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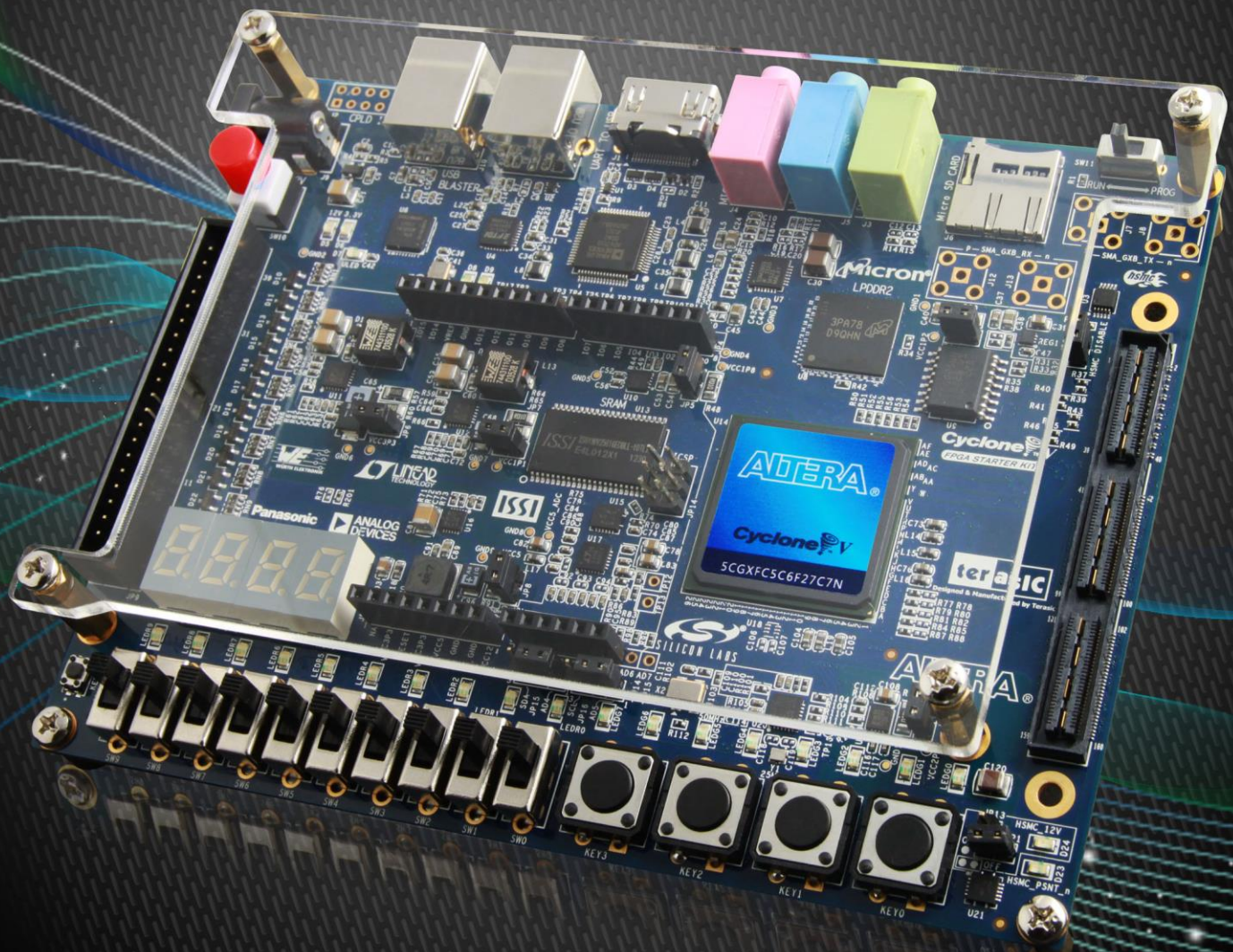
Cyclone V GX Starter Kit

User Manual



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CONTENTS

Chapter 1

Introduction

The Cyclone V GX Starter Kit presents a robust hardware design platform built around the Altera Cyclone V GX FPGA, which is optimized for the lowest cost and power requirement for transceiver applications with industry-leading programmable logic for ultimate design flexibility. With Cyclone V FPGAs, you can get the power, cost, and performance levels you need for high-volume applications including protocol bridging, motor control drives, broadcast video converter and capture cards, and handheld devices. The Cyclone V GX Starter Kit development board includes hardware such as Arduino Header, on-board USB Blaster, audio and video capabilities and much more. In addition, an on-board HSMC connector with high-speed transceivers allows for an even greater array of hardware setups. By leveraging all of these capabilities, the Cyclone V GX Starter Kit is the perfect solution for showcasing, evaluating, and prototyping the true potential of the Altera Cyclone V GX FPGA.

The Cyclone V GX Starter Kit contains all components needed to use the board in conjunction with a computer that runs the Microsoft Windows XP or later.

1.1 Package Contents

Figure 1-1 shows a photograph of the Cyclone V GX Starter Kit package.

Figure 1-1 The Cyclone V GX Starter Kit package contents

The Cyclone V GX Starter Kit package includes:

- The Cyclone V GX Starter board
- Quick Start Guide
- 12V DC Power Supply
- Type A Male to Type B Male USB Cable

1.2 Cyclone V GX Starter Kit System CD

The Cyclone V GX Start Kit (C5G) System CD contains the documentation and supporting materials, including the User Manual, Control Panel, System Builder, reference designs and device datasheets. User can download this System CD from the web (http://www.c5g.terasic.com).

1.3 Layout and Components

This section presents the features and design characteristics of the board.

A photograph of the board is shown in **Figure 1-2** and **Figure 1-3.** It depicts the layout of the board and indicates the location of the connectors and key components.

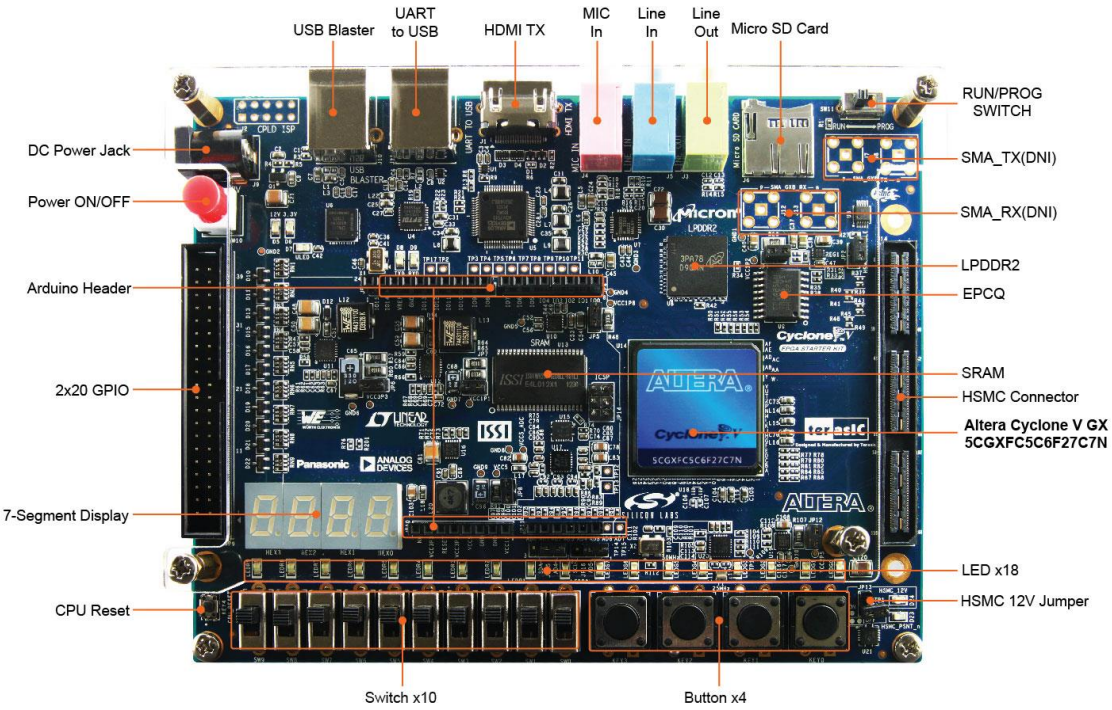

Figure 1-2 Development Board (top view)

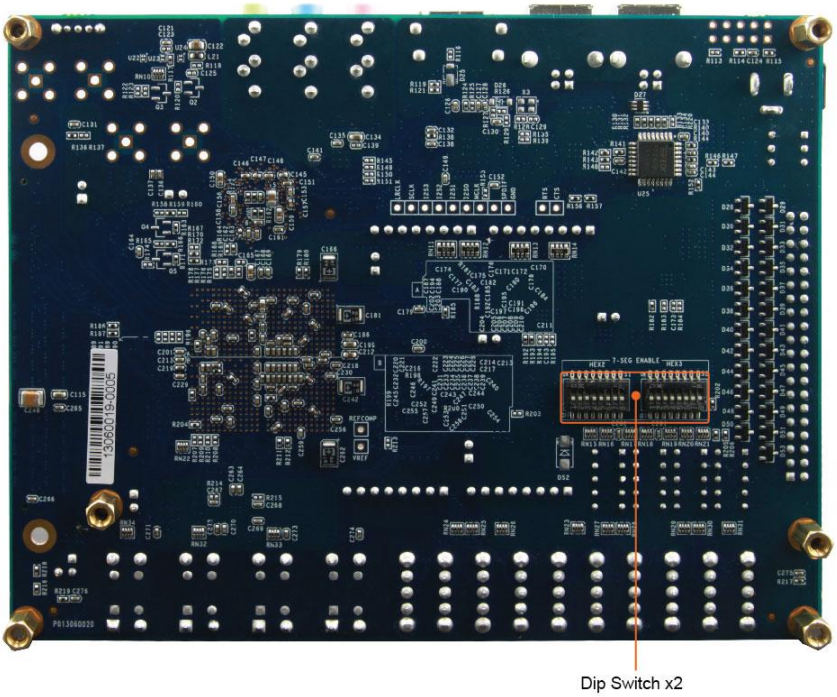

Figure 1-3 Development Board (bottom view)

This 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 is provided on the board:

FPGA Device

- Cyclone V GX 5CGXFC5C6F27C7N Device
- 77K Programmable Logic Elements
- 4884 Kbits embedded memory
- Six Fractional PLLs
- Two Hard Memory Controllers
- Six 3.125G Transceivers

Configuration and Debug

- Quad Serial Configuration device – EPCQ256 on FPGA
- On-Board USB Blaster (Normal type B USB connector)
- JTAG and AS mode configuration supported

Memory Device

- 4Gb LPDDR2 x32 bits data bus
- 4Mb SRAM x16 bits data bus

Communication

- UART to USB

Connectors

- HSMC x 1, including 4-lanes 3.125G transceiver,
- 2x20 GPIO Header
- Arduino header, including analog pins.
- SMA x 4 (DNI), one-lane 3.125G transceiver

Display

- HDMI TX, compatible with DVI v1.0 and HDCP v1.4

Audio

- 24-bit CODEC, Line-in, line-out, and microphone-in jacks

Micro SD Card Socket

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

ADC

- 12-Bit Resolution, 500Ksps Sampling Rate. SPI Interface.
- 8-Channel Analog Input. Input Range : 0V ~ 4.096V.

Switches, Buttons and LEDs

- 18 LEDs
- 10 Slide Switches

- 4 Debounced Push Buttons
- 1 CPU reset Push Buttons
- Four 7-Segments

Power

- 12V DC input

1.4 Block Diagram of the Cyclone V GX Starter Board

Figure 1-4 gives the block diagram of the board. To provide maximum flexibility for the user, all connections are made through the Cyclone V GX FPGA device. Thus, the user can configure the FPGA to implement any system design.

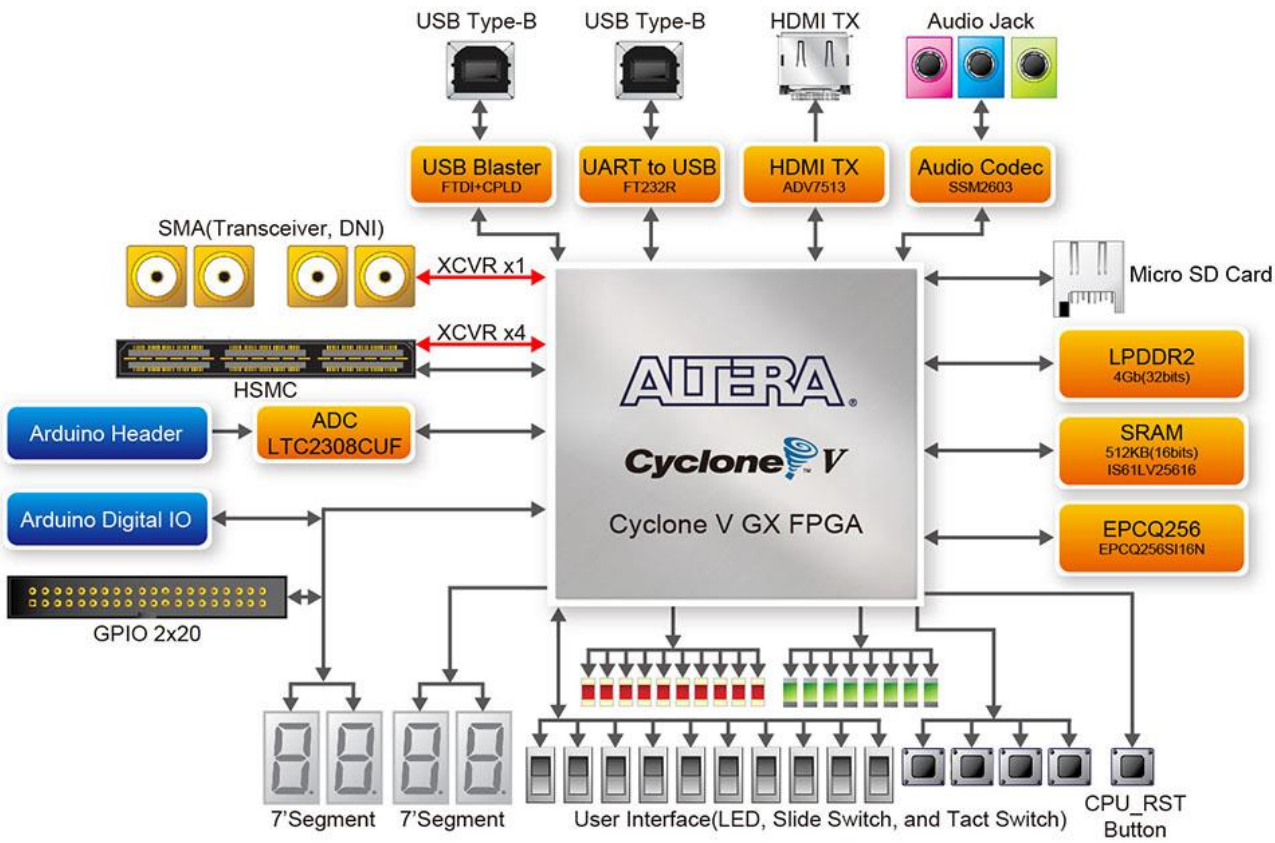

Figure 1-4 Board Block Diagram

1.5 Getting Help

Here are the addresses where you can get help if you encounter any problem:

- Terasic Technologies

Taiwan/ 9F, No.176, Sec.2, Gongdao 5th Rd, East Dist, Hsinchu City, Taiwan 300-70

Email: support@terasic.com

Tel.: +886-3-5750-880

Web: http://www.c5g.terasic.com

Chapter 2

Control Panel

The Cyclone V GX Starter 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 any 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" on the Cyclone V GX Starter Kit **System CD**. It's free of installation, just copy the whole folder to your host computer and launch the control panel by executing the "C5G_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 13.1 or a later version is installed successfully on your PC.

2. Set the RUN/PROG switch to the RUN position.

3. Connect the USB cable provided to the USB Blaster port, connect the 12V power supply, and turn the power switch ON.

4. Start the executable C5G_ControlPanel.exe on the host computer. The Control Panel user interface shown in **Figure 2-1** will appear.

5. The C5G_ControlPanel.sof bit stream is loaded automatically as soon as the C5G_ControlPanel.exe is launched.

6. In case of a disconnect, click on CONNECT where the .sof will be re-loaded onto the board.

Please note 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 to use; experience it by setting the ON/OFF status for some LEDs and observing the result on the C5G board.

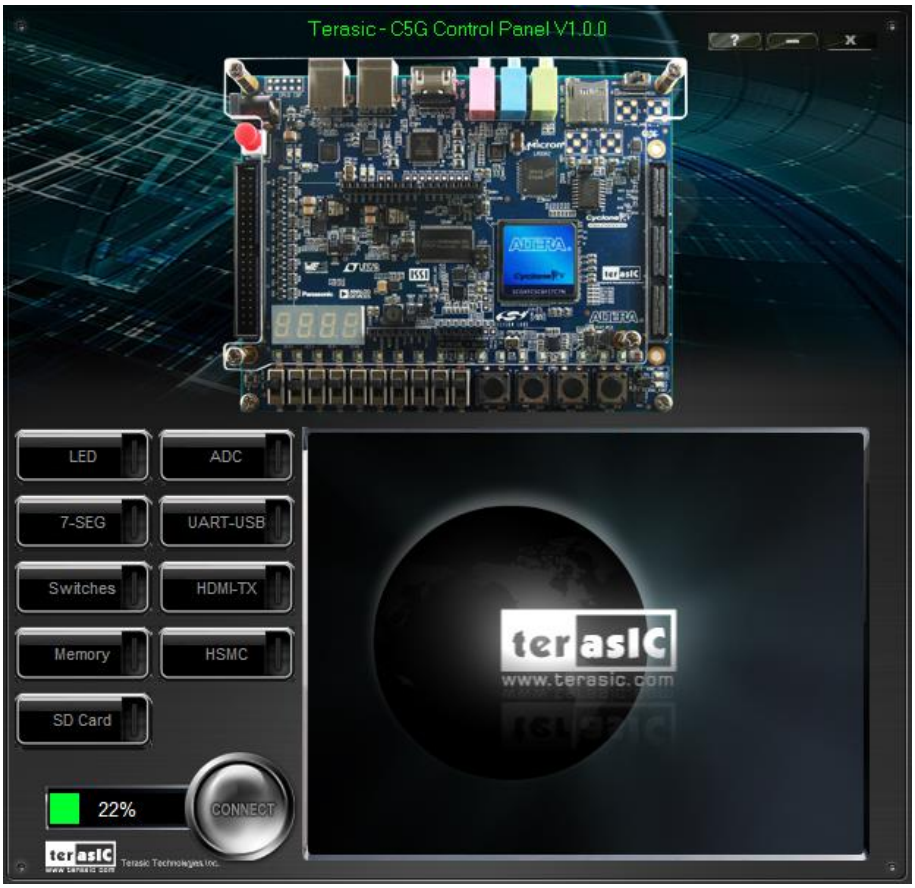

Figure 2-1 The C5G Control Panel

The concept of the C5G 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 Cyclone V Starter board.

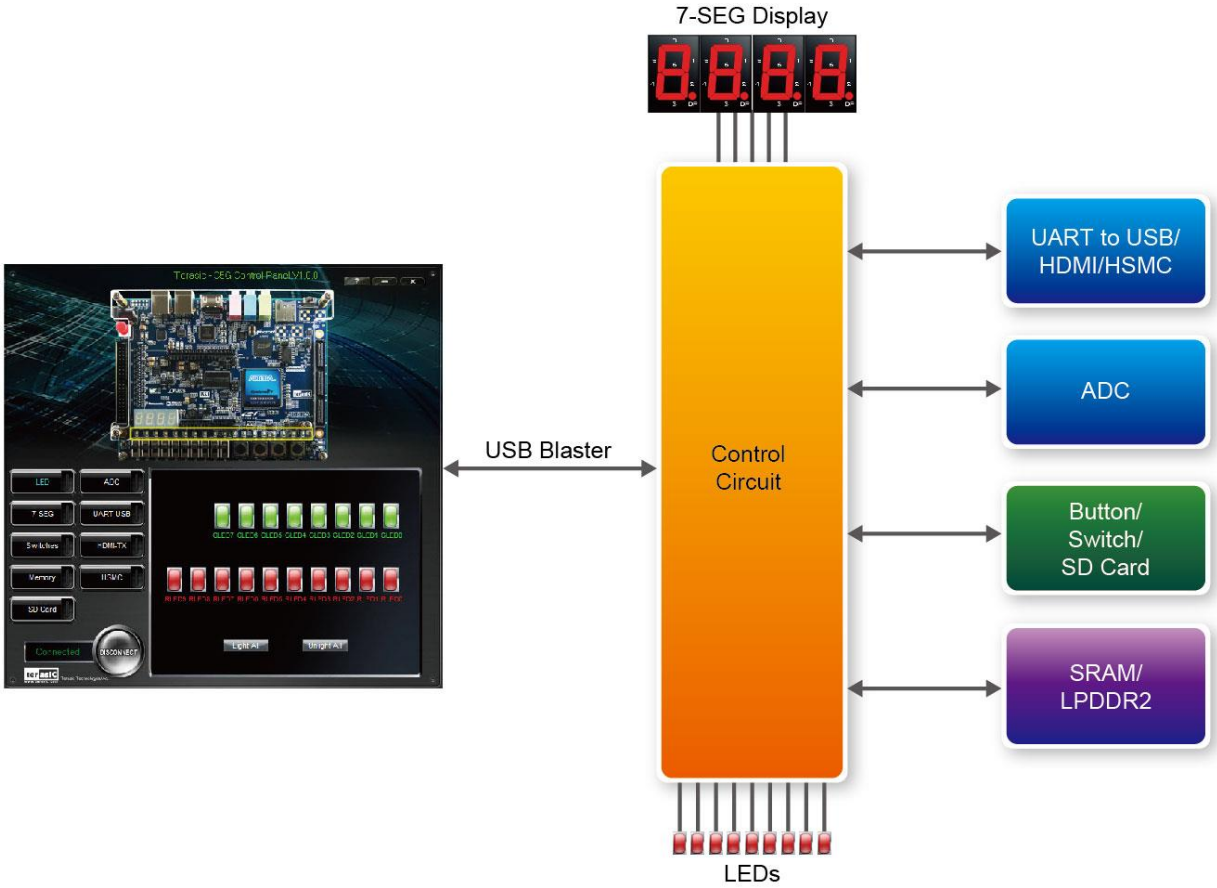

Figure 2-2 The C5G Control Panel concept

The C5G Control Panel can be used to light up LEDs, change the values displayed on the 7-segment, monitor buttons/switches status, read/write the SRAM and LPDDR2 Memory, output HDMI-TX color pattern to VGA monitor, verify functionality of HSMC connector I/Os, communicate with PC via UART to USB interface, read SD Card specification information. The feature of reading/writing a word or an entire file from/to the 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

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

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 Cyclone V GX Starter board which are updated immediately. Note that the dots of the 7-SEGs are not enabled on the Cyclone V GX Starter board.

Figure 2-4 Controlling 7-SEG 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 2-5. 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 2-5 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 to verify if the buttons and switches are functioning correctly. Thus, it can be used for troubleshooting purposes.

2.4 SRAM/LPDDR2 Controller and Programmer

The Control Panel can be used to write/read data to/from the SRAM and LPDDR2 chips on the Cyclone V GX Starter board. As an example, we will describe how the LPDDR2 may be accessed; the same approach is used to access the SRAM. Click on the Memory tab and select "LPDDR2" to reach the window in **Figure 2-6.**

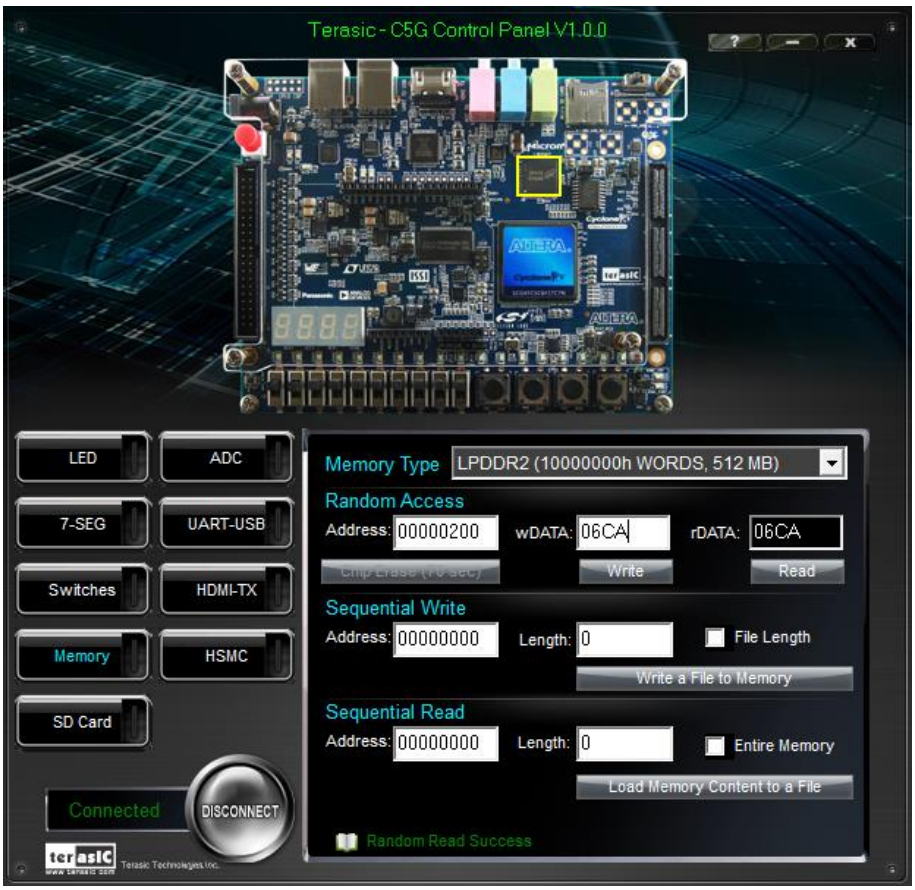

Figure 2-6 Accessing the LPDDR2

A 16-bit word can be written into the LPDDR2 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 2-6** 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 LPDDR2 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 check mark 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 location 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 LPDDR2 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 LPDDR2 are to be copied (which involves all 512 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 SRAM.

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 2-7**.

2. Insert an SD Card to the Cyclone V GX Starter 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 2-7 Reading the SD Card Identification and Specification

2.6 ADC

From the Control Panel, users are able to view the eight-channel 12-bit analog-to-digital converter reading. The values shown are the ADC register outputs from all of the eight separate channels. The voltage shown is the voltage reading from the separate pins on the extension header. **Figure 2-8** shows the ADC readings when the ADC tab is chosen.

Figure 2-8 Reading of eight channel ADC

2.7 UART-USB Communication

The Control Panel allows users to verify the operation of the UART to USB serial communication interface on the Cyclone V GX Starter Board. The setup is established by connecting a USB cable from the PC to the USB port where the Control Panel communicates to the terminal emulator software on the PC, or vice versa. The Receive terminal window on the Control Panel monitors the serial communication status. Follow the steps below to initiate the UART communication:

1. Choosing the UART-USB tab leads to the window in **Figure 2-9.**

2. Plug in an USB cable from PC USB port to the USB to UART port on Cyclone V GX Starter board.

3. The UART settings are provided below in case a connection from the PC is used. **Figure 2-10** shows the screen shot of UART configuration in Putty utility.

Baud Rate: 115200

Parity Check Bit: None

Data Bits: 8

Stop Bits: 1

Flow Control (CTS/RTS): OFF

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.

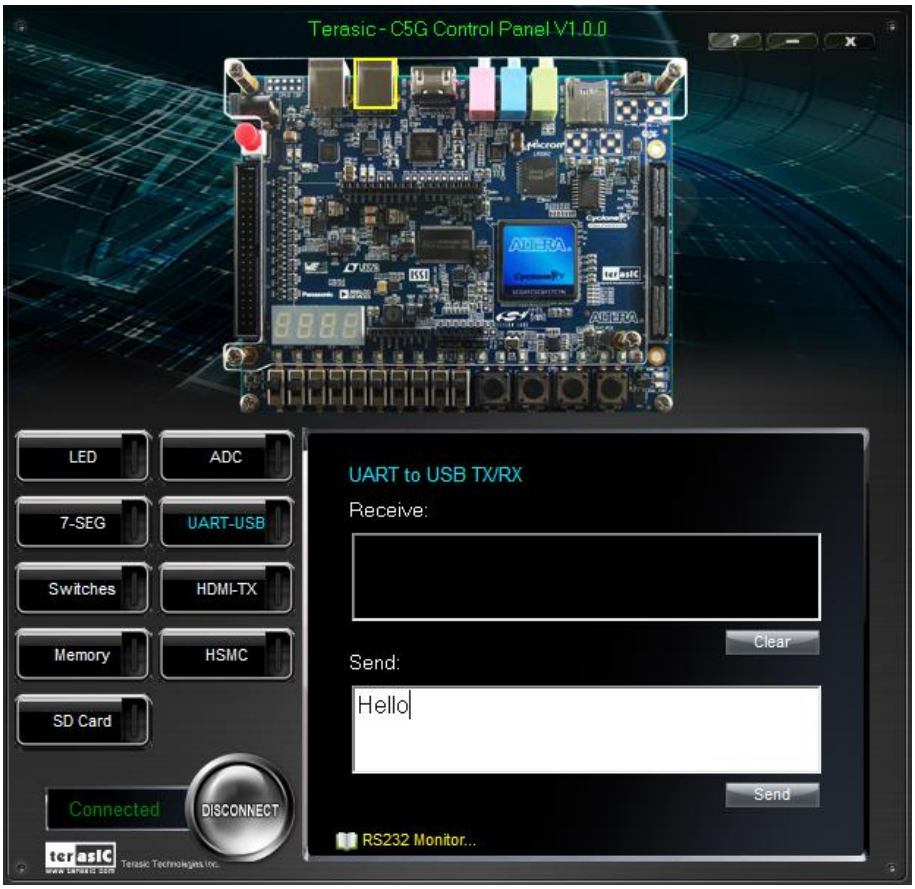

Figure 2-9 UART to USB Serial Communication

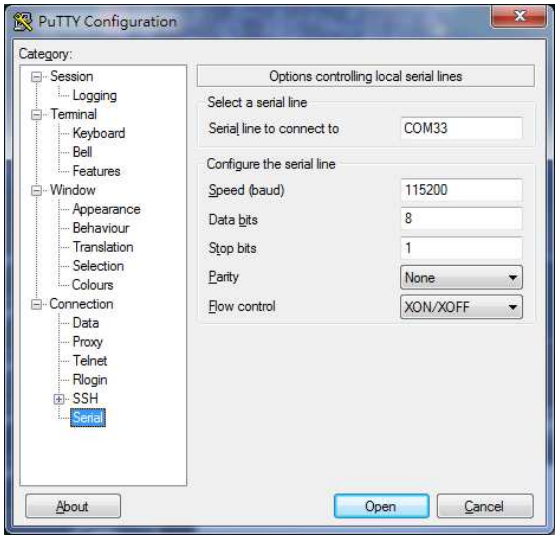

Figure 2-10 UART Configuration in PuTTY

2.8 HDMI-TX

C5G Control Panel provides video pattern function that allows users to output color pattern to HDMI interfaced LCD monitor using the Cyclone V GX Starter board. Follow the steps below to generate the video pattern function:

Note, do not installed HSMC loopback board while using HDMI-TX function because the loopback board will inference the I2C bus of HDMI.

1. Choosing the Video tab leads to the window in **Figure 2-11**.
2. Plug a HDMI cable to the HDMI connector of the Cyclone V GX Starter board and LCD monitor.
3. The LCD monitor will display the same color pattern on the control panel window.
4. Click the drop down menu shown in **Figure 2-11** where you can output the selected pattern individually.

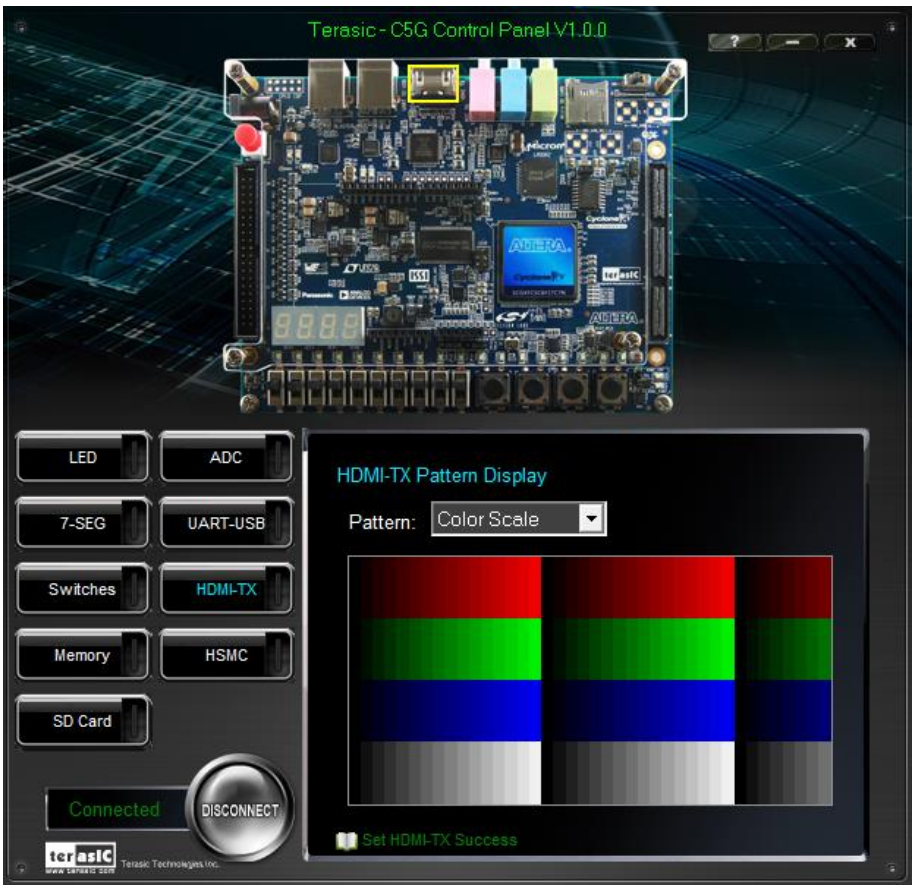

Figure 2-11 Controlling VGA display

2.9 HSMC

Select the HSMC tab to see the window shown in **Figure 2-12**. 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 remember to turn off the Cyclone V GX Starter 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://hsmc_loopback.terasic.com)

Figure 2-12 HSMC loopback verification test performed under Control Panel

2.10 Overall Structure of the C5G Control Panel

The C5G Control Panel is based on a Nios II Qsys system instantiated in the Cyclone V 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 Qsys builder. The source code is not available on the C5G System CD.

To run the Control Panel, users should follow the configuration setting according to Section 3.1. **Figure 2-13** 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.

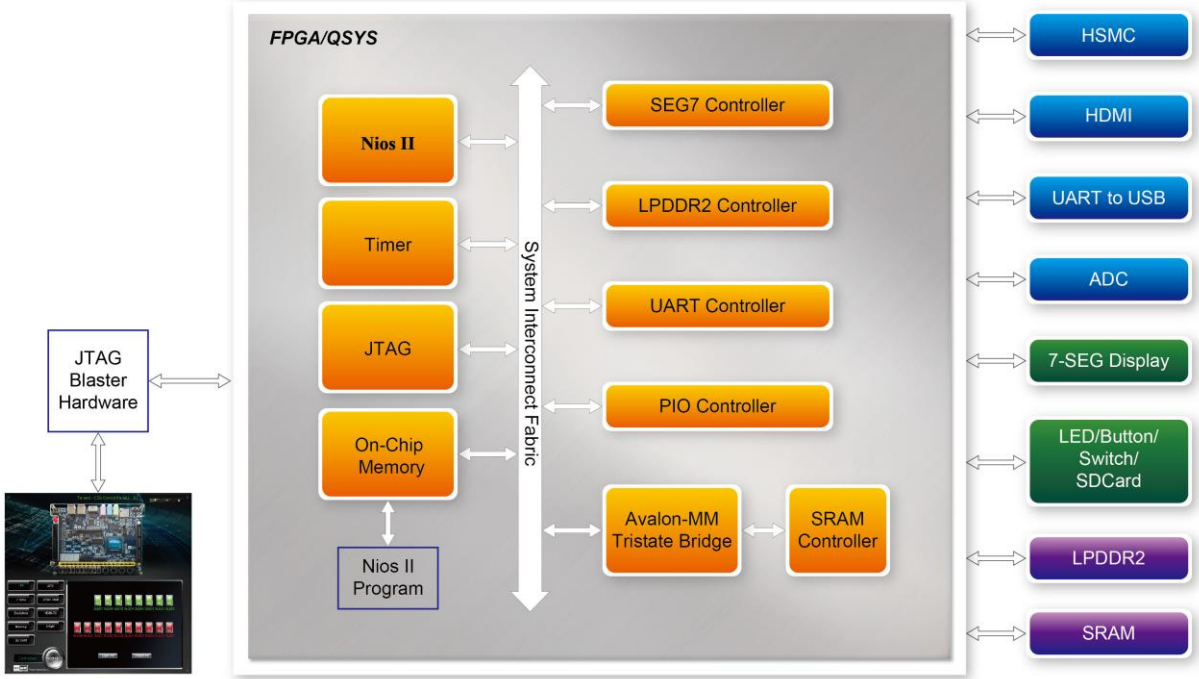

Figure 2-13 The block diagram of the C5G control panel

Chapter 3

Using the Starter Kit

In this chapter we introduce the important components on the Cyclone V GX Starter Kit.

3.1 Configuration, Status and Setup

The Cyclone V GX Starter board contains a serial configuration device that stores configuration data for the Cyclone V GX FPGA. This configuration data is automatically loaded from the configuration device into the FPGA when powered on. Using the Quartus II software, it is possible to reconfigure the FPGA at any time, and it is also possible to change the non-volatile data that is stored in the serial configuration device. Both types of programming methods are described below.

1. JTAG programming: In this method of programming, named after the IEEE standards Joint Test Action Group, the configuration bit stream is downloaded directly into the Cyclone GX FPGA. The FPGA will retain this configuration as long as power is applied to the board; the configuration information will be lost when the power is turned off.

2. AS programming: In this method, called Active Serial programming, the configuration bit stream is downloaded into the Altera EPCQ256 serial configuration device. It provides non-volatile storage of the bit stream, so that the information is retained even when the power supply to the Cyclone V GX Starter board is turned off. When the board's power is turned on, the configuration data in the EPCQ256 device is automatically loaded into the Cyclone V GX FPGA.

■ JTAG Chain on Cyclone V GX Starter board

To use JTAG interface for configuring FPGA device, the JTAG chain on Cyclone V GX Starter Kit must form a closed loop that allows Quartus II programmer to detect FPGA device. **Figure 3-1** illustrates the JTAG chain on Cyclone V GX Starter board. Shorting pin1 and pin2 on JP2 can disable the JTAG signals on HSMC connector that will form a closed JTAG loop chain on Cyclone V GX Starter board (See **Figure 3-2**). Thus, only the on-board FPGA device (Cyclone V GX) will be detected by the Quartus II programmer. If users want to include another FPGA device or interface containing FPGA device in the chain via HSMC connector, remove JP2 Jumper (open pin1 and pin2 on JP2) to enable the JTAG signal ports on the HSMC connector.