 2010

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## 1. Getting Started

## Introduction

Welcome to the Altera<sup>®</sup> Cyclone<sup>®</sup> III FPGA Starter Kit, which includes a full-featured field-programmable gate array (FPGA) development board, hardware and software development tools, documentation, and accessories needed to begin FPGA development.

The development board includes an Altera Cyclone III FPGA and comes preconfigured with a hardware reference design stored in flash memory. You can use the development board as a platform to prototype a variety of FPGA designs.

The starter kit provides an integrated control environment that includes a software controller in a control panel application, a USB command controller, a multi-port SRAM/DDR SDRAM/flash memory controller, and example designs specified in Verilog code. You can use this design as a starting point for test designs.

This user guide addresses the following topics:

- How to set up, power up, and verify correct operation of the development board.
- How to install the Cyclone III FPGA Starter Kit.
- How to install the Altera<sup>®</sup> Quartus II Web Edition software.
- How to set up and use the control panel, a graphical user interface (GUI), to manipulate components on the board, implement applications.
- How to configure the Cyclone III FPGA.
- How to set up and run example designs.

For complete details on the development board, refer to the *Cyclone III FPGA Starter Board Reference Manual*.

| Before You | Before proceeding, check the contents of the kit:   |
|------------|---|
| Begin      | <ul> <li>Cyclone III FPGA Starter Development Board</li> <li>12-V DC power supply</li> <li>USB cable</li> </ul> |

For the most up-to-date information on this product, visit the Altera website at www.altera.com/products/devkits/altera/kit-cyc3-starter.html.

## Further Information

For other related information, refer to the following websites:

| For More Information About                               | Refer To  |
|--|---|
| Additional daughter cards<br>available for purchase      | www.altera.com/products/devkits/<br>kit-daughter_boards.jsp             |
| Cyclone III handbook                                     | www.altera.com/literature/lit-cyc3.jsp                                  |
| Cyclone III reference designs                            | http://www.altera.com/products/devkits/altera/kit-<br>cyc3-starter.html |
| eStore if you want to<br>purchase devices                | www.altera.com/buy/devices/buy-devices.html                             |
| Cyclone III Orcad symbols                                | www.altera.com/support/software/download/pcb/<br>pcbpcb_index.html      |
| Nios <sup>®</sup> II 32-bit embedded processor solutions | www.altera.com/technology/embedded/<br>emb-index.html                   |

## Software Installation

This section describes the following procedures:

- "Installing the Cyclone III FPGA Starter Kit"
- "Installing the Quartus II Web Edition Software" on page 1–4

#### Installing the Cyclone III FPGA Starter Kit

The license-free Cyclone III FPGA Starter Kit installer includes all the documentation and design examples for the kit.

To install the Cyclone III FPGA Starter Kit, follow these steps:

1. Download the Cyclone III FPGA Starter Kit installer from the Cyclone III FPGA Starter Kit page of the Altera website. Alternatively, you can request a development kit DVD from the Development Kits, Daughter Cards & Programming Hardware page of the Altera website.

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2. Follow the on-screen instructions to complete the installation process.

The installation program creates the Cyclone III FPGA Starter Kit directory structure shown in Figure 1–1.

Figure 1–1. Cyclone III FPGA Starter Kit Default Installed Directory Structure

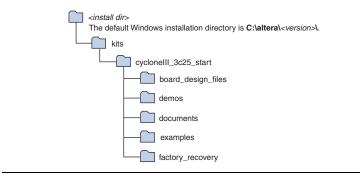


Table 1–1 lists the file directory names and a description of their contents.

| Table 1–1. Installe | ed Directory Contents  |
|---------------------|--|
| Directory Name      | Description of Contents  |
| board_design_files  | Contains schematic, layout, assembly, and bill of material board design files. Use these files as a starting point for a new prototype board design. |
| demos               | Contains demonstration projects that may or may not contain up-to-date source code.  |
| documents           | Contains the development kit documentation.  |
| examples            | Contains the example design files for the Cyclone III FPGA Starter Kit   |
| factory_recovery    | Contains programming files for returning board to factory default condition.   |

#### Installing the Quartus II Web Edition Software

The Quartus II Web Edition software provides the necessary tools for developing hardware and software for Altera FPGAs. Included in the Quartus II Web Edition software are the Quartus II software, the Nios II EDS, and the MegaCore<sup>®</sup> IP Library. The Quartus II software (including SOPC Builder) and the Nios II EDS are the primary FPGA development tools for creating the reference designs in this kit.

To install the Quartus II Web Edition software, follow these steps:

- 1. Download the Quartus II Web Edition software from the Quartus II Web Edition Software page of the Altera website. Alternatively, you can request a DVD from the Altera IP and Software DVD Request Form page of the Altera website.
- 2. Follow the on-screen instructions to complete the installation process.
  - If you have difficulty installing the Quartus II software, refer to Quartus II Installation & Licensing for Windows and Linux Workstations.

The Quartus II Web Edition software includes the following items:

- Quartus II software—The Quartus II software, including the SOPC Builder system development tool, provides a comprehensive environment for system-on-a-programmable-chip (SOPC) design. The Quartus II software integrates into nearly any design environment and provides interfaces to industry-standard EDA tools.
  - To compare the Quartus II subscription and web editions, refer to *Altera Quartus II Software—Subscription Edition vs. Web Edition.* The kit also works with the subscription edition.
- MegaCore IP Library—A library that contains Altera IP MegaCore functions. You can evaluate MegaCore functions with the OpenCore Plus feature to perform the following tasks:
  - Simulate behavior of a MegaCore function in your system
  - Verify functionality of your design, and quickly and easily evaluate its size and speed
  - Generate time-limited device programming files for designs that include MegaCore functions
  - Program a device and verify your design in hardware

The OpenCore Plus hardware evaluation feature is an evaluation tool for prototyping only. You must purchase a license to use a MegaCore function in production.



- For more information about OpenCore Plus, refer to *AN 320: OpenCore Plus Evaluation of Megafunctions*.
- Nios® II Embedded Design Suite (EDS)—A full-featured tool set that allows you to develop embedded software for the Nios II processor which you can include in your Altera FPGA designs.

#### Licensing Considerations

The Quartus II Web Edition software is license-free and supports Cyclone III devices without any additional licensing requirement. This kit also works with the Quartus II Subscription Edition software, after you obtain the proper license file. To purchase a subscription, contact your Altera sales representative.



## 2. Development Board and Control Panel Setup

## Development Board Setup

The development board is preloaded with an example design to demonstrate the Cyclone<sup>®</sup> III device and board features. At power-up, the preloaded design also enables you to quickly confirm that the board is operating correctly.

Figure 2–1 shows the Cyclone III development board layout and components.

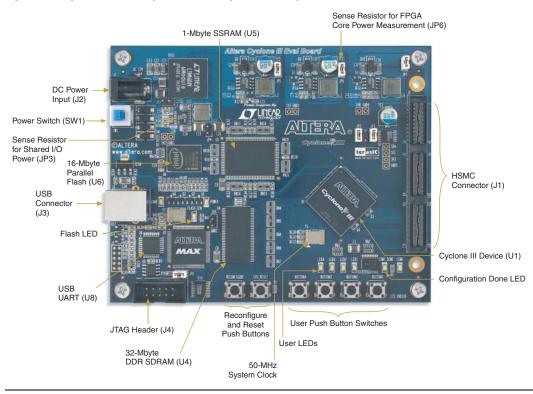


Figure 2–1. Cyclone III Development Board Layout and Components

#### Requirements

Before you proceed, ensure that the follwing items are installed:

- Altera<sup>®</sup> Quartus<sup>®</sup> II software on the host computer
- Cyclone III FPGA Starter Kit
- USB-Blaster<sup>TM</sup> driver software on the host computer. The Cyclone III FPGA starter development board includes an integrated USB-Blaster circuitry for FPGA programming.

#### **Powering Up the Development Board**

To power-up the development board, follow these steps:

- 1. Ensure that the ON/OFF switch (SW1) is in the OFF position (up).
- 2. Connect the USB-Blaster cable from the host computer to the USB-Blaster port on the development board.
- 3. Connect the 12-V DC adapter to the development board and to a power source.



Only use the supplied 12-V power supply. Power regulation circuitry on the board could be damaged by supplies greater than 12 V.

- 4. Press the power switch (SW1).
- 5. Confirm that all four user LEDs are ON.

## Installing the USB-Blaster Driver

The Cyclone III FPGA development board includes an integrated USB-Blaster circuitry for FPGA programming. However, for the host computer and board to communicate, you must install the USB-Blaster driver on the host computer.

Installation instructions for the USB-Blaster driver are available on the Altera website at www.altera.com/support/software/drivers/ dri-index.html. On the "Altera Programming Cable Driver Information" page of the Altera website, locate the table entry for your configuration and click the link to access the instructions.

## Control Panel Setup

Setting up the control panel involves the following:

- Configuring the FPGA
- Starting the control panel
- Power up the board and ensure that is is operational.

For more information about using the control panel, refer to the "Using the Control Panel" chapter.

## Configuring the FPGA Using the Quartus II Programmer

You can use the Quartus II Programmer to configure the FPGA with a specific **.sof**. Before configuring the FPGA, ensure that the Quartus II Programmer and the USB-Blaster driver are installed on the host computer, the USB cable is connected to the development board, power to the board is on, and no other applications that use the JTAG chain are running.

To configure the Cyclone III FPGA, follow these steps:

- 1. Start the Quartus II Programmer.
- 2. Click Add File and select the path to the desired .sof.
- 3. Turn on the **Program/Configure** option for the added file.
- 4. Click **Start** to configure the selected file to the FPGA. Configuration is complete when the progress bar reaches 100%.



## 3. Using the Control Panel

## **Overview**

The control panel consists of the following:

- The graphical user interface (GUI) application on the host computer
- The standard Nios II hardware design running on the board's Cyclone III FPGA device

After installing the Cyclone III FPGA Starter Kit, you can locate the control panel for the hardware and software in the *<kit path>\demos\control\_panel* directory.

The design downloaded to the Cyclone III device implements a command controller that processes board commands sent over the USB-Blaster from the control panel. To perform the appropriate actions, the command controller communicates with the controller of the targeted board I/O device.

You can perform the following actions with the control panel:

- Light up LEDs
- Detect push button presses
- Read from and write to the DDR SDRAM, SRAM, flash memory, and on-chip RAM

The following sections describe how to perform the above actions with the control panel already open on the host computer. If not already open, launch the control panel as described in "Control Panel Start".

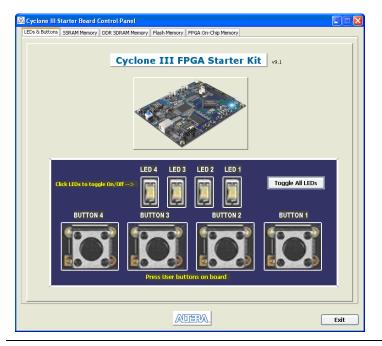
## Control Panel Start

The Cyclone III development board is shipped with an example design stored in the flash memory which configures the Cyclone III FPGA upon power-up with the standard Nios II design.

For an older version of the Cyclone III development board shipped with the Cyclone III FPGA Starter Kit v7.1.0, v7.2.0, or 8.0.0 application, you must manually configure the **cycloneIII\_3c25\_start\_niosII\_standard.sof** into the FPGA before launching the control panel application. You can locate the source for the example design in the *<kit path>\examples\cycloneIII\_3c25\_starter\_board\_standard* directory.

To launch the control panel user interface, run the **control\_panel.exe** program found in the *<kit path*>\**demos**\**control\_panel** directory (Figure 3–1).

Figure 3–1. Control Panel Window



## LEDs and Buttons

#### **Illuminating LEDs**

To illuminate an LED, follow these steps:

- 1. The **LED & Buttons** tab should be visible when the application runs. If it is not visible, click the **LED & Buttons** tab (Figure 3–2).
- 2. Click on LEDs to individually turn on the LEDs.

#### **Buttons Indicators**

1. Press the push-button switches on the board. Notice that buttons on the GUI change accordingly.

Figure 3–2. Control Panel Window for LEDs and Buttons



## DDR SDRAM/ SSRAM/On-Chip Controller

You can perform the following types of memory read/write operations with the control panel:

- Read from and write to the DDR SDRAM, SSRAM, or on-chip device
- Write entire contents of a file, to the DDR SDRAM, SSRAM, or on-chip device
- Read contents of the DDR SDRAM, SSRAM, or on-chip device, to a file

The following sections describe how to access the DDR SDRAM. You can use the same procedure to access the SSRAM.

#### **Read/Write Data**

To read from and write to the DDR SDRAM, follow these steps:

 Click the DDR SDRAM tab (Figure 3–3). The Address column indicates the hex address of the DDR SDRAM. The values inside the 0-3, 4-7, 8-B, and C-F columns are the DDR SDRAM contents in hex words format.

Figure 3–3. Control Panel DDR SDRAM Tab

|                  | J4) - 32MB (16 x             | DRAM Memory Flash | - //           | .hip Memory<br>100 to 0x5FFFF1 | T                   |
|------------------|------------------------------|-------------------|----------------|--------------------------------|---------------------|
| art Address: 020 | and the second second second | 24) Add 835       | range. 0x40000 |                                | Save File Load File |
| Address          | 0-3                          | 4 - 7             | 8 - B          | C - F                          | Data to Ascii-Text  |
| 2000000          | 00000000                     | 00000000          | 00000000       | 00000000                       |                     |
| 2000010          | FFFFFFFF                     | FFFFFFFF          | FFFFFFFF       | FFFFFFF                        |                     |
| 2000020          | 00000000                     | 00000000          | FFFFFFFF       | 00000000                       |                     |
| 2000030          | 00000000                     | 00000000          | 00000000       | FFFFFFFF                       |                     |
| 2000040          | OOFFOOFF                     | OOFFOOFF          | OOFFOOFF       | OOFFOOFF                       |                     |
| 2000050          | FFFF0000                     | FFFF0000          | FFFFFFFF       | FFFFFFFF                       |                     |
| 2000060          | 02020202                     | 03030303          | OOFFOOFF       | OOFFOOFF                       |                     |
| 2000070          | OOFFOOFF                     | OOFFOOFF          | OOFFOOFF       | OOFFOOFF                       |                     |
| 2000080          | OOFFOOFF                     | OOFFOOFF          | OOFFOOFF       | OOFFOOFF                       |                     |
| 2000090          | OOFFOOFF                     | OOFFOOFF          | OOFFOOFF       | OOFFOOFF                       |                     |
| 20000A0          | OOFFOOFF                     | OOFFOOFF          | OOFFOOFF       | OOFFOOFF                       |                     |
| 2000080          | OOFFOOFF                     | OOFFOOFF          | OOFFOOFF       | OOFFOOFF                       |                     |
| 20000c0          | OOFFOOFF                     | OOFFOOFF          | OOFFOOFF       | OOFFOOFF                       |                     |
| 20000D0          | OOFFOOFF                     | OOFFOOFF          | OOFFOOFF       | OOFFOOFF                       |                     |
| 20000E0          | OOFFOOFF                     | OOFFOOFF          | OOFFOOFF       | OOFFOOFF                       |                     |
| 20000F0          | OOFFOOFF                     | OOFFOOFF          | OOFFOOFF       | OOFFOOFF                       |                     |
| 2000100          | OOFFOOFF                     | OOFFOOFF          | OOFFOOFF       | OOFFOOFF                       |                     |
| 2000110          | OOFFOOFF                     | OOFFOOFF          | OOFFOOFF       | OOFFOOFF                       |                     |
| 2000120          | OOFFOOFF                     | OOFFOOFF          | OOFFOOFF       | OOFFOOFF                       |                     |
| 2000130          | OOFFOOFF                     | OOFFOOFF          | OOFFOOFF       | OOFFOOFF                       |                     |
| 2000140          | OOFFOOFF                     | OOFFOOFF          | OOFFOOFF       | OOFFOOFF                       |                     |
| 2000150          | OOFFOOFF                     | OOFFOOFF          | OOFFOOFF       | OOFFOOFF                       |                     |
| 2000160          | OOFFOOFF                     | OOFFOOFF          | OOFFOOFF       | OOFFOOFF                       |                     |
| 2000170          | OOFFOOFF                     | OOFFOOFF          | OOFFOOFF       | OOFFOOFF                       |                     |
| 2000180          | OOFFOOFF                     | OOFFOOFF          | OOFFOOFF       | OOFFOOFF                       |                     |
| 2000190          | OOFFOOFF                     | OOFFOOFF          | OOFFOOFF       | OOFFOOFF                       |                     |
| 20001A0          | OOFFOOFF                     | OOFFOOFF          | OOFFOOFF       | OOFFOOFF                       |                     |
| 20001B0          | OOFFOOFF                     | OOFFOOFF          | OOFFOOFF       | OOFFOOFF                       |                     |
| 20001C0          | OOFFOOFF                     | OOFFOOFF          | OOFFOOFF       | OOFFOOFF                       |                     |
| 20001D0          | OOFFOOFF                     | OOFFOOFF          | OOFFOOFF       | OOFFOOFF                       |                     |
| 20001E0          | OOFFOOFF                     | OOFFOOFF          | OOFFOOFF       | OOFFOOFF                       |                     |
|                  |                              |                   |                |                                |                     |

2. To write a 32-bit word to the DDR SDRAM, click the desired location, enter the desired value in hex format, and press **Enter**.

#### **Read from a File**

To read the contents of a file and load it to the DDR SDRAM, follow these steps:

- 1. Click Load File.
- 2. Browse to **sample.txt** located in the **control\_panel** directory and click **Open**. This step instantiates the DDR SDRAM controller and loads the text contents into the DDR SDRAM. Notice that the **Data to Ascii-text** column shows the DDR SDRAM contents in Ascii value.

#### Write to a File

To write the contents of the DDR SDRAM to a file, follow these steps:

- 1. Click Save File.
- 2. Enter the start and end addresses of the DDR SDRAM.
- 3. Choose a file name and click **Save**. This instantiates the controller to read the DDR SDRAM contents from the start address to the end address, and write the contents to a file.

## Flash Memory Programmer

You can perform the following operations to read from and write to the board's flash memory with the control panel:

- Perform a CFI query of flash memory
- Erase select blocks of flash memory
- Write 32-bit hex word to flash memory
- Write a binary file to flash memory
  - Load the contents of the flash memory into a file



Do not exit from the control panel while erasing the flash memory.

#### **Flash Memory Tab**

To use the flash memory functions, click the **Flash Memory** tab (Figure 3–4).

Figure 3–4. Control Panel Flash Memory Tab

| 000      | CFI Query   | Reset   | Frase Block  |  |
|----------|---|---|--|--|
|          |   |   | LI USE DIOLK   |  |
| 0-3      | 4 - 7   | 8 - B   | C - F  | Data to Ascii-Text   |
| 54686973 | 20697320  | 61207361  | 6D706C65   | This is a sample   |
| 20746578 | 74206669  | 6C652070  | 726F7669   | text file provi  |
| 64656420 | 666F7220  | 74686520  | 6578616D   | ded for the exam   |
| 706C6520 | 6F662077  | 72697469  | 6E672061   | ple of writing a   |
| 2066696C | 6520746F  | 206D656D  | 6F727920   | file to memory   |
| 7573696E | 6720416C  | 30217261  | 20437963   | using AlOira Cyc   |
| 6C6F6E65 | 20494949  | 20537461  | 72746572   | lone III Starter   |
| 20486974 | 20436F6E  | 74726F6C  | 2050616E   | Kit Control Pan  |
| 656C2061 | 70706069  | 63617469  | 6F6E2E20   | el application.  |
| 49662074 | 6865206D  | 656D6F72  | 79207772   | If the memory wr   |
| 69747465 | 6E20746F  | 20697320  | 466C6173   | itten to is Flas   |
| 68207468 | 6E652074  | 68652076  | 6F6C6174   | h thne the volat   |
| 696C6520 | 636F6E74  | 656E7473  | 2077696C   | ile contents wil   |
| 6C207065 | 72736973  | 74207570  | 6F6E2070   | l persist upon p   |
| 6F776572 | 20637963  | 6C696E67  | 20746865   | ower cycling the   |
| 20626F61 | 72642C20  | 486F7765  | 00000000   | board, Howe  |
| 74686973 | 2066696C  | 65206361  | 6E206265   | this file can be   |
| 20657261 | 73656420  | 62792063  | 6C69636B   | erased by click  |
| 696E6720 | 74686520  | 45726173  | 65206275   | ing the Erase bu   |
| 74746F6E | 2E204F74  | 68657220  | 6D656D6F   | tton. Other memo   |
| 20606160 | 2020606C  | 20206560  | 61726120   | `a` `l e`ara   |
| 7460616C | 63204064  | 64612061  | 20436120   | t`alc @dda a Ca  |
| 64686420 | 20494140  | 20006061  | 20706572   | dhd IA@ .`a per  |
| 20426164 | 20406F66  | 64224D64  | 20406068   | Bad @ofd"Md @`h  |
| 206C2061 | 60706869  | 00002061  | 616E2020   | l a`phi aan  |
| 41202064 | 68642065  | 64206F62  | 61206170   | A dhd ed oba ap  |
| 20602064 | 68206420  | 20692020  | 44686163   | `dh d i Dhac   |
| 68206420 | 68642074  | 68652060  | 6E646174   | h d hd the `ndat   |
| 69646520 | 60206264  | 646C7020  | 20656864   | ide `bddlp ehd   |
| 64206064 | 62206060  | 64206160  | 62622060   | d `db ``d a`bb `   |
| 64206460 | 20612062  | 6C606C61  | 20204865   | d d` a bl`la He  |
|          | 20746578<br>6455420<br>70666520<br>20666960<br>20466960<br>20486974<br>65622061<br>49662074<br>6572061<br>65776572<br>204267468<br>69207468<br>69207468<br>69207468<br>69207468<br>69207468<br>69207468<br>692074572<br>00506160<br>744566820<br>20426164<br>20622061<br>41202064 | $\begin{array}{cccccc} 20746578 & 74206669 \\ 6455420 & 66567220 \\ 706c6520 & 66662077 \\ 706c6520 & 6760416 \\ 6455420 & 6720416 \\ 73736956 & 6720416 \\ 6c676855 & 20494949 \\ 536c2051 & 70706c59 \\ 856c2051 & 70706c59 \\ 89620746 & 68552050 \\ 69747455 & 68207466 \\ 685207466 & 68552074 \\ 696c6520 & 63569674 \\ 6207466 & 68552074 \\ 6207665 & 72736973 \\ 67776572 & 20637963 \\ 20626761 & 72642020 \\ 74686973 & 2066696 \\ 2066510 & 2020605 \\ 7466673 & 206696 \\ 2066510 & 2020405 \\ 7466673 & 206646 \\ 2060516 & 6320406 \\ 20662164 & 2040676 \\ 20662164 & 2040676 \\ 20662046 & 68642074 \\ 20662046 & 68642074 \\ 2062064 & 68264207 \\ 68206420 & 68642074 \\ 2042066 & 6220606 \\ \end{array}$ | $\begin{array}{c} 20746578 & 74206669 & 6c52070 \\ 6455420 & 6667220 & 7468520 \\ 706c5520 & 6672077 & 72697469 \\ 2066696c & 6520746F & 2069569 \\ 70736968 & 6720416C & 30217261 \\ 6c676865 & 20494949 & 20537461 \\ 6c67686 & 205206 & 6550672 \\ 6c7776572 & 20637963 & 6c696867 \\ 72736973 & 74207370 & 6c696676 & 6520361 \\ 206520 & 6356420 & 665520 & 65562720 \\ 2066567 & 74586420 & 662792063 \\ 6c696672 & 74586520 & 45727657 \\ 20665670 & 74586420 & 662792063 \\ 6c686420 & 20290464 & 64612061 \\ 20426164 & 2049474 & 206051 \\ 20426164 & 20496766 & 64224064 \\ 20662164 & 204906766 & 64224064 \\ 20662164 & 204906766 & 64224064 \\ 20662616 & 65200665 & 642260661 \\ 202662064 & 682642074 & 6655220 \\ 20602616 & 682642074 & 6652206 \\ 68206420 & 68642074 & 665206 \\ 68206420 & 2069661 \\ 2062064 & 682642074 & 665206 \\ 68206420 & 206961 \\ 20626264 & 68264274 & 6652206 \\ 68206420 & 2069616 \\ 20206264 & 682642074 & 665206 \\ 68206420 & 206961 \\ 2062616 & 6220606 & 64226066 \\ 2020606 & 68206420 \\ 20602640 & 682642074 & 665206 \\ 68206420 & 006616 \\ 20206264 & 68206420 & 2065206 \\ 68206420 & 006661 \\ 20620640 & 68264074 & 6652060 \\ 68206420 & 006616 \\ 62206064 & 6220606 & 6420676 \\ 68206420 & 006616 \\ 00002061 \\ 000002061 \\ 00002061 \\ 00002061 \\ $ | 20746578         74206669         6c652010         726F7669           6455420         6667220         74666520         65786165           706c6520         6667220         74666520         65786165           706c6520         66662077         72697469         65872061           706c6520         6762077         72697469         65872061           70736968         67204162         30217261         20437963           73736968         67204162         30217261         724637863           6768652         20494949         20537461         72746572           20485974         20436766         6452016         656672           9462074         6865200         6556672         79207772           67747465         68207468         20697320         466c6173           69207468         68652074         68552076         67662173           69207468         68652074         68552076         67662173           69207468         2062774         686572         20776962           620706572         20637963         6C696672         20746865           726572         20637963         6C596672         20746865           746869732         2065466         22017570 |

#### **CFI Query**

The common flash interface (CFI) flash memory devices conform to basic flash commands. The most basic command is Query which switches the device into a ROM table mode so that features of the flash device are determined by reading values from the table.

To perform a CFI query using the host application, click **CFI Query**. Notice that the memory table displays contents that correlate with the table contents as described in the device datasheet.

To put the flash device back in user mode, press **Reset** on the control panel.

#### **Read/Write Data**

To read from and write to the flash memory, follow these steps:

|                    |          | Address range: |          |  |                    |   |
|--------------------|----------|----------------|----------|--|--------------------|---|
|                    |          |                |          | Contraction of Contractory Contractory |                    |   |
| Start Address: 000 | 000000   | CFI Query      | Reset    | Erase Block                            |                    |   |
| Address            | 0 - 3    | 4 - 7          | 8 - B    | C - F                                  | Data to Ascii-Text |   |
| 00000000           | 54686973 | 20697320       | 61207361 | 6D706C65                               | This is a sample   | - |
| 00000010           | 20746578 | 74206669       | 6C652070 | 726F7669                               | text file provi    |   |
| 00000020           | 64656420 | 666F7220       | 74686520 | 6578616D                               | ded for the exam   |   |
| 00000030           | 706C6520 | 6F662077       | 72697469 | 6E672061                               | ple of writing a   |   |
| 00000040           | 2066696C | 6520746F       | 206D656D | 6F727920                               | file to memory     |   |
| 00000050           | 7573696E | 6720416C       | 30217261 | 20437963                               | using AlO!ra Cyc   | - |
| 00000060           | 6C6F6E65 | 20494949       | 20537461 | 72746572                               | lone III Starter   |   |
| 00000070           | 204B6974 | 20436F6E       | 74726F6C | 2050616E                               | Kit Control Pan    | - |
| 00000080           | 656C2061 | 70706C69       | 63617469 | 6F6E2E20                               | el application.    | - |
| 00000090           | 49662074 | 6865206D       | 656D6F72 | 79207772                               | If the memory wr   |   |
| 0A000000           | 69747465 | 6E20746F       | 20697320 | 466C6173                               | itten to is Flas   | - |
| 00000080           | 68207468 | 6E652074       | 68652076 | 6F6C6174                               | h thne the volat   | - |
| 000000c0           | 696C6520 | 636F6E74       | 656E7473 | 2077696C                               | ile contents wil   |   |
| 000000000          | 6C207065 | 72736973       | 74207570 | 6F6E2070                               | l persist upon p   | - |
| 000000E0           | 6F776572 | 20637963       | 6C696E67 | 20746865                               | ower cycling the   |   |
| 000000F0           | 20626F61 | 72642C20       | 486F7765 | 00000000                               | board, Howe        | - |
| 00000100           | 74686973 | 2066696C       | 65206361 | 6E206265                               | this file can be   | - |
| 00000110           | 20657261 | 73656420       | 62792063 | 6C69636B                               | erased by click    | - |
| 00000120           | 696E6720 | 74686520       | 45726173 | 65206275                               | ing the Erase bu   |   |
| 00000130           | 74746F6E | 2E204F74       | 68657220 | 6D656D6F                               | tton. Other memo   | - |
| 00000140           | 20606160 | 2020606C       | 20206560 | 61726120                               | `a` `l e`ara       | - |
| 00000150           | 7460616C | 63204064       | 64612061 | 20436120                               | t'alc @dda a Ca    | - |
| 00000160           | 64686420 | 20494140       | 20006061 | 20706572                               | dhd IA@ .`a per    | - |
| 00000170           | 20426164 | 20406F66       | 64224D64 | 20406068                               | Bad @ofd"Md @`h    | - |
| 00000180           | 206C2061 | 60706869       | 00002061 | 616E2020                               | l a`phi aan        | - |
| 00000190           | 41202064 | 68642065       | 64206F62 | 61206170                               | A dhd ed oba ap    | - |
| 000001A0           | 20602064 | 68206420       | 20692020 | 44686163                               | `dh d i Dhac       | - |
| 00000180           | 68206420 | 68642074       | 68652060 | 6E646174                               | h d hd the `ndat   | - |
| 000001c0           | 69646520 | 60206264       | 646C7020 | 20656864                               | ide bddlp ehd      |   |
| 000001D0           | 64206064 | 62206060       | 64206160 | 62622060                               | d 'db 'd a bb '    | - |
| 000001E0           | 64206460 | 20612062       | 6C606C61 | 20204865                               | d d` a bl`la He    | - |
|                    |          |                |          |  |                    | - |
|                    |          |                | ADTERA   |  | Ex                 |   |

Figure 3–5. Control Panel Flash Memory Tab

- 1. Click **Erase Block** to perform a block erase of the flash memory. The **Address** column indicates the hex address of the flash memory. The values inside the **0-3**, **4-7**, **8-B**, and **C-F** columns are the flash memory contents in hex words format.
- 2. To write a 32-bit word to the flash memory, click the desired location, enter the desired value in hex format, and press **Enter**.



# 4. Measuring Power on the Cyclone III Starter Board

## Introduction

One of the main features of the Cyclone<sup>®</sup> III device is its low power consumption. You can measure the power of the 3C25 device on the Cyclone III starter board under various conditions with an example design provided with the kit.

The power example design allows you to control the amount of logic utilized in the FPGA, the clock frequency, the number of I/Os being used, and measure the effect on the power to the Cyclone III device. Because the Cyclone III starter board has only four buttons and four LEDs, interaction with the board is minimal as defined below.

Table 4–1 describes the functionality of the four input buttons that control the power example design.

| Table 4–1. Four l | Table 4–1. Four Input Button Functionality |                |  |  |  |  |  |  |
|-------------------|--|----------------|--|--|--|--|--|--|
| Button            | FPGA Pin                                   | Туре           | Description  |  |  |  |  |  |
| 1                 | F1   | Reset          | Resets the demo to the beginning, node i_nrst.   |  |  |  |  |  |
| 2                 | F2   | Toggle         | Advances the example design to the next higher frequency, node <code>i_nfreq_next</code> . |  |  |  |  |  |
| 3                 | A10  | Toggle         | Advances the example design to the next higher resource utilization, node_i_nperc_next.    |  |  |  |  |  |
| 4                 | B10  | Press and Hold | Enables the outputs to toggle, node<br>i_noutput_ena.                                      |  |  |  |  |  |

Tables 4–2 and 4–3 describe how the LEDs indicate the example design's current power state.

| Table 4–2. LEDs Power State (Frequency) |      |      |       |                 |  |  |  |
|---|------|------|-------|-----------------|--|--|--|
| Dioplaya                                | L    | EDs  | State | Clock Frequency |  |  |  |
| Displays                                | MSB  | LSB  | Sidie | (MHz)           |  |  |  |
| Frequency                               | LED2 | LED1 | 00    | 0               |  |  |  |
|   |      |      | 01    | 33              |  |  |  |
|   |      |      | 10    | 67              |  |  |  |
|   |      |      | 11    | 100             |  |  |  |

| Table 4–3. LEDs Power State (Resources) |      |      |       |                  |  |  |  |
|---|------|------|-------|------------------|--|--|--|
| Dianlava                                | LE   | Ds   | State | % of Design Hand |  |  |  |
| Displays                                | MSB  | LSB  | State | % of Design Used |  |  |  |
| Resources                               | LED4 | LED3 | 00    | 25%              |  |  |  |
|   |      |      | 01    | 50%              |  |  |  |
|   |      |      | 10    | 75%              |  |  |  |
|   |      |      | 11    | 100%             |  |  |  |

The design used for power measurement is a replicated set of randomly filled ROMs that feed a multiplier block and a shift register that is fed by a signal that changes every clock cycle. Tables 4–2 and 4–3 show the power state which represent the percent of the full design used. As compiled, this full design uses:

- Logic elements: 22,493/24,624 (91%)
- Combinational functions: 1,961/24,624 (8%)
- Dedicated logic registers: 21,133/24,624 (86%)
- Total registers: 21,133
- Total pins: 73/216 (34%)
- Total memory bits: 524,288/608,256 (86%)
- Embedded Multiplier 9-bit elements: 128/132 (97 %)
- Total PLLs: 1/4 (25%)

| Measuring |
|-----------|
| Power     |

The example design is located in

<*kit install*>\**examples**\**cycloneIII\_3c25\_start\_power\_demo**. Configure the FPGA with the **.sof** found in the directory.

The input clock (i\_clk PIN\_B9) is the 50-MHz oscillator on the board, which generates the input clock for the reference design through a PLL

For more information on configuring the FPGA, refer to "Configuring the FPGA Using the Quartus II Programmer" on page 2–3.

Current sense resistors  $(0.010 \Omega \pm 1\%)$  are installed at locations JP6 (FPGA core power) and JP3 (FPGA I/O power + other device I/O power). With a digital multimeter set to mV measurement range, the resistor at location JP6 measures the core power. The resistor at location JP3 measures the I/O power. To measure the current being used in various configurations, use the following steps:

To obtain the power (P) in milliwatts, measure *<Measured Voltage>* (the voltage across the sense resistors at JP6 or JP3) in mV and calculate the nominal power using the equation:

P = 100 x <*Measured Voltage*> x <*Supply Voltage*>

where *<Supply Voltage>* is 1.2 V for JP6 and 2.5 V for JP3.

You can use the four input buttons to advance through the various power state as outlined in Table 4–2. Notice how current increases as frequency and resource usage increase.

You can also measure the I/O power consumed by measuring the voltage across sense-resistor JP3 when Button 4 is pressed and held. Because this 2.5-V power rail is shared with other devices, there is a nominal 100 mW that must be subtracted from the calculated I/O power to obtain the FPGA I/O power.

The number of I/O pins used is controlled by the resource state (shown in Tables 4–2 and 4–3). For each increment in resources, 16 additional I/O pins are added (refer to Table 4–4).

| Table 4–4. I/O Pin & Resource State |                    |  |  |  |  |
|-------------------------------------|--------------------|--|--|--|--|
| LED4/LED3                           | Number of I/O Pins |  |  |  |  |
| 00                                  | 16                 |  |  |  |  |
| 01                                  | 32                 |  |  |  |  |
| 10                                  | 48                 |  |  |  |  |
| 11                                  | 64                 |  |  |  |  |

Similarly, the toggle-frequency of these I/O pins is set by the overall design frequency (refer to Table 4–1).

#### **Changing the Example Design**

The source code for the Cyclone III power example design is also provided so you can use it as a starting point for your own measurements. You can adjust the number of outputs by changing parameter NUM\_OUTPUTS\_PER\_STAMP. The default is 16, which for four resource percentage steps equates to 16 x 4 = 64.

The appropriate pins to be used as outputs are pre-assigned to the HSMC connector (J1). If you would like to look at more than the 76 I/Os available on J1, you need to make the appropriate pin assignments.



## Appendix A. Programming the Configuration Flash Device

| Overview   | The Intel® P30 flash device uses active parallel flash configuration to configure the Cyclone® III device on power up. The Cyclone III Starter Board has a factory default configuration programmed into the P30 flash; however, after developing your own project, you may want to replace this factory default configuration with your own. This appendix describes how to reprogram the Intel P30 flash device.   |
|--|--|
| Creating a<br>Flash-<br>Programmable<br>POF File | <ul> <li>After a Quartus II compilation, a Programmer Object File (.pof) is created.<br/>Before you can program this file into the Intel P30 flash device on the<br/>Cyclone III development board, you must modify the .pof by performing<br/>the following steps:</li> <li>1. Choose Convert Programming File from the File menu. The<br/>Convert Programming Files window opens (refer to Figure A–1).</li> </ul> |

Figure A–1. Convert Programming Files Window

| D 약 당행 중 사용 등 사용 가<br>reject Navigator<br>Entry       | - X / I I I I I I I I I I I I I I I I I I   |               |
|---|---|---------------|
| Completion Herarchy                                   | Convert Programming Files     Specify the kyot files to convert and the type of programming file to generate.     You can also most type file is chromoton that are the conversion takes information created here for     have one.     Conversion stells Files         Open Conjection Schip Data.         Save Conversion Selap   | 1             |
| Henorchy Prime of Design Units                        | Odput programming like poer     Programming like poer     Programming like poer     Ordingstation device: EPC16      Mode: Total Passave Senail     Plagame:     Crides #00/pasame.throwodput.like pod     device.cdl     device.cdl     Plagame:     File poer     Fil | rsion 8.0     |
| E      Concile Design     P-     Analysis 1.5yrthesis | Input Riss to convert   | Documentation |
| Type Message  |   |               |

- 2. Select the following settings:
  - **Programming File Type:** Programmer Object File (.pof)
  - Configuration Device: CFI\_128MB
  - Mode: Active Parallel
  - File Name: Type the name of the flashable .pof to write

If you choose to overwrite the existing **.pof**, a warning message occurs.

3. Under Input file to the convert, select Configuration Master under SOF Data. Refer to Figure A-2.

Before moving to the next step, ensure that the setting for the **Configuration Device** is CFI\_128MB.

Figure A-2. Input File to Convert

| File/Data area       | Properties | Start Address | Add <u>H</u> ex Dat |
|----------------------|------------|---------------|---------------------|
| SOF Data             | Page 0     | <auto></auto> | ]                   |
| Configuration Master |            |               | Add Sof Data        |
| High Byte (D[158])   |            |               |                     |
| Low Byte (D[70])     |            |               | Add File            |
|                      |            |               |                     |
|                      |            |               | <u>R</u> emove      |
|                      |            |               |                     |
|                      |            |               |                     |
|                      |            |               |                     |
|                      |            |               | Down                |
|                      |            |               |                     |
|                      |            |               | Properties          |
|                      |            |               |                     |
|                      |            |               |                     |
|                      |            | General       | te Close            |

- 4. Click Add File.
- 5. Choose the **.sof** you want to convert and click **OK**.
- 6. Select **SOF Data** and click **Properties**. The **SOF Data Properties** window appears.
- 7. Select and type the following settings as shown in Figure A–3:
  - **Pages:** 0
  - Address mode for selected pages: Start
  - Start address (32-bit hexadecimal): 0x020000

Figure A–3. SOF Data Properties

| □6<br>□7                         |            |
|----------------------------------|------------|
| Selected pages comment: Page_(   | )          |
| Address mode for selected pages  |            |
| Start                            | •          |
| Start address (32-bit hexadecima | ox020000   |
| End address (32-bit hexadecimal  | OXFFFFFFFF |

- The flash address 0x20000 is the default starting address from which the Cyclone III device starts loading configuration data.
- 8. Click **OK**. Figure A–4 shows the updated **Convert Programming Files** window.

Figure A–4. Updated Convert Programming Files Window

| ools | <u>W</u> indow                                 |  |                      |                             |  |
|------|--|--|----------------------|-----------------------------|--|
|      |  | onvert and the type of progr<br>file information from other file |                      |                             | created here for   |
|      | Conversion setup files                         |  |                      |                             |  |
|      | Open Cony                                      | zersion Setup Data   | <u>s</u>             | ave Conversion Setup        | »  |
|      | Output programming file                        |  |                      |                             |  |
|      | Programming file type:                         | Programmer Object File (   | (.pof)               |                             | -  |
|      | Options  | Configuration device:  | CFI_128MB - M        | ode: Active Parallel        |  |
|      | File name:                                     | C:/temp/cyclonelll_3c2   |                      |                             |  |
|      | Advanced                                       | Remote/Local update dif  |                      |                             |  |
|      |  |  |                      |                             |  |
|      |  | IV MEMORY MAD FILE   |                      |                             |  |
|      |  | Memory Map File  |                      |                             |  |
|      | Input files to convert                         | y♥ Memory Map rile   |                      |                             |  |
|      | File/Data area                                 | j⊻ memory map rilê   | Properties           | Start Address               | Add <u>H</u> ex Data   |
|      | File/Data area<br>⊡ SOF Data                   |  | Properties<br>Page 0 | Start Address<br>0x00020000 |  |
|      | File/Data area<br>SOF Data<br>Configuration    | Master   | Page 0               |                             | Add <u>H</u> ex Data<br>Add <u>S</u> of Data                   |
|      | File/Data area<br>SOF Data<br>                 | Master<br> _3c25_start_my_first_fpg<br> 58])                     | Page 0               |                             | Add Sof Data   |
|      | File/Data area<br>□ SOF Data<br>□configuration | Master<br> _3c25_start_my_first_fpg<br> 58])                     | Page 0               |                             |  |
|      | File/Data area<br>SOF Data<br>                 | Master<br> _3c25_start_my_first_fpg<br> 58])                     | Page 0               |                             | Add Sof Data   |
|      | File/Data area<br>SOF Data<br>                 | Master<br> _3c25_start_my_first_fpg<br> 58])                     | Page 0               |                             | Add <u>S</u> of Data<br>Add <u>File</u><br><u>R</u> emove      |
|      | File/Data area<br>SOF Data<br>                 | Master<br> _3c25_start_my_first_fpg<br> 58])                     | Page 0               |                             | Add <u>S</u> of Data<br>Add <u>File</u>                        |
|      | File/Data area<br>SOF Data<br>                 | Master<br> _3c25_start_my_first_fpg<br> 58])                     | Page 0               |                             | Add <u>S</u> of Data<br>Add <u>File</u><br><u>R</u> emove      |
|      | File/Data area<br>SOF Data<br>                 | Master<br> _3c25_start_my_first_fpg<br> 58])                     | Page 0               |                             | Add <u>S</u> of Data<br>Add <u>E</u> ile<br><u>R</u> emove     |
|      | File/Data area<br>SOF Data<br>                 | Master<br> _3c25_start_my_first_fpg<br> 58])                     | Page 0               |                             | Add <u>S</u> of Data<br>Add <u>E</u> ile<br><u>R</u> emove     |
|      | File/Data area<br>SOF Data<br>                 | Master<br> _3c25_start_my_first_fpg<br> 58])                     | Page 0               |                             | Add Sof Data<br>Add Eile<br>Remove<br>Up<br>Down<br>Properties |
|      | File/Data area<br>SOF Data<br>                 | Master<br> _3c25_start_my_first_fpg<br> 58])                     | Page 0               |                             | Add Sof Data<br>Add Eie<br>Remove<br>Up                        |
|      | File/Data area<br>SOF Data<br>                 | Master<br> _3c25_start_my_first_fpg<br> 58])                     | Page 0               | <u>b</u> c00020000          | Add Sof Data<br>Add Eile<br>Remove<br>Up<br>Down<br>Properties |

- 9. Click **Generate**. If you are overwriting the input **.pof** you will receive a warning asking if you want to overwrite it. Click **Yes** to overwrite the file or enter a different filename. When the Quartus II software finishes converting the file, you can use the converted **.pof** to program the on-board parallel flash device.
  - The Quartus II software also generates a MAP file, which can help you debug issues with locations in the flash device.

# Programming the Flash Device

Altera recommends that you do not overwrite the factory hardware and factory software images unless you are an expert with the Altera tools or deliberately overwriting the factory design. If you unintentionally overwrite the factory image, perform these flash programming instructions using the **cycloneIII\_3c25\_start\_niosII\_standard.pof** found in the **factory\_recovery** directory for the object file in step 9.

To program the flash device, follow these steps:

- 1. Open the Quartus II Programmer.
- 2. Click **Auto Detect** from the button list to the left of the programming file list area.
- 3. Select the detected Cyclone III 3C25 device.
- 4. Choose **Attach Flash Device** (Edit menu). The **Select Flash Device** window opens.
- 5. Turn on the **Flash Memory** and **CFI\_128MB** options (refer to Figure A–5).

#### Figure A–5. Select Flash Device

| Select Flash Device | Device name<br>CFI_128MB<br>CFI_256MB<br>CFI_256MB<br>CFI_32MB<br>CFI_512MB<br>CFI_512MB<br>CFI_64MB<br>CFI_96MB | New<br>Import<br>Export |
|---------------------|--|-------------------------|
|                     |  | Eemove<br>Check         |
|                     | ОК   | Cancel                  |

6. Click OK.

- 7. In the Quartus II Programmer, select the CFI\_128MB device.
- 8. Click Change File from the button list at the left of the programming file area.
- 9. Select the converted .pof that you generated in the previous section.
- 17 To restore factory flash contents, choose cycloneIII\_3c25\_start\_niosII\_standard.pof located in the factory\_recovery directory as your converted .pof.
- 10. Turn on the **Program/Configure** option for all devices shown in the Programmer.
  - [F
    - Turning on the option for the .pof enables all three options, which is what you want to do (refer to Figure A–6).

Figure A–6. POF Options

| 🏓 Start       | File                      | Device      | Checksum | Usercode | Program/<br>Configure | Verify | Blank-<br>Check | Examine | Security<br>Bit | Erase | ISP<br>CLAMP |
|---------------|---------------------------|-------------|----------|----------|-----------------------|--------|-----------------|---------|-----------------|-------|--------------|
| 📲 Stop        | Factory default PFL image | EP3C25      | 00000000 | FFFFFFF  | ✓                     |        |                 |         |                 |       |              |
| == 0.0p       | C:/temp/cyclonelll_3c25   | . CFI_128MB | 0014E1AD |          |                       |        |                 |         |                 |       |              |
| Auto Detect   | L Page_0                  |             |          |          | V                     |        |                 |         |                 |       |              |
| X Delete      |                           |             |          |          |                       |        |                 |         |                 |       |              |
| 🌽 Add File    |                           |             |          |          |                       |        |                 |         |                 |       |              |
| 👺 Change File |                           |             |          |          |                       |        |                 |         |                 |       |              |
| 🗳 Save File   |                           |             |          |          |                       |        |                 |         |                 |       |              |
| 😂 Add Device  |                           |             |          |          |                       |        |                 |         |                 |       |              |
| 📫 Up          |                           |             |          |          |                       |        |                 |         |                 |       |              |
| 🔑 Down        |                           |             |          |          |                       |        |                 |         |                 |       |              |
|               |                           |             |          |          |                       |        |                 |         |                 |       |              |

- 11. Click Start. The Programmer loads the special flash programming hardware into the FPGA, which allows the Programmer to communicate with the flash device. The Programmer sends the .pof to the flash device via the flash programming hardware. The Quartus II Message window displays the bank addresses as they are erased and then written.
- 12. To configure the Cyclone III 3C25 with your design from the on-board flash device, either push the reconfiguration button or turn the Cyclone III Starter Board off and then on again.



# **Additional Information**

## **Revision History**

The table below displays the revision history for the chapters in this user guide.

| Chapter | Date       | Version | Changes Made   |
|---------|------------|---------|--|
| All     | July 2010  | 1.2.0   | <ul> <li>Removed "Licensing the Quartus II Software".</li> <li>Updated Figure 1–1 on page 1–3.</li> <li>Updated "Installing the Quartus II Web Edition Software" on page 1–4.</li> <li>Updated "Installing the Cyclone III FPGA Starter Kit" on page 1–2.</li> <li>Updated "Further Information" on page 1–2.</li> <li>Updated Copyright information.</li> </ul> |
| All     | March 2010 | 1.1.0   | <ul> <li>Updated the directory structure in Figure 1–1.</li> <li>Updated "Control Panel Start" section and Figure 3–1.</li> <li>Updated "LEDs" section and Figure 3–2.</li> <li>Updated "DDR SDRAM/SSRAM Controller and Programmer" section and Figure 3–3.</li> <li>Updated "Flash Memory Programmer" section and Figure 3–4.</li> </ul>                        |
| 1, 2, 4 | June 2008  | 1.0.1   | <ul> <li>Updated directory structure figure and installed directory contents table.</li> <li>Updated the control panel user interface executable file name.</li> <li>Updated the kit directory path.</li> <li>Updated the configuration SOF file name.</li> <li>Updated kit's example design file name.</li> </ul>   |
| All     | April 2007 | 1.0.0   | First publication.   |

## How to Contact Altera

For the most up-to-date information about Altera products, refer to the following table.

| Contact Note (1)                | Contact<br>Method | Address                   |
|---------------------------------|-------------------|---------------------------|
| Technical support               | Website           | www.altera.com/support    |
| Technical training              | Website           | www.altera.com/training   |
|                                 | Email             | custrain@altera.com       |
| Product literature              | Website           | www.altera.com/literature |
| Non-technical support (General) | Email             | nacomp@altera.com         |
| (Software Licensing)            | Email             | authorization@altera.com  |

#### Note to Table:

(1) You can also contact your local Altera sales office or sales representative.

## Typographic Conventions

This document uses the typographic conventions shown below.

| Visual Cue                                  | Meaning   |  |
|---|---|--|
| Bold Type with Initial<br>Capital Letters   | Command names, dialog box titles, checkbox options, and dialog box options are shown in bold, initial capital letters. Example: <b>Save As</b> dialog box.  |  |
| bold type                                   | External timing parameters, directory names, project names, disk drive names, filenames, filename extensions, and software utility names are shown in bold type. Examples: <b>f</b> <sub>MAX</sub> , <b>\qdesigns</b> directory, <b>d:</b> drive, <b>chiptrip.gdf</b> file. |  |
| Italic Type with Initial Capital<br>Letters | Document titles are shown in italic type with initial capital letters. Example: <i>AN 75: High-Speed Board Design.</i>  |  |
| Italic type                                 | Internal timing parameters and variables are shown in italic type.<br>Examples: $t_{PIA}$ , $n + 1$ .   |  |
|   | Variable names are enclosed in angle brackets (< >) and shown in italic type.<br>Example: <i><file name=""></file></i> , <i><project name=""></project></i> . <b>pof</b> file.  |  |
| Initial Capital Letters                     | Keyboard keys and menu names are shown with initial capital letters. Examples:<br>Delete key, the Options menu.   |  |
| "Subheading Title"                          | References to sections within a document and titles of on-line help topics are shown in quotation marks. Example: "Typographic Conventions."  |  |

| Visual Cue                          | Meaning   |  |
|-------------------------------------|---|--|
| Courier type                        | Signal and port names are shown in lowercase Courier type. Examples: data1, tdi, input. Active-low signals are denoted by suffix n, e.g., resetn.   |  |
|                                     | Anything that must be typed exactly as it appears is shown in Courier type. For example: c:\qdesigns\tutorial\chiptrip.gdf. Also, sections of an actual file, such as a Report File, references to parts of files (e.g., the AHDL keyword SUBDESIGN), as well as logic function names (e.g., TRI) are shown in Courier. |  |
| 1., 2., 3., and<br>a., b., c., etc. | Numbered steps are used in a list of items when the sequence of the items is important, such as the steps listed in a procedure.  |  |
| ••                                  | Bullets are used in a list of items when the sequence of the items is not important.  |  |
| $\checkmark$                        | The checkmark indicates a procedure that consists of one step only.   |  |
|                                     | The hand points to information that requires special attention.   |  |
| CAUTION                             | A caution calls attention to a condition or possible situation that can damage or destroy the product or the user's work.   |  |
| WARNING                             | A warning calls attention to a condition or possible situation that can cause injury to the user.   |  |
| 4                                   | The angled arrow indicates you should press the Enter key.  |  |
| ••••                                | The feet direct you to more information on a particular topic.  |  |