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Contact us

Tel: +86-755-8981 8866 Fax: +86-755-8427 6832

Email & Skype: info@chipsmall.com Web: www.chipsmall.com

Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China





Stratix III Development Kit

User Guide



101 Innovation Drive
San Jose, CA 95134
www.altera.com

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Introduction

Welcome to the Altera® Stratix® III Development 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 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 HDL code to help you get started quickly with your own designs.

The development board includes an Altera Stratix III FPGA configured with a hardware reference design stored in flash memory. You 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:

- Stratix III development board
- Altera Complete Design Suite DVD containing:
 - Quartus® II Software, Development Kit Edition (DKE)
 - MegaCore® IP Library
 - Nios® II Embedded Design Suite
- Stratix III Development Kit CD-ROM including design examples
- Accessory daughter cards
- Power supply, cables, and documentation


Kit Features

This section briefly describes the following Stratix III Development Kit features:

- **Stratix III Development Board**—a prototyping platform that allows you to develop and prototype hardware designs running on the Stratix III FPGA.
 - For specific information about board components and interfaces, refer to the *Stratix III Development Board Reference Manual*.
- **Quartus II Software, Development Kit Edition (DKE)**—The Quartus II software (available on the DVD) provides a comprehensive environment for system-on-a-programmable-chip (SOPC) design. 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
 - A one-year Quartus II software license (Windows platform only)

 The Quartus II DKE software license allows you to use the product for 12 months. After 12 months, you must purchase a renewal subscription to continue using the software. For more information, refer to the Altera website at www.altera.com.

- **MegaCore IP Library**—This library (available on the DVD) contains Altera IP MegaCore functions. You can evaluate MegaCore functions by using the OpenCore® Plus feature to do the following:
 - 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

 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**—This full-featured set of tools (available on the DVD) allows you to develop embedded software on the Nios II processor running on Altera FPGAs.
- **Stratix III Development Kit Design Examples**—The design examples (available on the CD-ROM) 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.

Documentation

The Stratix III Development Kit CD-ROM contains the following documents:

- **Readme.txt**—Contains special instructions and refers to the kit documentation.
- *Stratix III Development Kit User Guide* (this document)—Describes how to use the kit.
- *Stratix III 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 Stratix III development board setup. Using this guide, you can do the following:

- Inspect the contents of the kit
- Install the Altera Complete Design Suite Tools
- Set up licensing
- Install the Stratix III Development Kit CD-ROM
- Set up, power up, and verify correct operation of the development board
- Configure the Stratix 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 *Stratix III 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 Stratix III Development Kit (ordering code: DK-DEV-3SL150N) contains the following items:

- Stratix III development board with an EP3SL150C3N Stratix III device
- Altera Complete Design Suite DVD containing:
 - One-year license of Quartus II Software (DKE), Windows platform only
 - MegaCore IP Library
 - Nios II Embedded Design Suite

- Stratix III Development Kit CD-ROM, which includes:
 - Reference designs and demonstrations
 - Stratix III development kit application and device drivers
 - Design examples and tutorials
 - *Stratix III Development Board Reference Manual*
 - *Stratix III Development Kit User Guide* (this document)
 - Schematic and board design files
- USB cable
- Accessory daughter cards:
 - Two loopback high-speed mezzanine connector (HSMC) cards
 - Debug HSMC card
 - 16 character × 2 line Liquid Crystal Display (LCD)
 - 128 × 64 dot matrix graphics LCD
- 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, go to the Altera website at www.altera.com/products/devkits/altera/kit-siii-host.html.

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 Stratix III development board can be damaged.

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



In typical applications with the Stratix 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 Stratix III development kit provides all of the hardware needed to use the board.



For Quartus II software requirements, refer to the Altera website at:
www.altera.com/products/software/products/quartus2web/sof-quarwebmain.html.

Software Requirements

This kit requires the following software:

- Windows XP operating system
- Quartus II software (refer to the **readme.txt** file on the CD-ROM for specific version requirements)

References

For other related information, refer to the following websites:

- For additional daughter cards available for purchase:
www.altera.com/products/devkits/kit-daughter_boards.jsp
- For the Stratix III device documentation:
www.altera.com/literature/lit-stx3.jsp
- For eStore if you want to purchase devices:
www.altera.com/buy/devices/buy-devices.html
- For Stratix III Orcad symbols:
www.altera.com/support/software/download/pcb/pcb-pcb_index.html
- For Nios II 32-bit embedded processor solutions:
www.altera.com/technology/embedded/emb-index.html

Introduction

The instructions in this section explain how to install the following:

- Stratix III Development Kit CD-ROM
- Stratix III Development Kit demo application and drivers
- The Quartus II Software (DKE) on the DVD, including MegaCore functions from the MegaCore IP Library



Before starting the installation, verify that you have complied with the conditions described in “[Software Requirements](#)” on page 2–3.

Installing the Development Kit CD-ROM

The Stratix III Development Kit CD-ROM contains the following items:

- The sample design and board design files
- *Quick Start Guide*
- *My First FPGA Tutorial*
- *My First Nios II Software Tutorial*
- *Stratix III Development Kit User Guide* (this document)
- *Stratix III Development Board Reference Manual*

To install the Stratix III Development Kit CD-ROM, perform the following steps:

1. Insert the Stratix III Development Kit CD-ROM into the CD-ROM drive.



The CD-ROM should start an auto-install process. If it does not, browse to the CD-ROM drive and double-click on the **setup.exe** file.

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

The installation program copies the Stratix III development kit files to an installation directory on the computer hard disk and creates a **Programs > Altera > Stratix III Development Kit <version#>** Windows Start menu shortcut. Use this shortcut later to launch the development kit graphical user interface (GUI).

The installation program creates the directory structure shown in [Figure 3–1](#) for the Stratix III development kit files. In this user guide, *<path>* refers to *<installation directory>\stratixIII_3s1150_dev* when locating the development kit files.

Figure 3-1. Stratix 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 Stratix 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.



The examples directory contains a golden top project example with all the pin-out and pin configuration information included.

Installing the Quartus II DVD

The Quartus II software is the primary FPGA development tool used to create the reference designs in this development kit. Additionally, you may want to install the Nios II Embedded Design Suite found in the Altera Complete Design Suite at www.altera.com/support/software/download/nios2/dnl-nios2.jsp. The Nios II embedded processor runs on Altera FPGAs. Some of the reference designs included in this development kit use the Nios II processor.

Insert the Altera Complete Design Suite DVD into the DVD drive, and click **Install subscription package** on the startup window. Follow the on-screen instructions and accept all default settings. After installing the software, request and install a license to enable it.



For information about obtaining a license file, refer to “Licensing Considerations” on page 3-3.

Installing the USB-Blaster Driver

The Stratix 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.

Licensing Considerations

Before using the Quartus II software, you must request a license file from the Altera website at www.altera.com/licensing and install it on your computer. When you request a license file, Altera emails you a **license.dat** file that enables the software.

To license the Quartus II software, you need your network interface card (NIC) ID, which is a 12-digit hexadecimal number that identifies your computer. Networked (or floating-node) licensing requires a NIC ID or server host ID. When obtaining a license file for network licensing, use the NIC ID from the computer that issues the Quartus II licenses to distributed users over a network. You can find the NIC ID for your card by typing `ipconfig/all` at a command prompt. Your NIC ID is the number on the physical address line, without the dashes.

To obtain a license, perform the following steps.

1. Go to the Altera website at www.altera.com/support/licensing/lic-choose.html.
2. Under **Development Kit Licenses Request**, click **Licenses for RoHS-Compliant Kits**.
3. Follow the on-screen instructions to request your license. You will receive a license file through email.



Before installing your license, close the following software if it is running on your computer:

- Quartus II software
 - MAX+PLUS® II software
 - LeonardoSpectrum™ synthesis tool
 - Synplify software
 - ModelSim® simulator
 - Precision RTL Synthesis Software
4. To install your license, refer to the *Specifying the License File* section in the *Quartus II Installation & Licensing for Windows Manual*, which is included with the kit.

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 2–3](#) and have completed the following requirements:

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

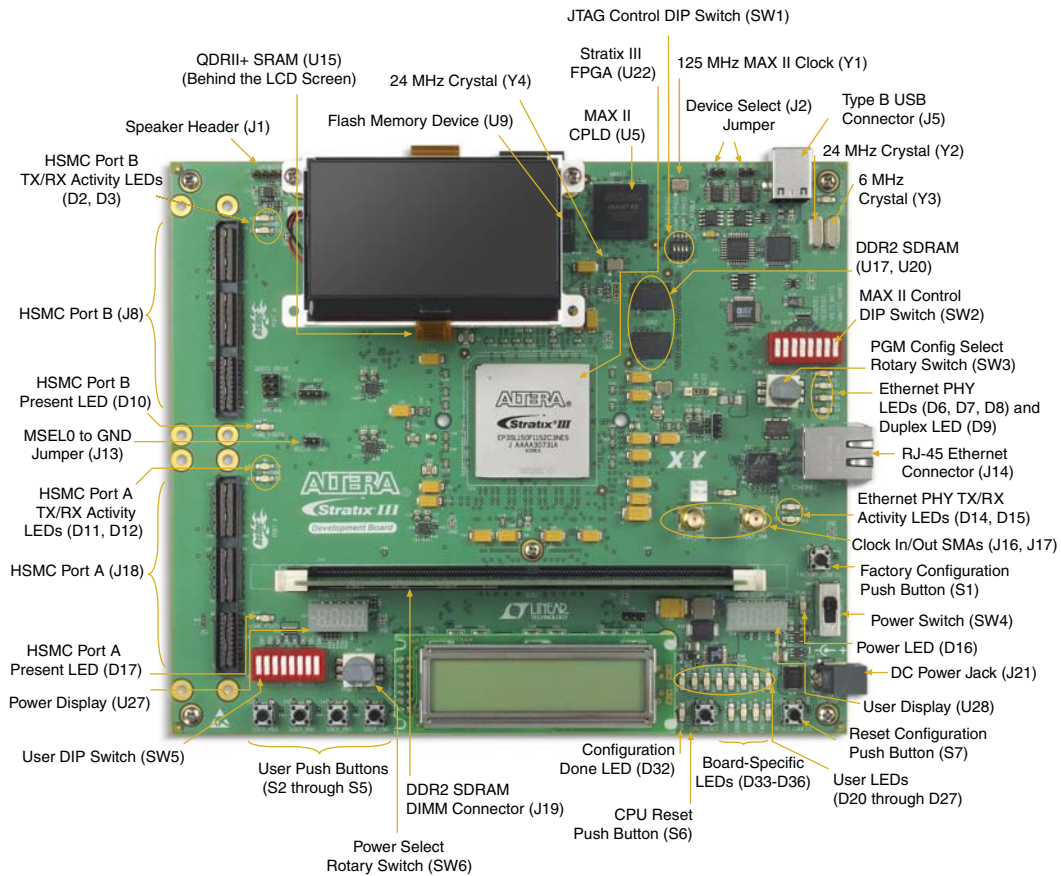


The Stratix III development board includes integrated USB-Blaster circuitry for FPGA programming. Host computer and development board cannot communicate without the USB-Blaster driver software installed. For installation information, refer to [“Installing the USB-Blaster Driver” on page 3–3](#).

Powering Up the Board

[Figure 4–1](#) shows the Stratix III development board and its components.

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



Before powering up, prepare the board as follows:

1. If cards are plugged into the HSMC ports, remove them.
2. Ensure that the POWER switch SW4 is in the OFF (or DOWN) position.
3. Configure the 8-position SW2 DIP switch to the default settings in [Table 4-1](#).

Table 4-1. Switch SW2 Settings (Part 1 of 2)

Switch	Name	Function		Default Position
		Position 0	Position 1	
1	mW/mA	mW	mA	0
2	V/W	V	W	1
3	RSV0	MAX_RESERVE0		X
4	RSV1	MAX_RESERVE1		X

Table 4-1. Switch SW2 Settings (Part 2 of 2)

Switch	Name	Function		Default Position
		Position 0	Position 1	
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

4. Ensure that the 4-position SW1 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-J2	JTAG_SEL-J3	SW1.1	SW1.2	SW1.3	SW1.4
ON	ON	ON	OFF	OFF	OFF

5. Ensure that the J13 MSEL0 GND jumper is ON.
6. Verify that the PGM CONFIG SELECT rotary switch SW3 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:

1. 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.

2. Slide the POWER switch to ON. The nearby blue POWER light-emitting diode (LED) lights up.
3. 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-3.

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 Stratix III FPGA, perform the following steps:

1. Verify that the 4-position SW1 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\stratixIII_3sl150_dev_my_first_fpga\stratixIII_3sl150_dev_my_first_fpga.sof`.
7. Turn on the **Program/Configure** option for 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

One of the main features of the Stratix III FPGA device is its low power consumption. You can measure the power used by the 3SL150 FPGA device on the Stratix 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 Stratix 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 5-2](#) and [Table 5-3](#) on page 5-2, respectively, represent the percent of full design used. As compiled, the full example design uses the following FPGA resources:

- Combinational adaptive look-up tables (ALUTs): 1,872 / 113,600 (2%)
- Dedicated logic registers: 106,640 / 113,600 (94%)
- Total registers: 106,640
- Total pins: 173 / 744 (23%)
- Total memory bits: 2,621,440 / 5,630,976 (47%)
- Embedded multiplier 18-bit elements: 320 / 384 (83%)
- Total PLLs: 1/8 (13%)

[Table 5-1](#) 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_T33).

Table 5-1. Four Input Button Functionality

User Push Button	FPGA Pin	Type	Description
User_PB0	B17	Reset	Resets the demo to the beginning, <code>i_nrst</code>
User_PB1	A17	Toggle	Advances the design example to the next higher frequency, <code>i_nfreq_next</code>
User_PB2	A16	Toggle	Advances the design example to the next higher resource utilization, <code>i_nperc_next</code>
User_PB3	K17	Toggle	Enables the outputs to toggle, <code>i_noutput_ena</code>

The LEDs in [Table 5-2](#) indicate the power-state values of the design example as User_PB1 advances frequency.

Table 5-2. Power State Indicators for Frequency

LED1 (C23)	LED0 (F21)	Frequency (MHz)
0	0	0
0	1	33
1	0	67
1	1	100

The LEDs in [Table 5-3](#) 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 5-3. Power State Indicators for Resources

LED6 (F19)	LED5 (C19)	LED4 (D19)	LED3 (A23)	LED2 (B23)	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
1	0	0	1	1	100	160

The resource state ([Table 5-3](#)) controls the number of I/O pins used. Each resource increment adds eight additional I/O pins ([Table 5-3](#)). Similarly, the overall design frequency ([Table 5-2](#)) 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 multimeter (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 SW6 sets the development board to measure and display FPGA core power or I/O output power (Table 5-4).

Table 5-4. Switch SW6 Power Selection

Switch Position	FPGA Power	I/O Bank
0	Core: VCCL, TBD V	—
7	I/O: 2.5 V	2
8	I/O: 2.5 V	4, 5, and 6

Measuring Core Power

To measure FPGA core power for various power states, perform the following steps:

1. Ensure that the 8-position SW2 DIP switch is configured to the default settings shown in Table 4-1 on page 4-2.
2. Download the `stratixIII_dev_power.sof` file as described in “Configuring the FPGA” on page 4-3. The power design example is in `<path>\demos\stratixIII_3sl150_dev_power`.
3. Set the POWER SELECT rotary switch SW6 to 0 to measure the internal V_{CC_INT} power in watts.
4. Observe the power on the 4-digit hexadecimal POWER DISPLAY.
5. Using the user input push buttons (Table 5-1 on page 5-1), advance through the power states in Table 5-2 and Table 5-3 on page 5-2. Notice how power increases as frequency and resources increase.

Measuring I/O Power

This example uses FPGA I/O banks 2, 4, 5, and 6. Using the SW6 settings (Table 5-4), measure the power for I/O banks 4, 5, and 6, then for I/O bank 2, by performing the following steps:

1. Ensure that the 8-position SW2 DIP switch is configured to the default settings shown in Table 4-1 on page 4-2.
2. Download the `stratixIII_dev_power.sof` file as described in “Configuring the FPGA” on page 4-3. The power design example is in `<path>\demos\stratixIII_3sl150_dev_power`.
3. Set the POWER SELECT rotary switch SW6 to 8.
4. Observe the 4-digit hexadecimal POWER DISPLAY for the I/O output power in watts on banks 4, 5, and 6.

5. Using the user input push buttons (Table 5-1 on page 5-1), advance through the power states in Table 5-2 and Table 5-3 on page 5-2. 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 J18. LED7 (E19), 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 Stratix III FPGA.
7. Press the User_PB3 button again to disable the outputs. LED7 turns off.
8. Set the POWER SELECT rotary switch SW6 to 7.
9. Repeat steps 4 through 7 to observe the I/O output power in watts on bank 2.

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 *Stratix III Development Board Reference Manual*.

Measuring Voltage with a DMM

To obtain power values by using a DMM, measure voltage across the sense-resistors, R215, R218, and R214 on the board, then use the voltage measurements to calculate power.



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

FPGA I/O power is distributed by banks (Table 5-5), for which the sense resistors are components R218 and R214. 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 R215.

Table 5-5. Sense Resistors

FPGA Power		Voltage	Sense Resistor	Resistor Value
I/O	Bank 2	2.5 V	R214	0.009 Ω
	Banks 4, 5 and 6	2.5 V	R218	0.009 Ω
Core: VCCL		1.1 V	R215	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 5-5.

then

Equation 5-1.

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

where

V_{SUPPLY} is 1.1 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 5-2](#) and [Table 5-3 on page 5-2](#).

Changing the Design Example

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

The design example uses 20 **stamp.v** modules, each with 8 outputs, for a total of 160 output pins. It assigns the pins selected as outputs to the HSMC connectors J8 and J18.

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 Stratix III Development Kit help familiarize new users with development board features. *My First FPGA 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 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 Quartus II software to build a simple logic counter which drives LEDs to flash on the development board.

After installing the Stratix III Development Kit CD-ROM, the *My First FPGA 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 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 Stratix III Development Kit CD-ROM, 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`.