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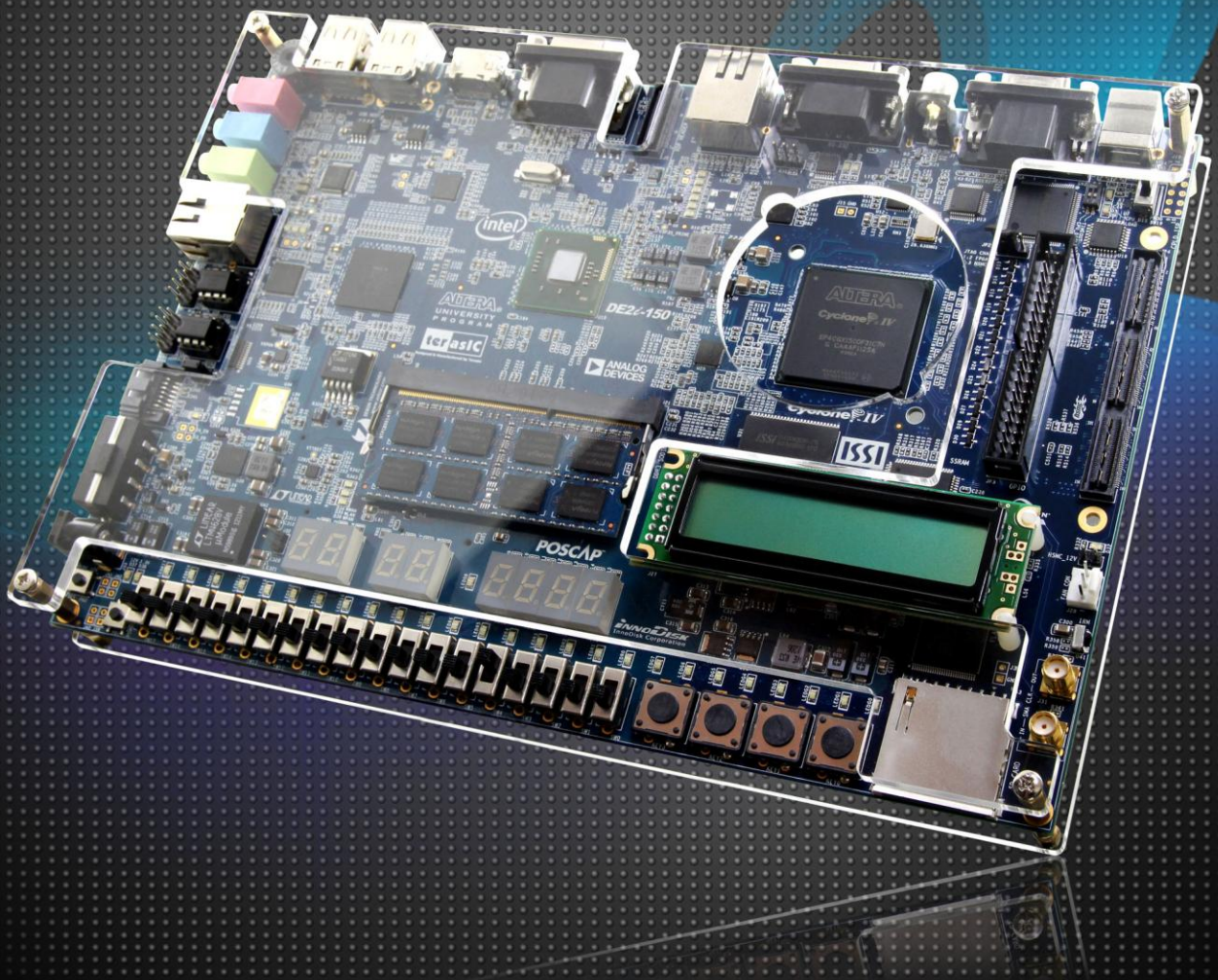
DE2i-150

DEVELOPMENT KIT

FPGA SYSTEM USER MANUAL



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CONTENTS

Chapter 1

Introduction of the FPGA System of DE2i-150 Board

This chapter presents the features and design characteristics of the DE2i-150 board.

1-1 Layout and Components

A photograph of the DE2i-150 board is shown in Figure 1-1 and Figure 1-2. It depicts the layout of the board and indicates the location of the connectors and key components.

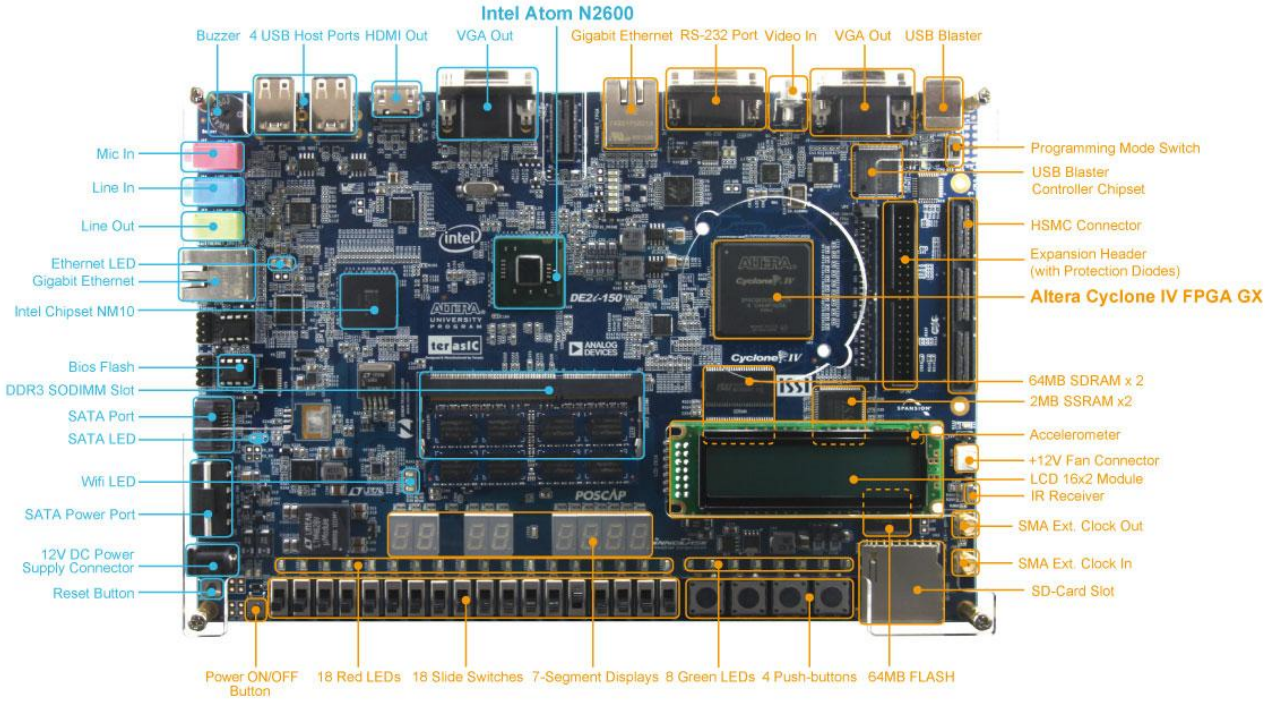

Figure 1-1 The DE2i-150 board (top view)

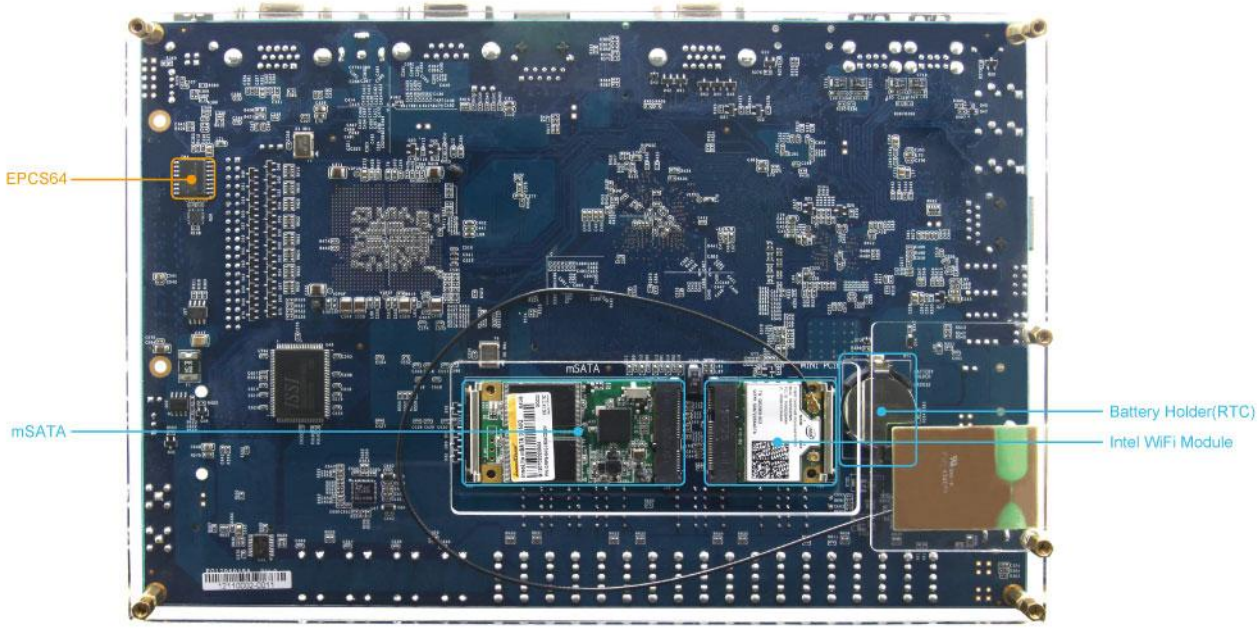

Figure 1-2 The DE2i-150 board (bottom view)

The DE2i-150 board has many features that allow users to implement a wide range of designed circuits, from simple circuits to various multimedia projects.

The following hardware (FPGA System) is provided on the DE2i-150 board:

- Altera Cyclone® IV 4CX150 FPGA device
- Altera Serial Configuration device – EPCS64
- USB Blaster (on board) for programming; both JTAG and Active Serial (AS) programming modes are supported
- Two 2MB SSRAM
- Two 64MB SDRAM
- 64MB Flash memory
- SD Card socket
- 4 Push-buttons
- 18 Slide switches
- 18 Red user LEDs
- 9 Green user LEDs
- 50MHz oscillator for clock sources
- VGA DAC (8-bit high-speed triple DACs) with VGA-out connector
- TV Decoder (NTSC/PAL/SECAM) and TV-in connector
- Gigabit Ethernet PHY with RJ45 connectors
- RS-232 transceiver and 9-pin connector

- IR Receiver
- 2 SMA connectors for external clock input/output
- One 40-pin Expansion Header with diode protection
- One High Speed Mezzanine Card (HSMC) connector
- 16x2 LCD module

In addition to these hardware features, the DE2i-150 board has software support for standard I/O interfaces and a control panel facility for accessing various components. Also, the software is provided for supporting a number of demonstrations that illustrate the advanced capabilities of the DE2i-150 board.

In order to use the DE2i-150 board, the user has to be familiar with the Quartus II software. The necessary knowledge can be acquired by reading the tutorials "*My_First_Fpga*". These tutorials are provided in the directory DE2i_150_tutorials on the **DE2i-150 System CD** that accompanies the DE2i-150 kit and can also be found on Terasic's DE2i-150 web pages.

1-2 Block Diagram of the DE2i-150 Board

Figure 1-3 gives the block diagram of the DE2i-150 board. To provide maximum flexibility for the user, all connections are made through the Cyclone IV GX FPGA device. Thus, the user can configure the FPGA to implement any system design.

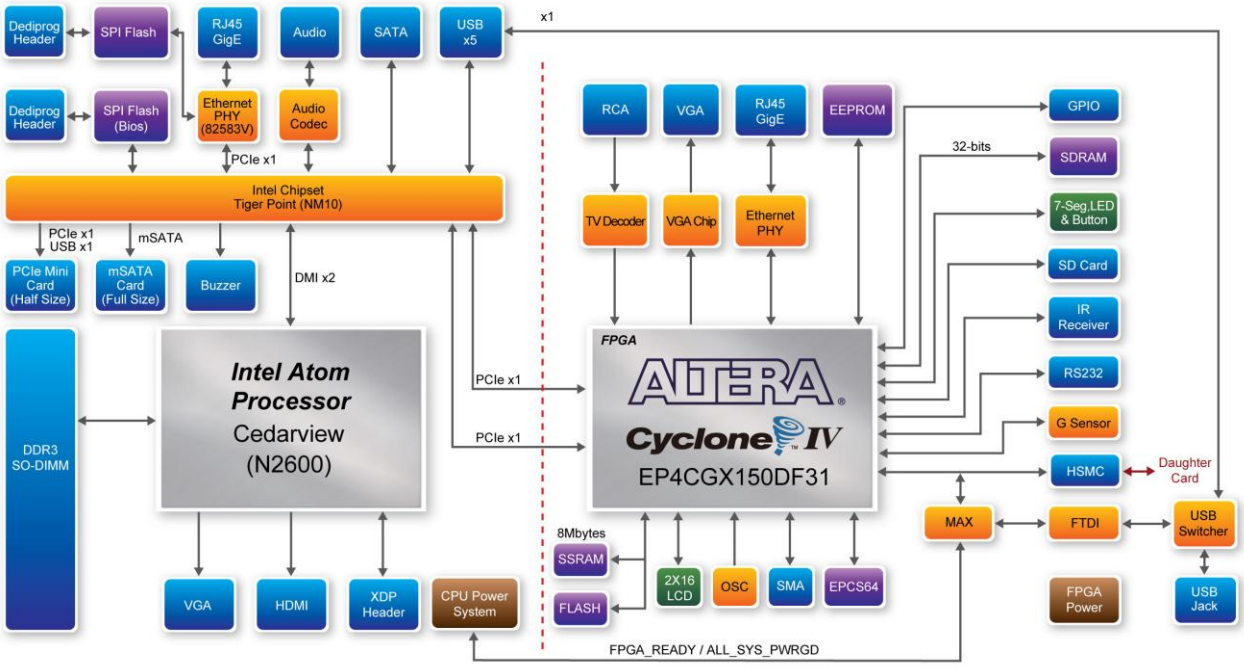

Figure 1-3 Block Diagram of DE2i-150

Following is more detailed information about the blocks in **Figure 1-3**:

FPGA device

- Cyclone IV EP4CGX150DF31 device
- 149,760 LEs
- 720 M9K memory blocks
- 6,480 Kbits embedded memory
- 8 PLLs

FPGA configuration

- JTAG and AS mode configuration
- EPCS64 serial configuration device
- On-board USB Blaster circuitry

Memory devices

- 128MB (32Mx32bit) SDRAM
- 4MB (1Mx32) SSRAM
- 64MB (4Mx16) Flash with 16-bit mode

SD Card socket

- Provides SPI and 4-bit SD mode for SD Card access

Connectors

- Ethernet 10/100/1000 Mbps ports
- High Speed Mezzanine Card (HSMC)
- 40-pin expansion port
- VGA-out connector
- VGA DAC (high speed triple DACs)
- DB9 serial connector for RS-232 port with flow control

Clock

- Three 50MHz oscillator clock inputs
- SMA connectors (external clock input/output)

Display

- 16x2 LCD module

Switches and indicators

- 18 slide switches and 4 push-buttons switches
- 18 red and 9 green LEDs
- 8 7-segment displays

Other features

- Infrared remote-control receiver module
- TV decoder (NTSC/PAL/SECAM) and TV-in connector

Chapter 2

DE2i-150 Control Panel

The DE2i-150 board comes with a Control Panel program that allows users to access various components on the board from a host computer. The host computer communicates with the board through a USB connection. The program can be used to verify the functionality of components on the board or be used as a debug tool while developing RTL code.

This chapter first presents some basic functions of the Control Panel, then describes its structure in the block diagram form, and finally describes its capabilities.

2-1 Control Panel Setup

The Control Panel Software Utility is located in the directory *"Tools/ ControlPanel"* in the **DE2i-150 System CD**. It's free of installation, just copy the whole folder to your host computer and launch the control panel by executing the "DE2i_150_ControlPanel.exe".

Specific control circuits should be downloaded to your FPGA board before the control panel can request it to perform required tasks. The program will call Quartus II tools to download the control circuit to the FPGA board through the USB-Blaster[USB-0] connection.

To activate the Control Panel, perform the following steps:

1. Make sure Quartus II 12.1 or later version is installed successfully on your PC.
2. Set the RUN/PROG switch to the RUN position.
3. Connect the supplied USB cable to the USB Blaster port, connect the 12V power supply, and turn the power switch ON.
4. Start the executable DE2i_150_ControlPanel.exe on the host computer. The Control Panel user interface shown in **Figure 2-1** will appear.
5. The DE2i_150_ControlPanel.sof bit stream is loaded automatically as soon as the DE2i_150_control_panel.exe is launched.

6. In case the connection is disconnected, click on CONNECT where the .sof will be re-loaded onto the board.

Please not that the Control Panel will occupy the USB port until you close that port; you cannot use Quartus II to download a configuration file into the FPGA until the USB port is closed.

7. The Control Panel is now ready for use; experience it by setting the ON/OFF status for some LEDs and observing the result on the DE2i-150 board.

Figure 2-1 The DE2i-150 Control Panel

The concept of the DE2i-150 Control Panel is illustrated in Figure 2-2. The "Control Circuit" that performs the control functions is implemented in the FPGA board. It communicates with the Control Panel window, which is active on the host computer, via the USB Blaster link. The graphical interface is used to send commands to the control circuit. It handles all the requests and performs data transfers between the computer and the DE2i-150 board.

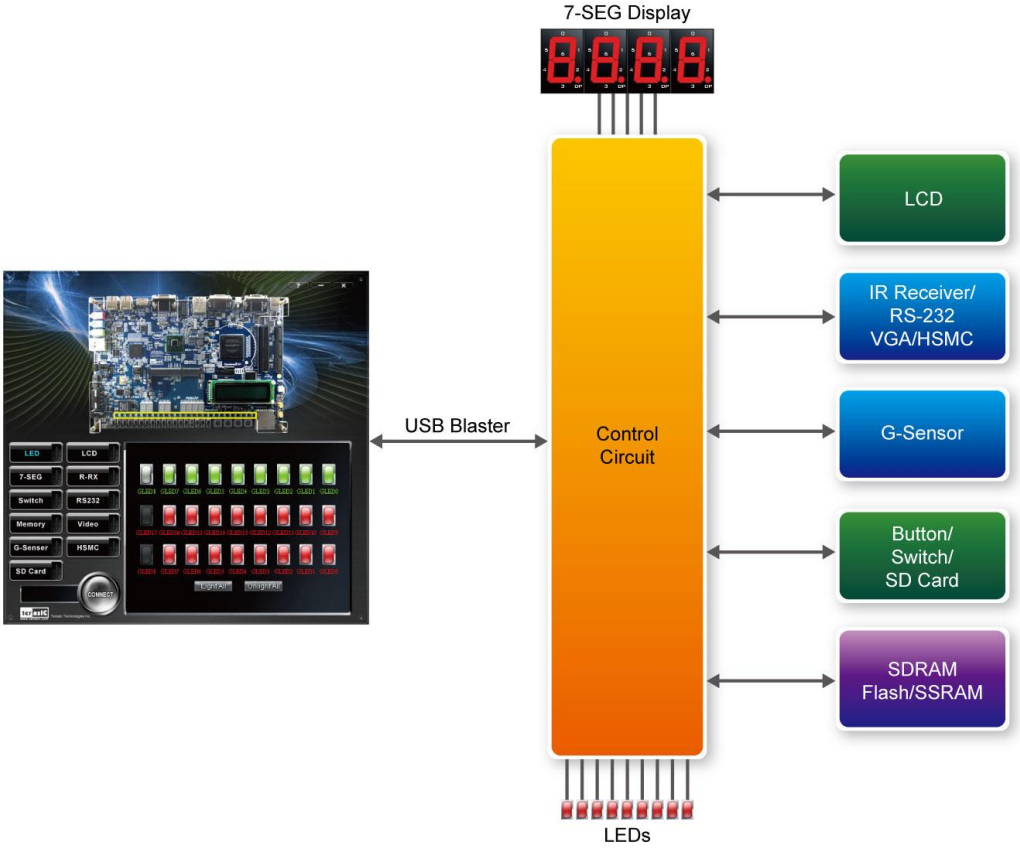

Figure 2-2 The DE2i-150 Control Panel concept

The DE2i-150 Control Panel can be used to light up LEDs, change the values displayed on 7-segment and LCD displays, monitor buttons/switches status, read/write the SDRAM, SSRAM and Flash Memory, output VGA color pattern to VGA monitor, verify functionality of HSMC connector I/Os, communicate with PC via RS-232 interface, read SD Card specification information, and display the resolution measurement of 3-axis accelerometer on the G-Sensor. The feature of reading/writing a word or an entire file from/to the Flash Memory allows the user to develop multimedia applications (Flash Audio Player, Flash Picture Viewer) without worrying about how to build a Memory Programmer.

2-2 Controlling the LEDs, 7-segment Displays and LCD Display

A simple function of the Control Panel is to allow setting the values displayed on LEDs, 7-segment displays, and the LCD character display.

Choosing the **LED** tab leads to the window in Figure 2-3. Here, you can directly turn the LEDs on or off individually or by clicking “Light All” or “Unlight All”.

Figure 2-3 Controlling LEDs

Choosing the 7-SEG tab leads to the window shown in Figure 2-4. From the window, directly use the left-right arrows to control the 7-SEG patterns on the DE2i-150 board which are updated immediately. Note that the dots of the 7-SEGs are not enabled on DE2i-150 board.

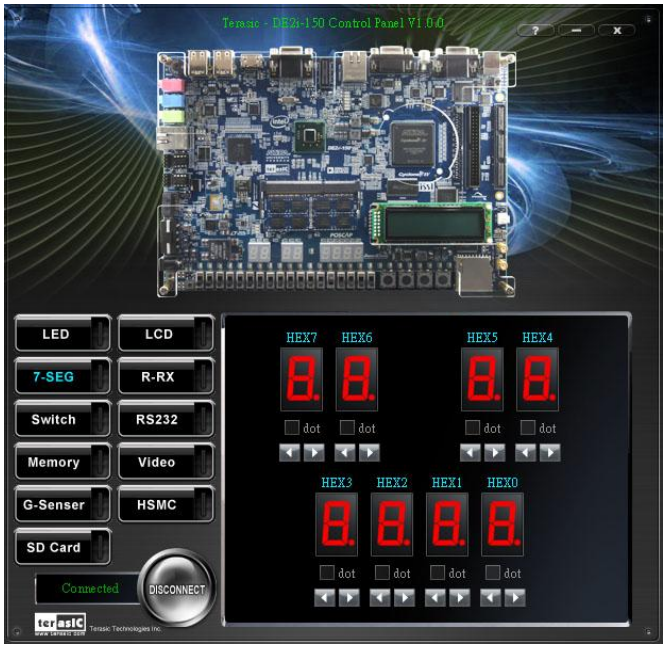

Figure 2-4 Controlling 7-SEG display

Choosing the LCD tab leads to the window in Figure 2-5. Text can be written to the LCD display by typing it in the LCD box then pressing the Set button.

Figure 2-5 Controlling the LCD display

The ability to set arbitrary values into simple display devices is not needed in typical design activities. However, it gives users a simple mechanism for verifying that these devices are functioning correctly in case a malfunction is suspected. Thus, it can be used for troubleshooting purposes.

2-3 Switches and Push-buttons

Choosing the Switches tab leads to the window in Figure 2-6. The function is designed to monitor the status of slide switches and push-buttons in real time and show the status in a graphical user interface. It can be used to verify the functionality of the slide switches and push-buttons.

Figure 2-6 Monitoring switches and buttons

The ability to check the status of push-button and slide switch is not needed in typical design activities. However, it provides users a simple mechanism for verifying if the buttons and switches are functioning correctly. Thus, it can be used for troubleshooting purposes.

2-4 SDRAM/SSRAM/Flash Controller and Programmer

The Control Panel can be used to write/read data to/from the SDRAM, SSRAM and Flash chips on the DE2i-150 board. As an example, we will describe how the SDRAM may be accessed; the same approach is used to access the SSRAM, and Flash. Click on the Memory tab and select “SDRAM” to reach the window in **Figure 2-7.**

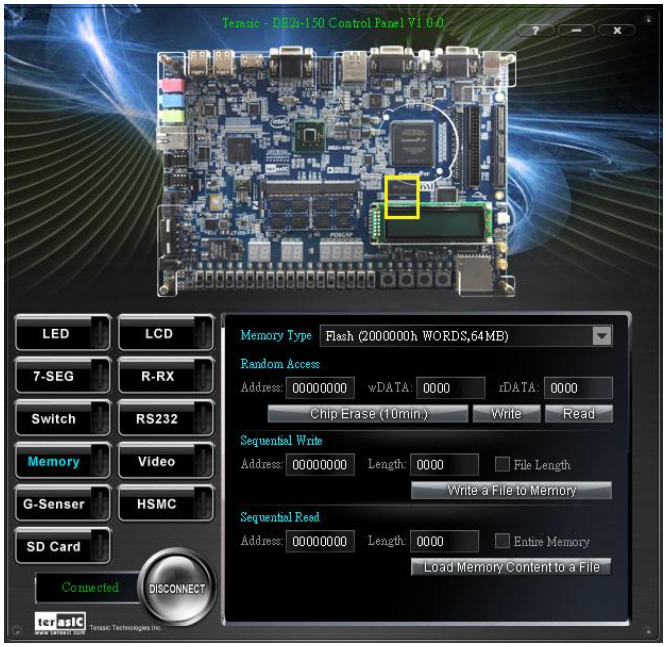

Figure 2-7 Accessing the SDRAM

A 16-bit word can be written into the SDRAM by entering the address of the desired location, specifying the data to be written, and pressing the Write button. Contents of the location can be read by pressing the Read button. Figure 2-7 depicts the result of writing the hexadecimal value 06CA into offset address 200, followed by reading the same location.

The Sequential Write function of the Control Panel is used to write the contents of a file into the SDRAM as follows:

1. Specify the starting address in the Address box.
2. Specify the number of bytes to be written in the Length box. If the entire file is to be loaded, then a checkmark may be placed in the File Length box instead of giving the number of bytes.
3. To initiate the writing process, click on the Write a File to Memory button.
4. When the Control Panel responds with the standard Windows dialog box asking for the source file, specify the desired file in the usual manner.

The Control Panel also supports loading files with a .hex extension. Files with a .hex extension are ASCII text files that specify memory values using ASCII characters to represent hexadecimal values. For example, a file containing the line

0123456789ABCDEF

Defines eight 8-bit values: 01, 23, 45, 67, 89, AB, CD, EF. These values will be loaded consecutively into the memory.

The Sequential Read function is used to read the contents of the SDRAM and fill them into a file as follows:

1. Specify the starting address in the Address box.
2. Specify the number of bytes to be copied into the file in the Length box. If the entire contents of the SDRAM are to be copied (which involves all 128 Mbytes), then place a checkmark in the Entire Memory box.
3. Press Load Memory Content to a File button.
4. When the Control Panel responds with the standard Windows dialog box asking for the destination file, specify the desired file in the usual manner.

Users can use the similar way to access the SSRAM and Flash. Please note that users need to erase the Flash before writing data to it.

2-5 SD Card

The function is designed to read the identification and specification information of the SD Card. The 4-bit SD MODE is used to access the SD Card. This function can be used to verify the functionality of the SD Card Interface. Follow the steps below to perform the SD Card exercise:

1. Choosing the SD Card tab leads to the window in **Figure 2-8.**
2. Insert an SD Card to the DE2i-150 board, and then press the Read button to read the SD Card. The SD Card's identification, specification, and file format information will be displayed in the control window.

Figure 2-8 Reading the SD Card Identification and Specification

2-6 RS-232 Communication

The Control Panel allows users to verify the operation of the RS-232 serial communication interface on the DE2i-150. The setup is established by connecting a RS-232 9-pin male to female cable from the PC to the RS-232 port where the Control Panel communicates to the terminal emulator software on the PC, or vice versa. Alternatively, a RS-232 loopback cable can also be used if you do not wish to use the PC to verify the test. The Receive terminal window on the Control Panel monitors the serial communication status. Follow the steps below to initiate the RS-232 communication:

1. Choosing the RS-232 tab leads to the window in **Figure 2-9.**
2. Plug in a RS-232 9-pin male to female cable from PC to RS-232 port or a RS-232 loopback cable directly to RS-232 port.
3. The RS-232 settings are provided below in case a connection from the PC is used:

- Baud Rate: 115200
- Parity Check Bit: None
- Data Bits: 8
- Stop Bits: 1
- Flow Control (CTS/RTS): ON

4. To begin the communication, enter specific letters followed by clicking Send. During the communication process, observe the status of the Receive terminal window to verify its operation.

Figure 2-9 RS-232 Serial Communication

2-7 VGA

DE2i-150 Control Panel provides VGA pattern function that allows users to output color pattern to LCD/CRT monitor using the DE2i-150 board. Follow the steps below to generate the VGA pattern function:

1. Choosing the Video tab leads to the window in **Figure 2-10.**
2. Plug a D-sub cable to VGA connector of the DE2i-150 board and LCD/CRT monitor.
3. The LCD/CRT monitor will display the same color pattern on the control panel window.
4. Click the drop down menu shown in **Figure 2-10** where you can output the selected color individually.

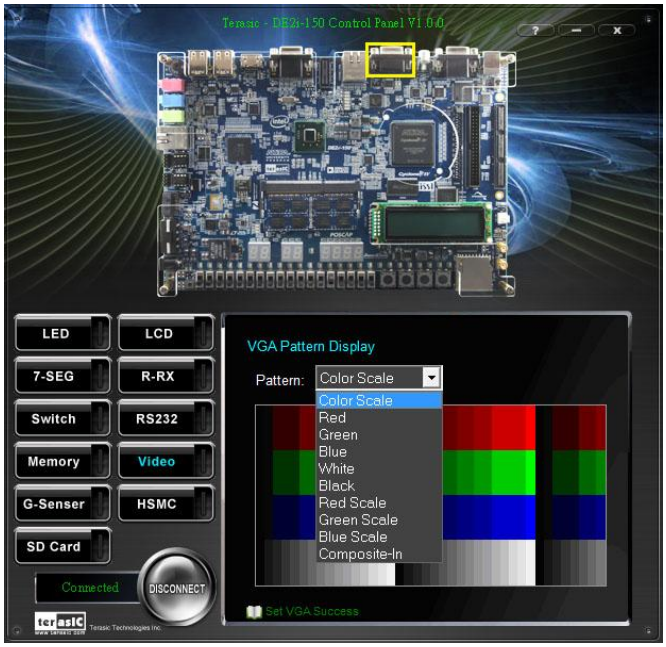

Figure 2-10 Controlling VGA display

2-8 HSMC

Select the HSMC tab to reach the window shown in Figure 2-11. This function is designed to verify the functionality of the signals located on the HSMC connector. Before running the HSMC loopback verification test, follow the instruction noted under the Loopback Installation section and click on Verify. Please note to turn off the DE2i-150 board before the HSMC loopback adapter is installed to prevent any damage to the board.

The HSMC loopback adapter is not provided in the kit package but can be purchased through the website below:
(http://www.terasic.com.tw/cgi-bin/page/archive.pl?Language=English&CategoryNo=78&No=495)

Figure 2-11 HSMC loopback verification test performed under Control Panel

2-9 IR Receiver

From the control panel, we can test the IR receiver on the DE2i-150 by sending scan code from a remote controller. Figure 2-12 depicts the IR receiver window when the IR tab is pressed. When the scan code is received, the information will be displayed on the IR Receiver window represented in hexadecimal. Also, the pressed button on the remote controller will be indicated on the graphic of remote controller on the IR receiver window. Note that there exists several encoding form among different brands of remote controllers. Only the remote controller comes with the kit is confirmed to be compatible with this software.

Figure 2-12 Testing the IR receiver using remote controller

2-10 G-Sensor

On the DE2i-150 board, the G-sensor function is being demonstrated by Spirit level .The user can rotate the DE2i-150 board to different directions, up or down, left or right. The bubble will travel quickly following your manners. Meanwhile, the control panel will show the accelerated data in x-axis, y-axis and z-axis as shown in Figure 2-12.

Note that the resolution measurement of 3-axis accelerometer is set to +- 2g

Figure 2-13 Testing the G-sensor

2-11 Overall Structure of the DE2i-150 Control Panel

The DE2i-150 Control Panel is based on a Nios II SOPC system instantiated in the Cyclone IV GX FPGA with software running on the on-chip memory. The software part is implemented in C code; the hardware part is implemented in Verilog HDL code with SOPC builder. The source code is not available on the DE2i_150 System CD.

To run the Control Panel, users should make the configuration according to Section 3.1. **Figure 2-14** depicts the structure of the Control Panel. Each input/output device is controlled by the Nios II Processor instantiated in the FPGA chip. The communication with the PC is done via the USB Blaster link. The Nios II interprets the commands sent from the PC and performs the corresponding actions.

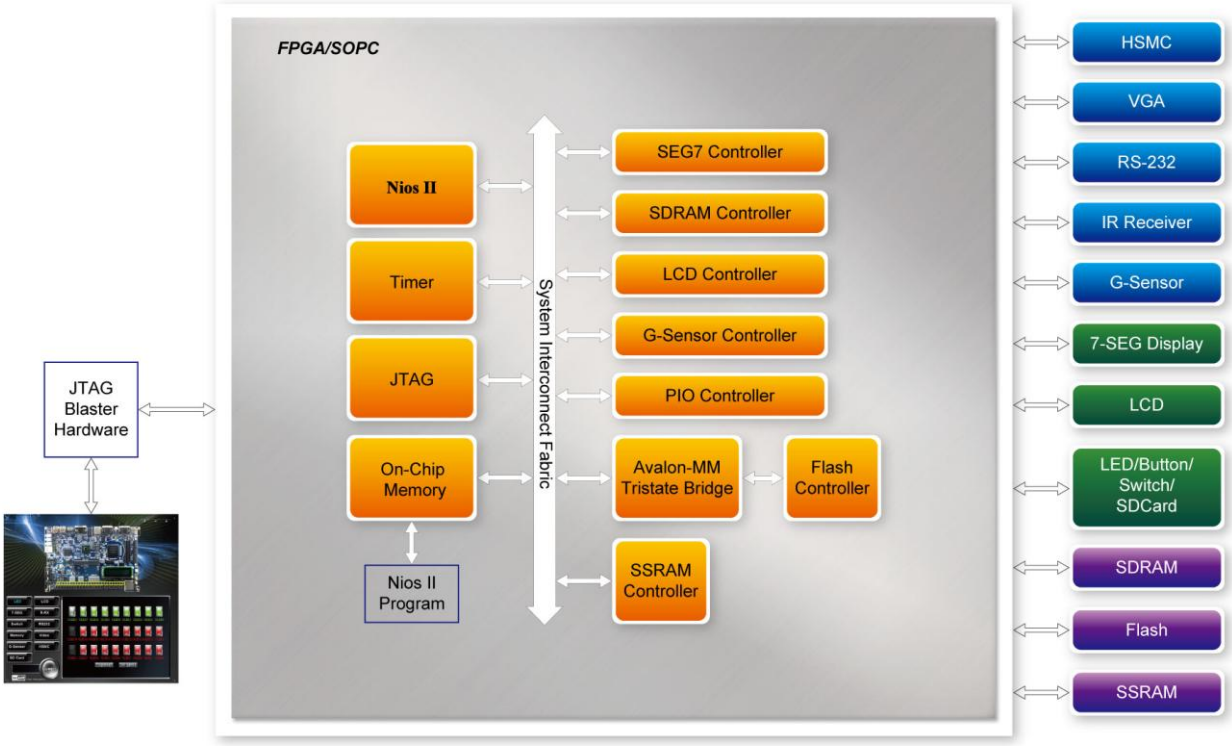

Figure 2-14 The block diagram of the DE2i-150 control panel

Chapter 3

Using the DE2i-150 Board

This chapter gives instructions for using the DE2i-150 board and describes each of its peripherals.

3-1 Monitor Function for the Status of FPGA Configuration

In the DE2i-150 power up sequence, there is a monitor circuit that monitors the status of the FPGA configuration. After it confirms the configuration is complete, the power up sequence will go to next state. If the configuration is not complete, the CPU will not initiate.

There is a 2-position dip-switch (SW20, as shown in Figure 3.1) on this circuit, which can be used for two settings.

The first switch configures TIMEOUT, which sets a timer in the monitor circuit to ignore any FPGA configuration failure. When the counter goes to the set value, the power up sequence state continue powering up the CPU regardless of whether the FPGA has not been configured normally or not.

The second switch position configures CPU_DIS, which disables CPU power up.

Table 3-1 shows the detailed setting for SW20.