EELE 367 – Logic Design
Lab #5 – Walking 1 Finite State Machine

Overview

In this lab you be designing a finite state machine (FSM) to create a *walking 1* pattern on the LEDs. A walking 1 pattern is where a vector contains all 0's except for a single bit containing a 1. On each clock edge, the 1 moves one position to either its left or right. For example: 0001 → 0010 → 0100 → 1000. This is also often called a *snake pattern*. You will be creating a walking 1 pattern that will move in one direction across the LEDs when a switch is asserted and the opposite direction with the switch is de-asserted. You will create your FSM using the three process behavioral modeling approach covered in Chapter 9. You will also use user-defined, enumerated data types for your states and allow the synthesizer to automatically assign the state codes. There are three parts to this lab, each with increasing complexity. In the first part of the lab you will create a walking 1 pattern that moves across the 8x blue LEDs on the I/O shield. In the second part you will expand the pattern to move across all 16-bits of the blue *and* red LEDs. In part 3 you will expand the pattern to move across the 16x blue/red LEDs and then move around the outside of the character displays.

Outcomes

After completing this lab you should be able to:

- Implement a finite state machine in VHDL using the three process behavioral modeling approach.
- Implement a finite state machine in VHDL using user-defined, enumerated states.
- Implement output vectors of a finite state machine in order to achieve the desired patterns on LEDs.

Deliverables

The deliverable(s) for this lab are as follows:

- Pre-lab: n/a.
- Demonstration of a walking 1 pattern across the 8-bits of the blue LEDs (60%).
- Demonstration of a walking 1 pattern across the 16-bits of the blue and red LEDs (10%)
- Demonstration of a walking 1 pattern across the 16-bits of the blue/red LEDs + the 9 outer segments of the character displays (20%). NOTE: See the following description for the exact LEDs to turn on.
- Uploading your top.vhd file for this lab to the course DropBox (10%).

Lab Work & Demonstration

Part 1 – Walking 1 Pattern Across the 8-bits of the blue LEDs (60%)

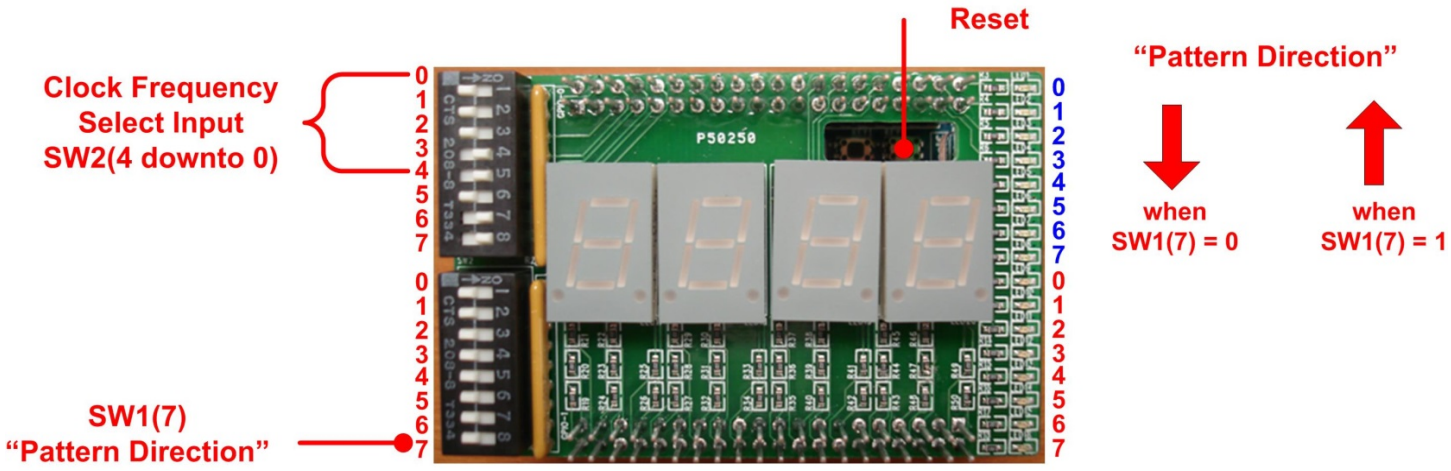
A. Create a New Quartus Project

You are going to create a new Quartus II project for this lab. Create a new folder called "Lab05_Walking_1_FSM". Open your Lab #4 project and copy it over to a new project in the directory you just created using *Project – Copy Project* in Quartus II. Open the new project.

NOTE: You will be using your clock_div_2ton.vhd and decoder_7seg_4in.vhd components from your prior labs so don't delete them. You won't be using your D-flip-flop component so you *can* delete it.

B. Create your Finite State Machine Model

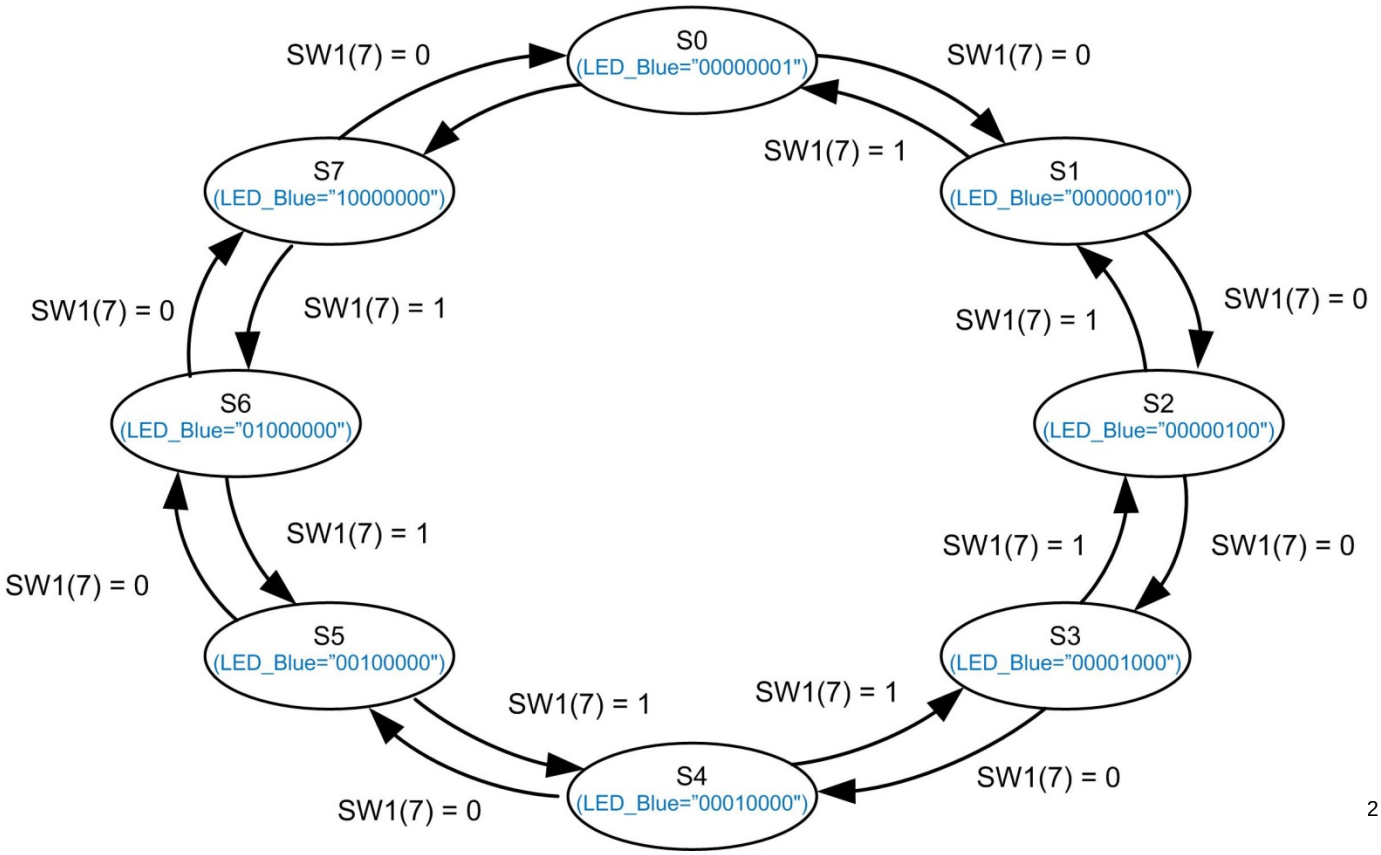
The FSM in this part will produce an 8-bit walking 1 pattern that will be displayed on the blue LEDs. One approach to accomplishing this is to create a FSM that has 8 unique states (e.g., S0, S1, S2,…, S7). Each state will have a corresponding output vector that drives the desired pattern to the blue LEDs. The following figure shows the desired behavior to be observed on the I/O shield.



Consider having the following output vectors for each state such that:

Current State	Output (LED_Blue)
S0	"00000001"
S1	"00000010"
S2	"00000100"
S3	"00001000"
S4	"00010000"
S5	"00100000"
S6	"01000000"
S7	"10000000"

This would allow us to simply create state transitions that either increment through the states (S0 → S1 → S2 …) or decrement through the states (S7 → S6 → S5 …) and the outputs will drive the LEDs as desired. Consider the following state diagram for this approach:

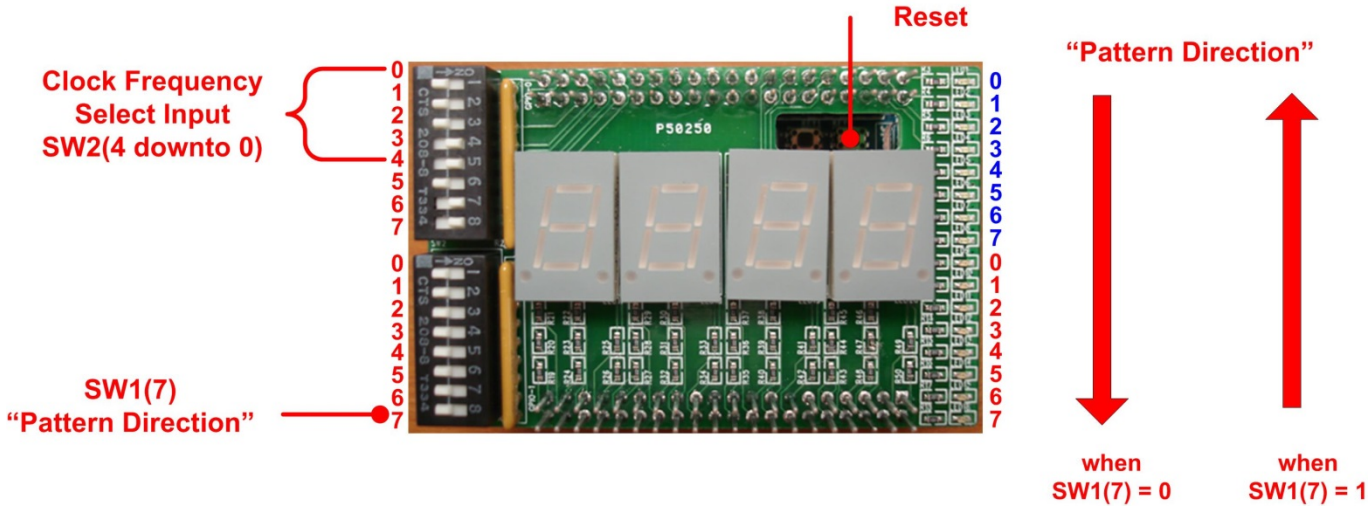


DEMO

C. Demonstrate the proper operation of your design (60% of your grade).

Part 2 – Walking 1 Pattern Across the 16-bits of the blue and red LEDs (10%)

A. Now alter your FSM to create a walking 1 pattern across blue and red LEDs as follows:
Hint: Could you increase the number of states from part 1 to 16?

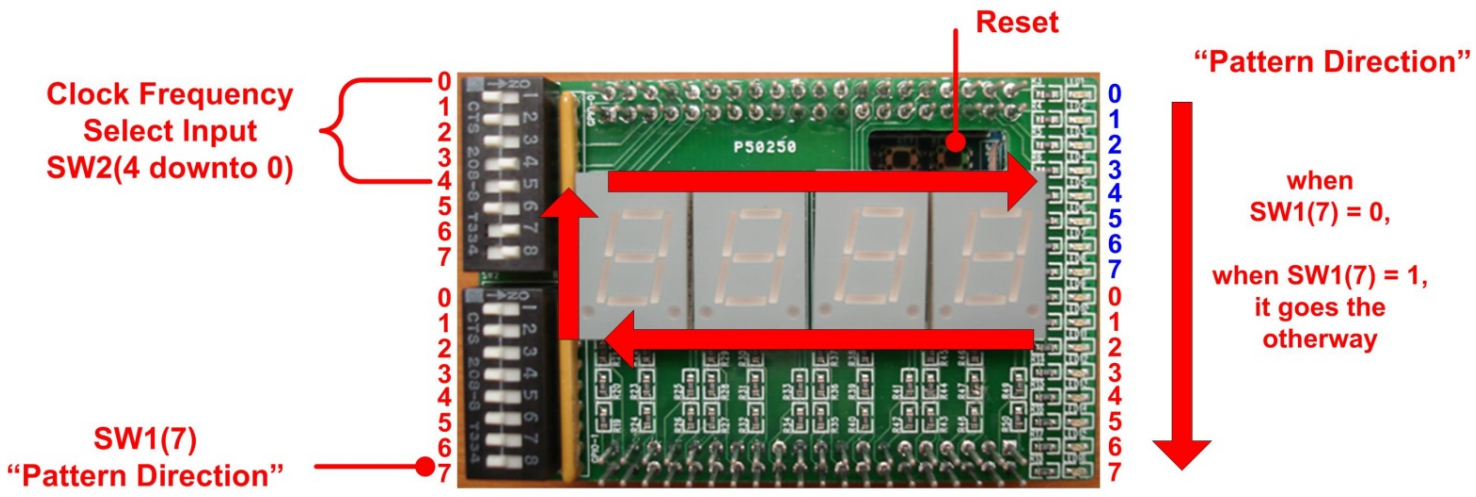


DEMO

B. Demonstrate the proper operation of your design (10% of your grade).

Part 3 – Walking 1 Pattern Across the blue/red LEDs Plus the Outside of the Character Displays (20%)

A. Now alter your FSM to create a walking 1 as follows:



DEMO

B. Demonstrate the proper operation of your design (20% of your grade).

Part 3 – Walking 1 Pattern Across the blue/red LEDs Plus the Outside of the Character Displays (20%)

Upload your top.vhd to the Lab #5 DropBox for the last 10% of your grade. If you didn't get through all three parts, just upload what you did get done.