Embedded Systems (CSCE 313)

Project 3

Project Objective

1. Learning how to program the 7-segments in DE2-115 Board.
2. Writing an application code that operates the counter and pattern on the 7-segments.
3. Writing an application code that operates the BCD to 7-segments, where A, B, C, D are the input lines and a, b, c, d, e, f, g are the output lines, and this output will be given to the 7-segment which displays the decimal number depending on the inputs.

Hardware Requirements

1. Use the same system that you designed in project2 and only remove the counter and pattern LEDs PIO components from the design.
2. Add five new PIO components to your system which represent the first five 7-segment in FPGA board. Add two more PIO components, one for the decoder input which represents the BCD inputs and the other for speed controller for the pattern and counter operation. Table.1 shows the components' features that you need to set it up.
   a. The first column shows that I/O pins that will be used in the Verilog code and connected with the exported signal of your nios system.
   b. The second and third columns show the PIO direction and width respectively that you need to specify when you select the component from IP Catalog.
   c. The fourth column shows the name that you need to rename the component with when you add it to your nios system. The fifth column shows the signal name that will be exported in the conduit signal.
3. Update the Verilog code as shown in the attached Verilog file.

Table 1: Hardware Settings

PIO board device	Direction	Width	Name	Conduit name
HEX0[7:0]	output	8-bit	segment0	seg0
HEX1[7:0]	output	8-bit	segment1	seg1
HEX2[7:0]	output	8-bit	segment2	seg2
HEX3[7:0]	output	8-bit	segment3	seg3
HEX4[7:0]	output	8-bit	segment4	seg4
PIO	input	4-bit	bcd_input	bcdin
PIO	input	1-bit	speed_controller	spcont

Application Requirements

a. You are required to write an application software that executes the functions described in Table.2 based on the values of the system mode as explained in the table.

Table 2: Software Functions

System Mode	SW [1:0]	Function
1	01	Decoder operation. Your decoder input is 4-bit, and the output is 8-bit. The decoder inputs are implemented by the four switches (SW5, SW4, SW3, SW2). The output of the decoder should be displayed on the fifth 7-segment unit in the board.
2	10	A counter starts incrementing from 0x00 to 0xFF, and the value displays on the first two 7-segments. If the mode changes, the counter stops on latest number. If the mode changes back to 1, the counter restarts.
3	11	A random pattern starts, and the value is displayed on the second two 7-segments. If the mode changes, the pattern stops at the latest value.

b. Both counter and random operations can be run on two different speeds based on the value of SW6.

   i. If SW[6] is ON, the speed is 300ms.
   ii. If SW[6] is OFF, the speed is 125ms.

Project Report (70%)

The project report will be graded out of 100, and the points will be distributed as following:

1. Your report should be written as a technical report. Please follow the following template:
   1. **Presentation** (5 points)
      a. Script: The report must be printed single sided on white A4 paper.
      b. Margins: All margins must be at least 2.54cm
      c. Page numbers: Number all pages consecutively starting at 1
   2. **Structure** (5 points):
      a. Start by writing the following in the top-middle first page of the report.
         1. Author (s)
         2. Title of the project
         3. Course
         4. Department
         5. University
      b. **Summary** (5 points): brief description about the main objective of the project and outcomes.
   3. **Discussion**: Answer the following questions as paragraphs where the title of each paragraph represents the given question name (or number) in bold.
         1. (5 points) **Question one:** What is the maximum width that the PIO components can have and why?

2. (5 points) **Question two:** What is the hardware function that is used to display the value 0x55 on LEDs?

3. (5 points) **Question three:** What is the total number of I/O pins that is used in a system which includes four seven-segment and four push button switches, in addition to clock and reset?

4. (10 points) **Question four:** You have an FPGA chip which consists of 2000 LEs. How many LABs (Logical Array Block) are there?

5. (15 points) **Question five:** Briefly explain the difference between Bare-Metal software and General-Purpose software (has Windows and Linux OS).

6. (15 points) **Question six:** Write an OpenCl code to execute the following scaler multiplication on 200x200 matrix A.

$$A_{new} = K \, A_{old}$$

4. **Results** (24 points)

   a. (12 points) After you compiled and synthesized your system, read the summary report from Quartus, and fill out the below table with the numbers from the report.

Logical Elements	Registers	Total Pins	Memory Bits

   b. (12 points, each picture is 3 points) Run the application software on the three different modes and include a picture that shows the output on the console for each case. You are required to submit only one picture per case.

5. **Conclusion** (6 points): Compare the hardware results between the table above and Table.1 of project 2.

Project Report (30%)

2. The main purpose of the demo is to test your project functionality and execution.

3. Demos will be checked and graded by the TA.

4. Demos will be graded out of 30. Below are how the demo points will be distributed.

5. Demos will be conducted during the lab time on the deadline day or before.

6. <u>Both partners must show up on that day. If a member didn't show up, he/she receives 0 unless an excused absence was provided.</u>

7. **An online quiz (on Blackboard) will be conducted on Monday 19th.**

   1. Questions related to the project.

   2. The quiz will be open any time between 10:00am until midnight on Monday 19th.

   3. It will be timed.

   4. One attempt is allowed.

Tasks	Point
Mode 1	/5
Mode 2	/5
Mode 3	/5
Quiz	/15

Project Submission

1) Save the project report as r3_username1_username2.pdf, username of both students in the group.

2) Only one attempt is allowed.

3) Only one group member submits to the project.

4) Remember: Any grade dispute must be raised within one week of the grade posting.