SCHOOL OF ELECTRONICS ENGINEERING

Subject Code: ECE3003

Microcontroller and its Applications

J-Component Report

Smart Street Light with Smart Zebra Cross

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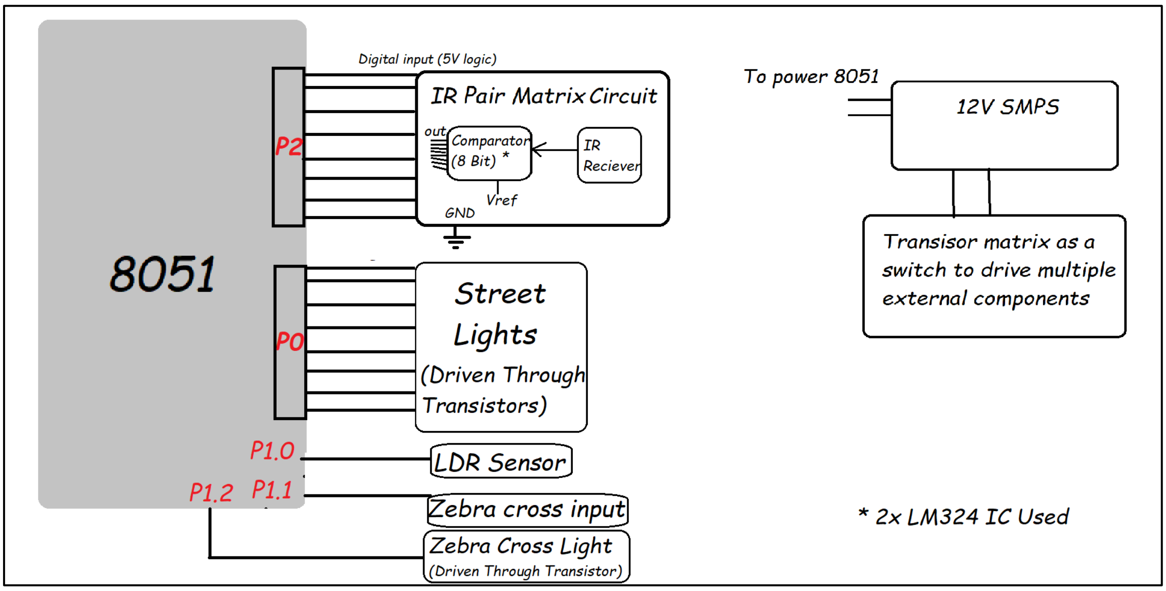
Aim:

- To track the vehicle movement and predict the street light turn ON flow direction
- To determine if a person is crossing the road through zebra crossing.
- Design a functional prototype using PCB designing and 3D printing

Block Diagram:

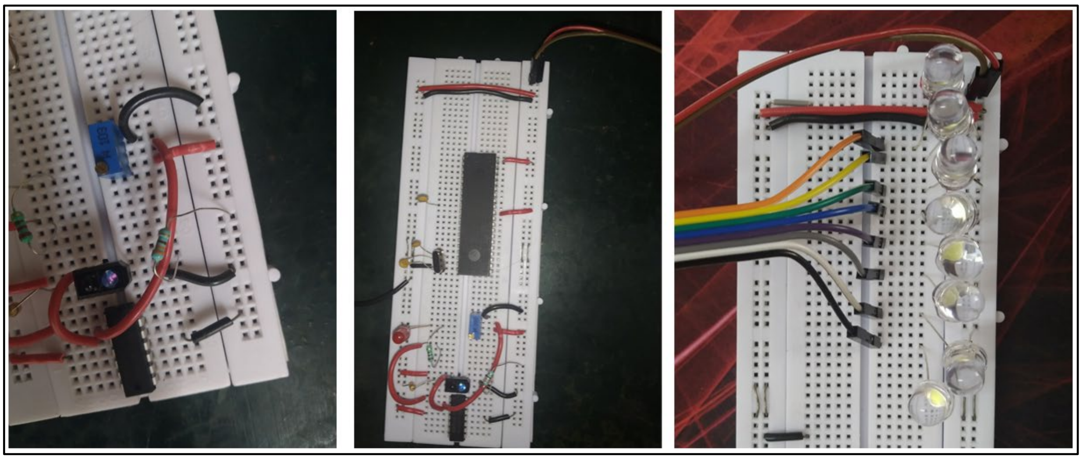


- **BLOCK 1: STREET LIGHTS**
  - 8mm LEDs are used as street light which draws around 100-150mA of current
  - So total current from 8 LEDs will be 800mA (min)
  - The 8051 can only supply 20mA of current per pin. Thus, BC547 BJTs are used to drive the LEDs
- **BLOCK 2: IR PAIR CIRCUIT**
  - 8 IR sensors are used to control the LEDs
  - Premade sensors would be bulky and add more cost. Hence, we designed our own sensor network circuit
  - LM324 IC has 4 OPAMPS in built. Hence 2 OPAMP ICs are required to take 8 sensor inputs. OPAMPS are configured as comparators.
  - Potentiometers are used to set the reference voltage at inverting input of OPAMPS.
- **BLOCK 3: LDR (AS DAY SENSOR)**
  - A LDR sensor is used to detect weather its DAY or NIGHT. It is connected to P1.0
  - Night => P1.0 = HIGH
  - DAY => P1.0 = LOW

- **BLOCK 4: ZEBRA CROSSING**
  - To design Smart Zebra cross, HCSRO4 ultrasonic sensor is used.
  - The data from the sensor is processed separately using ATTiny85 microcontroller
  - The sensor will ignore vehicle movement and only give output when someone starts crossing the road
  - The output of the sensor is connected to P1.1
  - RED led strips are used in zebra crossing and is connected to pin P1.2 through transistor network
- **BLOCK 5: POWER SUPPLY**
  - 12V Power supply is used to power the circuit
  - 12V is stepped down using a buck convertor to 5V

Block implementations

- **Phase 1: Testing Different Parts of the Circuit**



The OPAMP configuration, LED's and the 8051 microcontrollers were tested with the required complimentary parts on a breadboard. IR transistor was used in Emitter-Follower Configuration with a 10K ohm Emitter resistance. The potentiometer was used as a reference input at the inverting input of the Op-Amp. During this testing, the resistor and potentiometer values were adjusted to give proper range sensitivity. The reference voltage set by the potentiometer was 0.580V. Standalone circuit of 8051 (AT89S52) was also tested. We used an 11.0592 MHz Crystal which has a load capacitance of 18pf. So, considering the stray capacitance of around 7pf, the value of external capacitors (C_1 and C_2) comes to be around 22pf. [$C_1 = C_2 = 2*(C_{load} - C_{stray})$].

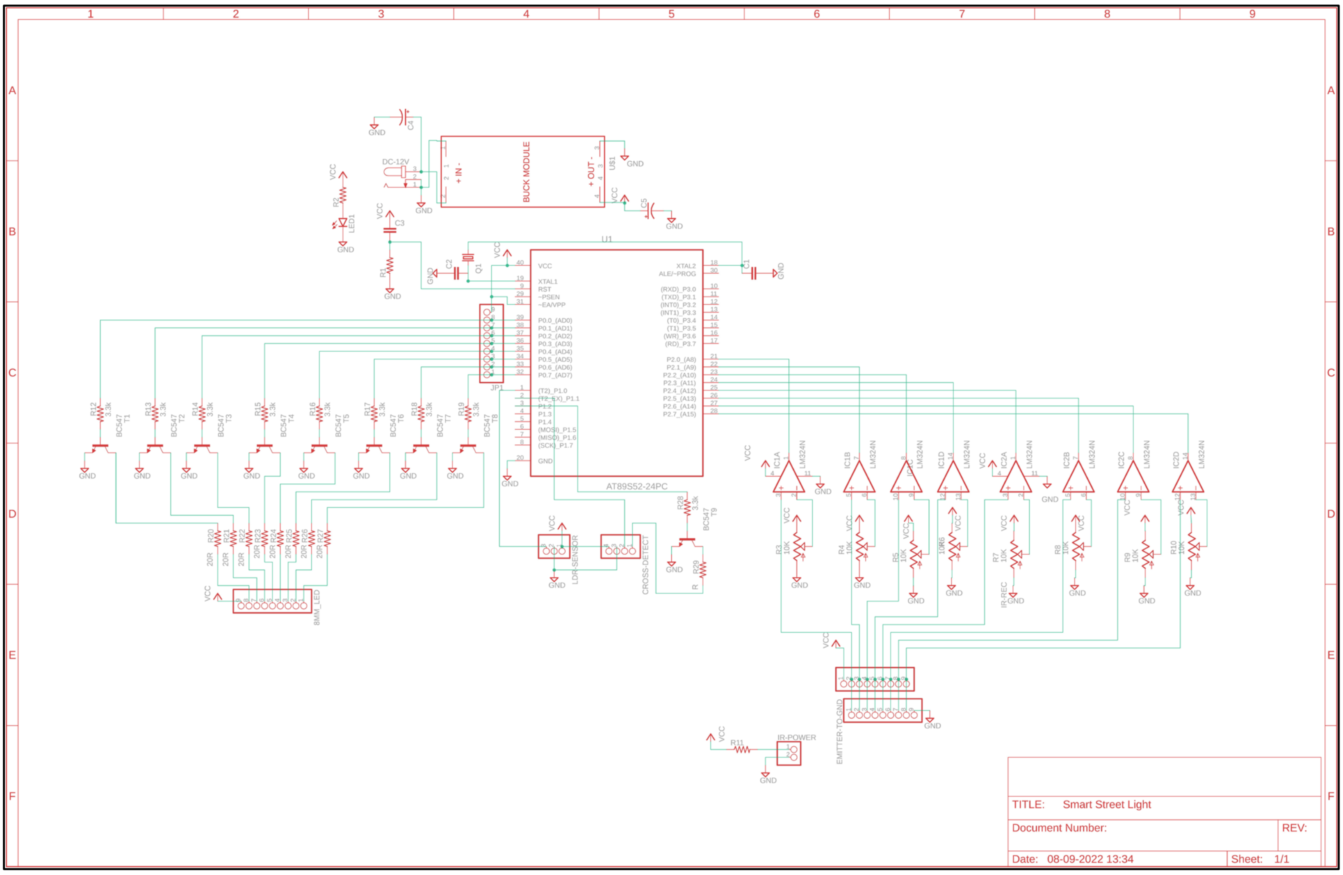
➢ **Phase 2: Creating Final Circuit Diagram**

Using EAGLE software, the final circuit diagram was designed, considering the breadboard testing and the power requirements.

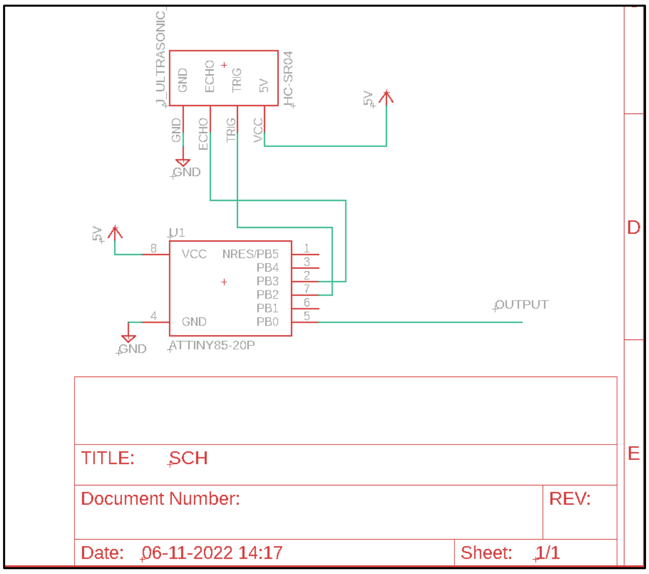
The following components were finalized and were implemented in the circuit:

S. No.	Component	Pcs.
1.	AT89S52 – 8051 based microcontrollers	1
2.	ATTiny85 microcontroller	1
3.	TCRT5000 (IR LED and IR Transistor Pair)	8
4.	LDR Sensor (Active Low type)	1
5.	Buck Convertor	1
6.	BC547 NPN BJT	9
7.	LM324N OPAMP	2
8.	HCSR04 ultrasonic sensor	1
9.	11.0592MHz crystal	1
10.	8mm LEDs	8
11.	10K Potentiometer	8
12.	Resistors 3.3k, 22Ohm	 9 8
13.	8x10k resistor networks	2
14.	Capacitors 470uF Electrolytic 0.1uF Ceramic 22pF Ceramic	 2 1 2
15.	Pin Headers 1x2, 1x3, 1x4, 1x8	 1, 1, 1, 2
16.	DC Jack	1

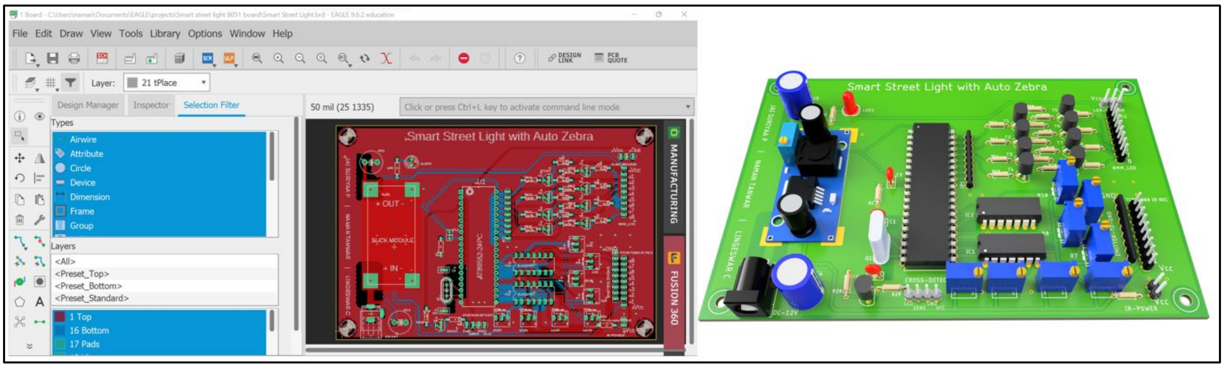
Final circuit Diagram,



Circuit Diagram for HCSRO4 based zebra crossing detection system,



➢ Phase 3: PCB Design using EAGLE

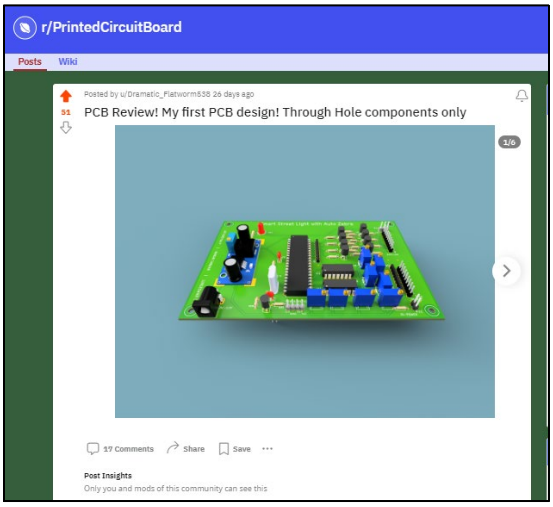


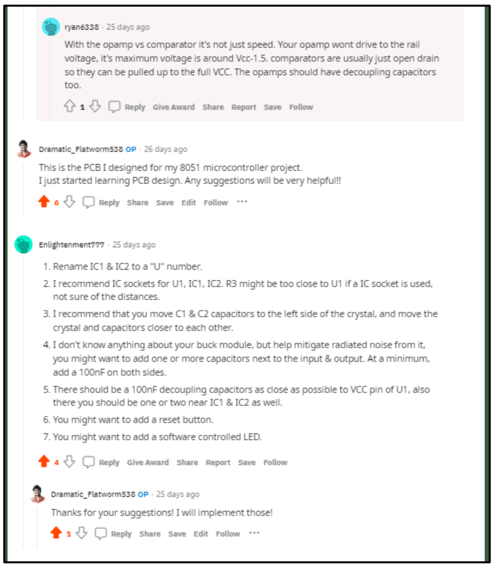
After the Schematic design, the board view was generated. Initially, we laid out the components as per the functionality discussed in the block diagram. For example, The OPAMP, the headers for IR transistors, and the potentiometers were grouped together as they work together. Similarly, the transistor – LED section, the crystal, and the power section was grouped. These sections were then placed according to the pinout of the microcontroller.

After all the placement were finalized, the board size was decided. The total board area is 130.81 cm^2.

Finally, the wires were routed manually to connect different components together. Here, thicker traces were used for the power delivery section and appropriately thinner traces were used for signal wires. The board designed is a 2-layer board with ground copper pours on both the layers.

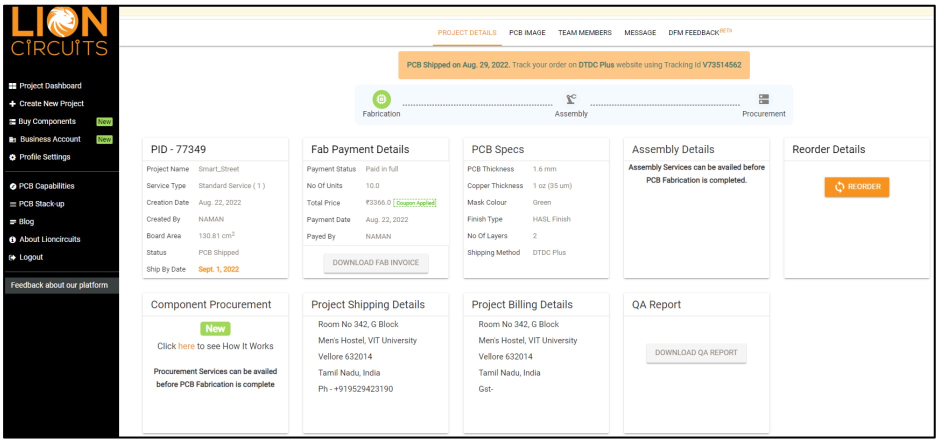
➢ Phase 4: PCB Review using Reddit

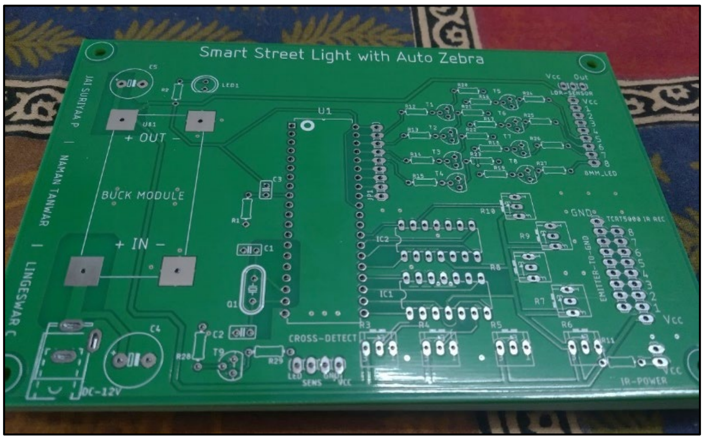




It is very important to get the PCBs reviewed before the manufacturing. We used Reddit to get our PCBs reviewed as it has a great community of electronics designers. They gave us some great feedback which we then implemented in our design.

- **Phase 5: Final PCB ordering using www.lioncircuits.com**



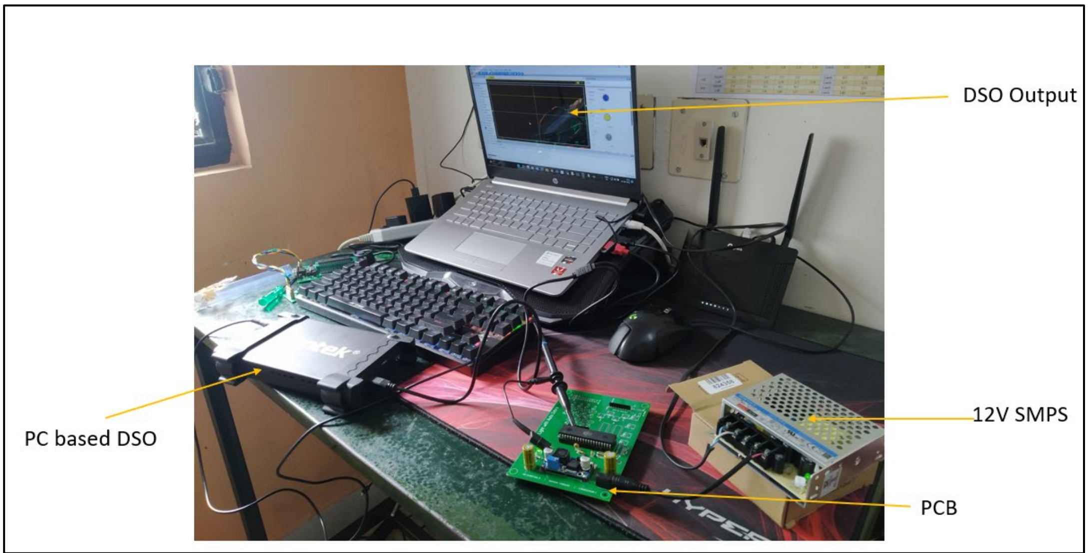


Lion Circuits is a Bengaluru based online PCB manufacturing company. We used their services to get our PCB manufactured. The minimum order quantity was 10pcs.

Here are the board parameters:

PCB Thickness	1.6mm
Copper Thickness	1 oz (35 um)
PCB Material	FR4
Mask Color	Green
Finish Type	HASL Finish
No Of Layers	2
Board Area	130.81 cm^2

➢ Phase 6: Soldering Components and simultaneous Testing

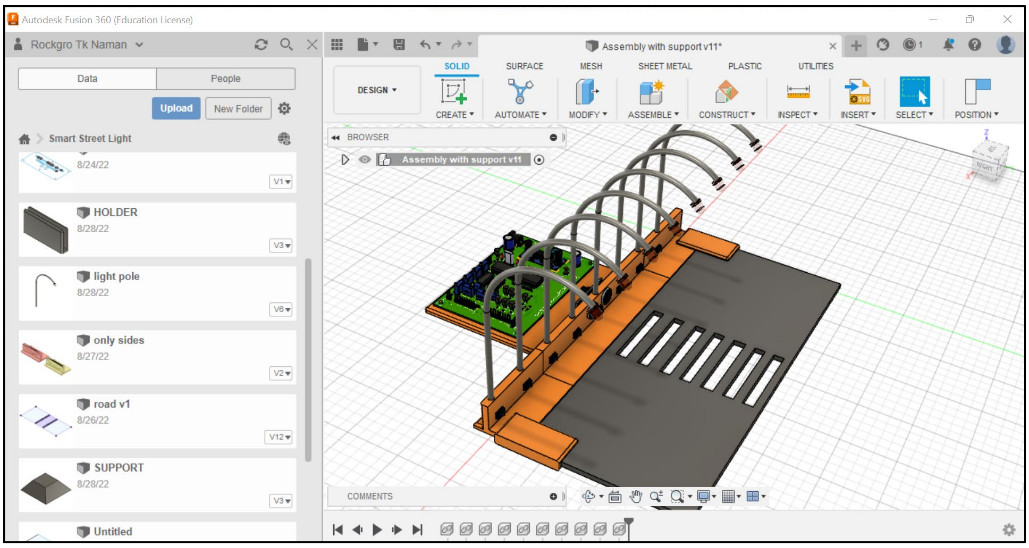


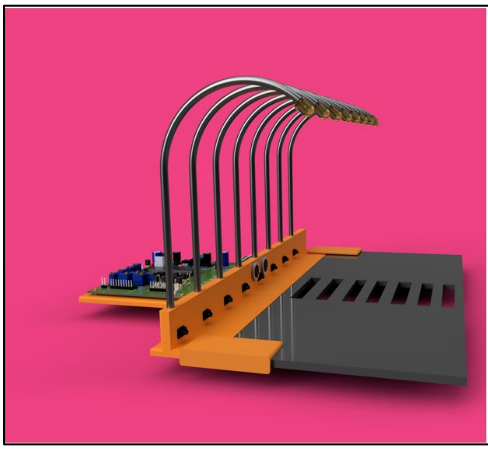
After the PCBs were manufactured and delivered (through DTDC), we started the soldering process of the components. All the components should not be soldered at once since it will make the troubleshooting process much harder. So, the components were soldered logically according to the block diagram. The power section was soldered first and the output voltage was set to 5V. We used an external 12v SMPS to power the board. Then the microcontroller's IC base and the crystal part was soldered and using a PC based DSO we checked if the crystal is producing correct frequency.

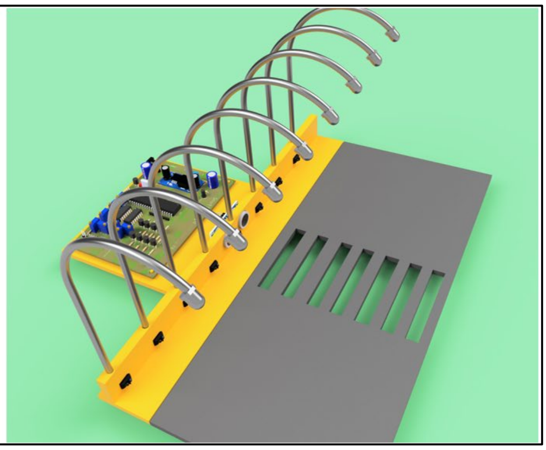
Then, the LEDS and the transistor part was soldered and using a simple code we check if we were able control the LEDs using the microcontroller. Here we ran into an issue, we were not able to control all the LEDs. After troubleshooting we found that we have soldered the 10k resistor network component in the wrong orientation. So, then we desoldered it and soldered it correctly. After this, the LEDs were successfully controlled using the microcontroller. Then we continued soldering the OPAMP section and its output was also verified using a simple code for 8051. Then we finally soldered the LDR and ultrasonic sensor headers.

The final PCB is shown below,

➢ **Phase 7: Designing 3D model using Fusion360, Rendering and 3D printing and Laser Cutting using an online service**







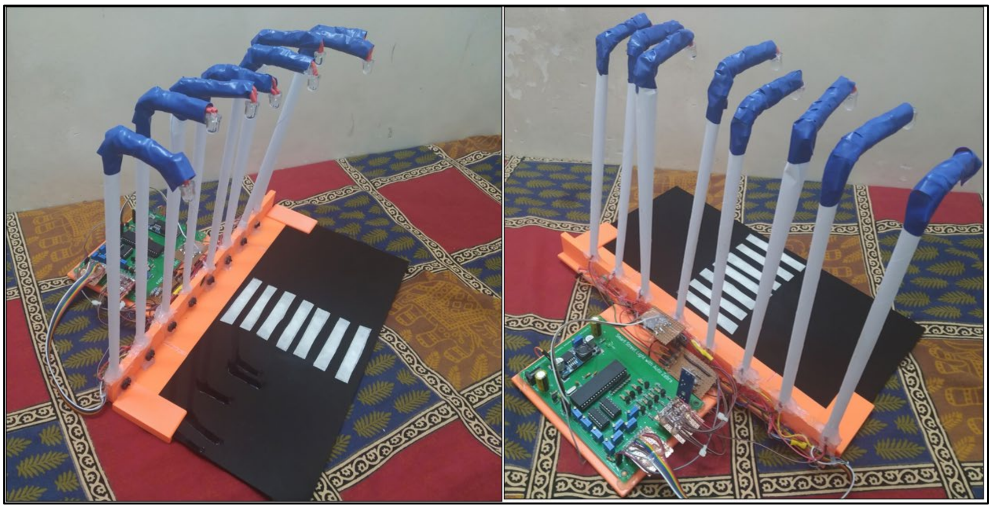
We designed a 3D model to contain the PCB and the other external components such as IR sensor pair, ultrasonic sensor and the zebra cross lights, and to demonstrate the functionality of our project. The 3D model was designed and rendered using Fusion 360.

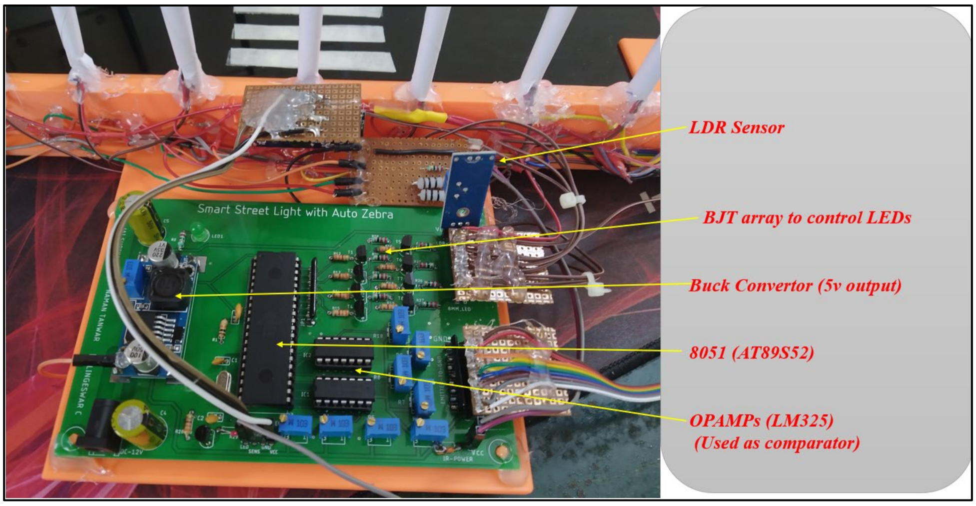
To reduce the manufacturing cost of this design we decided to laser cut the Road part (represented with grey colour) with black acrylic sheet and the rest was 3D printed in PLA (represented with orange). The road lights was made manually using paper rolls.

We used the online 3D printing and laser cutting services of robu.in to get our parts manufactured.

- **Phase 8: Final Assembly**

Finally, the complete project was assembled accordingly. The final assembled project is shown below.





The PCB and the other external components were secured in place using hot glue. To connect different electronic components jumper wire and ribbon cables were used.

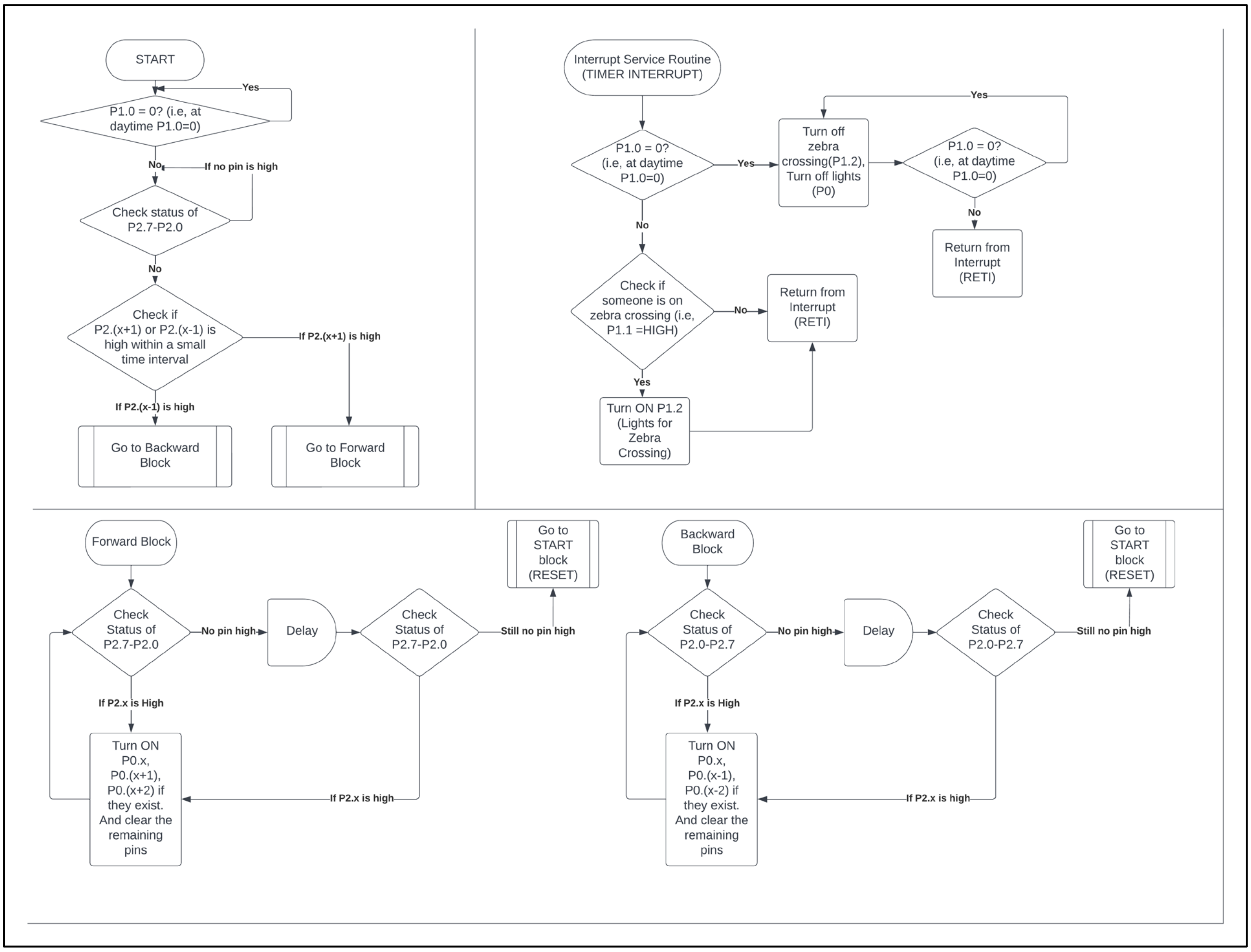
The street lamp post was made using A4 paper rolls which then was secured in place using hot glue.

During the placement of the IR pair, we realised that the IR components were interfering with each other and the acrylic sheet. So, we modified the sensor by pushing the sensor pair a little inwards from its casing so that we can achieve a direct straight beam of IR with less divergence in the surrounding. Also, during the placement of the sensor in the assembly, we simultaneously tested each IR sensor pair while hot gluing it to the assembly.

Code Implementation:

Flowchart of the main code:

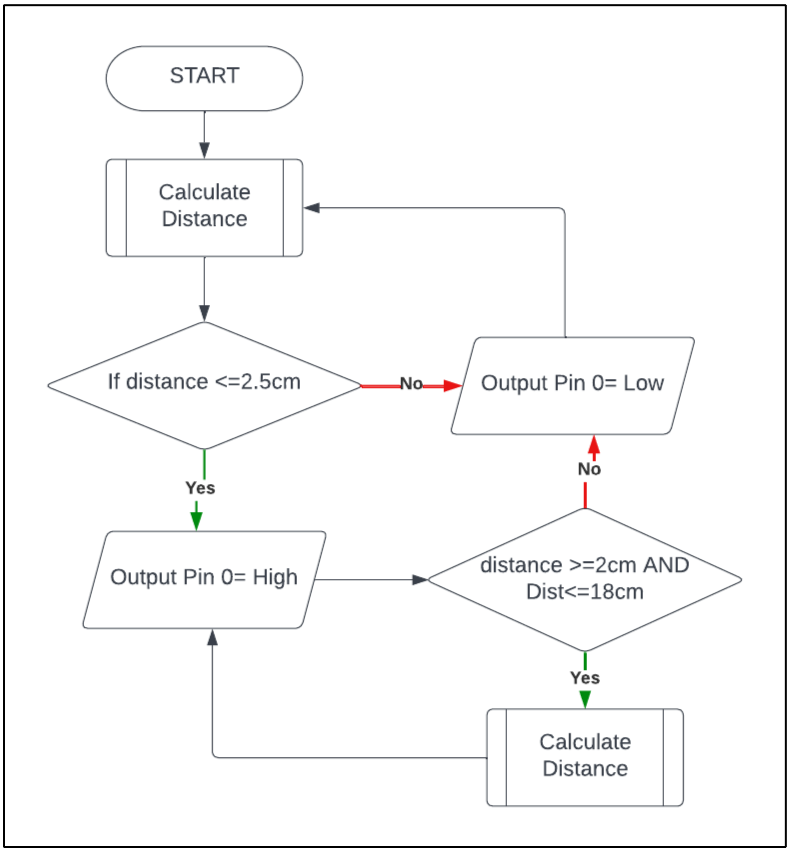
This is the flow chart of the algorithm we designed to control all the parts of this build.



Basically, it checks every input pin (input from IR sensor block) to detect the presence of an object (car). After which, it determines if the object is moving in forward direction or backward direction by checking the x+1 and x-1 pins. After the determination of the direction, three lights in the front of the object are turned on according to the direction of the movement. If the Object is moving in forward direction, then 3 lights in forward direction will turn on and vice versa.

A timer interrupt is used to check if someone is crossing the road and to check if daytime has started. According the decisions were made to turn on the red zebra cross light in case of someone crossing the road, or to switch off every single light and operation if its daytime.

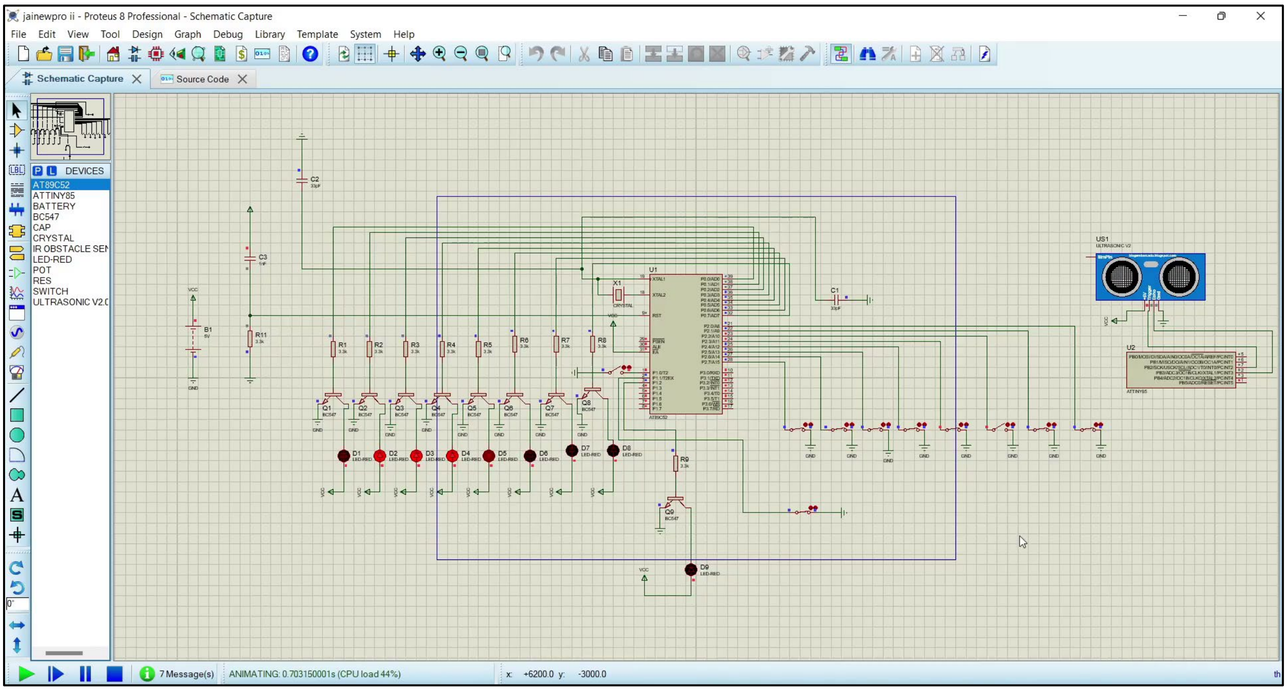
Flowchart of the smart zebra crossing code:



After calculating the distance using HCSR04 ultrasonic sensor, it will check if the person has reached the zebra crossing (if the starting distance is less than 2.5cm). If that’s true, then the zebra crossing lights will turn ON until the person has crossed the road. This eliminates the detection of vehicles as persons since the starting distance condition is not fulfilled.

Proteus simulation screenshot:

The entire operation was also simulated using Proteus.



To simulate the LDR and the IR sensor section, we directly used switches since they were not available in the Proteus.

The OPAMP section was increasing the simulation rendering time so that section was also removed from the simulation.

Final Results:

The PCB design was tested and using a suitable algorithm we were able to track the vehicle movement and turn ON three lights in front of it. Using timer interrupt we checked the status of different pins connected to zebra crossing and LDR and determined if the zebra crossing lights should be turned ON. Using LDR we determined if its daytime or not and acted accordingly.

Hence, we were successful to fulfil our initial aims.

Pros:

- Vehicle direction detection using custom IR sensors.
- Extended support for different models of IR transistor. This is possible because we used potentiometers to set the reference voltage which can be adjusted for different models of IR transistors.
- Only people walking on the zebra crossing will be detected and the vehicles will be ignored (since our algorithm ignores those movements)
- The PCBs can be stacked together in series to control multiples of 8 street lights. Only one extra flag pin will be required.
- Since we considered excess current requirements, this project can be easily connected to relays to control real 220V street lights.

Cons:

- It won't work if multiple cars are present on the road.
  Remedy: With multiple cars, we can turn ON all the lights (Normal operation) as it will ensure more safety. Also, the intention of using this system is to save power when very less cars are present on the road.
- If a person is crossing the road but not using the zebra crossing the system won't work.

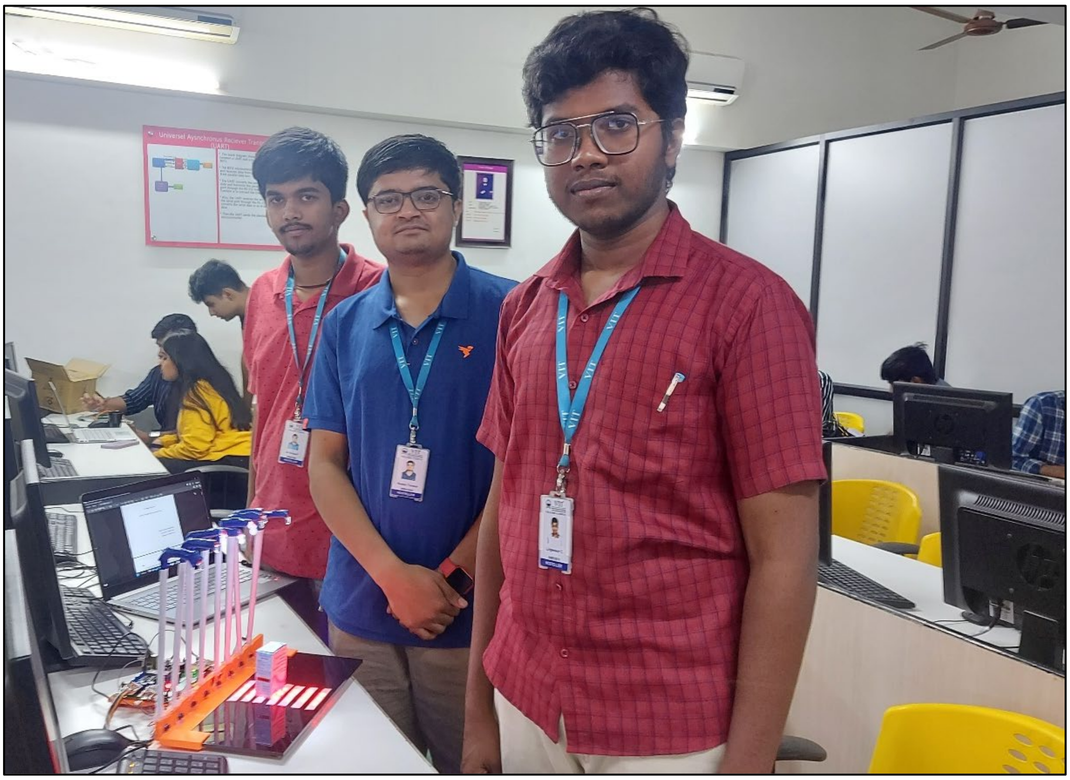
References:

- IR pair TCRT5000 datasheet by Vishay Intertechnology
- LM324 datasheet by Fairchild Semiconductor
- AT89S52 datasheet by Atmel
- HC49US Crystal 11.0592MHz datasheet by ILSI

The following reference papers were referred to take inspiration. Although, no circuit or method or any code shown was used directly for this project.

- Chetna Badgaiyan, Palak Sehgal, "Smart Street Lighting System", International Journal of Science and Research (IJSR), Volume 4 Issue 7, July 2015, 271 – 274.
- N. Yoshiura, Y. Fujii and N. Ohta, "Smart street light system looking like usual street lights based on sensor networks," 2013 13th International Symposium on Communications and Information Technologies (ISCIT), 2013, pp. 633-637, doi: 10.1109/ISCIT.2013.6645937.

Group Photo:



Group members (Left to Right):

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