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Cyclone III FPGA Starter Kit

User Guide

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Contents

1. Getting Started

Introduction

Welcome to the Altera® Cyclone® 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® 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 Begin

Before proceeding, check the contents of the kit:

- Cyclone III FPGA Starter Development Board
- 12-V DC power supply
- USB cable

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 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-starter.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

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.

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

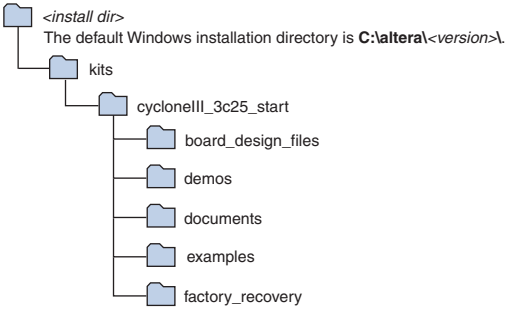


Table 1–1 lists the file directory names and a description of their contents.

Table 1–1. 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 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® 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.

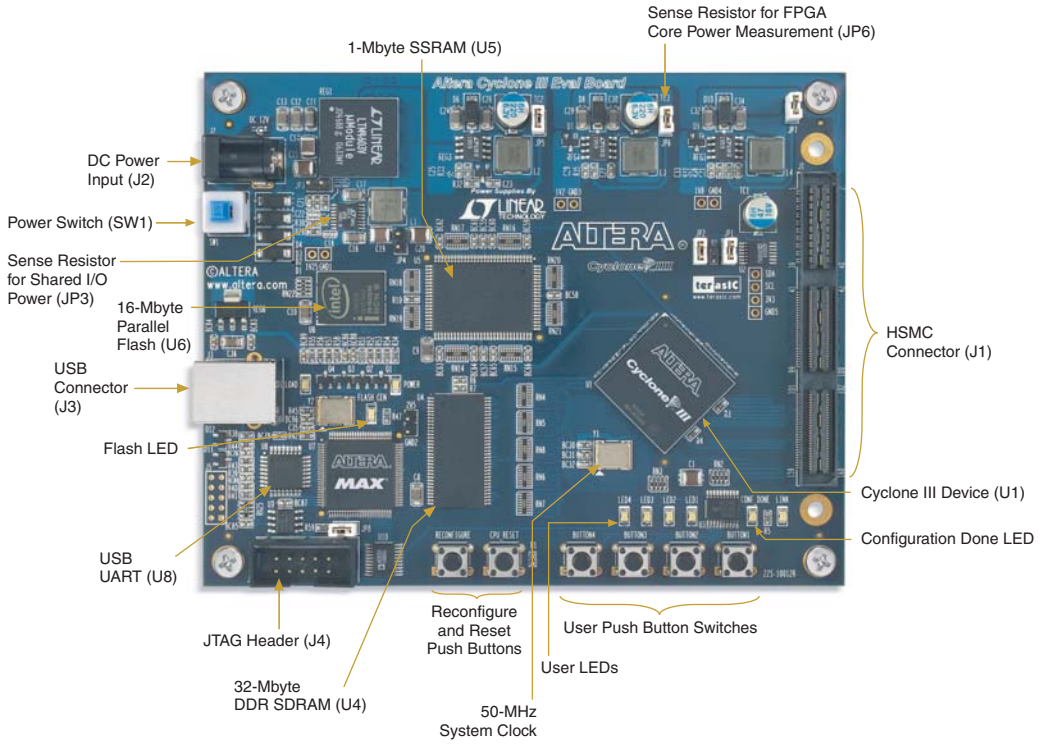
2. Development Board and Control Panel Setup

Development Board Setup

The development board is preloaded with an example design to demonstrate the Cyclone® 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® Quartus® II software on the host computer
- Cyclone III FPGA Starter Kit
- USB-Blaster™ 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

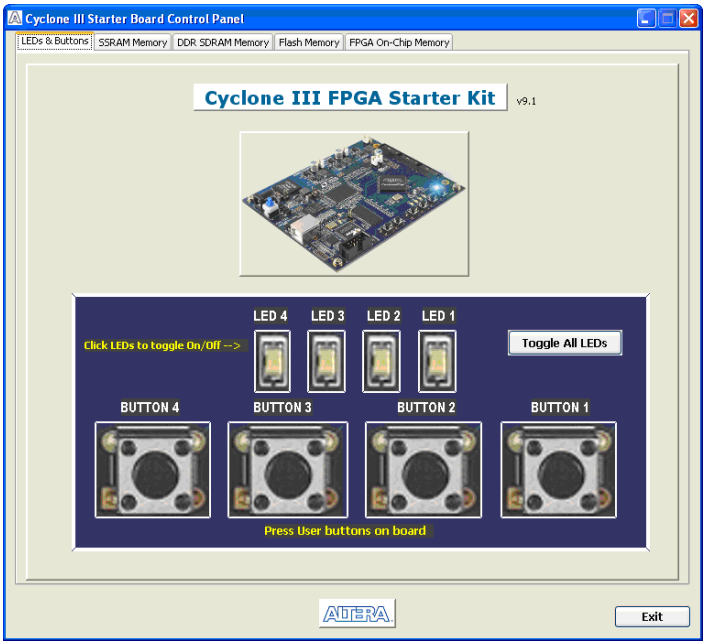
The Cyclone III development board is shipped with an example design stored in the flash memory which configures the Cyclone III FPGA upon power-up with the standard Nios II design.

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

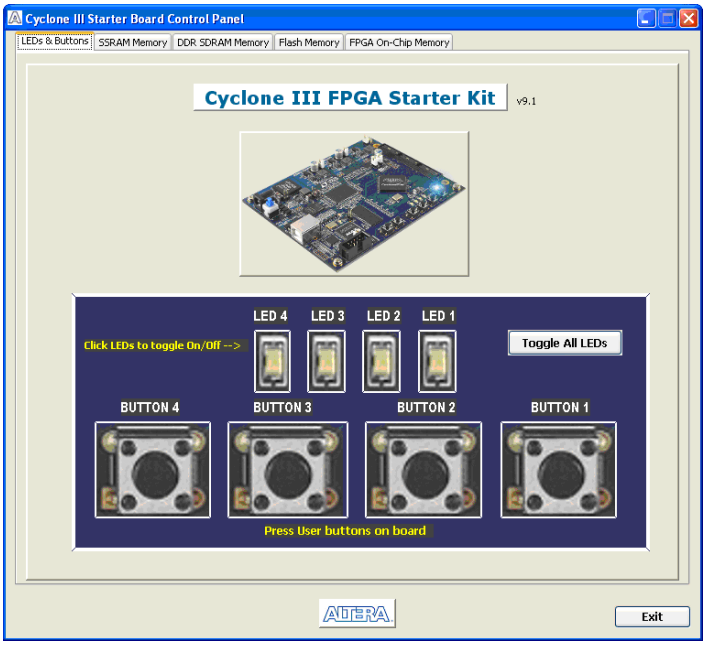
To illuminate an LED, follow these steps:

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

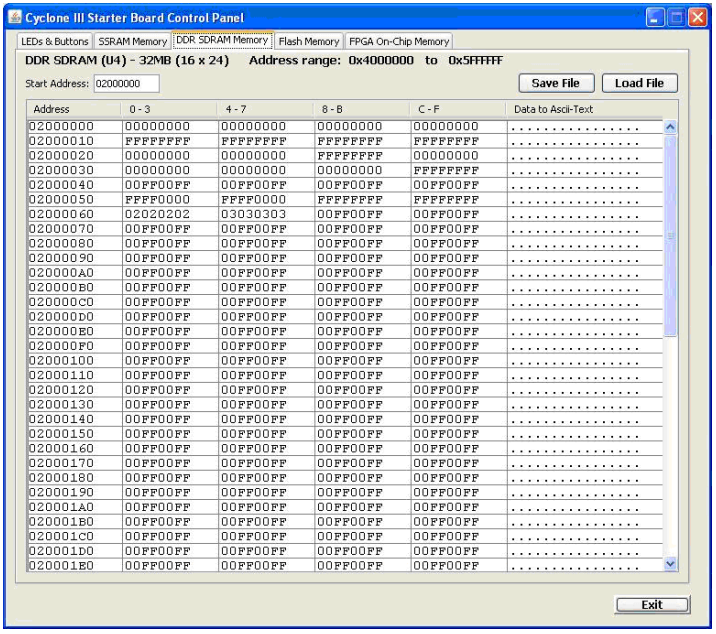
The following sections describe how to access the DDR SDRAM. You can use the same procedure to access the SSRAM.

Read/Write Data

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

1. 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



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:

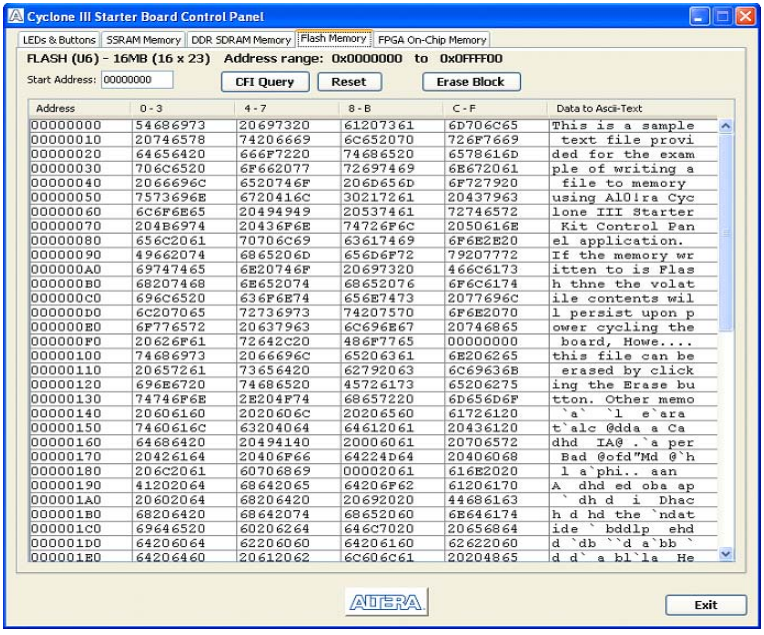
- Perform a CFI query of flash memory
- Erase select blocks of flash memory
- Write 32-bit hex word to flash memory
- Write a binary file to flash memory
- Load the contents of the flash memory into a file

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



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.

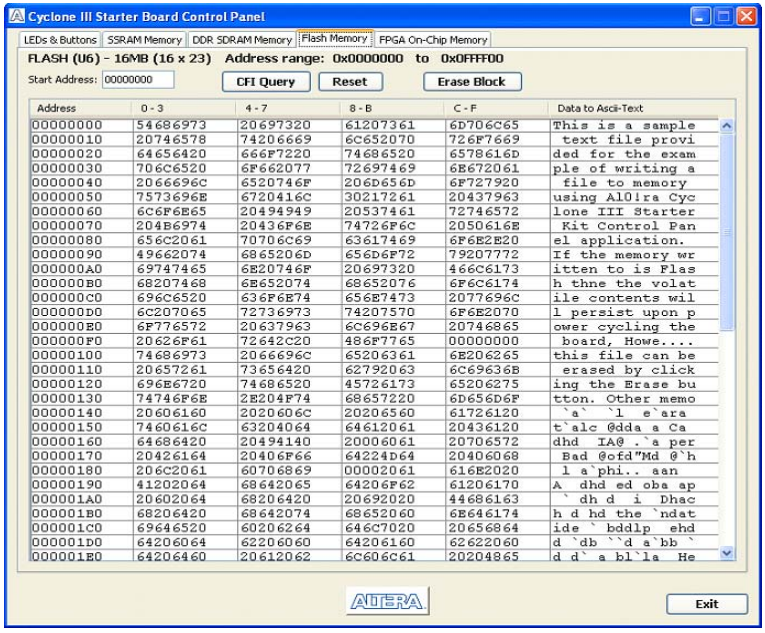
To perform a CFI query using the host application, click **CFI Query**. Notice that the memory table displays contents that correlate with the table contents as described in the device datasheet.

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:

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® 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 Input Button Functionality

Button	FPGA Pin	Type	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 `i_nfreq_next`.
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 `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)

Displays	LEDs		State	Clock Frequency (MHz)
	MSB	LSB		
Frequency	LED2	LED1	00	0
			01	33
			10	67
			11	100

Table 4–3. LEDs Power State (Resources)				
Displays	LEDs		State	% of Design Used
	MSB	LSB		
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 Ω ± 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.