**EE 316 Computer Engineering Junior Lab (Spring 2017)**

**Design Project 2**

* **Specification:** Design and Implementation of an I2C controller for a 7-segment display
* **Lab Demonstration Due Date:** February 9, 2017
* **Report Due:** February 13, 2017

**Parts List:**

1. Altera DE2 Board
2. Digilentinc’s Nexy4 Board
3. Sparkfun’s 7-segment display

Design an I2C controller for a seven-segment display to show the outputs of a 16-bit synchronous digital system.

The specifications are:

* The system operates at an "effective clock" of 1 Hz. The synchronous system has an output sequence of length 9. The sequence repeats, when it is enabled. The output sequence in HEX is the following:

0000, 0A0A, 5050, FE45, AABB, CCDD, FEED, DEAD, BEEF

* The design will be implemented on both Xilinx’s NexysTM4 board using Xilinx’s Vivado CAD tool and Altera’s DE2 board using Quartus II version 13.0.
* For the Nexy4 boards the center button (BTNC) initializes the system (asynchronously) to the first number of the sequence when it is pressed and held. Once BTNC is released, the system will start counting with a 1 sec delay. BTNL toggles system’s direction. The system starts in the forward mode. If the key is pressed, it will change into the backward-counting mode. If it is pressed again, the direction will reverse. The BTNR toggles between system-enable or disable. The button inputs must be debounced, registered and must include an edge-detector circuit. For the DE2 board, you will need to replace BTNC, BTNL and BTNR with KEY0 through KEY2, respectively.
* Both systems will use single port ROM IP-cores to store the system sequence.
* The output should be displayed on 4 of the on-board 7 segment displays on the right. Turn off the other 7-segment displays on the board.
* The design will contain an [external 7-segment display](https://www.sparkfun.com/products/11442). This is a newer display can be controlled in one of the three ways: Serial TTL, Serial SPI or Serial I2C. The display will be controlled using the **I2C Serial protocol**.
* Write a Testbench and simulate the I2C controller in Xilinx’s Vivado’s simulation tool and Altera’s ModelsSim.
* Use LeCroy Logic Analyzer (LogicStudio) to capture the sequence before you connect to the external display.

Two examples of the LogicStudio’s saved acquisitions have been posted in Moodle, one of these was controlled using an Arduino Uno board and the second one used the FPGA version of the I2C controller. Note, the external 7-segment display was not connected to the FPGA when the data was collected; hence a NACK is generated instead of an ACK as shown in the data collected for the Arduino Uno board that had the external I2C 7-segment display.

**Option1: (5 points**) In this design, instantiate a Logic Analyzer available in Xilinx Vivado and SignalTap in Quartus II for debugging the design before you connect to the external supply.

**Option 2: (5 points**) Since the display can also be controlled using the serial TTL and serial SPI, design will have capabilities to also use the other two modes of communication.

**Useful Links:** (Note: some of the materials included in the links are copyrighted. Do not use any code without taking explicit permission from the owner of the code developer.)

1. [Sparkfun 7-Segment Serial Display](https://www.sparkfun.com/products/11442) (see Documents)

https://www.sparkfun.com/products/11442

1. [The I2C-bus and how to use it (including specifications)](http://www.i2c-bus.org/fileadmin/ftp/i2c_bus_specification_1995.pdf)

http://www.i2c-bus.org/fileadmin/ftp/i2c\_bus\_specification\_1995.pdf

1. [I2C master (VHDL):](https://eewiki.net/pages/viewpage.action?pageId=10125324) (version 2.1 with some modification is posted on Moodle)

https://eewiki.net/pages/viewpage.action?pageId=10125324

1. [Implementing an I2C Master Bus:](http://faculty.lasierra.edu/~ehwang/digitaldesign/public/projects/DE2/I2C/I2C.pdf)

http://faculty.lasierra.edu/~ehwang/digitaldesign/public/projects/DE2/I2C/I2C.pdf

**Teams:**

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| --- | --- | --- | --- | --- | --- | --- |
| **Team1** | **Team2** | **Team3** | **Team4** | **Team5** | **Team6** | **Writer** |
| Bruska | Griffin | Bruce | Lowit | Oliver | Marsanskis |  |
| Trahan | Zander | Heck | Shippee | Craddock | Straw |  |
| Beyer | strenk | Farden | Law | Michaels | Kuhns |  |