IEC LAB-1

Assignment Report
(4 Way Adaptive traffic light controller system)

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1 Introduction

1.1 Referenced documents

1. Nptel course- Hardware modeling using Verilog –Course in NPTEL
2. Traffic light controller assignment

1.2 Design library name

Traffic light controller

1.3 People involved in the block

Riya Chordia (2021EEN2024)

1.4 Glossary

4 way Traffic Light, FSM, Control Inputs, pedestrian, emergency, Sensor, Adaptation, 7-segment display.

2 Function

2.1 Brief overview

There are two data path units and one control unit.

Data path units:

Sensor unit and adaptation unit.

Control path unit:

Display Timer

- **Sensor unit:** Each sensor unit finds the number of vehicles waiting at the corresponding road when the signal is just turning from Red to Green and averages it over k cycles {consider k between 50 to 100}. Average value for road i is denoted by Ni.
- **Adaptation unit:** The adaptation unit performs updation of the Green signal durations (TG,i) after getting the Ni values from the sensor units as follows

TG,i <= TG,i + b * (Ni - 0.25 * Sum j in {N, E, S, W} Nj) , for i in {N, E, S, W} (consider b as 1)

- Display Timer unit: The display timer unit takes the TG,i values provided by the adaptation unit, rounds these off to multiples of t (take t as 10) and uses these to turn the signals on or off . It also takes care of the following features.

1.The Time remaining for the next change of the signal to be displayed on the 2 Seven Segment Displays.

2.All Red Phase

a.When any pedestrian button is pressed then the system should wait for until the green signal signal is done then introduces the orange phase followed by all signals at red for 10 seconds.

b.All red phase is also introduced when there is an emergency request which halts the green signal operation introducing an orange signal phase followed by all signals at red for 10

2.2 Interfaces

Signal name	I/O	Description	Logical Grouping
Clk	Input	clock for the system	1 bit
Rst	Input	reset for the system	1 bit
Ped	input	pedestrian input case	1 bit
Emer	input	emergency input case	1 bit
TGi	input	Initial value of TG	8 bit
TO	input	Timing of Orange Signal	8 bit
Nn	Input	vehicle count at north Road	8 bit
Ne	Input	vehicle count at east Road	8 bit
Ns	Input	vehicle count at south Road	8 bit
Nw	Input	vehicle count at west Road	8 bit
Nno	output	avg vehicle count at n_road	8 bit
Neo	output	avg vehicle count at e_road	8 bit
Nso	output	avg vehicle count at s_road	8 bit
Nwo	output	avg vehicle count at w_road	8 bit
TGn	output	Adapted values of TG for n_road	8 bit
TGe	output	Adapted values of TG for e_road	8 bit
TGs	output	Adapted values of TG for s_road	8 bit
TGw	output	Adapted values of TG for w_road	8 bit
TGno	output	Round off values of TGn	8 bit
TGeo	output	Round off values of TGe	8 bit
TGso	output	Round off values of TGs	8 bit
TGwo	output	Round off values of TGw	8 bit
n_count	output	North road counter	8 bit
e_count	output	East road counter	8 bit
s_count	output	South road counter	8 bit
w_count	output	West road counter	8 bit
n_light	output	light at north road	3 bit
e_light	output	light at east road	3 bit
s_light	output	light at south road	3 bit
w_light	output	light at west road	3 bit
n_msb	output	seven segment display of MSB	7 bit

n_lsb	output	seven segment display of LSB	7 bit
e_msb	output	seven segment display of MSB	7 bit
e_lsb	output	seven segment display of LSB	7 bit
s_msb	output	seven segment display of MSB	7 bit
s_lsb	output	seven segment display of LSB	7 bit
w_msb	output	seven segment display of MSB	7 bit
w_lsb	output	seven segment display of LSB	7 bit

2.3 Architecture

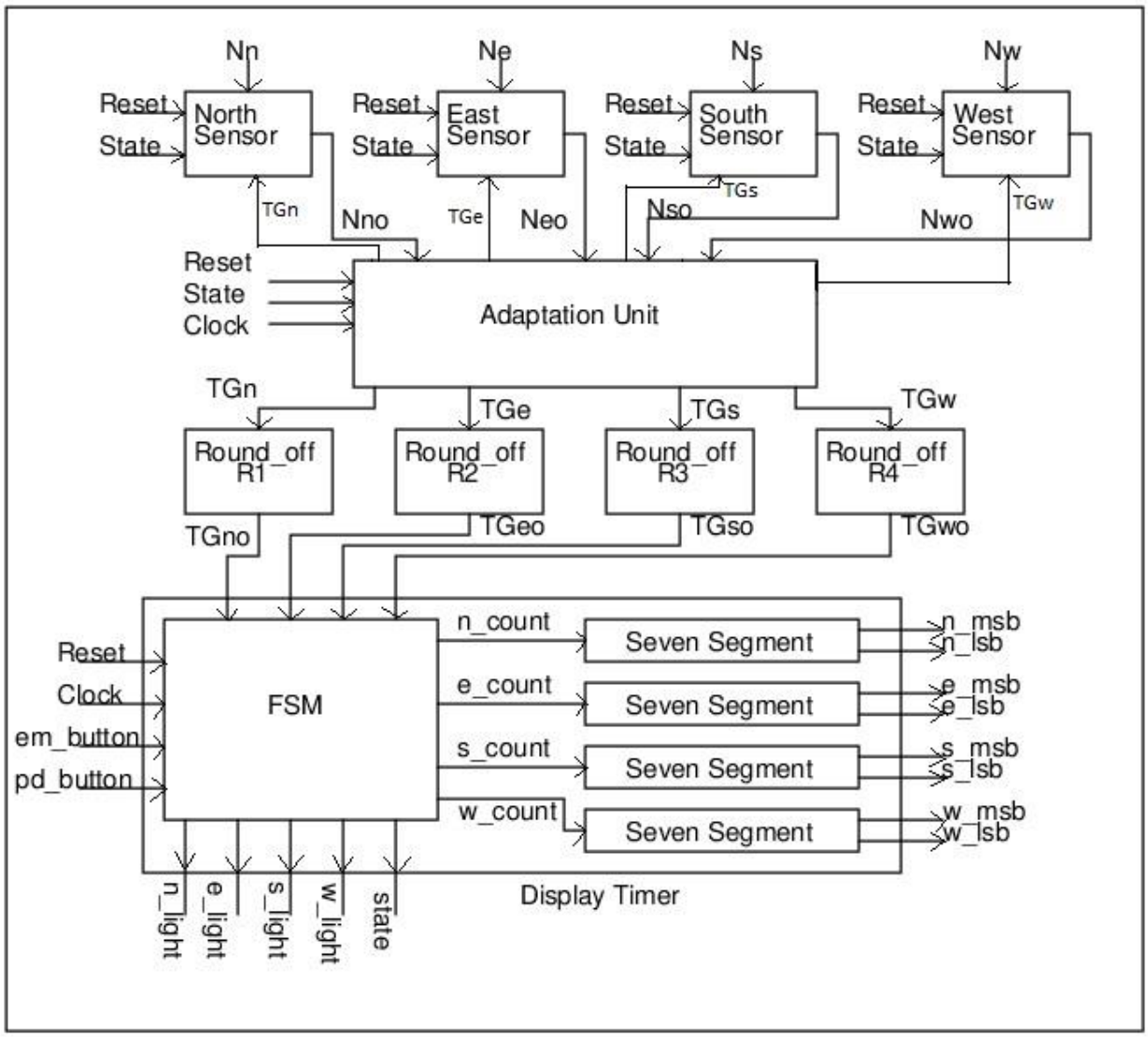


Fig. 1 Top-down Architecture of traffic light controller

2.4 Detailed functional description

There are 8 modules used.

1. Final module: It interconnects and calls all the lower modules.
2. Sensor: There are four sensor modules for each road :
   N_sensor, E_sensor, S_sensor and W_sensor.
   Each sensor takes in the value of the present state and the new count for the number of vehicles at each state and averages it over 60 cycles.
3. Adaptation: The adaptation unit takes in the average vehicle count from all the sensors and the present state and generate new TG values according to a particular mathematical expression provided in the problem statement.
4. Adap_sen_merge: This module integrates the adaptation unit and the sensor unit.
5. Roundoff: It takes in the TG values from the adaptation unit and round off these to multiples of 10.
6. Display timer: It is a master module that integrates the roundoff module, basicfsm and 7 segment display. It takes pedestrian, emergency and TG values as input and display down counting and states as the output.
7. Basicfsm:. It takes pedestrian, emergency and TG values as input and display down counting at each state and color at each state.
8. Msb_lsb_7seg: Takes in the count and break into msb and lsb and sends it to to_7seg.
9. to_7seg: Takes in the value and display the seven segment outcome. There are eight 7 segment present, two for each module.

3 Verification Strategy

3.1 Tools and Version

Xilinix ise 2014

3.2 Checking mechanisms

Checking method used is the behavioral check in the ise software for the errors in codes and then waveforms are simulated and checked manually. Every test is reported success or failure if it works or do not works respectively according to the given problem statement.

4 Testbench

Testbench has been created separately for all the modules.
All the modules are tested individually for which simulation outputs is shown in Result section.

5 Design Microarchitecture

Top down architecture design methodology has been used.

5.1 Top Level Interface

Top level architecture is shown above with clock to each unit and reset to all the block.

When reset is given, the state goes to initial state (North) and all the timing changes are set to the default values.

Asynchronous input pedestrian is given to control block waits for the state to finish its counter state and emergency input does not wait for the state to finish and changes according to the next state.

5.2 Sub-Block Description

Sensor Unit-

Based on the clock and no. of inputs in each road taken from each cycle for the K=64 cycle. After computing average in the sensor block, the output is send to the adaptation unit. Here we also update the Tgi value so that the timing for the Green and Orange signal gets updated for getting inputs.

Adaptation Unit-

After taking the Average value from the Sensor , this unit calculates the freen signal time Tgi for each road using the equation given above and the tgi value is send to display timer unit.

Display Timer Unit-

In this unit, there is FSM having 9 states . FSM is shown below. This FSM makes the continuous transition from one state to another with the clock.

Here there are two asynchronous inputs pedestrian and emergency which acts as interrupts in the FSM.

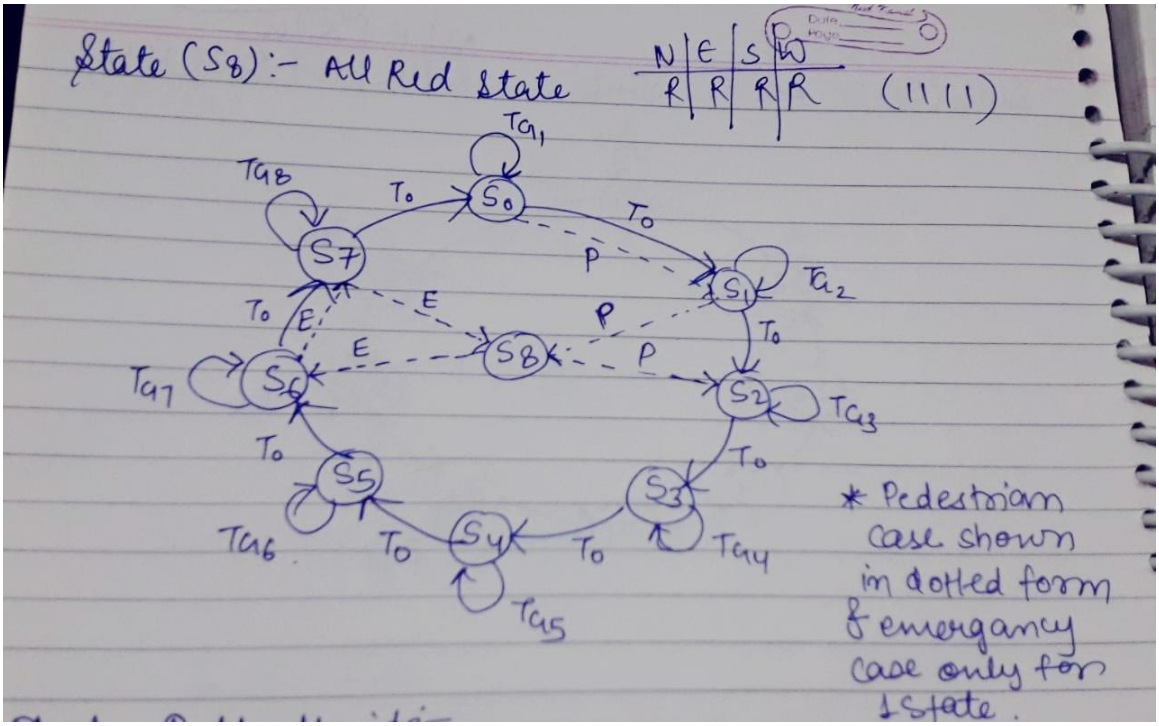
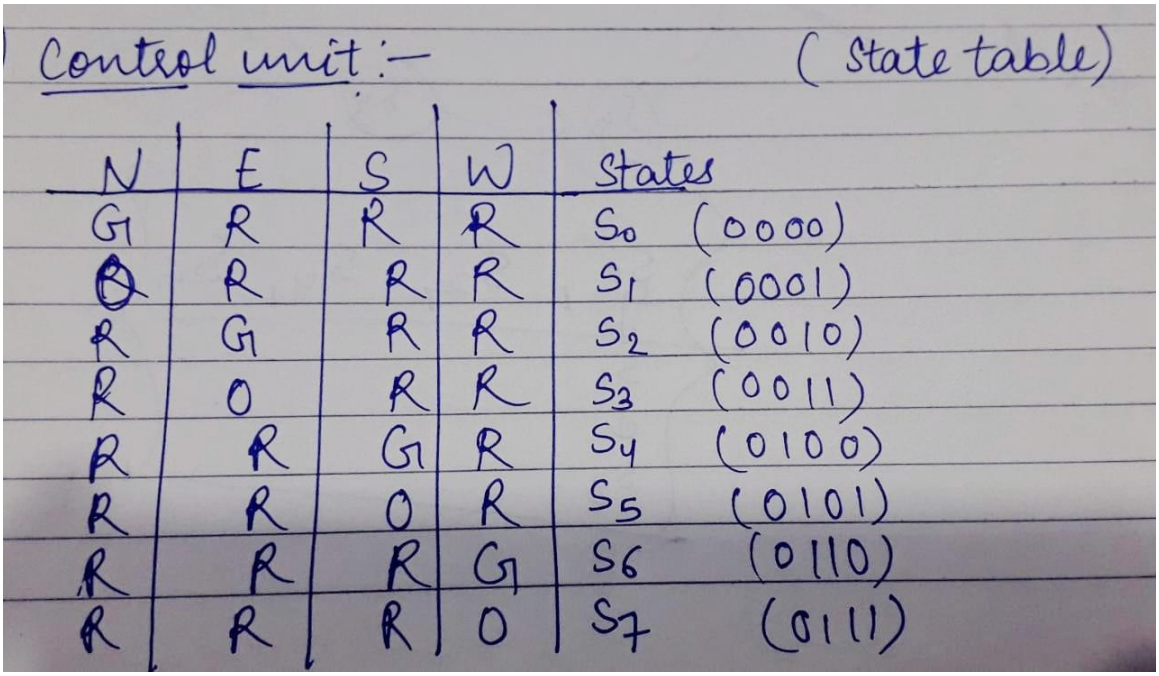


Fig. 2 State diagram of basic FSM



Control unit :- (State table)

N	E	S	W	States
G	R	R	R	S_0 (0000)
O	R	R	R	S_1 (0001)
R	G	R	R	S_2 (0010)
R	O	R	R	S_3 (0011)
R	R	G	R	S_4 (0100)
R	R	O	R	S_5 (0101)
R	R	R	G	S_6 (0110)
R	R	R	O	S_7 (0111)

Fig. 3 State Table

6 Results

Basic fsm code working according to the state diagram and 4 counters implemented at each road is doing down counting.

n_counter = TGn;
e_counter = TGn + TO;
s_counter = 2*(TO) +TGe +TGn;
w_counter = TGe +TGn + TGs + 3*(TO)
tCycle= TGn+TGe+TGs+TGw + 4*(TO)

values used in the testbench:
TGn =5;
TGe=10;
TGs=5;
TGw=5;
TO =3;

Light 1 represents green light.
Light 2 represents orange light.
Light 4 represents red light.

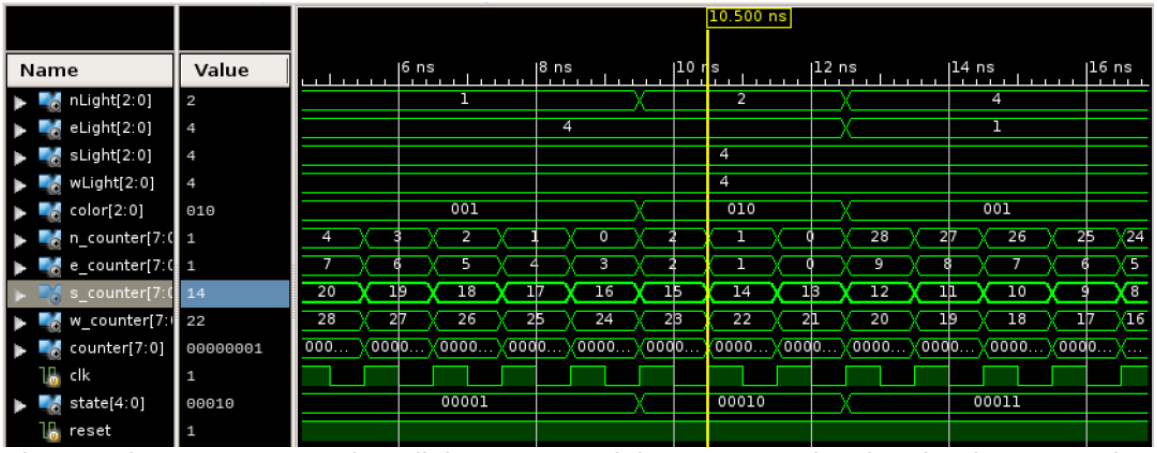


Fig.4 Basic FSM representing all the states and the counters showing the down counting at the respective roads.

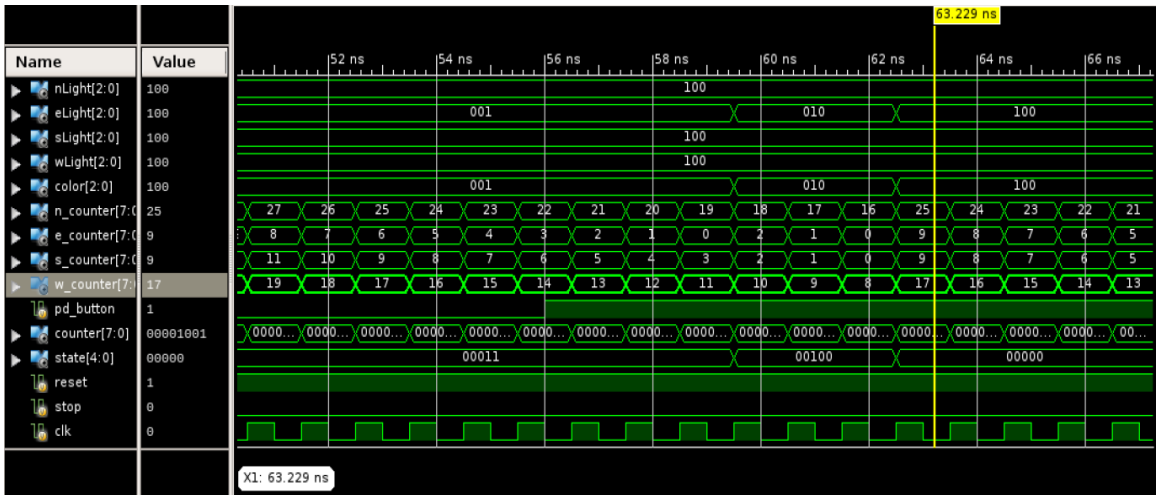


Fig. 5 Pedestrian button is high after completing north and orange state for east road, all the roads turn red to 10 seconds.

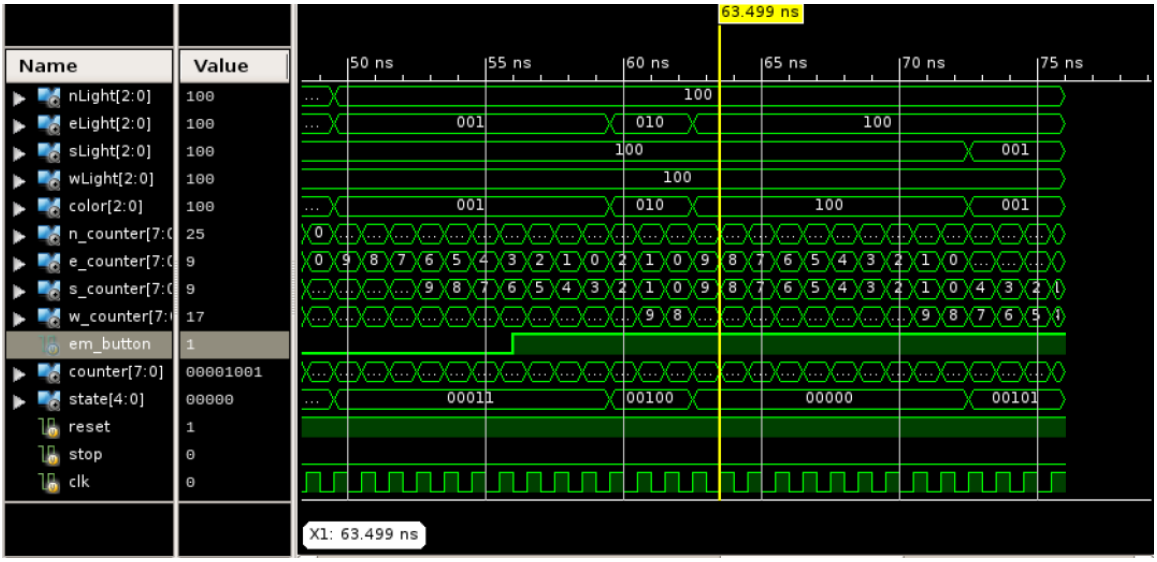


Fig. 6 Emergency button is high and all the roads turns to red for 10 seconds..

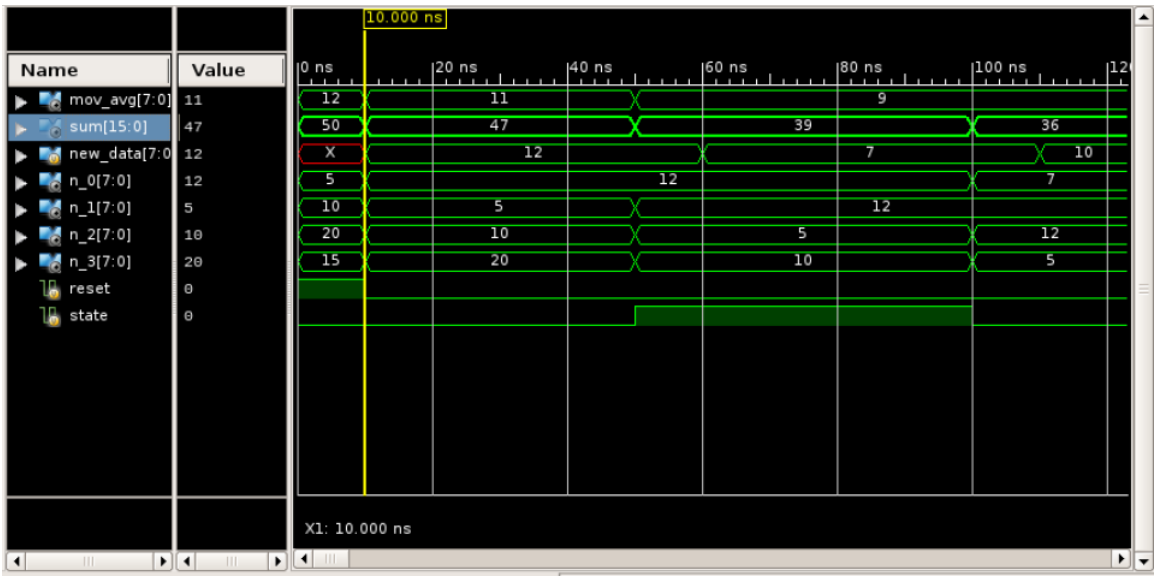


Fig. 7 Sensor Unit

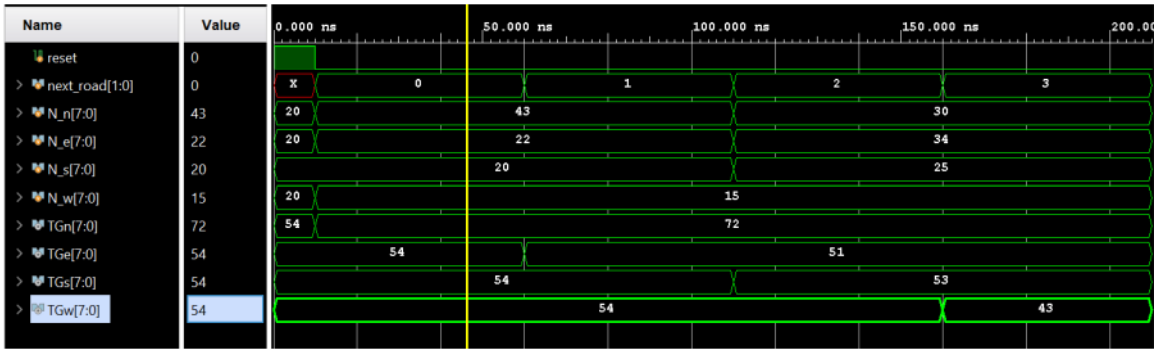


Fig. 8 Adaptation Unit

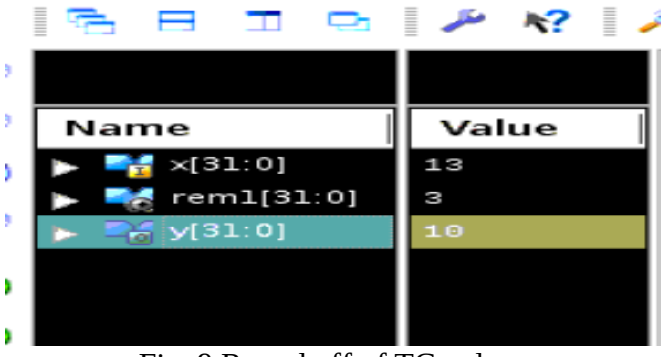


Fig. 9 Round off of TG values

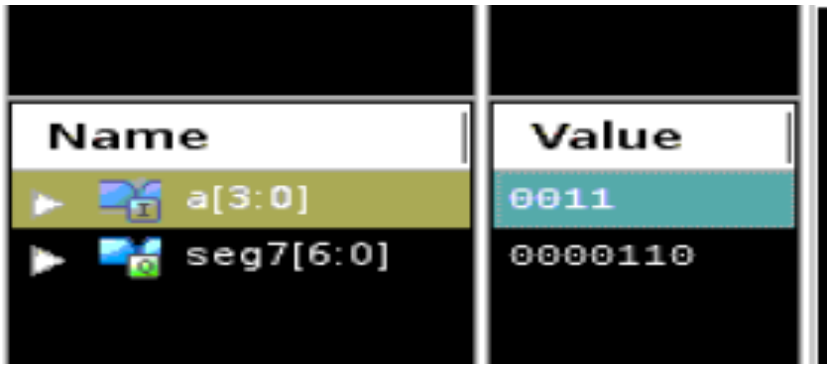


Fig. 10 Seven Segment display

Fig. 11 Seven Segment display of MSB and LSB values of input.

7 Bugs known at submission date

- Individual modules are working properly with no bugs.
- Can't integrate the individual modules for example can't send the counter values from the basic fsm module to seven segment display module.