Digital Electronics (EEE)

Term Project

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Table of Contents:

1. Introduction

Autonomous Traffic System with Conditional Applications

1.1 Problem Statement:

The mission of this circuit is to control a 4 way cross road street traffic signal automatically using timed traffic lights and traffic poles, thus reducing costs for management. A controlled automated pole system would motivate proper traffic etiquette in third world countries thus leading to lower chances of accidents in the aforementioned crossroads or areas.

1.2 Objectives:

The tools of our circuit's set-up includes, but are not limited to, using Flip Flops, Logic Gates, Stepper motor, Counters and so forth to create a basic simulation of a traffic control system. We want this circuit's objectives to function in the following modes:

→ Mode 1: This mode always remains active and ensures proper timed traffic lights and when the poles go down.

→ Mode 2: This mode is for emergency siren use and is used during times of need decided appropriate.

→ Mode 3: This mode establishes customised pole and traffic system, meaning it enables a user to establish either vertical pass through or horizontal pass through (Red lights on two sides and green lights on the other two with poles opened).

1.3 Synopsis:

During the quarantine, isolation is heavily advised and that would lead to empty roads. Third world countries do not have its citizens prioritise road safety laws regardless of presence of law enforcers. Our automated system ensures that rules are followed by default without the need for a presence of a governing figure at all times thus ensuring the health concerns of law enforcers and also the safety concerns of vehicle drivers.

1.4 Gantt Chart:

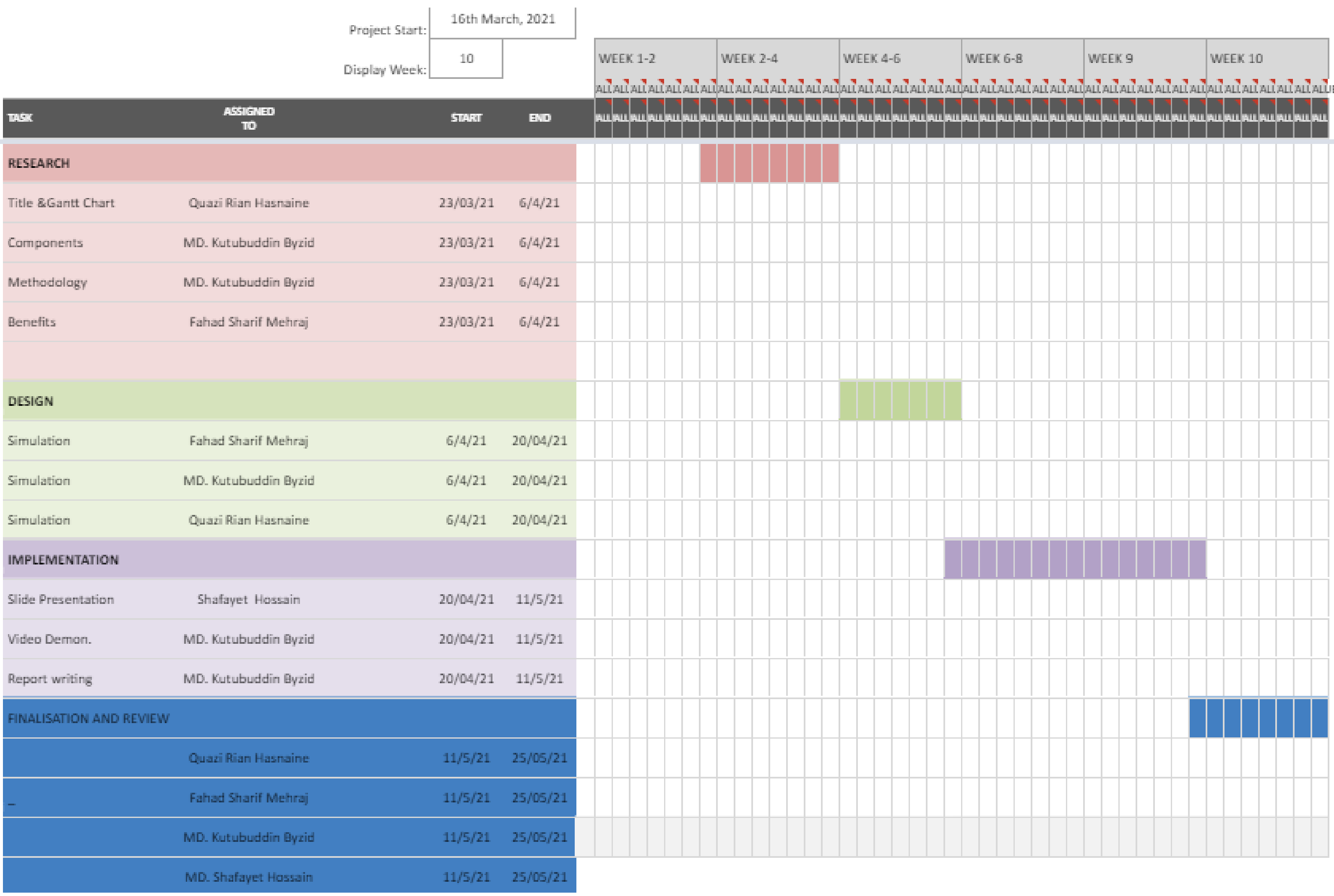


Figure 1.1 Gantt Chart

2. System Model

2.1 Methodology:

Our entire project has been simulated in Proteus 8 Professional software which allows us to use a variety of Integrated Circuits (IC), chips, logic gates, motors and other essential parts that are needed for the project made in real life.

Instead of giving graphs, which would include 4 inputs and a total of around 10 outputs which would lead to a hassle for interpretation, we have used screenshots to convey regular and special cases of our project.

We have divided our project into 4 essential parts/segments, each taking decisions or showing outputs. These include:

→ **Switcher:** The switcher or control centre, this section includes three 4013 ICs (single D Flip Flops) and a 40175 IC (this IC has 4 D Flip Flops inside it). These connect most of the manual switches to the rest of the sections thus acting as the control centre.

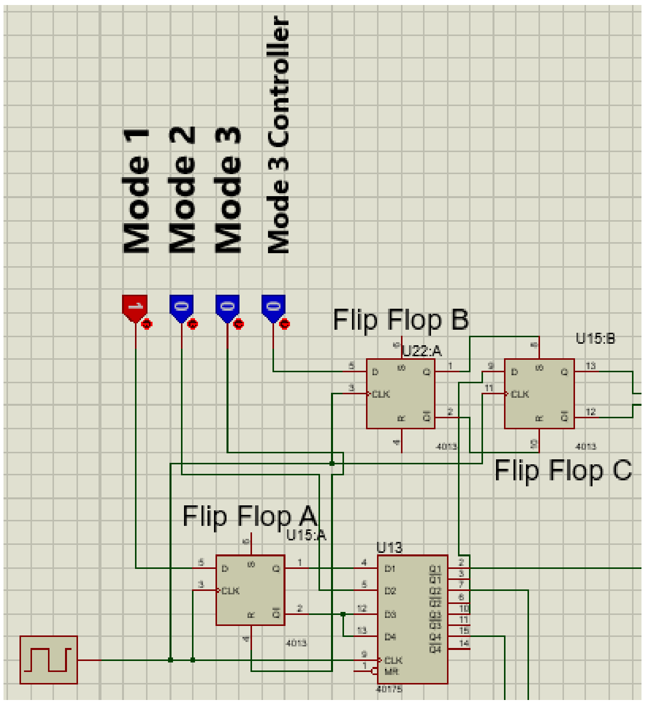


Figure 2.1 Switcher

→ **Siren Circuit:** This simple siren circuit generates a tone that sounds very similar to a siren. It is made using resistors, capacitors, and PNP, NPN transistors.

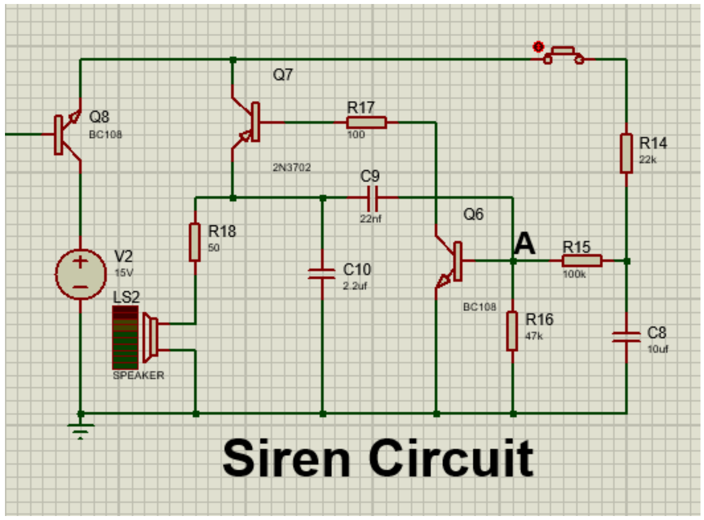


Figure 2.2 Siren Circuit

→ **Traffic System Timer:** This section includes a NE555 timer circuit connected to an IC 4017 counter which gives an input to each of the traffic lights along with the stepper motor to control the times for each lights (Red, Orange and Green) and the stepper motor (The poles which go up and down to open or block the road respectively).

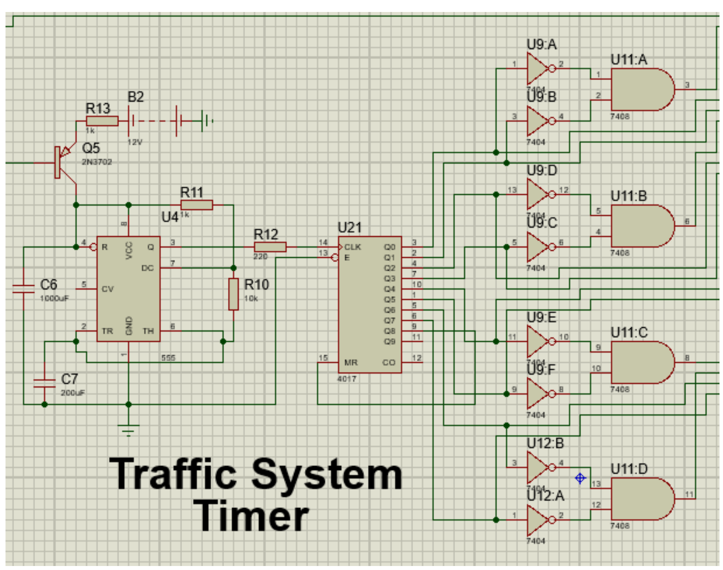


Figure 2.3 Traffic System Timer

→ **Traffic Lights and Poles:** This section gives us the outputs of our project and includes traffic lights, driver circuits, switches and stepper motors connected to the rest of the circuit.

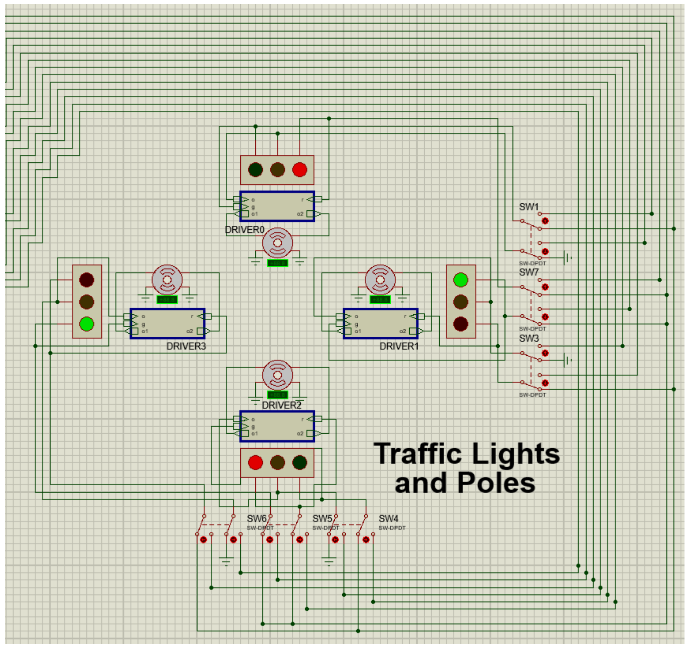


Figure 2.4 Traffic Lights and Poles

The inputs of the circuit are given to the *Switcher* panel. The outputs are attained from the *Siren Circuit* and the *Traffic Lights and Poles* section.

2.2 Circuit Explanation:

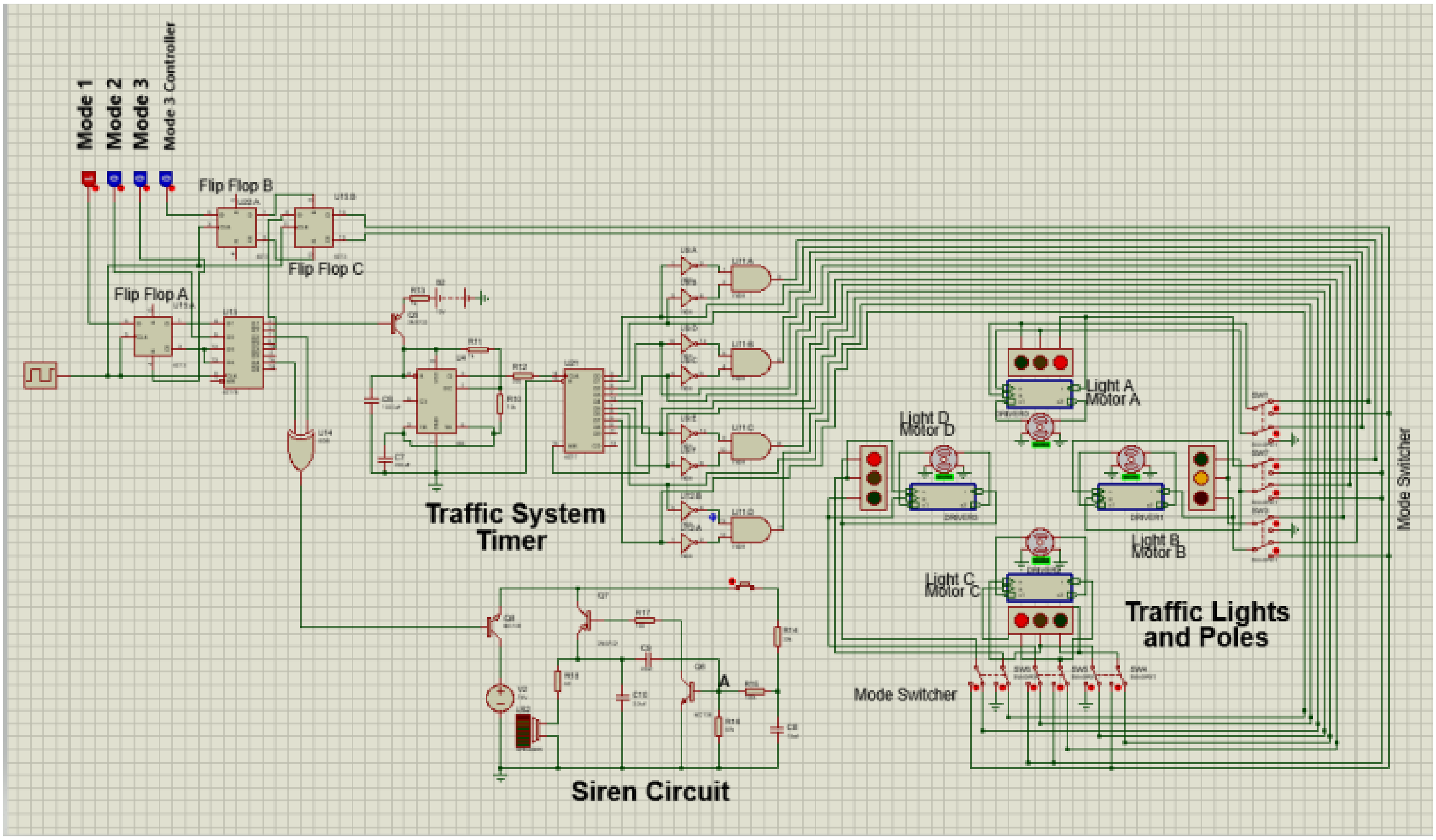


Figure 2.5 Full Circuit

The figure above shows the entire circuit with all of its segments and interconnections. Below is a detailed analysis of how each mode of operation works and how each of the segments function or give outputs.

→ **Mode 1:**

Mode 1 is always kept in a "high" state using a switch. When the input is high, the signal is fed to Flip Flop A. The output from this Flip Flop is sent to the D1 input of the 40175 IC which has 4 D Flip Flops inside. Since it is a D Flip Flop it gives an output "1" when the input is "1". Therefore, Q1 is high, this gives a voltage in the base side of the 2N3702 transistor (Q5 in above circuit). This acts as a switch and connects the battery to the rest of the timer circuit. The timer circuit includes a NE555 IC, capacitors and resistors. The circuit gives a timed output to the clock of the 4017 Counter IC (U21 in above circuit).

In the counter,
Q0, Q1 are connected to the green and orange lights of Light A. From nodes of each of Q0 and Q1 we added inverters to the output and connected to an AND gate

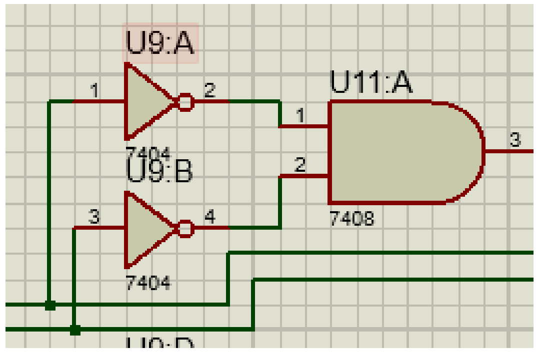


Figure 2.6 Connections to Light A

This acts like a NAND gate and gives a signal “1” to the red light of Light A. This means that after Q0 = 1, it goes “0” then Q1 = 1 followed by “0” and when both of them are “0”, the signal for red signal = 1. Therefore sequentially first the green signal lights up, followed by the orange one and lastly the red one.

After this, Q2, Q3 signals become “1” respectively and light up the green and orange signals of Light B sequentially and so forth until Q7 which lights up Lights D. After this Q8 is connected to the Master Reset (MR) pin of 4017 IC which resets the outputs to Q0 and repeats in a loop.

Let’s consider
Q0, Q1, Q_{01} to be signals for Light A and call them Group A,
Q2, Q3, Q_{23} to be signals for Light B and call them Group B,
Q4, Q5, Q_{45} to be signals for Light C and call them Group C,
Q6, Q7, Q_{67} to be signals for Light D and call them Group D.

Now we take group A (all the groups have identical connections to the driver circuit which will be described below). Below attached is an image of group A:

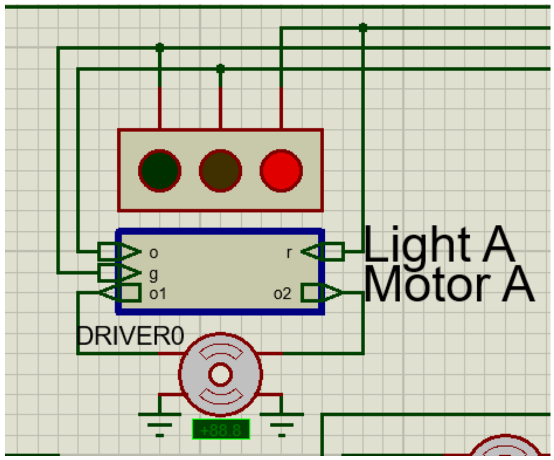


Figure 2.7 Motor A connections

The inputs from Q0, Q1 and Q_{01} are branched to the inputs of the *Driver* circuit. This *Driver* circuit connects the stepper motor (used as a traffic pole for blocking the red when red signal is given) parallelly to the light sequence. When Q0 and Q1 = 1, the motor signal is at 0 degrees angle (held vertically) and when Q_{01} = 1, the poles are at 90 degrees (held horizontally) thus blocking the road. We have devised this using a sub circuit with inputs o, g, r and outputs o1 and o2. Below attached is a figure for the child sheet of the driver circuit:

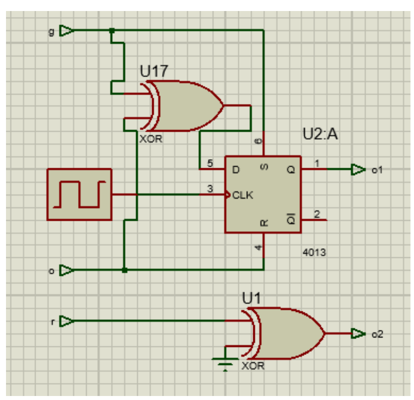


Figure 2.8 Driver0 Childsheet

Here, we use a D Flip Flop (IC 4013) and XOR gates. There is a XOR gate between g, o inputs connected to the input D pin, and input “g” is connected to the Set pin, input “o” is connected to the Reset pin. Input r is connected to an XOR gate to o2 (o2 = 1 only when r = 1). Each alphabet resembles the connections from green, orange and red lights.

When g = 1, o = 0, r = 0, then o1 = 1 and o2 = 0. This gives a 0 degree shift to the stepper motor (vertical).
When g = 0, o = 1, r = 0, then o1 = 0 and o2 = 0. This keeps the shift to 0 degree (still vertical).
When g = 0, o = 0, r = 1, then o1 = 0 and o2 = 1. This gives a 90 degree shift to the stepper motor (horizontal), thus blocking the road.

This cycle repeats for each stepper motors A, B, C, D and thus synchronised with the traffic signals.

→ **Mode 2:**

Mode 2 is our first “emergency case” modification to our automated circuit. This is a *Siren* mode. When Mode 2 switch = 1, the high input is fed to the D2 input of the 40175 IC in the *Switcher* panel. The output Q2 is attached to a XOR gate and to the BC108 NPN transistor base side.

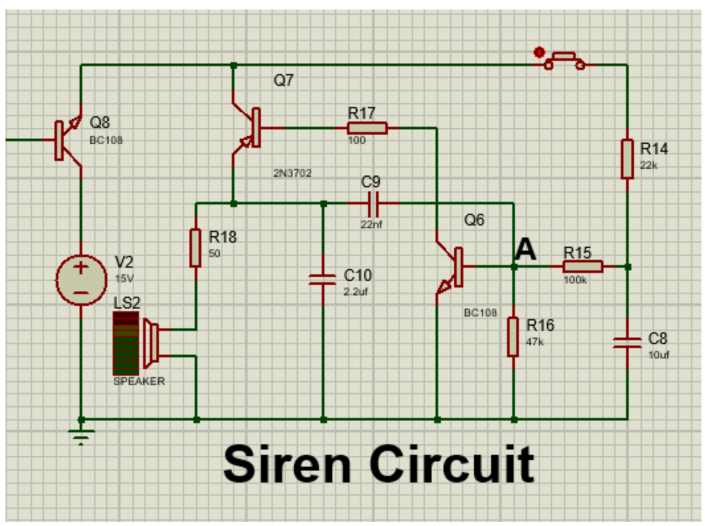


Figure 2.2 Siren Circuit

This lets current flow through the *Siren Circuit* and acts like a switch. This simple siren circuit generates a tone that sounds very similar to a siren. The generator part of the circuit is made of the combination of PNP and NPN transistors. Together, they generate an up and down going signal tone, the resistor R16, R15 is fed from an RC circuit. We keep the switch closed, when our *Switcher* panel sends out a “1” condition, the BC108 transistor connects the entire circuit and the capacitor C10 charges via resistor R14 slowly until it reaches the maximum voltage level. This increasing voltage results to a decreasing time constant at the junction - A. This furthermore results in an increasing frequency of the multivibrator.

After the *Switcher* panel gives a "0" condition, the capacitor C10 discharges slowly resulting in a decreasing frequency cycle. Through the combination of the two time constants a sawtooth waveform is generated. The signal heard from the speaker will be an increasing or decreasing tone resulting from the conditions set by the *Switcher* panel.

→ **Mode 3:**

Mode 3 is our second "emergency case" modification to our automated system. Mode 3 is designed in a way that when Mode 3 is active, Mode 1 is deactivated since both Mode's functions can not in any way be active simultaneously. This is done using Flip Flop A, the input switch of mode 3 is connected to the Reset Pin of Flip Flop A. Therefore when Mode 3 is in logic high, the Q output = 0 and therefore shutting down the *Traffic System Timer* segment and now $\overline{Q}$ = 1. This logic "1" is fed into the D3 and D4 inputs of 40175 IC. Therefore output Q3 = 1, this is fed into the D input pin for Flip Flop C.

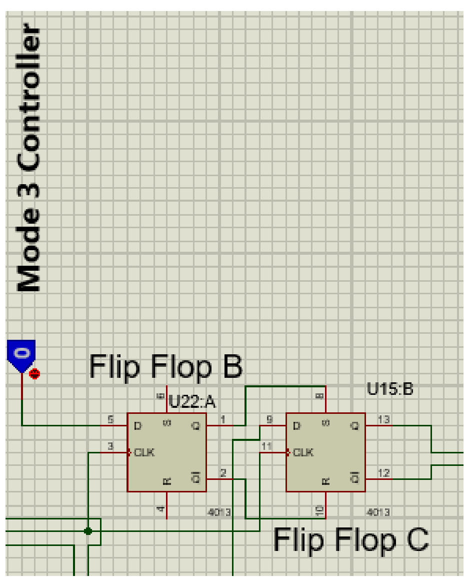
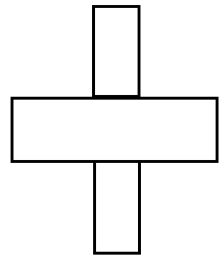


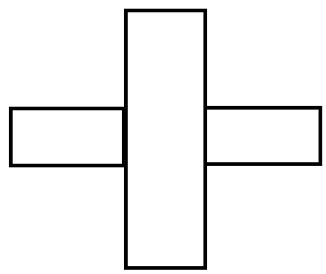
Figure 2.9 Flip Flops B and C

Flip Flop B and C acts as a control mechanism for the modified emergency case using the *Mode 3 Controller* switch. We take two cases:

Case 1: Horizontal Pass through



Case 2: Vertical Pass through



When Mode 3 = “1”, the D input of Flip Flop C is logic “1”. The *Mode 3 Controller* switch is connected to the D input pin of Flip Flop B. The Q and $\overline{Q}$ outputs of Flip Flop B are connected to the Set and Reset pin of Flip Flop C respectively. Therefore,

Mode 3 Controller = 0, means Flip Flop C Q = 0, $\overline{Q}$ = 1

Mode 3 Controller = 1, means Flip Flop C Q = 1, $\overline{Q}$ = 0

These Q and $\overline{Q}$ outputs of Flip Flop C result in the establishment of Case 1 and Case 2. The outputs from Q and $\overline{Q}$ are connected to Light A B C D, motor A B C D using a set of SW-DPDT switches. We can use a switch system that can switch between 12 inputs each (12 + 12 = 24 total inputs). Below attached is a figure for the *Mode Switcher* used:

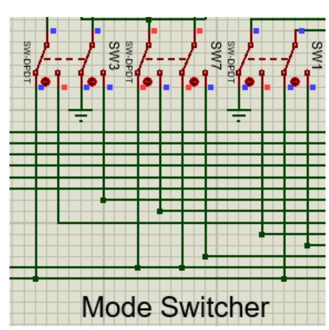


Figure 2.10
Mode Switcher

When the *Mode Switcher* is in “up” condition, the inputs to the Lights A B C D and Motors A B C D are connected to the *Traffic System Timer* outputs (giving a sequential output).
When the *Mode Switcher* is in “down” condition, the inputs to the Lights A B C D and Motors A B C D are connected to the outputs Q and $\overline{Q}$ from Flip Flop C (fixed output) thus ensuring Mode 3 active operation.

The output Q is connected to the green lights and g inputs of the Light A, C and Motor A, C and to the red lights and r inputs of Light B, D and Motor B, D.
And the output $\overline{Q}$ is connected to the green lights and g inputs of the Light B, D and Motor B, D and to the red lights and r inputs of Light A, C and Motor A, C.
The “down” condition of the *Mode Switcher* for the orange lights are grounded because they aren’t necessary here.

Now let’s consider the switches are in “down” condition, Mode 3 switch is in logic “1”, therefore the entire circuit is now operating in Mode 3 “emergency case”.

Now that we have set the conditions, we will establish the combination required to set Case 1 or Case 2 active. These are as follows:

→ **Case 1:**

Mode 3 switch = logic “1”, *Mode 3 Controller* switch = logic “0”, *Mode Switcher* mode = “down”,
These conditions would let to Q of Flip Flop B = 0, and for Flip Flop C the Set pin = 0, Reset pin = 1, Q = 0 and $\overline{Q}$ = 1. This would satisfy Case 1 conditions.

→ **Case 2:**

Mode 3 switch = logic “1”, *Mode 3 Controller* switch = logic “1”, *Mode Switcher* mode = “down”,
These conditions would let to Q of Flip Flop B = 1, and for Flip Flop C the Set pin = 1, Reset pin = 0, Q = 1 and $\overline{Q}$ = 0. This would satisfy Case 2 conditions.

Below attached are figures for Case 1 (Figure 2.11.a) and Case 2 (Figure 2.11.b) respectively:

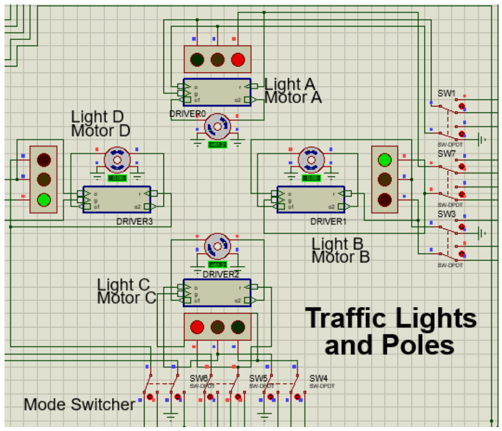


Figure 2.11.a Case 1

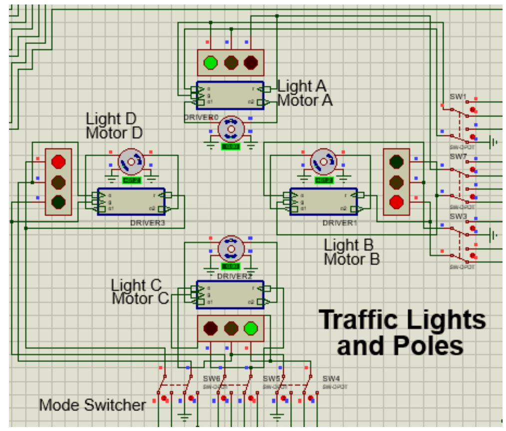


Figure 2.11.b Case 2

The D3 input of the IC 40175 is also connected to the D4 input of the IC 40175. The output Q4 is added with the Q2 output using an XOR gate and fed to the base of the BC108 transistor (switch) of the Siren Circuit.

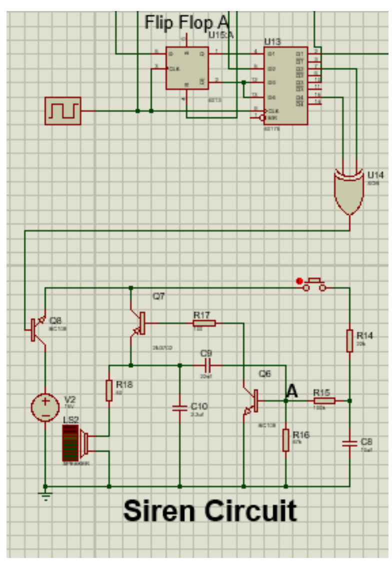


Figure 2.12

This means that the *Siren Circuit* would be active if:

→ *Mode 2* switch = logic “1”, *Mode 3* switch = logic “0”

→ *Mode 2* switch = logic “0”, *Mode 3* switch = logic “1”

Therefore the Siren would ring when the “emergency case” of *Mode 3* is active or of *Mode 2* is active individually. If the siren is unnecessary when *Mode 3* is active then the switch from the *Siren Circuit* can be kept open.

2.3 Equipments:

Equipment Name	Quantity
AT-700 Trainer Board	1
IC - 7404 (Hex Inverters)	8
IC - 7408	4
IC - 4013 (1 bit D FF)	7
IC - 4017 (Counter)	1
IC - 40175 (4 bit D FF)	1
NE555 Timer/Oscillator	1
Traffic Lights (LEDs)	4x3
PNP BJT (2N3702)	2
NPN BJT (BC108)	2
Speaker	1
SW-DPDT switches	6
XOR gate	9
Buttons	1
Motor Bi-Stepper	4
Resistors	9
Capacitors	5
Clocks	2
Voltage Source	-
Connecting wires	-

2.4 Performance Examples for each Modes and Cases:

Mode 1:

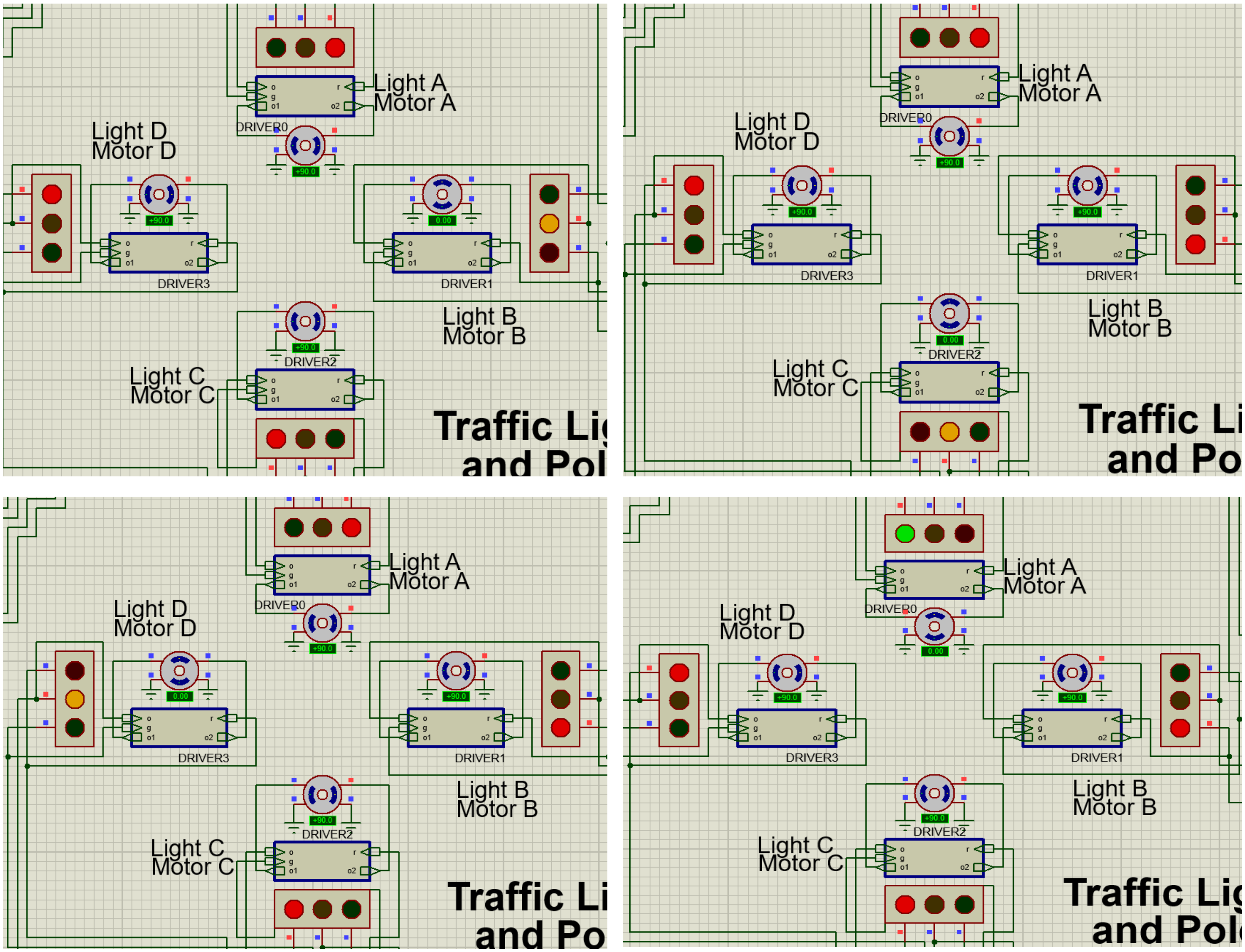


Figure 2.13 Mode 1 Examples

Mode 2:

Figure A has *Mode 2* = “0”, Figure B has *Mode 2* = “1”

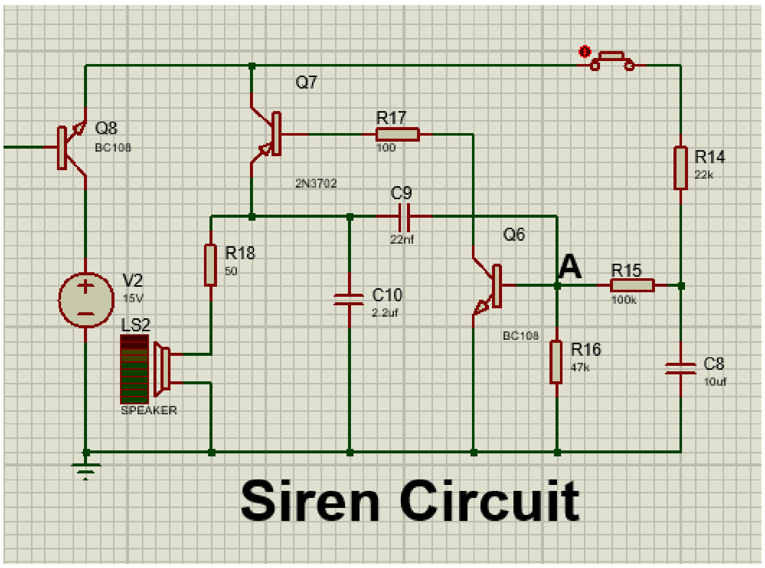


Figure 2.14.a Siren On

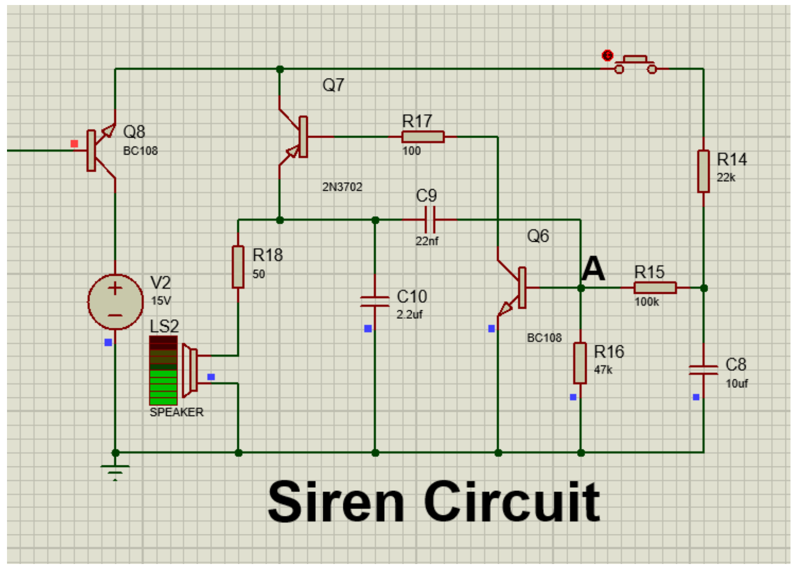


Figure 2.14.b Siren Off

Mode 3:

Below includes screenshots of Case 1, Case 2 and circuit with switch of *Siren Circuit* open and close condition while the switch is opened and closed respectively (from left to right).

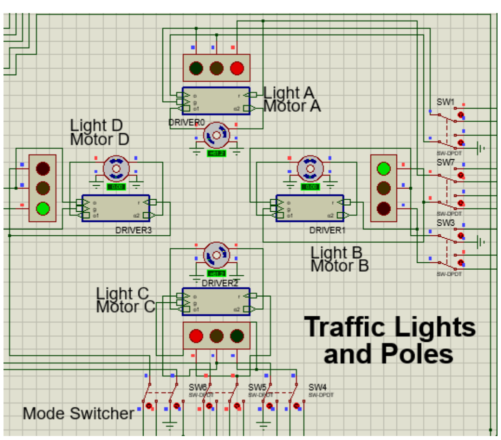


Figure 2.11.a Horizontal

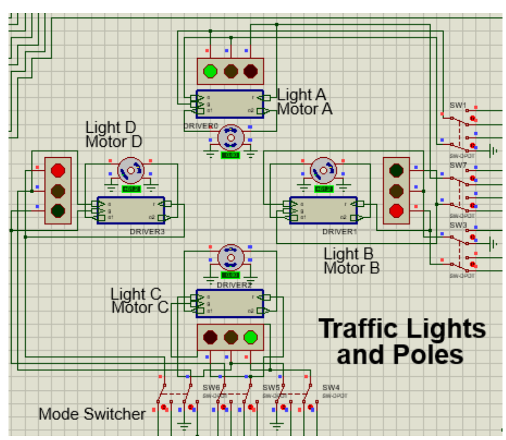


Figure 2.11.b Vertical

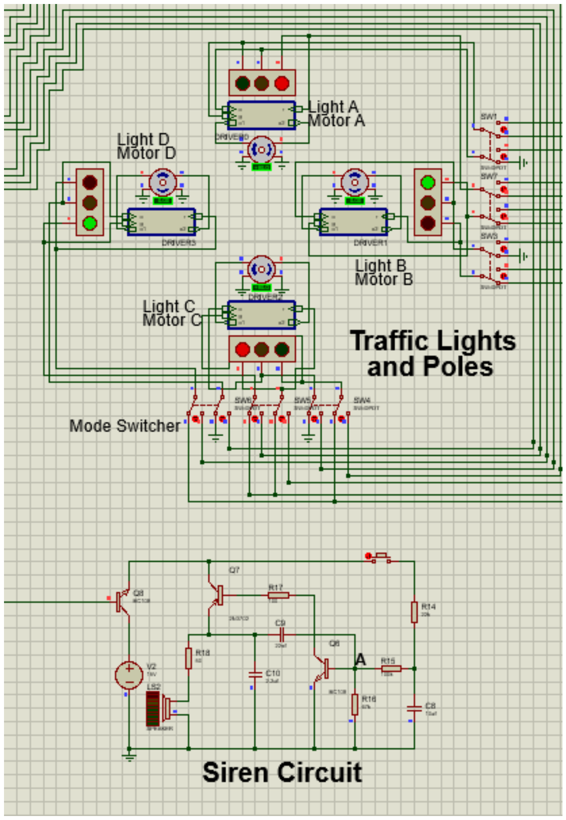


Figure 2.15.a Switch Open

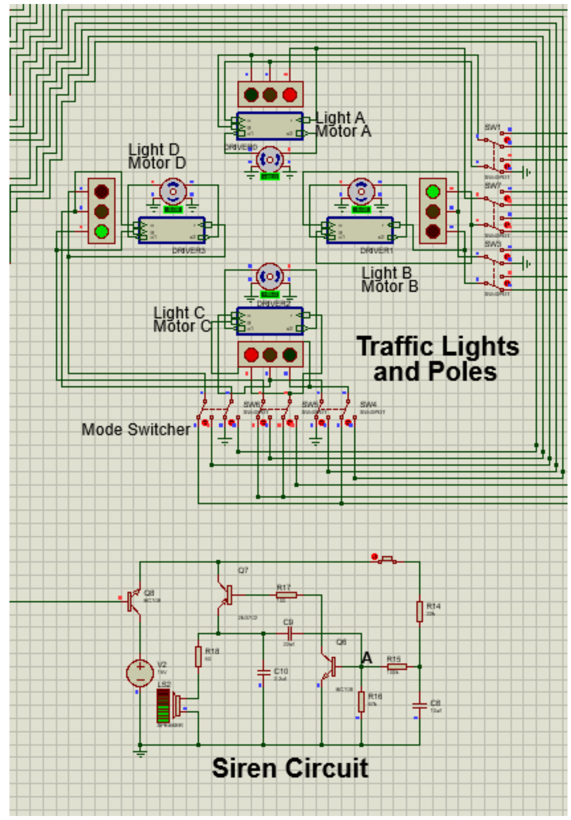


Figure 2.15.b Switch Closed

3. Discussion

3.1 Alternate Designs and Troubleshooting Issues:

→ **Mode Switcher:**

Initially we designed the circuit such that the outputs Q and $\overline{Q}$ of the *Mode 3* Flip Flop C and the output Q1 from the IC 40175 which follow through the *Traffic System Timer* segment to the traffic lights were parallely added as shown in the figure below. To make sure that the outputs from each mode do not inter-mingle with each other, we added a button "A" to the Q3 output to make sure the Lights A B C D and Motors A B C D receive only one signal at a time.

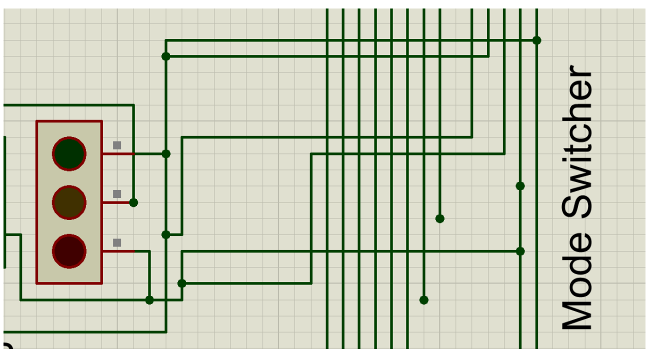


Figure 3.1.a Parallel Connections between Mode 1 and Mode 3 to the Lights Motors A B C D.

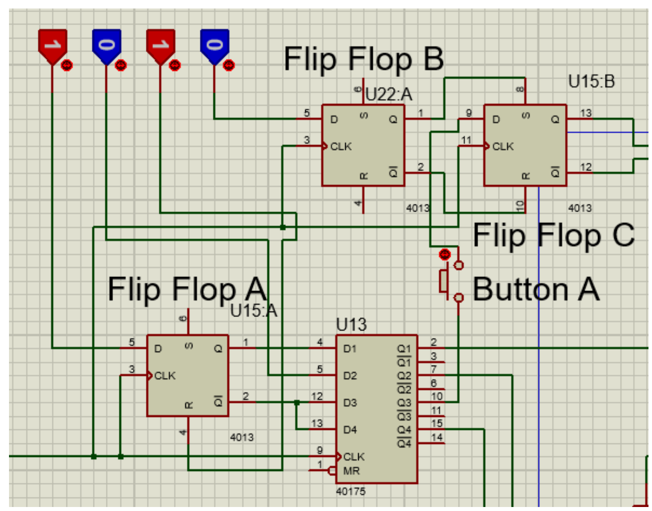


Figure 3.1.b Addition of Button "A"

However, this did not work because the inputs to the Lights and Motors A B C D were in floating state or error state therefore showing no lights whatsoever as shown in Figure 3.1.a.

Instead we have added a Mode Switcher which consists of 6 sets of SW-DPDT switches, thus removing the parallely added connections to the Lights and Motors A B C D and removing the need for a button to the input of Flip Flop C. The outputs Q and $\overline{Q}$ of the *Mode 3* Flip Flop C and the output Q1 from the IC 40175 which follow through the *Traffic System Timer* segment to the traffic lights are now separately added to the sink (Lights and Motors A B C D). This gives proper timed or manual inputs (Logic “1” and “0”) to the sink. This has been proven in the following figures:

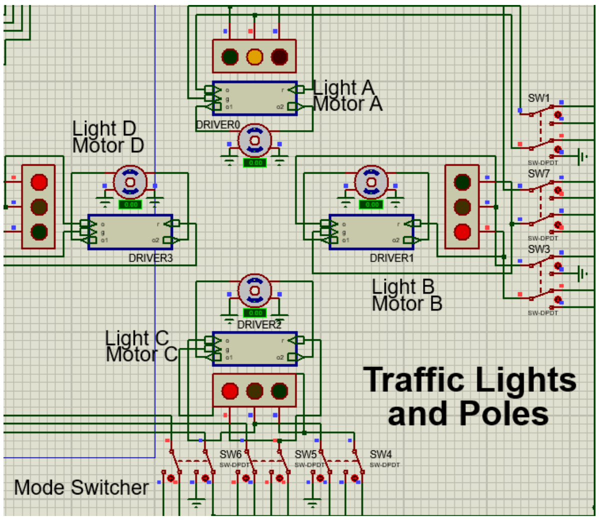


Figure 3.2.a *Mode switcher* = “up”
Mode 1 = active

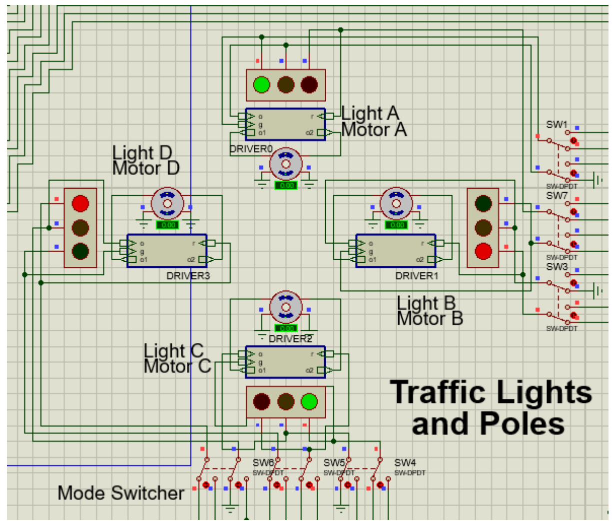


Figure 3.2.b Mode Switcher = “down”
Mode 3 = active

→ **Alternate Traffic System Timer Set-Up:**

We had also considered an alternate design for the *Traffic System Timer* segment which would bypass the need for NAND gates and use inverters only. This set up allows for either horizontal pass or vertical pass at all times. The figure is shown below:

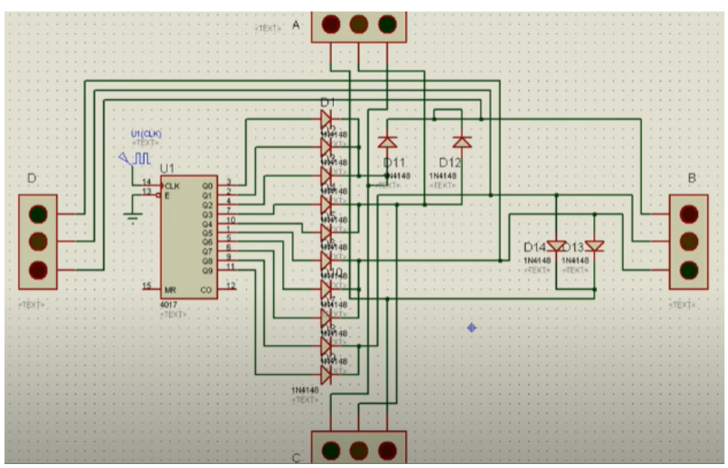


Figure 3.3 Alternate Set-Up

The problem with this design is it only allows for horizontal or vertical pass ways, this would result to safety concerns because let's consider the following case:

If the green lights of light B and D are on, the red lights of light A and C are on, vehicles coming from road B can not go to road C because vehicles are already blocking the road from direct D to B. Hence this would create obstruction.

To solve this we have created an automated “one green signal at a time” approach which moves sequentially thus bypassing the obstruction created by two roads having a green signal at the same time. If we decrease the amount of time that the green signal is activated (Using the NE555 timer modification) then we could account for the loss time due to traffic jam caused by one path opened instead of two as shown in this model. Furthermore unlike our model, this one does not have a NE555 timer circuit to modify its clock rate for the IC 4017 counter.

→ **Driver Circuit Modification:**

Connections to the stepper motor pins (4) must be added in such a way that it allows both vertical (0 degrees) and horizontal (90 degrees) movements. Initially we planned on connecting the “o” and “g” pin to the Reset and Set pins of the D Flip Flop inside the circuit, while applying a logic high to the D input of the Flip Flop. This has been demonstrated in the diagram below:

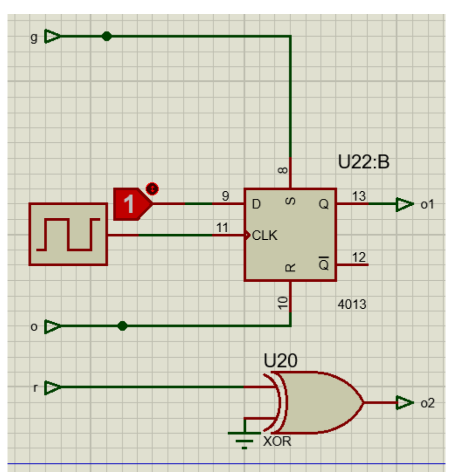


Figure 3.4 Alternate Driver Set Up

This set up would give the following results:

When g = 1, o = 0, r = 0, then o1 = 1 and o2 = 0. This gives a 0 degree shift to the stepper motor (vertical).
When g = 0, o = 1, r = 0, then o1 = 0 and o2 = 0. This keeps the shift to 0 degree (still vertical).
When g = 0, o = 0, r = 1, then o1 = 1 and o2 = 1. This gives a 90 degree shift to the stepper motor (horizontal), thus blocking the road.

For the third case, o1 = 1 and o2 = 1 would give an incorrect information to the pole thus setting it down at 61 degrees instead of 90 degrees because both inputs of the stepper motor are high.

Instead we have taken a XOR gate between “o” and “g” and fed that output to the D input, this makes sure that when both “o” and “g” are inactive, o1 = 0, therefore ensuring proper pole positioning. The figure for the formation we used have been given below:

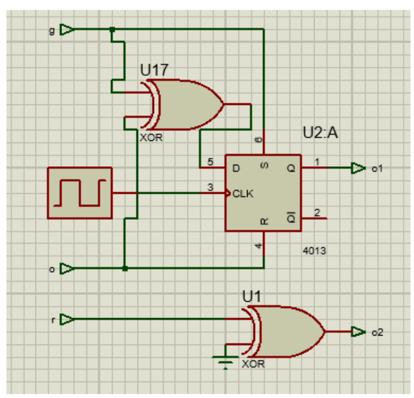


Figure 2.8

3.2 Estimated Costs and Feasibility:

This traffic control system is mainly designed to reduce traffic Problems, i.e.; in general the four sides of the road at a signal point are controlled automatically. We can use LEDs instead of conventional incandescent halogen bulbs. LEDs are tiny, purely electronic lights that are extremely energy efficient and have a very long life. Each LED is about the size of a pencil eraser, so hundreds of them can be used together in an array. The LEDs are replacing the old-style incandescent halogen bulbs rated at between 50 and 150 watts. LED bulbs save a lot of energy. Let us assume a traffic light uses 100-watt bulbs today. The light is on 24 hours a day, so it uses 2.4 kilowatt-hours per day. A big city has thousands of intersections, so **it can cost millions of dollars** just to power all the traffic lights. LED bulbs might consume 15 or 20 watts instead of 100, so the **power consumption drops by a factor of five or six**. A city can easily **save a million dollars a year** by replacing all of the bulbs with LED units. Moreover, they generally last 5-7 years compared to just a year for incandescent light. Also, no traffic police will be required so salaries given to traffic police will not be required which is cost efficient. Due to the camera in our design, anybody breaking the law the image of the nameplate of the car will be sent directly to police offices. In this way the costing is reduced heavily .Summing up, through the implementation of this system it has the following results:

i. Minimize conflicting movement
ii. Provide orderly movement of traffic
iii. Provide driver confidence by engaging the right ways
iv. Means of interrupting heavy traffic
v. Coordinated for continuous vehicle movement

Moreover, at the current price rates, this entire circuit can be manufactured within 25 dollars without the external poles for obstruction.

3.3 Non - Technical Constraints:

With implementing our mode of operation, there are many constraints that one might face in a developing country such as Bangladesh. To get further into the matter, we have taken the Bangla-Motor Signal, situated in Dhaka, Bangladesh as our thought experimental room.

→ **Mode of Operation:**

We have established that our primary target is to prioritise using our circuit in *Mode 1* for all roads. However this mode only allows for movement for one signal at a time (i.e. 1 green signal and 3 red signals), the problem with this is demography and statistics wise, the roads connecting Shahbagh to Kawran Bazar (horizontal passway) contains much more vehicles than the roads connecting Mogh Bazar to Kathal Bagan (vertical passway). Therefore, our system of having only 1 green signal at a time would be unfeasible. The circuit must operate in *Mode 3* and a suitable clock (adjusted with the time required for horizontal and vertical passway) must be added to the *Mode 3 Controller* pin, this would ensure proper automated passway.

→ **Manual Assistance needed for Siren Circuit Switching:**

We have provided an *Emergency Mode* (Siren Circuit) to assist in such times of need. However if looked closely, we have fed the same input to D3 and D4 pins of the 40175 IC in the *Switcher* segment. And Q4 output is connected to the Siren Circuit BC108 transistor (Switch) by an XOR gate with Q2 output. This would mean, whenever *Mode 3* is activated, the siren would also start buzzing. This measure was given so that during cases like creating a pathway for emergency fire truck movement, National Security danger, the people would be warned and notified through the siren too. However since Bangla Motor pathway has been under construction, if it is decided that the circuit operates in *Mode 3* and blocks one of the pathways (either horizontal or vertical) then the siren would continuously keep ringing. This would be a nuisance to the countless

passerby’s and civilians living near Bangla Motor signal.
To counter this we have added an additional button in the *Siren Circuit*, this can help keep the sirens off while *Mode 3* is active and also can satisfy our need for the presence of a siren when needed (example situation given above).

3.4 Conclusion and Future Work:

This is actually a venture which can be made with lower cost. Along these lines, our point is to proceed with this work. We need to construct this and execute it in the busy 4 go across way streets. By, this we can get a decent traffic signal framework in a cheap amount.

Automatic traffic light control systems are useful equipment for controlling traffic at junctions. The country can save many hours usually lost in traffic problems. Accidents may also be prevented and lives can be saved. The government should endeavor to encourage the installation of this system of traffic at necessary junctions in order to reduce the number of accounts associated with roads.

Drivers and pedestrians should also learn to abide by the rules associated with the system so as to ease traffic congestion and avoid unnecessary stress on the road and fear of crossing intersections by the pedestrians.

In the future, we believe that an AI camera system can be added which would recognise vehicle movement faster, and feedback more information to our circuit. For example if there exists a vehicle that breaks a traffic law, or if there is an accident, then the camera can capture the number plates easily or send an automated message to an ambulance/fire truck service if need be respectively.

3.5 References:

1) Jaeger, “Microelectronic Circuit Design”, McGraw-Hill 1997, ISBN 0-07-032482-4, pp. 226-233
2) Webster, F.V. “Traffic Signal Settings” Road Research.
3) (23) emergency siren circuit| how to make in proteus - YouTube
4) Mahanta, D. “Traffic Light Control System”.