BCA181 PRELIM EXAM

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Introduction

DE2-115 Factory Configuration

Purpose: In this activity you will learn to use the Quartus II, and FPGAs to create a demonstration of the basic features of the board. Implementing and simulating the red and green LED's, LCD, VGA display and speakers of the Altera DE2-115 board.

Overview: LEDs, LCD, VGA display, and an audio codec are all included in the DE2-115 Factory Configuration. Using the Quartus II may be implemented and simulated in the development environment. And writing to memory-mapped registers will lead to LEDs being controlled. The MegaWizard Plug-In Manager may be used to build the LCD and VGA interfaces, while the TimeQuest Timing Analyzer program can be used to optimize the timing limitations of the VGA interface. The audio codec is linked to the FPGA through an I2S interface.

Theory: LEDs are controlled by memory-mapped registers on the DE2-115 board, which features other peripherals including LCD, VGA display, and audio codec that may be implemented using Quartus II. The MegaWizard Plug-In Manager and Quartus II emulator may be used to implement the LCD and VGA interfaces, respectively, and emulate their capabilities. TimeQuest Timing Analyzer may be used to improve the timing restrictions for the VGA interface. The I2S interface, which connects the audio codec and can be simulated and tested using Quartus II, MegaWizard, and other software, is also implementable.

DE2-115 Music Synthesizer

Purpose: In this activity you will learn to use the Quartus II, and FPGAs to create a demonstration of the basic features of the board. This demonstration shows how to implement a Multi-tone Electronic Keyboard using a DE2 115 board with a PS/2 Keyboard and a speaker.

Overview: A digital hardware platform for composing and performing music is called the DE2-115 Music Synthesizer. The Altera DE2-115 development board serves as its foundation,

and a variety of hardware and software components are used to create it. VHDL or Verilog HDL may be used to program the synthesizer so that users can add their own musical instruments, effects, and processing algorithms. All things considered, the DE2-115 Music Synthesizer is a flexible tool for investigating digital music synthesis and creating new musical instruments and effects.

Theory: The digital signal processing (DSP) theory and hardware design ideas form the foundation of the DE2-115 music synthesizer. A high-speed FPGA, analog-to-digital and digital-to-analog converters, and concepts from music theory are all included on the board. Users of the synthesizer may design and perform a variety of musical sounds and instruments that can be combined to produce melodies and harmonies. Additionally, it supports a number of musical elements, including polyphony, varied waveforms, envelopes, filtering, and modulation, which may be combined to produce a variety of musical effects and genres. A potent platform for delving into the field of digital music synthesis is offered by the synthesizer.

Procedure

DE2-115 Factory Configuration

The DE2-115 board can be demonstrated by connecting it to a computer via USB cable, powering it on, observing the various displays and LEDs, optionally connecting a VGA display and/or a speaker, and exploring the provided Verilog HDL source code.

Here are the detailed instructions to demonstrate the functionality of the DE2-115 board:

- Open the project directory named "DE2_115_Default".
- Connect the DE2-115 board to your computer via USB cable to the USB Blaster port.
- Power on the DE2-115 board. If the default factory configuration of the DE2-115 board is not currently stored in the EPCS64 device, you will need to download the bit stream to the board using either JTAG or AS programming.
- Once the board is powered on, you should be able to observe that the 7-segment displays are displaying a sequence of characters, and the red and green LEDs are flashing. Additionally, "Welcome to the Altera DE2-115" is shown on the LCD display.
- Optionally, you can connect a VGA display to the VGA D-SUB connector. When connected, the VGA display should show a color picture.
- You can also optionally connect a powered speaker to the stereo audio-out jack.
- To hear a 1 kHz humming sound from the audio-out port, place slide switch SW17 in the DOWN position. Alternatively, if slide switch SW17 is in the UP position, and you connect the microphone in port with a microphone and/or connect the line-in port with an

audio player's output, you will hear the sound from the microphone or audio player or mixed sound from both.

- The Verilog HDL source code for this demonstration is provided in the DE2_115_Default folder. You can use the top-level Verilog HDL file called DE2_115_Default.v as a template for other projects because it defines ports that correspond to all of the user-accessible pins on the Cyclone IV E FPGA.

DE2-115 Music Synthesizer

The Multi-tone Electronic Keyboard can be implemented on the DE2-115 board by using a PS/2 Keyboard as the piano keyboard for input. The Cyclone IV E FPGA on the DE2-115 board functions as the Music Synthesizer SOC to produce music and tones. The VGA monitor connected to the DE2-115 board displays which key is being pressed during the playback of the music. Additionally, a speaker is used to play the generated music and tones.
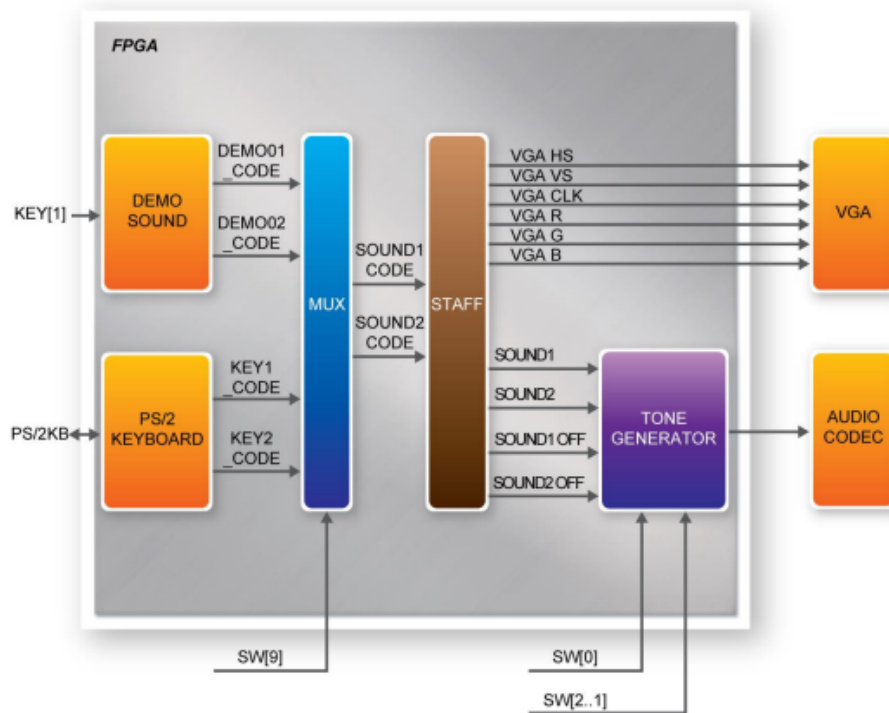

Figure 6-23   Block diagram of the Music Synthesizer design

The Music Synthesizer block diagram consists of four main blocks: DEMO_SOUND, PS2_KEYBOARD, STAFF, and TONE_GENERATOR. The DEMO_SOUND block contains a pre-stored sound for users to play. The PS2_KEYBOARD block handles user input from the

PS/2 keyboard, while the STAFF block draws the corresponding keyboard diagram on the VGA monitor when a key is pressed. The TONE_GENERATOR is the heart of the music synthesizer SOC, and users can switch between the PS2_KEYBOARD and DEMO_SOUND as the music source using SW9. Users can repeat the demo sound by pressing KEY1. The TONE_GENERATOR block has two tones: String and Brass, which are controlled by SW0. The audio codec on the DE2-115 board has two channels that can be turned ON/OFF using SW1 and SW2.

Here are the detailed instructions to demonstrate the Music Synthesizer:

- First, go to the project directory named "DE2_115_Synthesizer".
- Next, connect a PS/2 Keyboard to the DE2-115 board.
- Then, connect the VGA output of the DE2-115 board to a VGA monitor (either LCD or CRT should work).
- After that, connect the lineout of the DE2-115 board to a speaker.
- Load the bit stream into the FPGA by executing the file "DE2_115_Synthesizer\demo_batch\DE2_115_Synthesizer.bat".
- Ensure that all switches (SW[9:0]) are in the 0 position (down).
- Press KEY1 on the DE2-115 board to start the music demo.
- To reset the circuit, press KEY0 on the DE2-115 board.

Table 6-5 and Table 6-6 illustrate the usage of the slide switches, push-button switches (KEYs), PS/2 Keyboard.

- **Slide Switches and Push-button switches**

Table 6-5   Usage of the slide switches and push-buttons switches (KEYs)

Signal Name	Description
KEY[0]	Reset Circuit
KEY[1]	Repeat the Demo Music
SW[0]	OFF: BRASS, ON: STRING
SW[9]	OFF: DEMO, ON: PS/2 KEYBOARD
SW[1]	Channel-1 ON / OFF
SW[2]	Channel-2 ON / OFF

- **PS/2 Keyboard**

Table 6-6   Usage of the PS/2 Keyboard Keys

Signal Name	Description
Q	-#4
A	-5
W	-#5
S	-6
E	-#6
D	-7
F	1
T	#1
G	2
Y	#2
H	3
J	4
I	#4
K	5
O	#5
L	6
P	#6
:	7
"	+1

Results

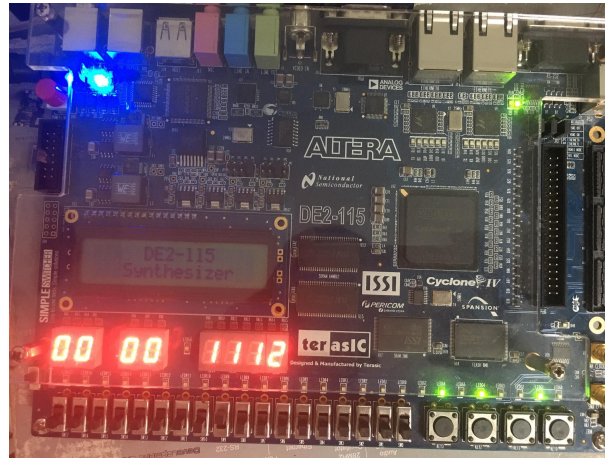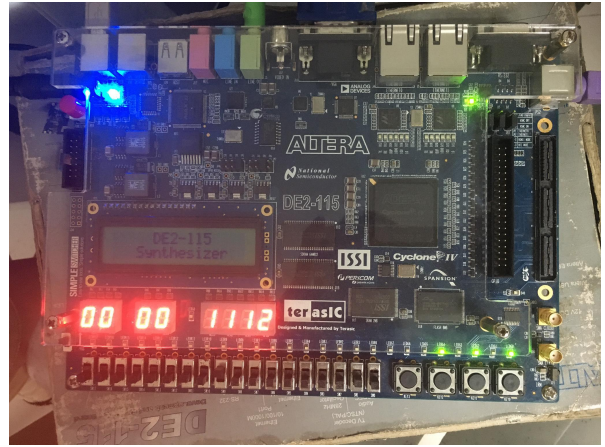## DE2-115 Factory Configuration

As the board is powered on, we observed that the 7-segment displays are displaying a sequence of characters, and the red and green LEDs are flashing. The LCD on the Altera displays "Welcome to the Altera DE2-115". And if we slide switch SW17 downwards, a humming sound from the audio-out port will be heard, and if we slide switch SW17 upwards, a sound from the microphone or audio player or mixed sound from both will be heard.
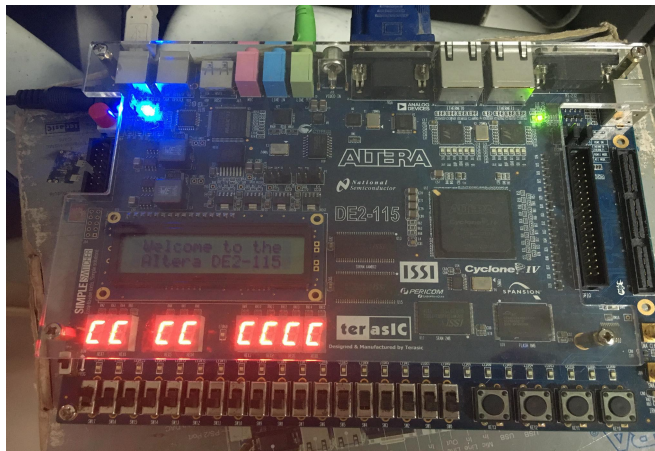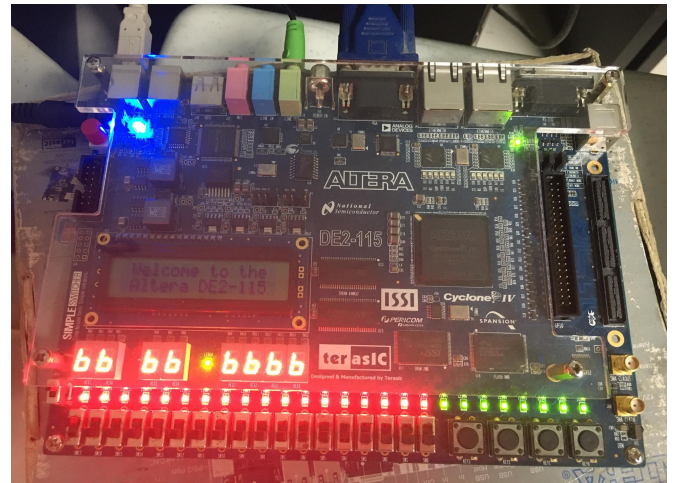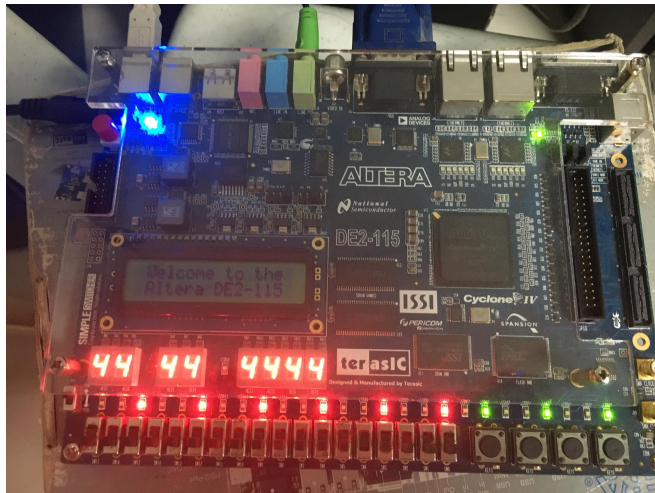
DE2-115 Music Synthesizer

At first we connect all the ports and simulate the file. We press the KEY1 on the DE2-115 board and we hear the music demo plays which was already stored in the file. And as you can see in the table above, there are keys that can be played using a keyboard with corresponding tones, and switches on the altera with corresponding functions. The monitor also displays the piano

tiles, it shows the keys that we have clicked on the keyboard. And as we press the KEY0 on the DE2-115 board, it resets the circuit

Demo

In this Google Drive contains the default and synthesizer demonstrations.
https://drive.google.com/drive/u/2/folders/1nmJKPI17zvOAhhm6KFfA4sgrqdc2SW1l