



Cyclone III FPGA Development Kit

User Guide



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Introduction

Welcome to the Altera® Cyclone® III Development Kit, which includes a full-featured FPGA development board, hardware and software development tools, documentation, and accessories needed to begin FPGA development.

The kit provides an integrated control environment that includes a USB command controller, a multi-port SRAM/DDR SDRAM/flash memory controller, Ethernet, an on-board meter, and example designs with demonstration circuitry specified in Verilog code to help you get started quickly with your own designs.

The development board includes an Altera Cyclone III FPGA configured with a hardware reference design stored in flash memory. Hardware designers can use the development board, along with example designs included in the kit, as a platform to prototype complex embedded systems.

The development kit includes these kit features and documentation:

- Cyclone III development board
- Accessory daughter cards
- Power supply, cables, and documentation

Kit Features

This section briefly describes the Cyclone III Development Kit features.

- **Cyclone III Development Board**—a prototyping platform that allows you to develop and prototype high-speed bus interfaces as well as evaluate Cyclone III transceiver performance.

 For specific information about board components and interfaces, refer to the *Cyclone III 3C120 Development Board Reference Manual*.

- **Quartus II Web Edition Software**—The Quartus II software integrates into nearly any design environment, with interfaces to industry-standard EDA tools. The kit includes:
 - The SOPC Builder system development tool
 - Quartus II Web Edition software

- **MegaCore IP Library**—This library contains Altera IP MegaCore functions. You can evaluate MegaCore functions by using the OpenCore® Plus feature to perform the following tasks:
 - Simulate behavior of a MegaCore function within 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
- **Nios II Embedded Software Design Tools**—This full-featured set of tools allows you to develop embedded software on the Nios II processor running on Altera FPGAs.
- **Cyclone III Development Kit Application and Drivers**—The application and drivers allow you to execute memory read and write transactions to the board.
- **Design Examples**—The design examples are useful for a variety of hardware applications and let you quickly begin board prototyping and device verification.

You only need to purchase a license for a MegaCore function when you are completely satisfied with its functionality and performance, and want to take your design to production.



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](#).

Documentation

The Cyclone III Development Kit contains the following documents:

- *Readme.txt*—Contains special instructions and refers to the kit documentation.
- *Cyclone III Development Kit User Guide* (this document)—Describes how to use the kit.
- *Cyclone III 3C120 Development Board Reference Manual*—Provides specific information about the board components and interfaces, steps for using the board, and pin-outs and signal specifications.

Introduction

This user guide familiarizes you with the contents of the kit and guides you through the Cyclone III development board setup. Using this guide, you can do the following:

- Inspect the contents of the kit
- Install the Altera Quartus II Web Edition software
- Install the Cyclone III Development Kit
- Set up, power up, and verify correct operation of the development board
- Configure the Cyclone III FPGA
- Find and use the tutorials
- Set up and run included application examples and demonstrations



For complete information about the development board, refer to the [Cyclone III 3C120 Development Board Reference Manual](#).

Before You Begin

Before using the kit or installing the software, check the kit contents and inspect the board to verify that you received all of the items listed in this section. If any of the items are missing, contact Altera before you proceed.

Check the Kit Contents

The Cyclone III Development Kit contains the following items:

- Cyclone III development board with an EP3C120F780C7N Cyclone III device
- USB cable
- Accessory daughter cards:
 - Two loopback high-speed mezzanine connector (HSMC) cards
 - Debug HSMC card
 - One 16 character × 2 line Liquid Crystal Display (LCD)
 - One 2.8-in. thin-film transistor (TFT) LCD module
- 16-V DC Power supply and adapters for North America, Europe, the United Kingdom, and Japan.



To ensure that you have the most up-to-date information about this product, refer to the [Cyclone III FPGA Development Kit](#) page.

Inspect the Board

Place the board on an anti-static surface and inspect it to ensure that it has not been damaged during shipment.



Without proper anti-static handling, the Cyclone III development board can be damaged.

Verify that all components are on the board and appear intact.



In typical applications with the Cyclone III development board, a heatsink is not necessary. However, under extreme conditions the board may require additional cooling to stay within operating temperature guidelines. You may wish to perform power consumption and thermal modeling to determine whether your application requires additional cooling.



For more information about power consumption and thermal modeling, refer to *AN 358: Thermal Management for FPGAs*.

Hardware Requirements

The Quartus II software has some minimum system requirements. Otherwise, the Cyclone III development kit provides all of the hardware needed to use the board.



For the Quartus II software requirements, refer to the [Quartus II Web Edition Software](#) page.

Software Requirements

This kit requires the following software:

- Windows XP operating system
- Quartus II Web Edition software



Refer to *Quartus II Installation & Licensing for Windows* for further information on the Quartus II system software requirements, especially heeding the following:

- A web browser, Microsoft Internet Explorer version 5.0 or later or Firefox version 2.0 or later. You need a web browser to register the Quartus II software and request license files. Refer to *“Licensing Considerations” on page 3–3*.
- Version 2.0 or later of the .NET framework.



If you receive an “Application Error” message when launching the demo application, install version 2.0 or later versions of the .NET framework. Some Windows versions do not have runtime DLL for the .NET application. You can download the .NET framework application from the following location:
www.microsoft.com/download.

References

For other related information, refer to the following websites:

Table 2-1.

For More Information About	Refer to
Additional daughter cards available for purchase	www.altera.com/products/devkits/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-cyc3.html
eStore if you want to purchase devices	www.altera.com/buy/devices/buy-devices.html
Cyclone III Orcad symbols	www.altera.com/support/software/download/pcb/pcbpcb_index.html
Nios® II 32-bit embedded processor solutions	www.altera.com/technology/embedded/emb-index.html

Introduction

This section describes the following procedures:

- “Installing the Cyclone III Development Kit”
- “Installing the Quartus II Web Edition Software” on page 3-2
- “Installing the USB-Blaster Driver” on page 3-3



Before starting the installation, verify that you have complied with the conditions described in “Software Requirements” on page 2-2.

Installing the Cyclone III Development Kit

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

To install the Cyclone III Development Kit, follow these steps:

1. Download the Cyclone III Development Kit installer from the [Cyclone III FPGA Development 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.
2. Follow the on-screen instructions to complete the installation process.

When the installation is complete, the Cyclone III Development Kit installation program creates the directory structure shown in [Figure 3-1](#), where *<path>* is the Cyclone III Development Kit installation directory.

Figure 3-1. Cyclone III Development Kit Installed Directory Structure



Table 3–1 lists the file directory names and a description of their contents.

Table 3–1. Installed 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 applications that may change from release to release.
documents	Contains the development kit documentation.
examples	Contains the sample design files for the Cyclone III Development Kit.
factory_recovery	Contains the original data programmed onto the board before shipment. Use this data to put the board into the original 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® 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 allow 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.

Installing the USB-Blaster Driver

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

-  To download the USB-Blaster driver, go to the Altera support site at www.altera.com/support/software/drivers/dri-index.html. To install it, go to www.altera.com/support/software/drivers/usb-blaster/dri-usb-blaster-xp.html.

Introduction

The instructions in this chapter explain how to install the development board and configure the FPGA.

Requirements

Before starting the installation, verify that you have complied with the conditions described in [“Hardware Requirements” on page 2–2](#) and have completed the following requirements:

- Quartus II software installed on the host computer
- USB-Blaster driver software installed on the host computer.

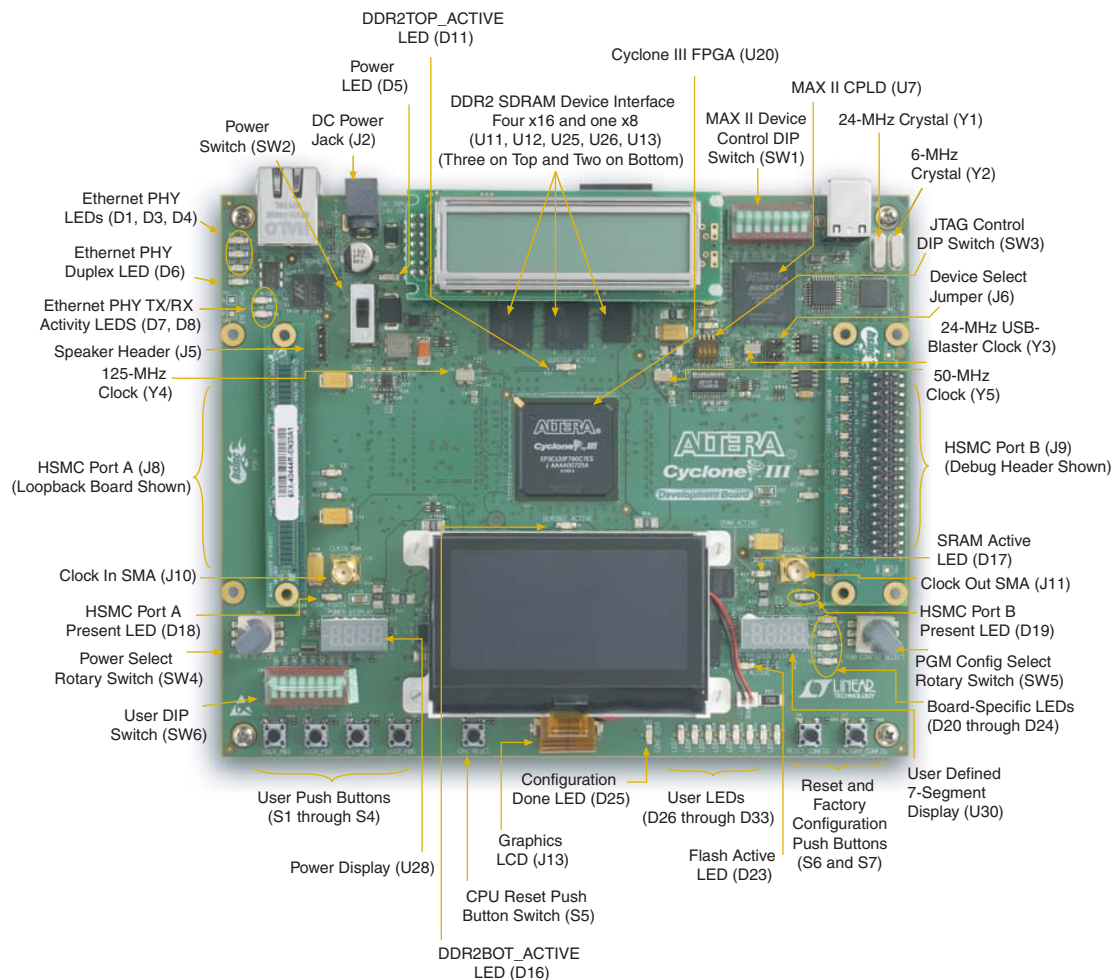


The Cyclone III development board includes integrated USB-Blaster circuitry for FPGA programming. Host computer and development board cannot communicate without the USB-Blaster driver software installed. For installation information, refer to [“Installing the USB-Blaster Driver” on page 3–3](#).

Powering Up the Board

Figure 4-1 shows the Cyclone III development board and its components.

Figure 4-1. Cyclone III Development Board Layout and Components



Before powering up, prepare the board by performing the following steps:

1. If cards are plugged into the high-speed mezzanine connector (HSMC) ports, remove them (Figure 4-1) shows a daughter card plugged into both port A and port B).
2. Ensure that the POWER switch SW2 is in the OFF (or DOWN) position.
3. Configure the 8-position SW1 DIP switch to the default settings in Table 4-1.

Table 4-1. Switch SW1 Settings (Part 1 of 2)

Switch	Name	Function		Default Position
		Position 0	Position 1	
1	mΩ/mA	mΩ	mA	0
2	V/Ω	V	W	1

Table 4-1. Switch SW1 Settings (Part 2 of 2)

Switch	Name	Function		Default Position
		Position 0	Position 1	
3	RSV0	MAX_RESERVE0		X
4	RSV1	MAX_RESERVE1		X
5	MAX0	PFL Disable	PFL Enable	1
6	MAX1	MAX_DIP1		X
7	MAX2	MAX_DIP2		X
8	MAX3	MAX_DIP3		X

Note to Table 4-1:

(1) X = don't care

- Ensure that the 4-position SW3 mini-DIP switches and the two jumpers are set to the default positions shown in Table 4-2.

Table 4-2. Initial Switch and Jumper Settings

DEV_SEL-J6	JTAG_SEL-J7	SW3.1	SW3.2	SW3.3	SW3.4
ON	ON	ON	OFF	OFF	OFF

- Verify that the PGM CONFIG SELECT rotary switch SW5 is set to 0.

At power up, the development board uses a preloaded configuration to demonstrate that the board is operating correctly.

Power up the development board by performing the following steps:

- Connect the 16-V DC adapter to the development board and to a power source.



Use only the supplied 16-V power supply. Power regulation circuitry on the board could be damaged by supplies greater than 16 V.

- Slide the POWER switch to ON. The nearby blue POWER light-emitting diode (LED) lights up.
- Confirm that user LEDs 0-7 flash in a scrolling, side-to-side pattern. For customized configurations, the pattern depends on the application.



For information about custom configurations, refer to “Programming the Flash Device” on page A-4.

Configuring the FPGA

Before configuring the FPGA, ensure that the Quartus II software and the USB-Blaster driver software are installed on the host computer and the development board is powered on.



For USB-Blaster driver installation information, refer to “Installing the USB-Blaster Driver” on page 3–3.

To configure the Cyclone III FPGA, perform the following steps:

1. Verify that the 4-position SW3 mini-DIP switches and the two jumpers are set to the default positions shown in [Table 4–2](#).
2. Connect the USB cable to the development board USB port.
3. Cycle the POWER switch OFF then ON.
4. Start the Quartus II software.
5. On the Tools menu, click **Programmer**. The Quartus II Programmer appears.
6. Click **Add File** and select
`<path>\...\examples\cycloneIII_3c120_dev_my_first_fpga\cycloneIII_3c120_dev_my_first_fpga.sof`.
7. Turn on **Program/Configure** to select the added file.
8. Click **Start** to download the selected file to the FPGA. The FPGA is configured when the progress bar reaches 100%.
9. Confirm that user LEDs 0-3 flash in a slow binary counting pattern.

Introduction

The Cyclone III FPGA Development Kit ships with the Board Update Portal design example stored in the factory portion of the flash memory on the board. The design consists of a Nios II embedded processor, an Ethernet MAC, and an HTML web server.

When you power up the board with the PGM CONFIG SELECT rotary switch (SW5) in position 0, the Cyclone III FPGA configures with the Board Update Portal design example. The design can obtain an IP address from any DHCP server and serve a web page from the flash on your board to any host computer on the same network. The web page allows you to upload new FPGA designs to the FPGA design 1 and design 6 (HW1 and SW1) portion of flash memory, and provides links to useful information on the Altera website, including links to kit-specific and design resources.



After successfully updating the FPGA design 1 and design 6 (HW1 and SW1) flash memory, you can load the user design from flash memory into the FPGA. To do so, set the PGM CONFIG SELECT rotary switch (SW5) to position 1 and power cycle the board.

The source code for the Board Update Portal design resides in the `<install dir>\kits\cycloneIII_3c120_dev\examples` directory. If the Board Update Portal is corrupted or deleted from the flash memory, refer to [“Restoring the Factory Design to the Flash Device” on page A-6](#) to restore the board with its original factory contents.

Connecting to the Board Update Portal Web Page

This section provides instructions to connect to the Board Update Portal web page.



Before you proceed, ensure that you have the following:

- A PC with a connection to a working Ethernet port on a DHCP enabled network.
- A separate working Ethernet port connected to the same network for the board.
- The Ethernet and power cables that are included in the kit.

To connect to the Board Update Portal web page, perform the following steps:

1. With the board powered down, set the PGM CONFIG SELECT rotary switch (SW5) to position 0.
2. Attach the Ethernet cable from the board to your LAN.
3. Power up the board. The board connects to the LAN's gateway router, and obtains an IP address. The LCD on the board displays the IP address.
4. Launch a web browser on a PC that is connected to the same network, and enter the IP address from the LCD into the browser address bar. The Board Update Portal web page appears in the browser.

5. Click **Cyclone III FPGA Development Kit** on the Board Update Portal web page to access the kit's home page. Visit this page occasionally for documentation updates and additional new designs.



You can also navigate directly to the [Cyclone III FPGA Development Kit](#) page of the Altera website to determine if you have the latest kit software.

Using the Board Update Portal to Update User Designs

The Board Update Portal allows you to write new designs to the FPGA design 1 and design 6 (HW1 and SW1) portion of flash memory. Designs must be in the Nios II Flash Programmer File (.flash) format.



Design files available from the [Cyclone III FPGA Development Kit](#) page of the Altera website include .flash files. You can also create .flash files from your own custom design. Refer to [“Creating a Flash File” on page A-1](#) for information about preparing your own design for upload.

To upload a design over the network into the FPGA design 1 and design 6 (HW1 and SW1) of flash memory on your board, perform the following steps:

1. Perform the steps in [“Connecting to the Board Update Portal Web Page”](#) to access the Board Update Portal web page.
2. In the **Hardware File Name** field specify the .flash file that you either downloaded from the Altera website or created on your own. If there is a software component to the design, specify it in the same manner using the **Software File Name** field, otherwise leave the **Software File Name** field blank.
3. Click **Upload**. The file takes about 20 seconds to upload.
4. To configure the FPGA with the new design after the flash memory upload process completes, set the PGM CONFIG SELECT rotary switch (SW5) to the 1 position and power cycle the board, or press the RESET_CONFIG push-button (S6).



As long as you do not overwrite the factory image in the flash memory device, you can continue to use the Board Update Portal to write new designs to the FPGA design 1 and design 6 (HW1 and SW1) portion of flash memory. If you overwrite the factory image, you can restore it by following the instructions in [“Restoring the Factory Design to the Flash Device” on page A-6](#).

Introduction

The kit includes a design example and application called the Board Test System to test the functionality of the Cyclone III FPGA development board. The application provides an easy-to-use interface to alter functional settings and observe the results. You can use the application to test board components, modify functional parameters, observe performance, and measure power usage. The application is also useful as a reference for designing systems. To install the application, follow the steps in [“Installing the Cyclone III Development Kit” on page 3–1](#).

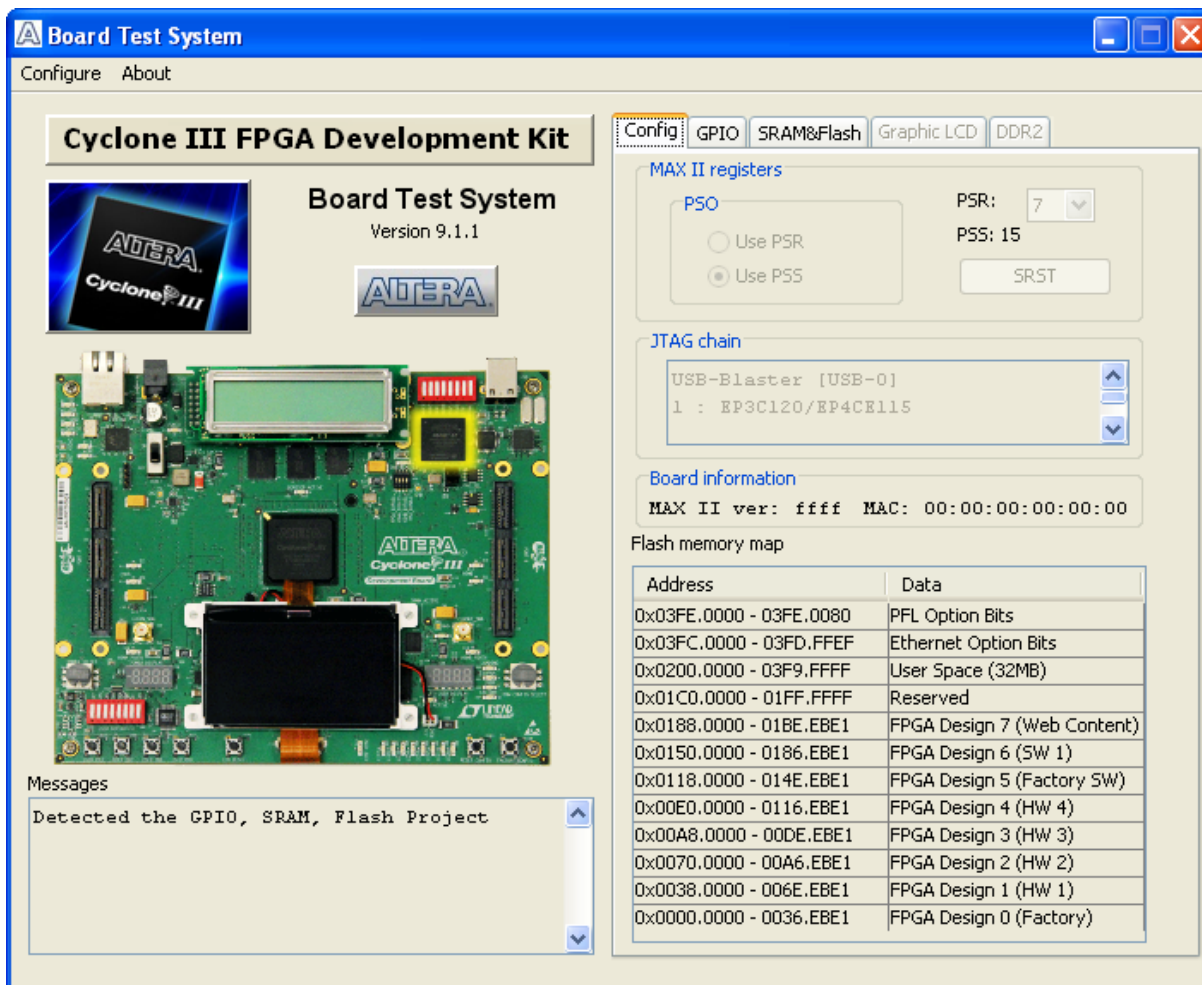
The application provides access to the following Cyclone III FPGA development board features:

- General purpose I/O (GPIO)
- SRAM
- Flash memory
- DDR2 memory
- Graphic LCD

The application allows you to exercise most of the board components. While using the application, you reconfigure the FPGA several times with test designs specific to the functionality you are testing.

A GUI runs on the PC which communicates over the JTAG bus to a test design running in the Cyclone III device. Figure 6-1 shows the initial GUI for a board that is in the factory configuration.

Figure 6-1. Board Test System Graphical User Interface



Several designs are provided to test the major board features. Each design provides data for one or more tabs in the application. The Configure menu identifies the appropriate design to download to the FPGA for each tab.

After successful FPGA configuration, the appropriate tab appears and allows you to exercise the related board features. Highlights appear in the board picture around the corresponding components.

Preparing the Board

With the power to the board off, perform the following steps:

1. Connect the USB cable to the board.
2. Verify the settings for the board settings DIP switch bank (SW3) match the settings in Table 4-2 on page 4-3.

3. Set the PGM CONFIG SELECT rotary switch (SW5) to position 1.
4. Turn the power to the board on. The board loads the design stored in the user hardware 1 portion of flash memory into the FPGA. If your board is still in the factory configuration or if you have downloaded a newer version of the Board Test System to flash memory through the Board Update Portal, the design that loads tests accessing the GPIO, SRAM, and flash memory.



To ensure operating stability, keep the USB cable connected and the board powered on when running the demonstration application. The application cannot run correctly unless the USB cable is attached and the board is on.

Running the Board Test System

To run the application, navigate to the *<install dir>\kits\cycloneIII_3c120_dev\examples\board_test_system* directory and run the **BoardTestSystem.exe** application.



On Windows, click **Start > All Programs > Altera > Cyclone III FPGA Development Kit <version> > Board Test System** to run the application.

A GUI appears, displaying the application tab that corresponds to the design running in the FPGA. The Cyclone III FPGA development board's flash memory ships preconfigured with the design that corresponds to the **Config, GPIO, SRAM&Flash** tabs.



If you power up your board with the PGM CONFIG SELECT rotary switch (SW5) in a position other than position 1, or if you load your own design into the FPGA with the Quartus II Programmer, you receive a message prompting you to configure your board with a valid Board Test System design. Refer to *"The Configure Menu"* for information about configuring your board.

Using the Board Test System

This section describes each control in the Board Test System application.

The Configure Menu

Each test design tests different functionality and corresponds to one or more application tabs. Use the Configure menu to select the design you want to use. [Figure 6-2](#) shows the Configure menu.

Figure 6-2. The Configure Menu



1. To configure the FPGA with a test system design, perform the following steps: On the Configure menu, click the configure command that corresponds to the functionality you wish to test.
2. In the dialog box that appears, click **Configure** to download the corresponding SRAM/Flash/GPIO design object file (.sof) to the FPGA. The download process usually takes about a minute.
3. When configuration finishes, the design begins running in the FPGA. The corresponding GUI application tab that interfaces with the design is enabled.

The Config Tab

The **Config** tab shows information about the board's current configuration. [Figure 6-1 on page 6-2](#) shows the **Config** tab. The tab displays the contents of the JTAG chain, the flash memory map, and other details stored on the board.

The following sections describe the controls on the **Config** tab.

MAX II Registers

The **MAX II registers** control allow you to view the current MAX II register values. The values are set when you load the test system design into the FPGA and is not configurable.

JTAG Chain

The **JTAG chain** control shows all the devices currently in the JTAG chain. The Cyclone III device is always the first device in the chain.

 Connecting a jumper shunt on J6 and an external USB-Blaster on J14 includes the MAX II device in the JTAG chain.

Board Information

The **Board information** controls display static information about your board.

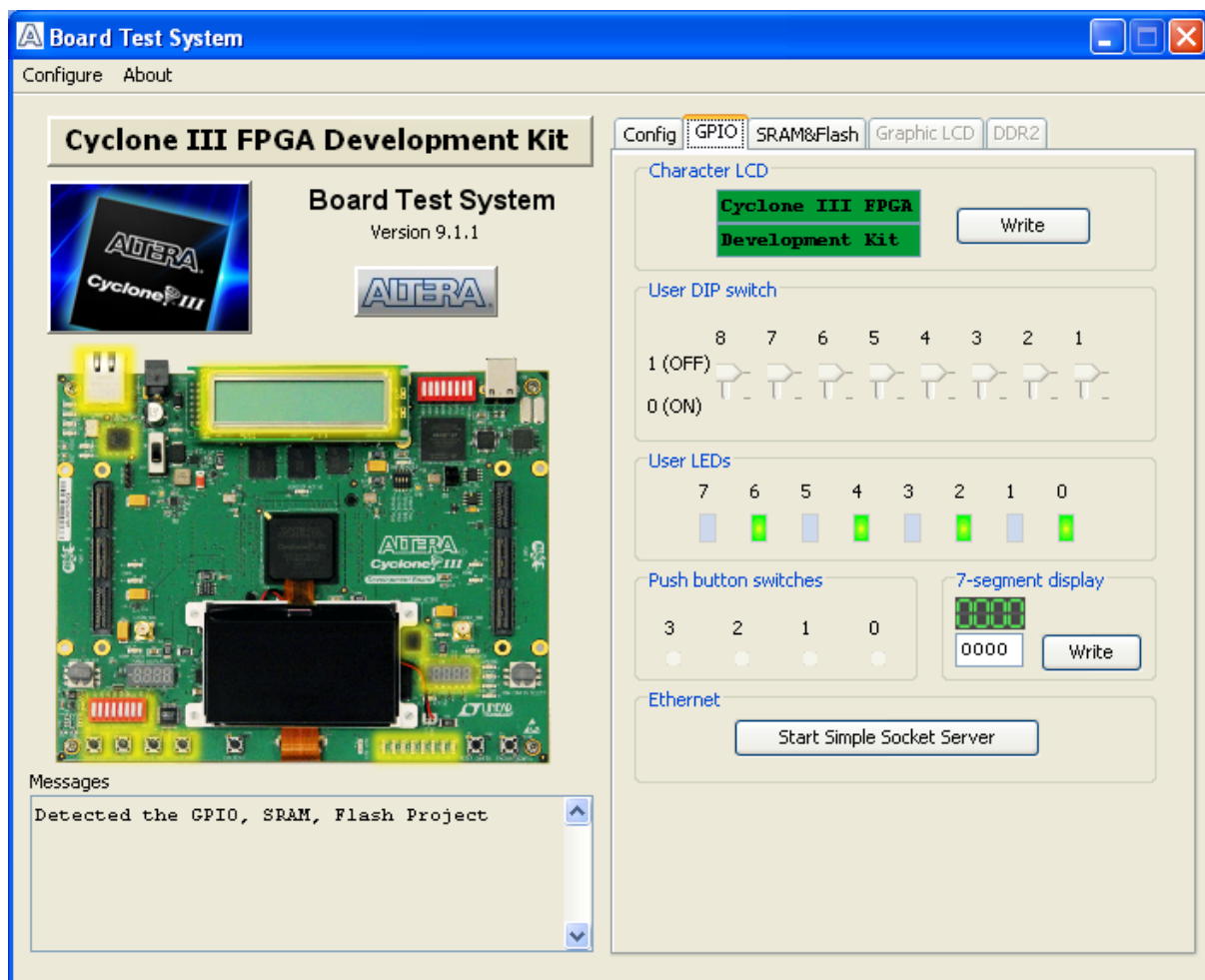
Flash Memory Map

The **Flash memory map** control shows the memory map of the flash memory device on your board.

The GPIO Tab

The **GPIO** tab allows you to interact with all the general purpose user I/O components on your board. You can write to the LCD, read user DIP switch settings, turn LEDs on or off, detect push button presses, write to the 7-segment display, and run an Ethernet application (the Simple Socket Server Test) on your board. [Figure 6-3](#) shows the **GPIO** tab.

Figure 6-3. The GPIO Tab



The following sections describe the controls on the **GPIO** tab.

Character LCD

The **Character LCD** controls allow you to display text strings on the character LCD on your board. Type text in the text boxes and then click **Write**.



If you exceed the 16 character display limit on either line, a warning message appears.

User DIP Switches

The read-only **User DIP switches** control displays the current positions of the switches in the user DIP switch bank (SW6). Change the switches on the board to see the graphical display change accordingly.

User LEDs

The **User LEDs** control displays the current state of the user LEDs. Click the graphical representation of the LEDs to turn the board LEDs on and off.

Push Button Switches

The read-only **Push button switches** control displays the current state of the board user push buttons. Press a push button (S1-S4) on the board to see the graphical display change accordingly.

7-Segment Display

The **7-segment display** control allow you to display hexadecimal numbers on the 7-segment display on your board. Type number in the text box and then click **Write**.



If you enter a hexadecimal value outside of the 0x0000 to 0xFFFF display limit, a warning message identifies the valid hexadecimal value range.

Ethernet

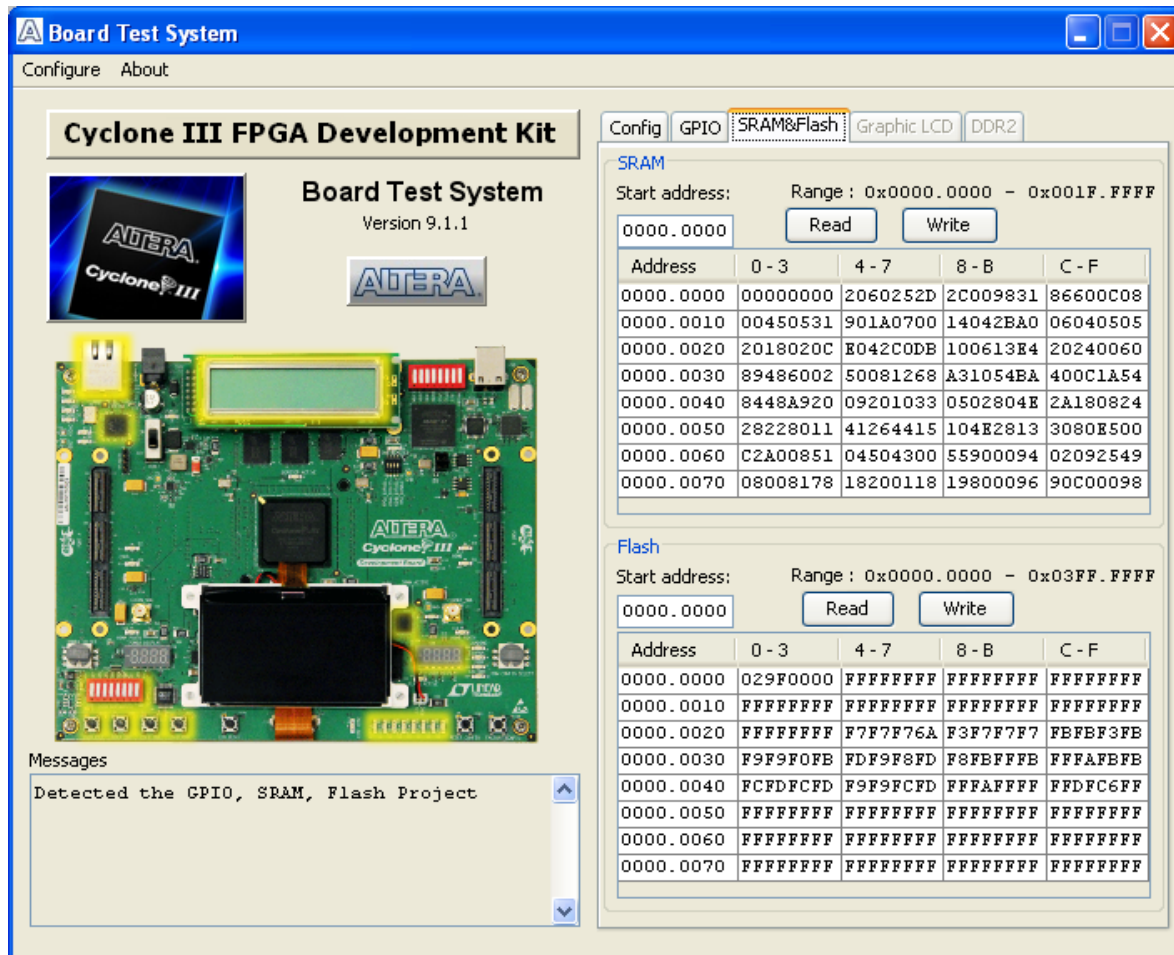
The **Ethernet** control allows you to run an Ethernet application (the Simple Socket Server Test) on your board.

Click **Start Simple Socket Server** to load the application which allows you to interactively enter keyboard characters to select menu items. The application responds to the keypress and takes appropriate action.

The SRAM&Flash Tab

The **SRAM&Flash** tab allows you to read and write SRAM and flash memory on your board. Figure 6-4 shows the **SRAM&Flash** tab.

Figure 6-4. The SRAM&Flash Tab



The following sections describe the controls on the **SRAM&Flash** tab.

SRAM

The **SRAM** control allows you to read and write the SRAM on your board. Type a starting address in the text box and click **Read**. Values starting at the specified address appear in the top row of the table. The SRAM addresses display in the format the Nios II processor within the FPGA uses, that is, each SRAM address is offset by 0x00000000. Thus, the first location in SRAM appears as 0x00000000 in the GUI. The base address of SRAM in this Nios II-based BTS design is 0x0D00.0000. The valid address range within the 2-MB SRAM is 0x0000.0000 through 0x001F.FFFF, as shown in the GUI.



If you enter an address outside of the 0x00000000 to 0x001FFF80 SRAM address space, a warning message identifies the valid SRAM address range.

To update the SRAM contents, change values in the table and click **Write**. The application writes the new values to SRAM and then reads the values back to guarantee that the graphical display accurately reflects the memory contents.

Flash

The **Flash** control allows you to read and write the flash memory on your board. Type a starting address in the text box and click **Read**. Values starting at the specified address appear in the top row of the table. The flash memory addresses display in the format the Nios II processor within the FPGA uses, that is, each flash memory address is offset by 0x00000000. Thus, the first location in flash memory appears as 0x00000000 in the GUI. The base address of flash memory in this Nios II-based BTS design is 0x0800.0000. The valid address range within the 64-MB flash memory is 0x0000.0000 through 0x03FF.FFFF, as shown in the GUI.



If you enter an address outside of the 0x00000000 to 0x03FFFF80 flash memory address space, a warning message identifies the valid flash memory address range.

To update the flash memory contents, change values in the table and click **Write**. The application writes the new values to flash memory and then reads the values back to guarantee that the graphical display accurately reflects the memory contents.

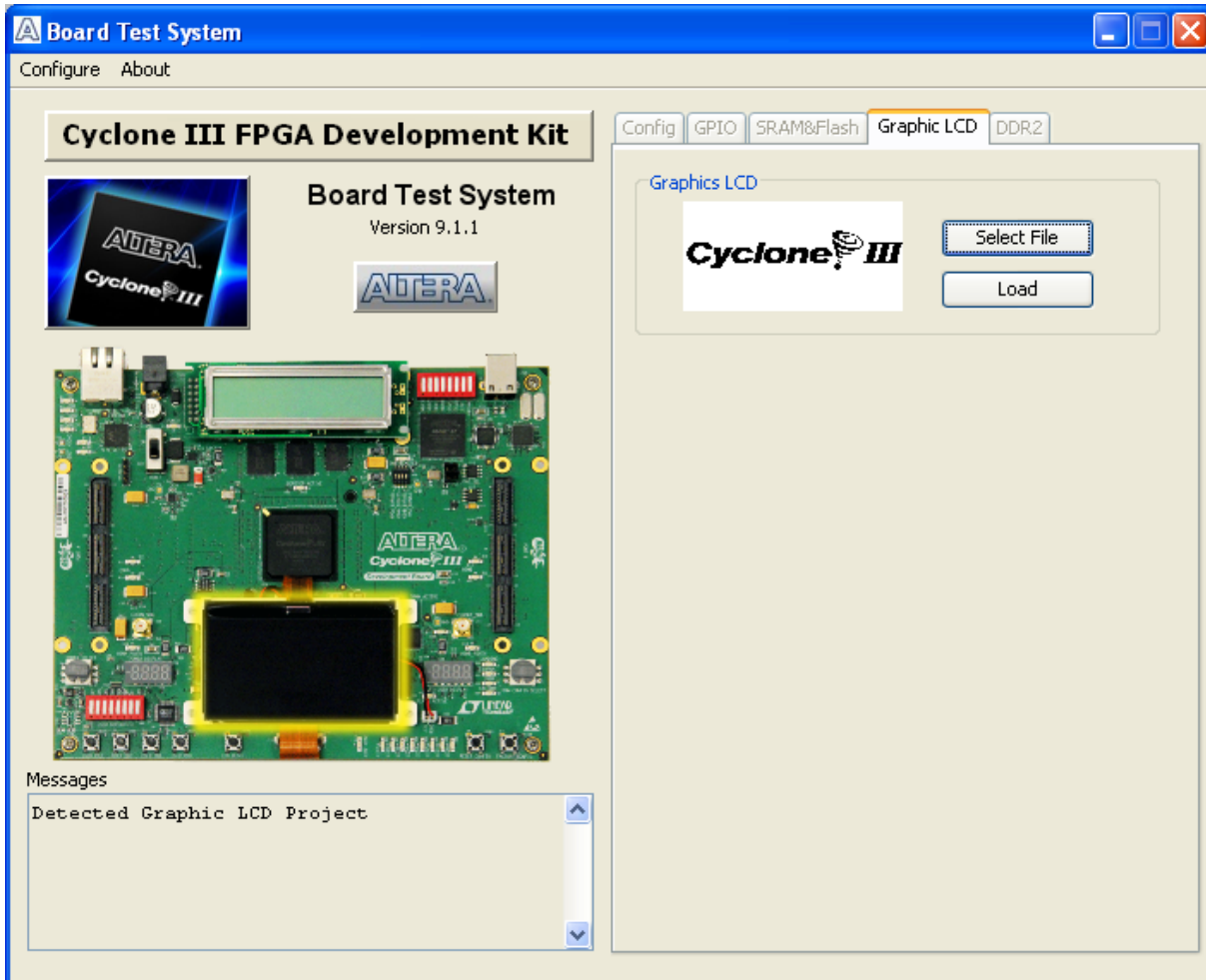


To prevent overwriting the dedicated portions of flash memory, the application limits the writable flash memory address range from 0x07000000 to 0x0701FF80 (which corresponds to the unused flash memory address range of 0x02000000 - 0x0201FF80 shown in [Figure 6-1 on page 6-2](#)).

The Graphic LCD Tab

The **Graphic LCD** tab allows you to write to the LCD on your board. Figure 6-3 shows the **Graphic LCD** tab.

Figure 6-5. The **Graphic LCD** Tab



The following section describes the controls on the **Graphic LCD** tab.

Graphics LCD

The **Graphics LCD** controls allow you to display Bitmap Image File (**.bmp**) on the graphic LCD on your board:

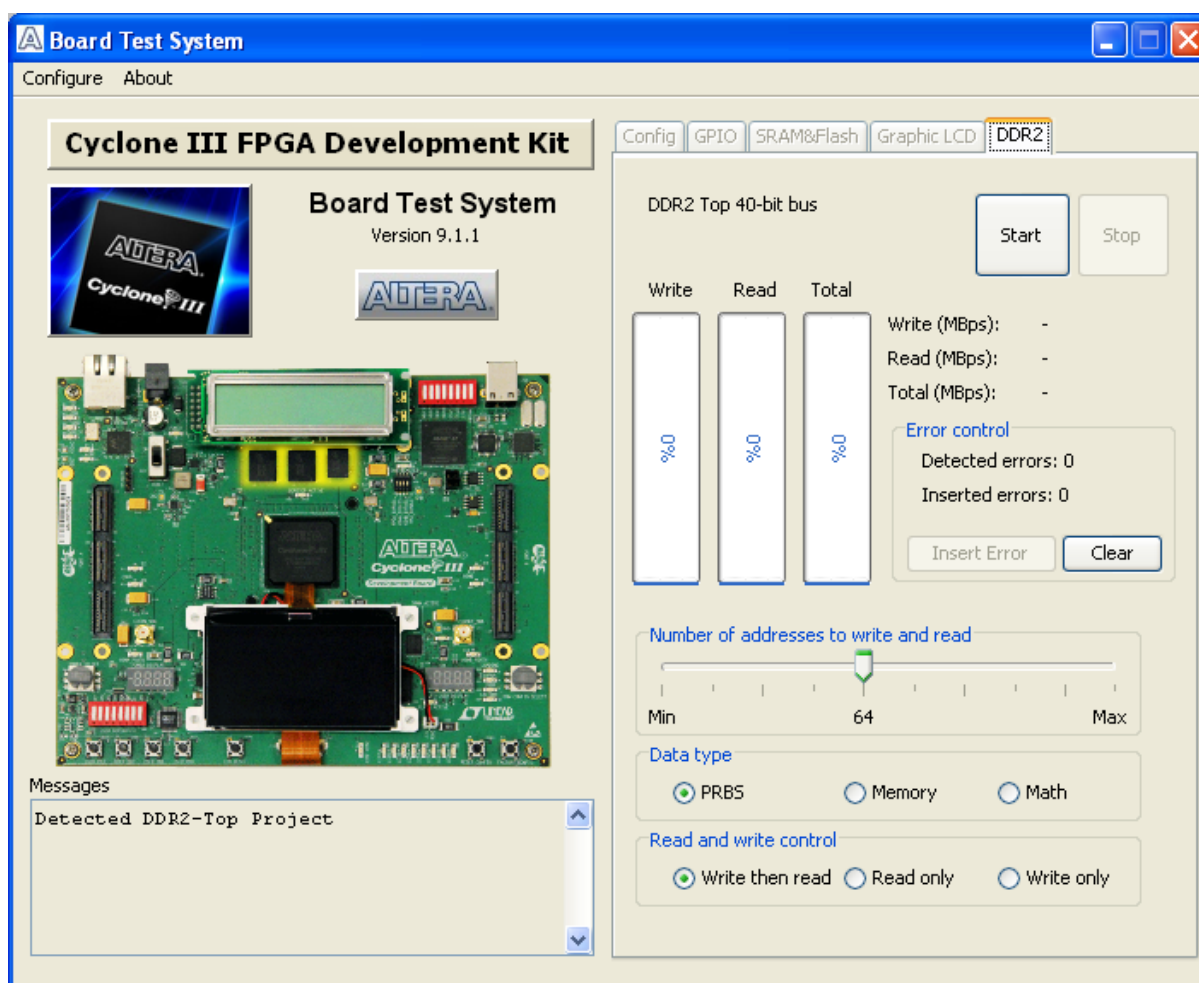
- **Select File**—opens the browser window to allow you to select a **.bmp** file to upload.
- **Load**—displays the selected **.bmp** file on the graphic LCD.

 The graphic LCD supports only 128x64 size **.bmp** files. There are three sample **.bmp** files located in `<install dir>\kits\cycloneIII_3c120_dev\examples\board_test_system` directory.

The DDR2 Tab

The **DDR2** tab allows you to read and write to one of two DDR2 memory ports on your board. The DDR2 memory configuration is divided into top design (implemented by DDR2 chip U11, U12, U13) and bottom design (implemented by DDR2 chip U25, U26). [Figure 6-6](#) shows the **DDR2** tab when the board is configured with DDR2 top design.

Figure 6-6. The DDR2 Tab



The following sections describe the controls on the **DDR2** tab.

Start

The **Start** control initiates DDR2 memory transaction performance analysis.

Stop

The **Stop** control terminates transaction performance analysis.

Performance Indicators

These controls display current transaction performance analysis information collected since you last clicked **Start**:

- **Write, Read, and Total** performance bars—show the percentage of maximum theoretical data rate that the requested transactions are able to achieve.
- **Write(MBps), Read(MBps), and Total(MBps)**—show the number of bytes of data analyzed per second. For DDR2 top design, the data bus is 40-bits wide and the frequency is 300 MHz double data rate, equating to a theoretical maximum bandwidth of 1500 MBps. For DDR2 bottom design, the data bus is 32-bits wide and the frequency is 300 MHz double data rate, equating to a theoretical maximum bandwidth of 1200 MBps.

Error Control

The **Error control** controls display data errors detected during analysis and allow you to insert errors:

- **Detected errors**—displays the number of data errors detected in the hardware.
- **Inserted errors**—displays the number of errors inserted into the transaction stream.
- **Insert Error**—inserts a one-word error into the transaction stream each time you click the button. **Insert Error** is only enabled during transaction performance analysis.
- **Clear**—resets the **Detected errors** and **Inserted errors** counters to zeros.

Number of Addresses to Write and Read

The **Number of addresses to write and read** control determines the number of addresses to use in each iteration of reads and writes. Valid values range from 8 to 8,192.

Data Type

The **Data type** control specifies the type of data contained in the transactions. The following data types are available for analysis:

- **PRBS**—selects pseudo-random bit sequences.
- **Memory**—selects a generic data pattern stored in the on-chip memory of the Cyclone III device.
- **Math**—selects data generated from a simple math function within the FPGA fabric.

Read and Write Control

The **Read and write control** specifies the type of transactions to analyze. The following transaction types are available for analysis:

- **Write then read**—selects read and write transactions for analysis.
- **Read only**—selects read transactions for analysis.
- **Write only**—selects write transactions for analysis.

Introduction

One of the main features of the Cyclone III FPGA device is its low power consumption. You can measure the power used by the 3C120 FPGA device on the Cyclone III development board for various conditions with a power design example provided with the kit.

With the power design example you can control the amount of logic utilized in the FPGA, the clock frequency, and the number of I/Os used, and measure the effect on power used by the Cyclone III device.

Power Design Example

The power design example uses a replicated module, **stamp.v**, that contains combinational logic, randomly filled ROMs, multiplier blocks, and shift registers that change with every clock cycle. The frequency and resource states indicated in [Table 7-2](#) and [Table 7-3 on page 7-2](#), respectively, represent the percent of the full design used. As compiled, the full example design uses the following FPGA resources:

- Total logic elements: 111,673 / 119,088 (94%)
- Total combinational functions: 12,293 / 119,088 (10%)
- Dedicated logic registers: 104,192 / 119,088 (87%)
- Total registers: 104,192
- Total pins: 165 / 532 (31%)
- Total virtual pins: 0
- Total memory bits: 2,490,368 / 3,981,312 (63%)
- Embedded multiplier 9-bit elements: 576 / 576 (100%)
- Total phase-locked loops (PLLs): 1/4 (25%)

[Table 7-1](#) describes the functionality of the four user push buttons that control the power design example. The on-board 50-MHz oscillator provides the input clock (`i_clk`, PIN_AH15).

Table 7-1. Four Input Button Functionality

User Push Button	FPGA Pin	Type	Description
User_PB0	AD7	Reset	Resets the demo to the beginning, <code>i_nrst</code>
User_PB1	AC12	Toggle	Advances the design example to the next higher frequency, <code>i_nfreq_next</code>
User_PB2	AH3	Toggle	Advances the design example to the next higher resource utilization, <code>i_nperc_next</code>
User_PB3	AA12	Toggle	Enables the outputs to toggle, <code>i_noutput_ena</code>

The LEDs in [Table 7-2](#) indicate the power-state values of the design example as User_PB1 advances frequency.

Table 7-2. Power State Indicators for Frequency

LED1 (AE20)	LED0 (AD15)	Frequency (MHz)
0	0	0
0	1	33
1	0	67
1	1	100

The LEDs in [Table 7-3](#) indicate the power-state values of the design example (and number of output pins, when enabled by User_PB3) as User_PB2 advances resource utilization.

Table 7-3. Power State Indicators for Resources

LED6 (AG19)	LED5 (AC17)	LED4 (AE15)	LED3 (AD19)	LED2 (AF18)	Resources (%)	Number of Outputs
0	0	0	0	0	5	8
0	0	0	0	1	10	16
0	0	0	1	0	15	24
0	0	0	1	1	20	32
0	0	1	0	0	25	40
0	0	1	0	1	30	48
0	0	1	1	0	35	56
0	0	1	1	1	40	64
0	1	0	0	0	45	72
0	1	0	0	1	50	80
0	1	0	1	0	55	88
0	1	0	1	1	60	96
0	1	1	0	0	65	104
0	1	1	0	1	70	112
0	1	1	1	0	75	120
0	1	1	1	1	80	128
1	0	0	0	0	85	136
1	0	0	0	1	90	144
1	0	0	1	0	95	152

The resource state ([Table 7-3](#)) controls the number of I/O pins used. Each resource increment adds 8 additional I/O pins ([Table 7-3](#)). Similarly, the overall design frequency ([Table 7-2](#)) sets the toggle frequency of these I/O pins.

Measuring Power

You can measure power by using the analog-to-digital (A/D) circuitry on the development board or by using a digital multi-meter (DMM) across on-board sense resistors. However, note that, depending on the DMM accuracy, the on-board A/D measurements tend to produce considerably more accurate results.

A/D Measurements

The POWER SELECT rotary switch SW4 sets the development board to measure and display FPGA core power or I/O output power (Table 7-4).

Table 7-4. Switch SW4 Power Selection

Switch Position	FPGA Power	I/O Banks
0	Core: V_{CC_INT} , 1.2 V	—
5	I/O: 2.5 V	1 and 2
6	I/O: 2.5 V	5 and 6

Measuring V_{CC_INT} Power

To measure FPGA core power at $V_{CC_INT} = 1.2$ V for various power states, perform the following steps:

1. Ensure that the 8-position SW1 DIP switch is configured to the default settings shown in Table 4-1 on page 4-2.
2. Download the `cycloneIII_3c120_dev_power_demo.sof` file as described in “Configuring the FPGA” on page 4-4. You can find the power design example in `<path>\...\examples\cycloneIII_3c120_dev_power_demo`.
3. Set the POWER SELECT rotary switch SW4 to 0 to measure the internal V_{CC_INT} power in watts.
4. Observe the power on the 4-digit hexadecimal power display.
The on-board power measurements are performed at a high rate. For this reason, it appears that the display is dithering; however, what is actually taking place is the very fast momentary changes on the power rail.
5. Using the user input push buttons (Table 7-1 on page 7-1), advance through the power states in Table 7-2 and Table 7-3 on page 7-2. Notice how power increases as frequency and resources increase.



For information about measuring power sources, refer to the *Cyclone III 3C120 Development Board Reference Manual*.

Measuring I/O Power

This example uses FPGA I/O banks 1, 2, 5, and 6. Using the SW4 settings (Table 7-4), measure the power for I/O banks 1 and 2, then for I/O banks 5 and 6, by performing the following steps:

1. Ensure that the 8-position SW1 DIP switch is configured to the default settings shown in Table 4-1 on page 4-2.

2. Download the `cycloneIII_dev_powerdemo.sof` file as described in “Configuring the FPGA” on page 4-4. The power design example is in `<path>\...\examples\cycloneIII_3c120_dev_powerdemo`.
3. Set the POWER SELECT rotary switch SW4 to 5.
4. Observe the 4-digit hexadecimal display for the I/O output power in watts on banks 1 and 2.
5. Using the user input push buttons (Table 7-1 on page 7-1), advance through the power states in Table 7-2 and Table 7-3 on page 7-2. Notice how power increases as frequency and resources increase.
6. Press the **User_PB3** button to enable the output pins on the HSMC connectors J8 and J9. LED7 (AF19), signal `o_noutput_ena_state`, lights to indicate that the outputs are enabled and toggling. Enabling the outputs further increases power for each resource utilization percentage used by the Cyclone III FPGA.
7. Press the **User_PB3** button again to disable the outputs. LED7 turns off.
8. Set the POWER SELECT rotary switch SW4 to 6.
9. Repeat steps 4 through 7 to observe the I/O output power in watts on banks 5 and 6.

The sum of power results from the two sets of I/O banks provides the total FPGA I/O power.



For specific information about on-board measurements and the POWER SELECT rotary switch, refer to the *Cyclone III 3C120 Development Board Reference Manual*.

Measuring Voltage with a DMM

To obtain power values by using a DMM, measure voltage across the sense resistors, R49, R48, and R51 on the board, then use the voltage measurements to calculate power.



For best results, use a DMM with six-digit for greater accuracy.

FPGA I/O power is distributed by banks (Table 7-5), for which the sense resistors are components R48 and R51. For the I/O power calculation, use the sum of voltage measurements across these resistors while outputs are enabled. For the FPGA core power calculation, measure the sense resistor voltage across R49.

Table 7-5. Sense Resistors

FPGA Power		Voltage	Sense Resistor	Resistor Value
I/O	Banks 1 and 2	2.5 V	R48	0.009 Ω
	Banks 5 and 6	2.5 V	R51	0.009 Ω
Core: V_{CC_INT}		1.2 V	R49	0.009 Ω

Calculating Power

To obtain the power P in watts, measure the voltage across the sense resistors, V_{SENSE} , and calculate the nominal power as follows:

If

V_{SENSE} = Voltage measured across the sense resistor

I_{SENSE} = Current through the sense resistor

V_{SUPPLY} = FPGA supply voltage

R_{SENSE} = Sense resistor value in [Table 7-5](#).

then

Equation 7-1.

$$P = VI = V_{SUPPLY} \times I_{SENSE} = \frac{V_{SUPPLY} \times V_{SENSE}}{R_{SENSE}}$$

where

V_{SUPPLY} is 1.2 V for the FPGA core and 2.5 V for FPGA I/O.

Voltage measurements on the DMM should increase as frequency and resource utilization increases according to [Table 7-2](#) and [Table 7-3 on page 7-2](#).

Changing the Design Example

The development kit includes source code for the Cyclone III power design example so you can use it as a starting point for your own measurements.

The design example uses 19 **stamp.v** modules, each with 8 outputs, for a total of 152 output pins. It assigns the pins selected as outputs to the HSMC connectors J8 and J9.

To change the number of outputs, modify the design example and assign the pins appropriately.



Power should track linearly with frequency and percentage resources. If you observe superlinear power measurements, some temperature issue may be the cause.

Introduction

The example designs and tutorials included in the Cyclone III Development Kit help familiarize new users with development board features. *My First FPGA Design Tutorial* and *My First Nios II Software Tutorial* provide step-by-step guidance for the first-time user.

My First FPGA Tutorial

My First FPGA Design Tutorial describes how to create a simple Altera FPGA design. The tutorial takes less than an hour to complete and provides an overview of the design flow using the Quartus II software to build a simple logic counter which drives LEDs to flash on the development board.

After installing the Cyclone III Development Kit, the *My First FPGA Design Tutorial* design and documentation can be found at `<path>\...\documents\tutorials\hardware_tutorials\my_first_fpga_tutorial.pdf`.

My First Nios II Software Tutorial

My First Nios II Software Tutorial introduces the basic system development flow for the Nios II processor. This tutorial provides a good starting point if you are new to the Nios II processor or to the general concept of using an embedded processor in an FPGA. In this tutorial, you use a standard, existing Nios II hardware system and create a software program to run on it.

After installing the Cyclone III Development Kit, the *My First Nios II Software Tutorial* design and documentation can be found at `<path>\...\documents\tutorials\software_tutorials\my_first_nios2_software_tutorial.pdf`.

Overview

There is a Common Flash Interface (CFI) type flash memory device on the Cyclone III development board. When you first receive the kit, this CFI flash device arrives programmed with a default factory configuration that was loaded from a Programmer Object File (.pof).

When you power up the board, the CFI flash device configures the FPGA with the default factory configuration using Passive Serial (PS) programming. If the configuration loads correctly, the user LEDs on the board flash sequentially from side to side.

As you develop your own project using the Altera tools, you may wish to program the flash device so that, upon power up, it loads the FPGA with your own design. Or you may wish to restore the default factory configuration to your board.

This appendix describes how to program the flash device. You can load an existing design from a .pof, but if your design exists only as an SRAM Object File (.sof), then first you must convert the .sof to a .pof. Programming the flash device also requires the use of the Altera parallel flash loader (PFL). Using this appendix, you can do the following:

- Create a flash file by converting a .sof to .pof
- Install the PFL
- Use the Quartus II Programmer to write a .pof to the flash device
- Restore the default factory configuration

Creating a Flash File

To create a flash-programmable configuration .pof, perform the following steps:

1. On the File menu in the Quartus II software, click **Convert Programming Files**.
2. In the **Convert Programming Files** dialog box, select the parameter values as shown in the following table:

Table A-1.

Parameter	Value
Programming file type	Programmer Object File (.pof)
Configuration device	CFI_512MB
Mode	1-bit Passive Serial
File name	<output_file.pof> This is the default file name. Change this to the file name you wish to use for your application. Save the file in < path>\...\examples\cycloneIII_3c120_dev_pfl.
Memory Map File	selected (default)

3. Click **Options**. In the **Options** dialog box, enter 0x3FE0000 and click **OK**.
This sets the option bit base address for the development kit to the required default, 0x3FE0000. The option bit sector stores the start address for each page of memory and also stores the Page Valid bits. The Page Valid bits indicate whether each page is successfully programmed.

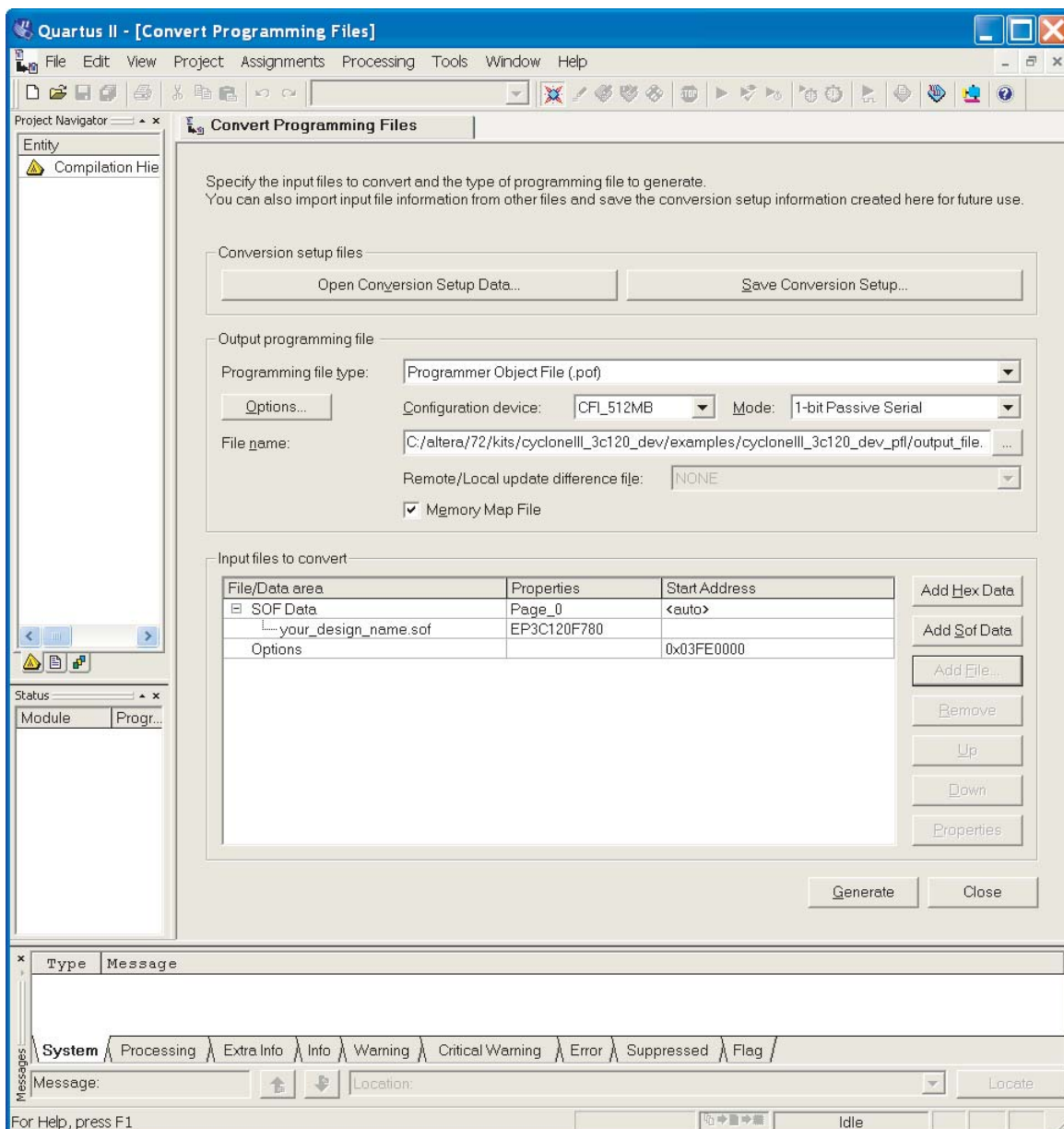


For more information about option bits and Page Mode Implementation of memory, refer to *Parallel Flash Loader Megafunction User Guide*.

4. Choose the **.sof** file you want to convert by selecting the row labeled **SOF Data** in the **Input files to convert** area and click **Add File**.
5. Browse to and select the file you wish to convert and click **OK**.
Figure A-1 shows the **Convert Programming Files** dialog box updated with the factory image **your_design_name.sof**.

 If you choose to overwrite an existing **.pof** file, you receive a warning message.

Figure A-1. Convert Programming Files Settings



- Click **Generate**. Generation takes a short time and it is confirmed by a “Generated... pof successfully” message.

You now have a successfully generated **.pof** that can be programmed to the flash device to automatically configure the FPGA on your Cyclone III development board.

Parallel Flash Loader Instantiation

The development kit includes a PFL megafunction design, `cycloneIII_3c120_dev_pfl`, in the directory `<path>\...\examples`. The Quartus II software uses the PFL to write programming files to the flash device, which then loads the FPGA on power up.

To write to a flash device, you must first program the PFL into the FPGA by using the Quartus II software as described in “[Programming the Flash Device](#)”, steps 1 through 8.



For more information about the PFL megafunction, refer to *Parallel Flash Loader Megafunction User Guide*.

Programming the Flash Device

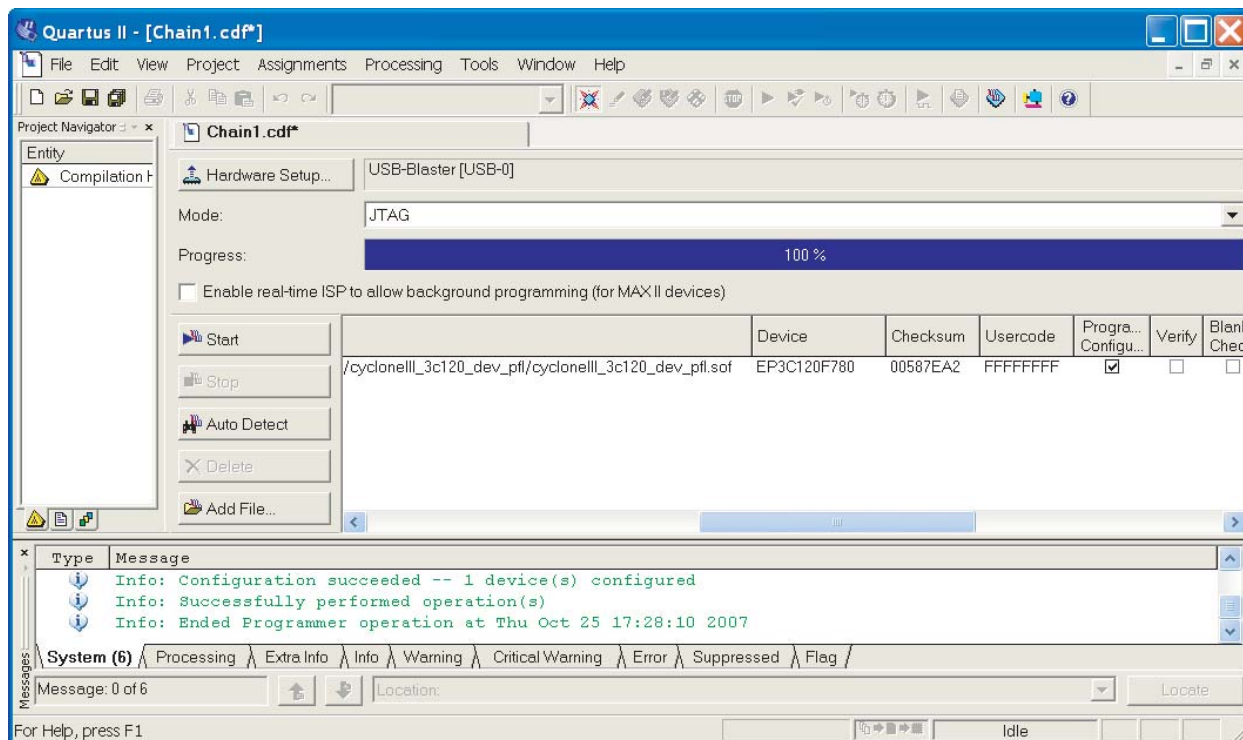
To program the flash device on the development board, you must first create a `.pof` flash file as described in “[Creating a Flash File](#)” on page A-1. The following procedure describes programming the PFL into the FPGA first, then uses the PFL to write the `.pof` flash file into the flash device.

To download a configuration bit stream into the flash device, perform the following steps:

1. Ensure that the POWER switch SW2 is in the OFF (or DOWN) position.
2. Verify the switch SW3 and jumper settings shown in [Table 4-2 on page 4-3](#).
3. Connect the USB cable to the USB port on the board.
4. Cycle the POWER switch OFF then ON.
5. On the Tools menu in the Quartus II software, click **Programmer**.
6. Click **Add File** and select
`<path>\...\examples\cycloneIII_3C120_dev_pfl\cycloneIII_3C120_dev_pfl.sof`.
7. Turn on the **Program/Configure** option for the added file.

8. Click **Start** to download the selected configuration file to the FPGA (Figure A-2). The FPGA is configured when the progress bar reaches 100%, after which it is ready to access and program the flash device.

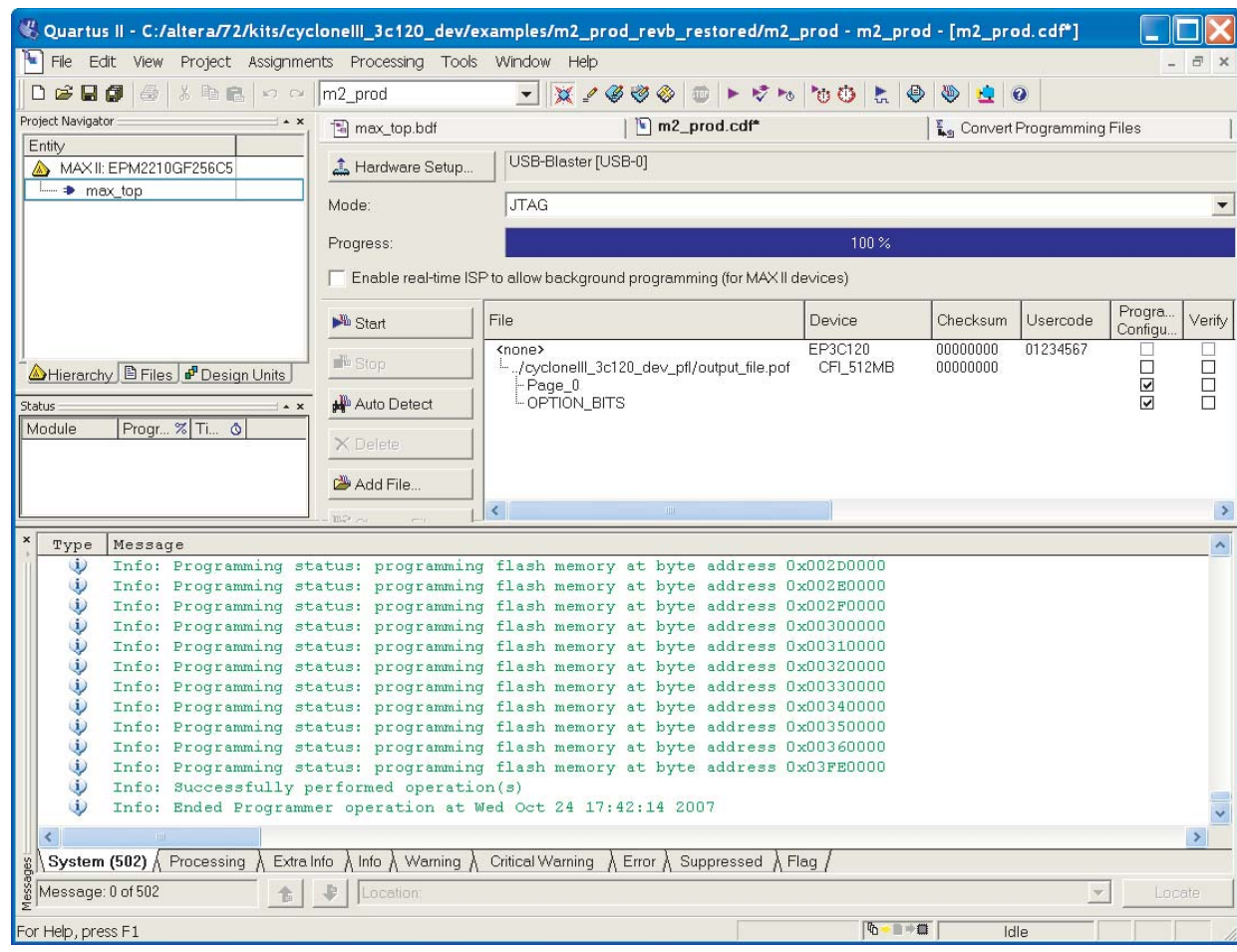
Figure A-2. PFL Programming



9. Click **Auto Detect**. The EP3C120 device and a child CFI_512MB device appear in the list of devices to be programmed.
10. Double-click the <File><none> field of the CFI_512MB row. The **Select New Programming File** dialog box appears. Select the desired .pof, in this example the <output_file>.pof flash file you created earlier, and click **Open**.

11. Turn on **Page_0** and **OPTION_BITS** options in the **Program/Configure** column that correspond to the CFI_512MB device (Figure A-3). This results in writes only to the flash page zero and the option bit register.

Figure A-3. Program/Configure Options



12. Click **Start**. The message window details the flash writing progress to successful completion. Flash writing to one page, as in this case, can take five to six minutes.

You have now successfully programmed the flash device with a configuration for your board. To configure the board from the flash device, power cycle the board as described in “Powering Up the Board” on page 4-2.

Powering on the board causes the flash device to load a new configuration into the FPGA device. The Configuration Done LED lights up and the hardware functions associated with the design take effect.

Restoring the Factory Design to the Flash Device

To restore the development board to factory conditions, repeat the steps for writing a new POF to the flash device as described in “Programming the Flash Device” on page A-4, except select the `cycloneIII_3c120_dev_factory_recovery.pof` file.

This chapter provides additional information about the document and Altera.

Document Revision History

The following table shows the revision history for this document.

Date	Version	Changes
September 2010	1.4	- Added Chapter 5, Board Update Portal and Chapter 6, Board Test System. - Converted document to new frame template and made textual and style changes.
July 2010	1.3	- Updated Figure 3-1 on page 3-1. - Updated “Installing the Quartus II Web Edition Software” on page 3-2. - Updated Table 2-1 on page 2-3. - Updated Copyright information. - General formatting edits.
March 2009	1.2	Updated Table 4-2 on page 4-3 .
August 2008	1.1	- Updated “Introduction” section. - Updated directory structure and information about the directory contents in Figure 3-1 and Table 3-1, respectively. - Removed Figure 3-2 and Figure 4-2. - Corrected SW3.4 information in Table 4-2. - Updated “Power Design Example” section with new compilation numbers. - Updated “Measuring Power” section. - Converted document to new frame template and made textual and style changes.
October 2007	1.0	First publication

How to Contact Altera

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

Contact (1)	Contact 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) (Software Licensing)	Email	nacomp@altera.com
	Email	authorization@altera.com

Note to Table:

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

Typographic Conventions

The following table shows the typographic conventions this document uses.

Visual Cue	Meaning
Bold Type with Initial Capital Letters	Indicate command names, dialog box titles, dialog box options, and other GUI labels. For example, Save As dialog box. For GUI elements, capitalization matches the GUI.
bold type	Indicates directory names, project names, disk drive names, file names, file name extensions, software utility names, and GUI labels. For example, \qdesigns directory, D: drive, and chiptrip.gdf file.
<i>Italic Type with Initial Capital Letters</i>	Indicate document titles. For example, <i>Stratix IV Design Guidelines</i> .
<i>italic type</i>	Indicates variables. For example, $n + 1$. Variable names are enclosed in angle brackets (< >). For example, <file name> and <project name>.pof file.
Initial Capital Letters	Indicate keyboard keys and menu names. For example, the Delete key and the Options menu.
“Subheading Title”	Quotation marks indicate references to sections within a document and titles of Quartus II Help topics. For example, “Typographic Conventions.”
Courier type	Indicates signal, port, register, bit, block, and primitive names. For example, data1, tdi, and input. The suffix n denotes an active-low signal. For example, resetn. Indicates command line commands and anything that must be typed exactly as it appears. For example, c:\qdesigns\tutorial\chiptrip.gdf. Also indicates sections of an actual file, such as a Report File, references to parts of files (for example, the AHDL keyword SUBDESIGN), and logic function names (for example, TRI).
	An angled arrow instructs you to press the Enter key.
1., 2., 3., and a., b., c., and so on	Numbered steps indicate a list of items when the sequence of the items is important, such as the steps listed in a procedure.
■ ■ ■	Bullets indicate a list of items when the sequence of the items is not important.
	The hand points to information that requires special attention.
	A question mark directs you to a software help system with related information.
	The feet direct you to another document or website with related information.
	A caution calls attention to a condition or possible situation that can damage or destroy the product or your work.
	A warning calls attention to a condition or possible situation that can cause you injury.
	The envelope links to the Email Subscription Management Center page of the Altera website, where you can sign up to receive update notifications for Altera documents.