1 DIGITAL LOGIC LABORATORY CSE 3201

1.1 LAB 09 FINITE STATE MACHINE

Objective:

Gain experience with Finite State Machines (FSM).

PRE-Lab

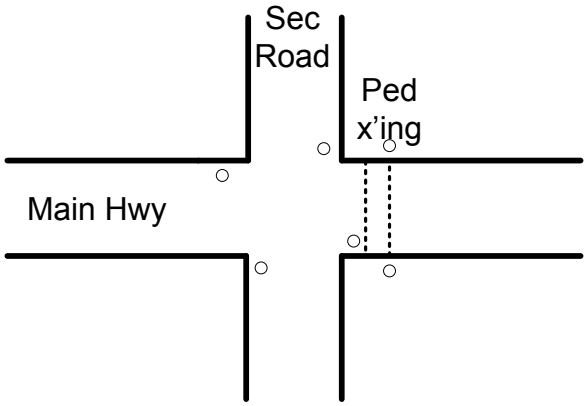
Please fully read and understand the description, provided below.

Create a traffic light controller, with following main components

a) A counter, for timing control

b) A State machine, for different states of the Traffic controller and appropriate outputs.

The figure below shows an intersection, for this controller.



Below are the requirements for this controller.

Highway:

1. The main highway (Main Hwy in the figure above) light stays green, unless a car is detected on the secondary road (Sec Road in the figure above), or a pedestrian makes a request to cross the main highway. Either of these requests initiates a sequence, which turns the highway light to, yellow and then red, followed by a green light on either secondary road or for the pedestrian crossing.

2. Also note that between successive car detections or pedestrian request, the highway is required to stay green a minimum amount of time, before initiating a switch sequence.

   Additionally, if both a car detection and a pedestrian request occur, while the highway light is green (or yellow), then a past record is used to determine who to service first. That is, if the last time a secondary road was green, then this time the pedestrian light would be turned green first, followed by the highway which is then followed by the secondary road.

   Please note that you are required to *store* car detection (via switch) or pedestrian request, (via a push button), which can be cleared, once those lights have been serviced. The logic here could also be used to *track* whether the secondary road or the pedestrian crossing was serviced last, for the case where both requests happen to be made.

3. The yellow light duration on the highway is of fixed length, though shorter (1/2 of the time) in duration, compared to the minimum green time for the highway.

Secondary road:

4. Secondary road shall stay green for
   a. A minimum amount of time, so that the detected car could pass.
   b. However if after this minimum time, car detection shows presence of additional car/s, then the secondary road light shall stay green for a maximum fixed time. After this time, irrespective if additional car/s are present or not, signal switching shall be initiated, to make the main highway green again.

Pedestrian crossing:

5. Pedestrian crossing green and yellow time shall be kept the same. This duration shall be the same as the yellow time for the main and secondary and also the minimum green time for the secondary road.

6. For simplicity reasons, the following times shall be kept same.
   a. All the yellow times, secondary road minimum green time and pedestrian green time. This time could be referred as ‘t_yellow’ or something similar.
   b. The minimum highway green time, shall be same as the maximum secondary green time. Remember the highway has no maximum green time limit, but has a minimum green time limit. The time could be referred as ‘t_secondary’ or something similar. This time could be 2x of ‘t_yellow’

Notes:

1. Follow guidelines for state machine coding; e.g., use enumerated data type for different states and ensure that outputs are registered.
2. While ‘next_state’ logic is combinational, ensure that inputs to it (timer, car, ped detection and of course the present state) are off registers.
3. For board demo for ‘t_yellow’ please use 3 or 4 seconds and for ‘t_secondary’ use 6 or 8 second duration. This shall allow TA to observer and validate your lab work.

4. Also note, that for RTL simulation purposes, using time in seconds would be very slow. As such you can reduce those durations, though maintaining the relation (2x) between 't_yellow' and 't_secondary'

LAB

Implement the design on the DE2 board. Bring out the traffic light on Red and Green LEDs. For Yellow lights, you may use red LEDs. It is recommended that you space LEDs to make it easy to observe and demonstrate.

Use one of the switches and a push button for car detection and pedestrian request, respectively.

Demonstrate the following sequences to the TA.

1. No Car or Pedestrian (Hwy light in green state)
2. Car present on secondary road, using the car switch. Turn the switch off, while secondary green light is on. (Secondary light sequence using 'min green interval)
3. Pedestrian crossing request, via the push button. (Ped crossing sequence)
4. Another car request, this time leave the switch on, while secondary green light is on.
5. With highway in green or yellow state, also make pedestrian request, while the car switch is still in detected (on) position. (Both car and pedestrian case)
6. Demonstrate the following sequence
    - Pedestrian crossing lights
    - Highway lights
    - Secondary crossing lights.

The implemented circuits must be demonstrated to the TA who will note a completed lab and ask questions about your design. When implementing the circuit be sure to use the instruments (oscilloscope, SignalTap, simulation) switches and lights to make it easy to demonstrate your circuits.

Evaluation

Lab demonstration, in-lab explanations and answers, debug and test approach.