

# CS 254: Assignment 8

Devansh Jain	Harshit Varma
190100044	190100055

April 10, 2021

## Contents

<b>Traffic Light Controller</b>	<b>1</b>
<b>State Machine 1</b>	<b>2</b>
<b>State Machine 2</b>	<b>4</b>

## Traffic Light Controller

### Finding Number of States

Let us consider states of the form  $(\_ \_ \_ \_)$   $(\_)$ , where the first set represents the color of lanes and each has value from G, Y, R and the second set represents counter from 0 to 7 (taking 1 unit as 5s).

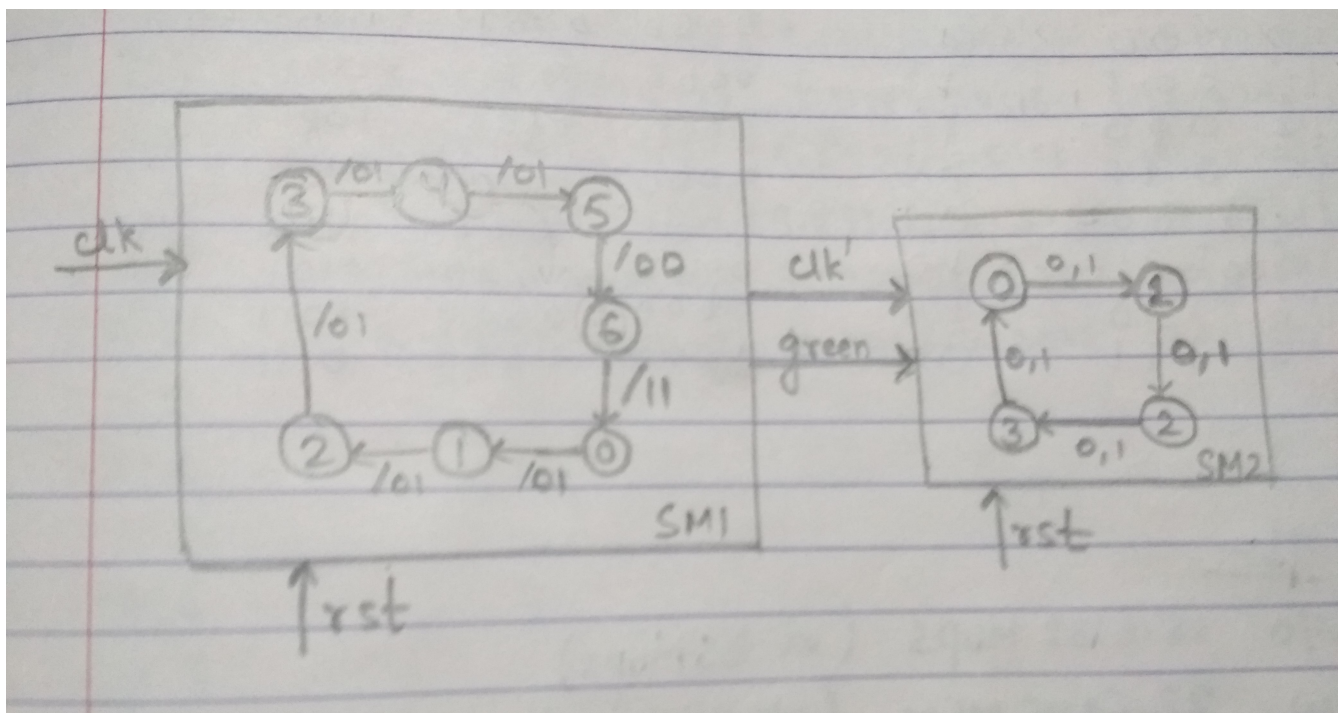
Possible States for Green: the first set will have 3Rs and 1G, second set would be from 0 to 5.

Possible States for Yellow: the first set will have 3Rs and 1Y, second set would be 6.

This gives us totally  $(6 + 1) \times 4 = 28$  states, which can be represented in 5 state variables.

For modularity, we split the 5 state variables into set of 3 and 2 state variables - first set (3 variables) storing the counter, second set (2 variables) storing the lane number.

### State Diagram



## State Machine 1

$$I = \phi$$

$$O = \{(\text{clk}' = 0, \text{green} = 0), (\text{clk}' = 0, \text{green} = 1), (\text{clk}' = 1, \text{green} = 1)\}$$

$$S = \{(\text{time} = 0), (\text{time} = 1), (\text{time} = 2), (\text{time} = 3), (\text{time} = 4), (\text{time} = 5), (\text{time} = 6)\}$$

$$S_0 = (\text{time} = 0)$$

$$\text{Number of state variables} = \lceil \log_2(7) \rceil = 3.$$

Let state variables be  $s_2, s_1, s_0$ .

## Variable Mapping

State	$s_2$	$s_1$	$s_0$
(time = 0)	0	0	0
(time = 1)	0	0	1
(time = 2)	0	1	0
(time = 3)	0	1	1
(time = 4)	1	0	0
(time = 5)	1	0	1
(time = 6)	1	1	0

Output	$\lambda_1$	$\lambda_0$
(clk' = 0, green = 0)	0	0
(clk' = 0, green = 1)	0	1
(clk' = 1, green = 1)	1	1

## State Transition Table

$s_2$	$s_1$	$s_0$	$\delta_2$	$\delta_1$	$\delta_0$	$\lambda_1$	$\lambda_0$
0	0	0	0	0	1	0	1
0	0	1	0	1	0	0	1
0	1	0	0	1	1	0	1
0	1	1	1	0	0	0	1
1	0	0	1	0	1	0	1
1	0	1	1	1	0	0	0
1	1	0	0	0	0	1	1

## K-Maps

$\delta_2$

		$s_1 s_0$			
		00	01	11	10
$s_2$	0	0	0	1	0
	1	1	1	X	0

$$\delta_2 = s_1 s_0 + s_2 \bar{s}_1$$

$\delta_1$

		$s_1 s_0$			
		00	01	11	10
$s_2$	0	0	1	0	1
	1	0	1	X	0

$$\delta_1 = \bar{s}_1 s_0 + \bar{s}_2 s_1 \bar{s}_0$$

$\delta_0$

		$s_1 s_0$			
		00	01	11	10
$s_2$	0	1	0	0	1
	1	1	0	X	0

$$\delta_0 = \bar{s}_1 \bar{s}_0 + \bar{s}_2 \bar{s}_0$$

$\lambda_1$

		$s_1 s_0$			
		00	01	11	10
$s_2$	0	0	0	0	0
	1	0	0	X	1

$$\lambda_1 = s_2 s_1$$

$\lambda_0$

		$s_1 s_0$			
		00	01	11	10
$s_2$	0	1	1	1	1
	1	1	0	X	1

$$\lambda_0 = \bar{s}_2 + \bar{s}_0$$

## State Machine 2

$I = \{(\text{green} = 0), (\text{green} = 1)\}$

$O = \{(\text{RRRG}), (\text{RRGR}), (\text{RGRR}), (\text{GRRR}), (\text{RRRY}), (\text{RRYR}), (\text{RYRR}), (\text{YRRR})\}$

$S = \{(\text{lane} = 0), (\text{lane} = 1), (\text{lane} = 2), (\text{lane} = 3)\}$

$S_0 = (\text{lane} = 0)$

Number of state variables =  $\lceil \log_2(4) \rceil = 2$ .

Let state variables be  $s_1, s_0$ .

## Variable Mapping

State	$s_1$	$s_0$
(lane = 0)	0	0
(lane = 1)	0	1
(lane = 2)	1	0
(lane = 3)	1	1

Input	$a$
(green = 0)	0
(green = 1)	1

Output	$g_3$	$g_2$	$g_1$	$g_0$	$y_3$	$y_2$	$y_1$	$y_0$	$r_3$	$r_2$	$r_1$	$r_0$
(RRRG)	0	0	0	1	0	0	0	0	1	1	1	0
(RRGR)	0	0	1	0	0	0	0	0	1	1	0	1
(RGRR)	0	1	0	0	0	0	0	0	1	0	1	1
(GRRR)	1	0	0	0	0	0	0	0	0	1	1	1
(RRRY)	0	0	0	0	0	0	0	1	1	1	1	0
(RRYR)	0	0	0	0	0	0	1	0	1	1	0	1
(RYRR)	0	0	0	0	0	1	0	0	1	0	1	1
(YRRR)	0	0	0	0	1	0	0	0	0	1	1	1

## State Transition Table

$a$	$s_1$	$s_0$	$\delta_1$	$\delta_0$	$g_3$	$g_2$	$g_1$	$g_0$	$y_3$	$y_2$	$y_1$	$y_0$	$r_3$	$r_2$	$r_1$	$r_0$
0	0	0	0	1	0	0	0	0	0	0	0	1	1	1	1	0
0	0	1	1	0	0	0	0	0	0	0	1	0	1	1	0	1
0	1	0	1	1	0	0	0	0	0	1	0	0	1	0	1	1
0	1	1	0	0	0	0	0	0	1	0	0	0	0	1	1	1
1	0	0	0	1	0	0	0	1	0	0	0	0	1	1	1	0
1	0	1	1	0	0	0	1	0	0	0	0	0	1	1	0	1
1	1	0	1	1	0	1	0	0	0	0	0	0	1	0	1	1
1	1	1	0	0	1	0	0	0	0	0	0	0	0	1	1	1

## K-Maps

 $\delta_1$ 

		$s_1 s_0$			
		00	01	11	10
$a$	0	0	1	0	1
	1	0	1	0	1

$$\delta_1 = \bar{s}_1 s_0 + s_1 \bar{s}_0 = s_1 \oplus s_0$$

 $\delta_0$ 

		$s_1 s_0$			
		00	01	11	10
$a$	0	1	0	0	1
	1	1	0	0	1

$$\delta_0 = \bar{s}_0$$

 $g_3$ 

		$s_1 s_0$			
		00	01	11	10
$a$	0	0	0	0	0
	1	0	0	1	0

$$g_3 = a s_1 s_0$$

 $g_2$ 

		$s_1 s_0$			
		00	01	11	10
$a$	0	0	0	0	0
	1	0	0	0	1

$$g_2 = a s_1 \bar{s}_0$$

 $g_1$ 

		$s_1 s_0$			
		00	01	11	10
$a$	0	0	0	0	0
	1	0	1	0	0

$$g_1 = a \bar{s}_1 s_0$$

$g_0$

		$s_1 s_0$			
		00	01	11	10
$a$	0	0	0	0	0
	1	1	0	0	0

$$g_0 = a \bar{s}_1 \bar{s}_0$$

$y_3$

		$s_1 s_0$			
		00	01	11	10
$a$	0	0	0	1	0
	1	0	0	0	0

$$y_3 = \bar{a} s_1 s_0$$

$y_2$

		$s_1 s_0$			
		00	01	11	10
$a$	0	0	0	0	1
	1	0	0	0	0

$$y_2 = \bar{a} s_1 \bar{s}_0$$

$y_1$

		$s_1 s_0$			
		00	01	11	10
$a$	0	0	1	0	0
	1	0	0	0	0

$$y_1 = \bar{a} \bar{s}_1 s_0$$

$y_0$

		$s_1 s_0$			
		00	01	11	10
$a$	0	1	0	0	0
	1	0	0	0	0

$$y_0 = \bar{a} \bar{s}_1 \bar{s}_0$$

$r_3$

		$s_1 s_0$			
		00	01	11	10
$a$	0	1	1	0	1
	1	1	1	0	1

$$r_3 = \bar{s}_1 + \bar{s}_0$$

$r_2$

		$s_1 s_0$			
		00	01	11	10
$a$	0	1	1	1	0
	1	1	1	1	0

$$r_2 = \bar{s}_1 + s_0$$

$r_1$

		$s_1 s_0$			
		00	01	11	10
$a$	0	1	0	1	1
	1	1	0	1	1

$$r_1 = s_1 + \bar{s}_0$$

$r_0$

		$s_1 s_0$			
		00	01	11	10
$a$	0	0	1	1	1
	1	0	1	1	1

$$r_0 = s_1 + s_0$$