Finite State Machine
ID1340
Digital System Design

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Contents

Abstract

The objective of this project is to design a finite state machine which will control the car lights according to the live input fed by the user. The car consists of 6 lights which have been depicted as LEDs on the breadboard and the user supplies the input as left, right or hazard. As long as the input is left, the 3 left LEDs light up in sequence followed by IDLE state cyclically. Likewise for right signal 3 right LEDs are lit up followed by IDLE state cyclically. For hazard signal all lights blink simultaneously.

Chapter 1

Designing The Circuit

1.1 Input Signals

To take live input from the user we read a character from the serial monitor using the *Serial.read()* function if there is a new character entered by the user. We assign the character entered to a char variable 'x' declared in the arduino code. If there is no new input from the user the previous input signal is continued.
The variables 'P', 'Q' denote the MSB and LSB of the input signal respectively.

- If the user enters 'L': the initial state assigned is that of LA glowing and the user input is assigned to '01'; Left signal is represented by '01' in the code. **P=0;Q=1;A=0;B=0;C= 1;**
- If the user enters 'R': the initial state assigned is that of RA glowing and the user input is assigned to '10'; Right signal is represented by '10' in the code. **P=1;Q=0;A=1;B=0;C= 0;**
- If the user enters 'H': the initial state assigned is that of Hazard Blinking and the user input is assigned to '00'; Hazard signal is represented by '00' in the code. **P=0;Q=0;A=0;B=0;C= 0;**

1.2 States

We may encounter **8 different states** in our execution and therefore use **3 bits** to denote the current state and the next state. Variables W, X, Y represent the current state in execution and A, B, C denote the next state where W and A are the MSBs respectively. We assign the following binary numbers to the each state.

Physical State	W	X	Y
Only LA is glowing	0	0	1
LA and LB are glowing	0	1	0
LA, LB, LC are glowing	0	1	1
Only RA is glowing	1	0	0
RA and RB are glowing	1	0	1
RA, RB, RC are glowing	1	1	0
No light glowing	1	1	1
All lights glowing	0	0	0

1.3 State Transition Diagram

The drawn state transition diagram is obtained and used to write transition states.

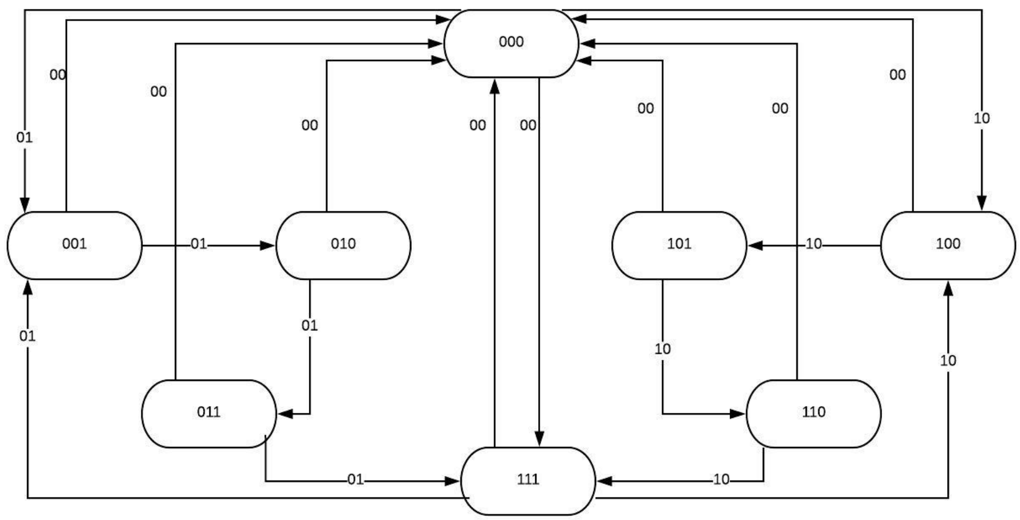

Figure 1.1: State Transition Diagram

1.4 Incorporating Flip Flops

We use **3 D flip-flops** as we encounter 2^3 states. Each flip-flop is used to transit 1 bit and it takes A, B, C as the 'D' and produces W, X, Y as the 'Q'. We provide A, B, C using Arduino Output pins : 2, 3, 4 and read W, X, Y from the flip-flops using defined Arduino Input pins: 5, 6, 7. The clear and preset of each flip-flop is given 1.

1.5 Transition Table

The combined transition table for all possible cases is as follows:

	01 (LEFT)	10 (RIGHT)	00 (HAZARD)
WXY	ABC	ABC	ABC
001	010	100	000
010	011	100	000
011	111	100	000
100	001	101	000
101	001	110	000
110	001	111	000
111	001	100	000
000	001	100	111

1.6 Transition Equations

For each bit there is a unique transition equation which are as follows:

$$A = (P.Q') + (P'.Q.W'.X.Y) + (P'.Q'.W'.X'.Y') \tag{1.1}$$

$$B = (P.Q'.W.X'.Y) + (P.Q'.W.X.Y') + ((P'.Q.W').(X+Y)) + (P'.Q'.W'.X'.Y') \tag{1.2}$$

$$C = ((P'.Q).((W'.X'.Y)')) + (P.Q'.W.Y) + (P'.Q'.W'.X'.Y') \tag{1.3}$$

Chapter 2

Implementation

2.1 Hardware Requirements

The hardware that was required to complete this project is:

1. Arduino UNO
2. USB A to USB B Adapter
3. Breadboard
4. 2 7474 ICs
5. 6 LEDs
6. 6 Resistors
7. Connecting Wires

2.2 Giving output to LEDs

Each LED should light up corresponding to the required state. Therefore we use 6 output pins from the arduino: 8, 9, 10, 11, 12, 13 corresponding to LC, LB, LA, RA, RB, RC respectively.

WXY	LC	LB	LA	RA	RB	RC
001	0	0	1	0	0	0
010	0	1	1	0	0	0
011	1	1	1	0	0	0
100	0	0	0	1	0	0
101	0	0	0	1	1	0
110	0	0	0	1	1	1
111	0	0	0	0	0	0
000	1	1	1	1	1	1

The logic for each output is as follows:

$$8(LC) : ((W'.X.Y) + (W'.X'.Y')) \tag{2.1}$$

$$9(LB) : ((W'.X.Y) + (W'.X'.Y') + (W'.X'.Y')) \tag{2.2}$$

$$10(LA) : W' \tag{2.3}$$

$$11(RA) : (W.X'.Y') + (W'.X'.Y') + (W.X'.Y) + (W.X.Y') \tag{2.4}$$

$$12(RB) : (W'.X'.Y') + (W.X'.Y) + (W.X.Y') \tag{2.5}$$

$$13(RC) : (W.X.Y') + (W'.X'.Y') \tag{2.6}$$