Assignment 2

Fundamentals of Digital System Design

Due Date: November 9, 2024

This assignment is based on the traffic light system explained below. In this assignment, you have to do the following,

1. State with reason which type of FSM (Moore or Mealy machine) is more suitable for the traffic light controller module (Fig. 2) in the description. (**Hint**: if the external timer will count k amount of time after **amber_timer_en** is high, we have to make sure that the system is in the amber state for exactly k time. Hence the timing of when the **amber_timer_en** signal becomes high is important.)
2. Make a **state diagram** and a **state transition table** of the FSM.

The completed assignment should be submitted as a .pdf file **on or before 11.59pm, November 9, 2024**.

Traffic Light System Description

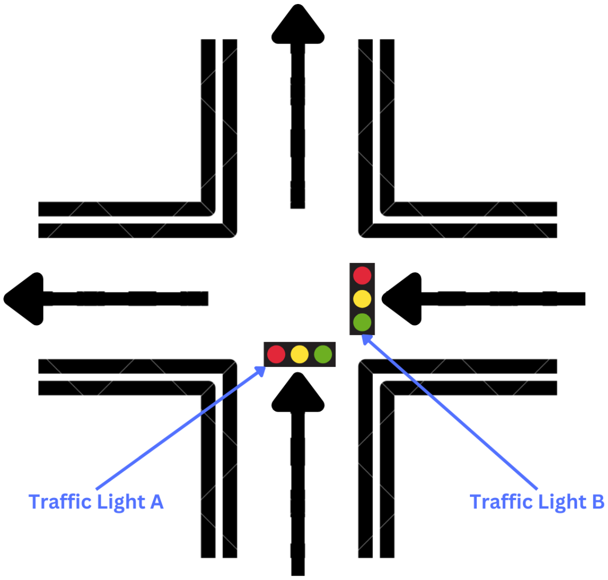


Figure 1: Traffic Light Configuration

The Figure 1 shows the traffic lights in this traffic light system. It contains two traffic lights for the two roads. In the roads, the vehicles move in the direction shown by the arrows. Both the traffic lights are equipped with a camera that evaluate whether there is traffic behind it. The traffic light controller will control both lights considering the level of traffic in the two roads. An external timer module is present to ensure that the traffic light shows the ”Amber” colour for a required amount of time. The traffic light A and traffic light B in the Figure 1 cannot be both ”Green” at the same time. The traffic light A has more priority over traffic light B.

The Figure 2 shows the I/O of the traffic light controller module for this scenario. The Table 1 gives the description of each I/O signal.

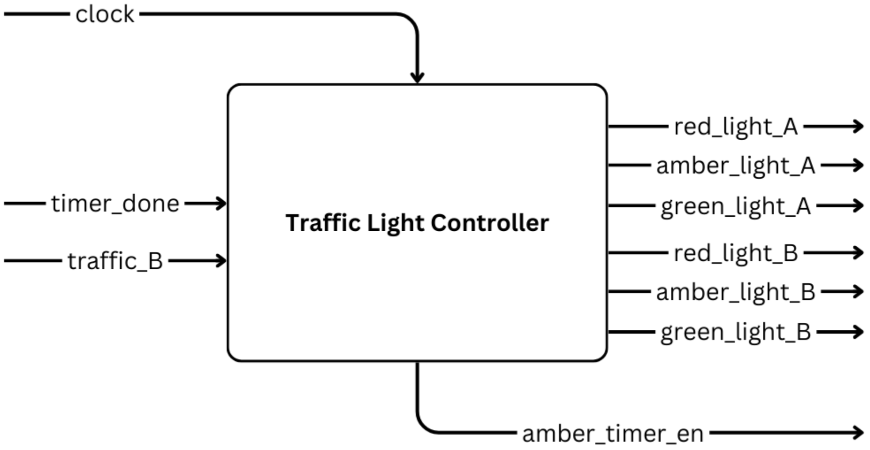


Figure 2: Traffic Light Module I/O

Signal	Type	Description
clock	input	clock signal
traffic_B	input	1: traffic in B **and** not traffic in A, 0: traffic in A **or** not traffic in B
timer_done	input	1: timer is done, 0: timer is on going
amber_timer_en	output	1: enable the amber timer in the timer module
red_light_A	output	on/off red light in traffic light A
amber_light_A	output	on/off amber light in traffic light A
green_light_A	output	on/off green light in traffic light A
red_light_B	output	on/off red light in traffic light B
amber_light_B	output	on/off amber light in traffic light B
green_light_B	output	on/off green light in traffic light B

Table 1: Traffic Light Controller I/O Description

At the start of the system, the traffic light A is **Green** while the traffic light B is **Red** since traffic light A has priority. It will stay in that manner

until **traffic_B** signal becomes high indicating that there is traffic in B and not in A. When the **traffic_B** is high, the traffic light A should go from **Green** to **Amber**. When it is **Amber**, it should enable (make high) the **amber_timer_en** to start a timer in the external timer module. Once the **timer_done** signal becomes high (when traffic light A is showing Amber), traffic light A should become **Red** while the traffic light B should become **Green**. The two traffic lights would keep displaying these colours until the **traffic_B** signal becomes low. When it becomes low, the traffic light B should become **Amber**. While in this state the **amber_timer_en** should become high. Once the **timer_done** signal becomes high, the traffic light B should become **Red** and the traffic light A should become **Green**.
Please note that the **traffic_B** signal would not have any effect when the traffic light is showing Amber.

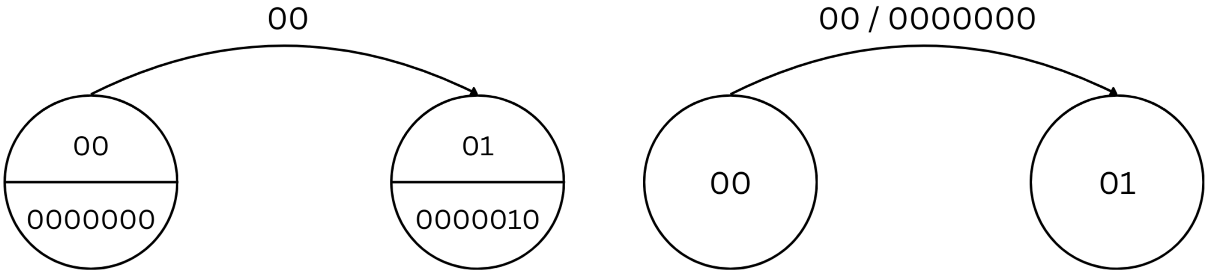
Please use the states in the Table 2 when making the FSM.

State	**Bit Pattern**	**Description**
$G_A R_B$	00	Traffic light A is Green and traffic light B is Red
$A_A R_B$	01	Traffic light A is Amber and traffic light B is Red
$R_A G_B$	10	Traffic light A is Red and traffic light B is Green
$R_A A_B$	11	Traffic light A is Red and traffic light B is Amber

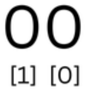
Table 2: States of the FSM

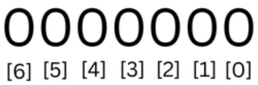
Additional Information

The state diagram of an FSM with 2 inputs and 7 outputs can be drawn as shown below.



Please use the following bit-indexing scheme for inputs and outputs when making the state diagram and the state transition table.





Index	Description
0	traffic_B
1	timer_done

Index	Description
0	red_light_A
1	amber_light_A
2	green_light_A
3	red_light_B
4	amber_light_B
5	green_light_B
6	amber_timer_en

1. Type of FSM: Moore or Mealy?

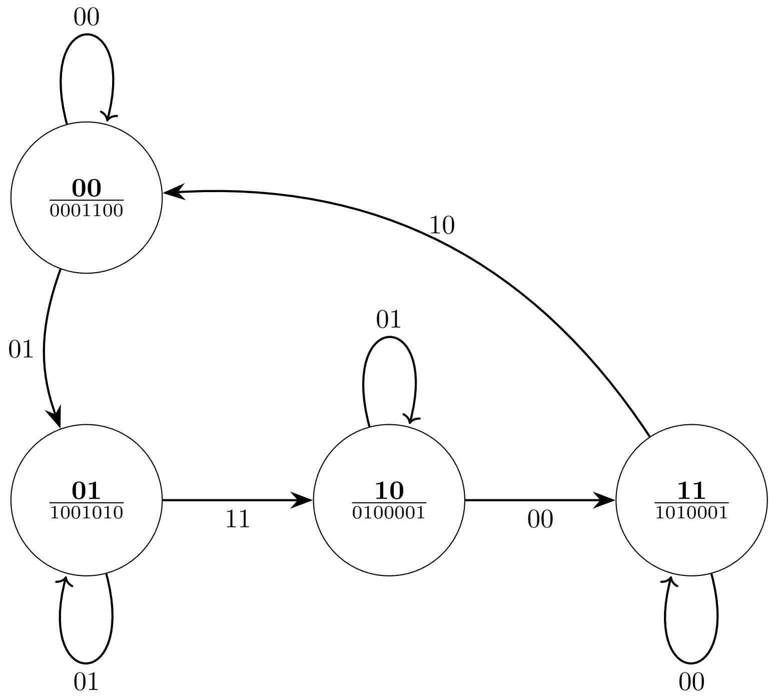
In a Moore machine, the output is a function of the current state **only**, and state changes occur **only at the positive or negative edge of the clock signal**. This ensures that once the system transitions to the amber state, the output (`amber_timer_en`) becomes stable and allows us to **precisely count k time** using a counter synchronized with the clock.

On the other hand, in a Mealy machine, the output depends on both the **current state and the input**. Since inputs can change at any time during a clock cycle, the output may also change asynchronously, even **in the middle of a clock cycle**. This behavior could lead to faults in counting `k` time, as the counter progresses only with the respective clock edges and may not align with the output changes of a Mealy machine.

Therefore, the Moore machine ensures stable and predictable timing behavior, making it the better choice for this traffic light system.

2. State Diagram and State Transition Table

State Diagram



Current State	**Next State**				**Output**
	00	**01**	**10**	**11**	
00	00	01	-	-	0001100
01	-	01	-	10	1001010
10	11	10	-	-	0100001
11	11	-	00	-	1010001

Table 1: State Transition Table