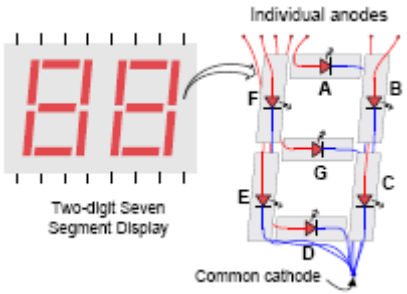
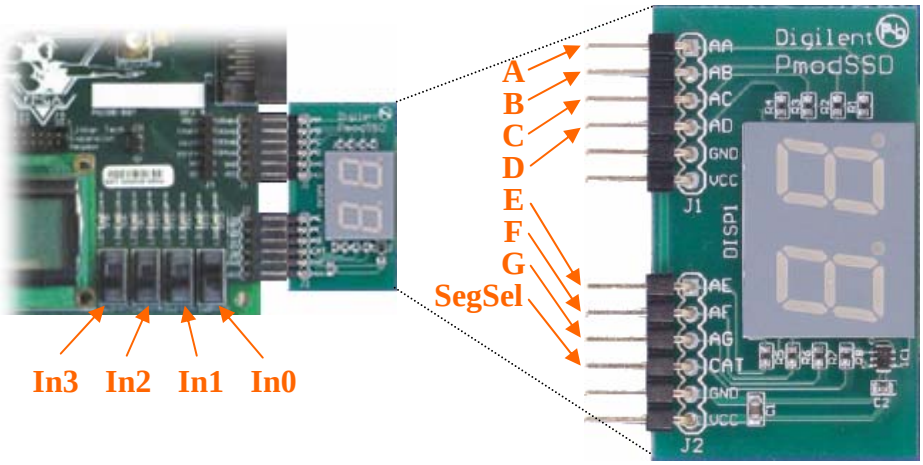
Lab 2: Binary to 7-segment LED Decoder

In this lab, you will build a decoder to display the hexadecimal digit of 4-bit binary number on a 7-segment LED display. The binary to 7-segment LED decoder has four 1-bit inputs `In3`, `In2`, `In1`, `In0`, and seven 1-bit outputs `A`, `B`, `C`, `D`, `E`, `F`, `G`, for controlling the seven segment of the LED display as shown in the figure to the right. Based on the input values the decoder will illuminate the correct segments of the LED display to output the single hexadecimal digit corresponding to the binary input value. For example, if our input is `0000`, we should output `ABCDEFG` = `1111110` to illuminate all LED segment except the middle segment, thereby displaying the digit 0.



The binary to 7-segment LED decoder will have one additional output to control which of the two 7-segment LED displays will be illuminated. Only one 7-segment LED display can be illuminated at any given time. Your design should include a 1-bit `SegSelect` output to control which display to use. You will also need to determine what value should be assigned to the `SegSelect` signal to illuminate the right (or top depending on your orientation) 7-segment LED display. You can determine this setting by either reading the datasheet for the 7-segment display



module or experimentally determining this value.

In order to download your decoder to the Spartan3E FPGA board you must map the inputs and outputs of the binary to 7-segment decoder to specific components. For this project we will map the input signals to the slide switches and map the output signals to the 7-segment LED display, as shown above. The corresponding .ucf file is:

```
NET "In3" LOC = "N17";
NET "In2" LOC = "H18";
NET "In1" LOC = "L14";
NET "In0" LOC = "L13";

NET "A" LOC = "B4";
NET "B" LOC = "A4";
NET "C" LOC = "D5";
NET "D" LOC = "C5";
NET "E" LOC = "A6";
NET "F" LOC = "B6";
NET "G" LOC = "E7";
NET "SegSel" LOC = "F7";
```

Lab Procedure

1. Determine which segments must be illuminated for the 16 possible input values ensuring that each value has a unique illumination pattern. Create a truth table for the binary to 7-segment decoder and determine the Boolean equations for each output.
2. Implement the binary to 7-segment LED decoder behaviorally expressing each output as a Boolean equation in Verilog.
3. Simulate your binary to 7-segment LED decoder to exhaustively test all possible input combinations.
4. Synthesize and download your binary to 7-segment LED decoder to the Spartan-3E Starter board and test your design exhaustively by trying all possible input combinations.
5. Determine which output setting of `SegSel` will illuminate the desired LED display. Re-synthesize and download your modified design if necessary.

Demo *(you must demo the following aspects to the TA)*

1. Verilog code for the binary to 7-segment LED decoder.
2. Simulation waveforms demonstrating correct functionality of the binary to 7-segment LED decoder for all possible inputs.
3. Synthesis and implementation of the binary to 7-segment LED decoder to Spartan 3E Starter Board demonstrating correct functionality for all possible inputs.

Lab Report Requirements *(In addition to the standard lab report format)*

1. Truth table and Boolean equations for your binary to 7-segment LED decoder design.
2. Verilog code for the decoder and the corresponding testbench code.
3. Simulation waveforms demonstrating correct functionality of the decoder for all possible inputs.
4. Clearly indicate which output setting for `SegSel` will illuminate the desired LED display