EE214 Digital Circuits Laboratory
Wadhwani Electronics Laboratory
Electrical Engineering IIT Bombay

Problem Set: 9 Date: October 20, 2023

TRAFFIC SIGNAL CONTROLLER

Introduction

Consider a four-way crossing. There will be four traffic signals installed at the front of each lane that turn green one by one. Thus a vehicle has to wait for all the three lanes to pass before the signal turns green.

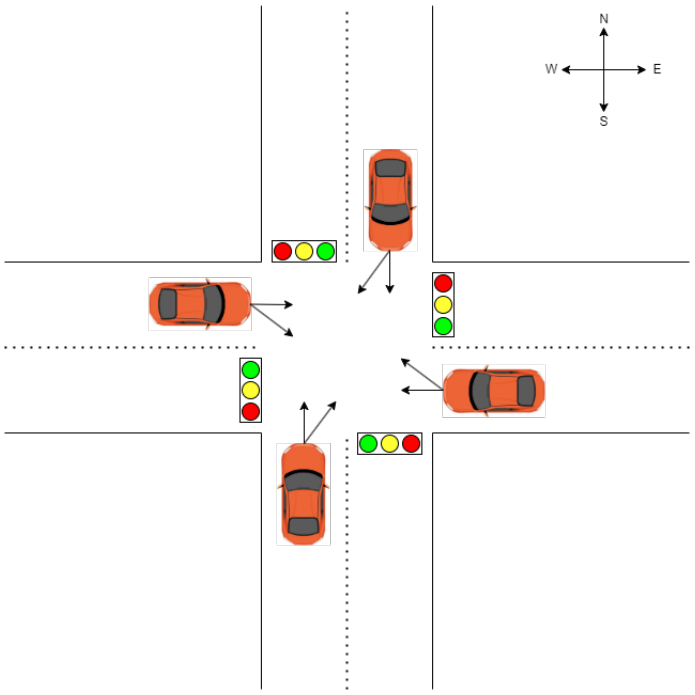

Figure 1: Traffic signal at a 4-way crossing

Design Statement

Design a controller to control the traffic lights of each lane with mentioned functionality.

- There will be 3 traffic lights : RED, YELLOW and GREEN
- The traffic light pattern for each signal is as follows
  $RED \implies YELLOW \implies GREEN \implies YELLOW \implies RED$
- GREEN signal will be turned ON in clockwise direction of the traffic signals
- For an individual signal one of the 3 color must be "ON" all of the time.
- For an individual signal, **NO** two color can be ON at the same time.
- No two signal can be GREEN at the same time.
- Two adjacent signal will be YELLOW at the same time in clockwise direction.
- For each signal GREEN light will be "ON" for 5 sec and **YELLOW** light will be "ON" for 1 sec.

Problem Statement

1. Create a state diagram for the above controller.
2. Design an FSM using VHDL in behavioral description and structural modelling to produce final output.
3. Use the 50 MHz clock to generate delay of 1 second and 5 seconds.
4. The output for each direction based on its state is given the below table
   E.g. For North Signal the corresponding decoder output will be North_0 and North_1.

Signal Value	North_1	North_0
RED = 0; YELLOW = 0; GREEN = 1;	0	1
RED = 0; YELLOW = 1; GREEN = 0;	1	0
RED = 1; YELLOW = 0; GREEN = 0;	1	1

5. Produce the corresponding outputs for all the directions i.e North, South, East and West.
6. Consider the initial state as North traffic signal is giving output "01" and all other traffic signal giving output of "11".
7. Introduce "RESET" functionality using the SW1 on board, so that the system resets to the state as described above.
8. **Pin Mapping:**

$$\begin{array}{cc} North\_1 \implies LED[1] & North\_0 \implies LED[0] \\ East\_1 \implies LED[3] & East\_0 \implies LED[2] \\ South\_1 \implies LED[5] & South\_0 \implies LED[4] \\ West\_1 \implies LED[7] & West\_0 \implies LED[6] \end{array}$$

9. Verify your design using ModelSim and check if the waveforms are appropriate. (The modelsim simulation will be slow for the given delays . For the simulation it is allowed to created delay for 5ms and 1ms in place of original delay given)
10. Use the Xenon board to verify the functionality by observing the LEDs.

Traffic Light Transitioning Table

- Assuming at t = 0 , the reset is applied.
- This below given table will iterate in a infinite loop.

Direction	t=0s	t=5s	t=6s	t=11s	t=12s	t=17s	t=18s	t=23s
North	GREEN	YELLOW	RED	RED	RED	RED	RED	YELLOW
East	RED	YELLOW	GREEN	YELLOW	RED	RED	RED	RED
South	RED	RED	RED	YELLOW	GREEN	YELLOW	RED	RED
West	RED	RED	RED	RED	RED	YELLOW	GREEN	YELLOW