Design Requirements
This lab will introduce you to the Altera platform tools for developing embedded systems for the DE2 board.

Part 1
Follow the informal tutorial in the lecture slides to implement a system with the following characteristics:

- One of the 24 LEDs on the board is always lit
- The lighted LED changes in a fixed periodic interval, which can be every 250 ms, 125 ms, or 50 ms, depending on the current mode of the system
- On each change, the lighted LED shifts to the left until it reaches LEDR17, at which point it shifts to the left until it reaches LEDG0, and then repeats
- Pushing KEY3 changes the period to 250 ms, KEY2 to 125 ms, and KEY1 to 50 ms
- The console (UART) should display the new period when the mode is changed

Part 2
Start with Use the design from part 1 for the following new features on our own:

- Add eight 7-bit parallel I/O modules (in output mode) to your SOPC design corresponding to each of the DE2’s seven-segment display
- Generate your NIOS system, then connect the resulting outputs to the HEX7 to HEX0 outputs in the top-level design
- Write code for your NIOS2 processor that will change the value of the seven-segment displays at the same period as the LEDs:
  - When the period is 250 ms, the 7-segment displays will light with random configurations
  - When the period is 125 ms, the 7-segment displays will follow a pattern where one segment is always lit, and the lit segment follows a clockwise circular path around the outermost ring of segments, for example:

```
(1) 88888888
(2) 88888888
(3) 88888888
(4) 88888888
(5) 88888888
(6) 88888888
```
• When the period is 50 ms, the 7-segment displays will show a decimal count from 0 to 99,999,999 and repeat

**Setting Up Output Ports for 7-Segment Displays**

Please make sure you check the documentation on the 7-segment LEDs before starting this lab:


Specifically, note that these 7-segment displays are active low and the segments go from the least significant bit to the most significant bit. In other words, when bit 0 is LOW the top segment will illuminate, and when bit 6 is LOW the middle segment will illuminate.

1. In SOPC Builder, add a 7-bit output parallel I/O (PIO) for each of the eight displays.

2. Add the following to the nios_system port map (somewhere under the line “nios_system DUT(“):

   ```
   .out_port_from_the_HEX0(HEX0),
   .out_port_from_the_HEX1(HEX1),
   .out_port_from_the_HEX2(HEX2),
   .out_port_from_the_HEX3(HEX3),
   .out_port_from_the_HEX4(HEX4),
   .out_port_from_the_HEX5(HEX5),
   .out_port_from_the_HEX6(HEX6),
   .out_port_from_the_HEX7(HEX7),
   ```

3. Delete the following lines from your Verilog code:

   ```
   assign HEX0 = 7’h00;
   assign HEX1 = 7’h00;
   assign HEX2 = 7’h00;
   assign HEX3 = 7’h00;
   assign HEX4 = 7’h00;
   assign HEX5 = 7’h00;
   assign HEX6 = 7’h00;
   assign HEX7 = 7’h00;
   ```

4. After doing this, the eight 7-segment HEX outputs will be connected from your SOPC design through the pins on the FPGA to the actual 7-segment displays. You can access them from your C code using, for example:
IOWR_ALTERA_AVALON_PIO_DATA(HEX0_BASE,3);
IOWR_ALTERA_AVALON_PIO_DATA(HEX1_BASE,4);
IOWR_ALTERA_AVALON_PIO_DATA(HEX2_BASE,5);
IOWR_ALTERA_AVALON_PIO_DATA(HEX3_BASE,6);
IOWR_ALTERA_AVALON_PIO_DATA(HEX4_BASE,12);
IOWR_ALTERA_AVALON_PIO_DATA(HEX5_BASE,56);
IOWR_ALTERA_AVALON_PIO_DATA(HEX6_BASE,87);
IOWR_ALTERA_AVALON_PIO_DATA(HEX7_BASE,127);

**Project Submission**

Each group must submit an archive of their complete project directory to Dropbox. Make sure you include your software (Eclipse projects).