LINE FOLLOWER & OBSTACLE AVOIDER ROBOT

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BE MECHATRONICS (Session 2022-2026)

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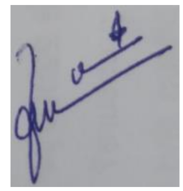
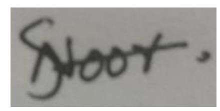
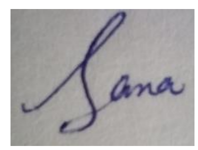
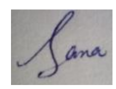
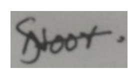
Team Member Name	**Role**	**Word count that each has written in assigned color code in report**	**Signature**
Fiza Fatima	Report writing Research Assembling schematic	Red 513	
Noor Ul Ain	Individual testing Individual code Code assembly Report Compilation	Blue 483	
Sana Raouf	Schematic Proteus Simulations PCB designing Soldering of Components	Green 521	
Sana and Noor	Individual testing of components		 

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Chapter 01: Preliminaries

Proposal

The project involves the design and development of REHBER robot that with follow a black line and avoid the obstacle. It will also have a functionality to store the path in SD Card and to display the values of circuit current, its voltages and the speed on a display and also sent these values on a mobile via Bluetooth.

1.1 Introduction

In the evolving field of robotics, integrating various functionalities in a single robot enhances its adaptability and usability in real-world applications. This proposal outlines the development of a multi-functional robot that can autonomously follow a line and avoid obstacles. This system is applicable in automated warehouses, manufacturing units, and other environments where robots must navigate pre-defined paths while avoiding potential hazards.

1.2 Objectives

The primary objectives of this project is to design an embedded System and firmware for a line-following robot that can:

- Implement obstacle detection and avoidance to ensure safe navigation.
- Ensure seamless integration between line-following and obstacle-avoiding functionalities.
- it will also detect the color of obstacle
- Upon reaching Point B it should reverse and recall the path to reach back Point A.
- Display the values of current, voltage and speed on OLED display.

1.3 System Overview

1.3.1 Hardware Components:

1. Chassis and Motors:

- A durable chassis equipped with DC motors for movement and steering.
- Motor drivers for controlling motor speed and direction.

2. Sensors:

- Line Follower Sensors:

  Infrared sensors (IR) to detect and follow lines on the ground.

- Obstacle Sensors:

  Ultrasonic or IR sensors to detect obstacles in the robot's path.

- Color sensor:

  To detect the color of obstacle

3. Microcontroller:

   A microcontroller (e.g. ESP32) to process sensor data and control actuators.

4. Power Supply:

   Battery pack providing sufficient power for all components.

1.3.2 Expected Outcomes:

- A fully functional robot capable of navigating a pre-defined path while avoiding obstacles.
- Demonstration of seamless interaction between line-following and obstacle-avoidance systems.
- Enhanced operational efficiency in environments requiring automated navigation.

1.3.3 Initial feasibility:

The proposed robot is feasible using widely available components, such as infrared sensors for line following and ultrasonic sensors for obstacle detection. The integration of these systems is straightforward with common microcontrollers (e.g., esp32). Preliminary tests indicate that the chosen algorithms for line detection and obstacle avoidance can operate in real-time with minimal computational overhead. The estimated cost and development time are reasonable, aligning with typical budget constraints and project timelines for similar robotics projects.

1.3.4 Technical Standards:

Specifications for Components of the Obstacle Avoider with Line Follower Robot

1. Small DC Motor Speed:

- Typical Speed: 100 to 600 RPM (Revolutions Per Minute)
- We use: 120 RPM
- Example: A small DC motor rated at 200 RPM provides a good balance between speed and torque for lightweight robotic applications.

2. Small IR Sensor Range:

- Typical Range: 2 to 80 cm
- We use: 2-10 cm for short-range

3. Length of 3-Wheeler Chassis:

- Typical Length: 10 to 20 cm
- We use:

~12 cm

4. Ultra-sonic sensor:

- Range: 2 cm to 4 meters
- Accuracy: ± 3 mm

1.4 Team Roles & Details:

1.4.1 Work Distribution:

SANA RAUF (221701)

- ✓ PCB designing and simulation
- ✓ Soldering

FIZA FATIMA (221692)

- ✓ Research
- ✓ Lab report
- ✓ Assembling

NOOR-UL-AIN (221704)

- ✓ Codes
- ✓ Assemble
- ✓ Testing

1.4.2 Work Break down structure:

Phases

To ensure precise project execution, it has been structured into two distinct phases, each addressing specific aspects of development and functionality.

First phase:

During the initial phase, our main goal was to create a robot car capable of tracking and staying on a designated path marked by a line. We developed and fine-tuned the car's mechanisms and sensors to ensure precise navigation along the line's route. This foundational step laid the groundwork for future enhancements and functionalities, setting the stage for more complex tasks in subsequent phases of the project.

Second phase:

In the second phase, our focus shifted to enhancing the robot's capabilities by constructing a PCB (Printed Circuit Board) housing obstacle avoidance components. These components, integrated into the robot's system, enable it to detect obstacles in its path and take appropriate actions to navigate around them. This phase involved designing and implementing the circuitry necessary for obstacle avoidance, thereby augmenting the robot's functionality beyond basic line following.

1.5 Estimated budgets:

Cost of project:

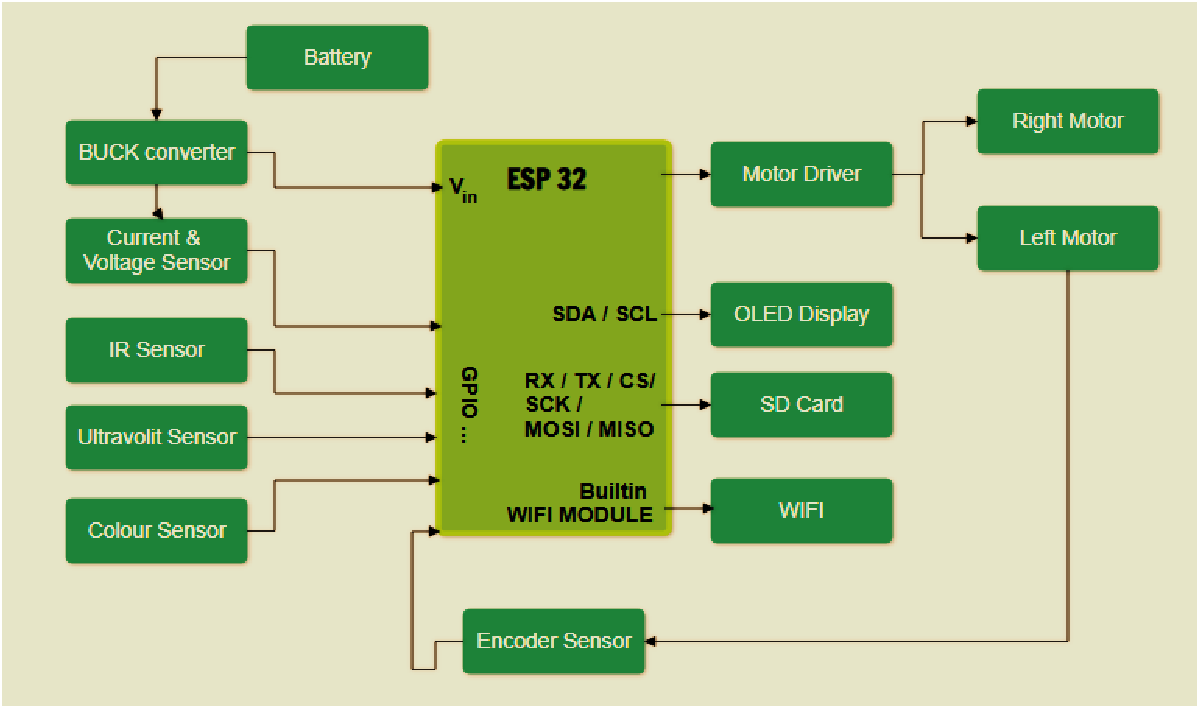
Components	Quantity	Cost
ESP32	1	1100
Battery	1	1000
IR sensor	3	120x3 = 360
IR encoder	1	120
Ultrasonic Sensor	1	200
Color sensor	1	1300
L298 mini Motor driver	1	140
Buck Converter	1	370
SD card Module	1	150
Car Casing + motors + wheels	1	1200
Current sensor	1	320
Voltage sensor(resistor)	2	5
OLED Display	1	500
Jack + switch +headers	1 +1 +3	30+20+90
PCB Board	1	700
Total	**22**	**7610**

Estimates amount: Rs. 8000

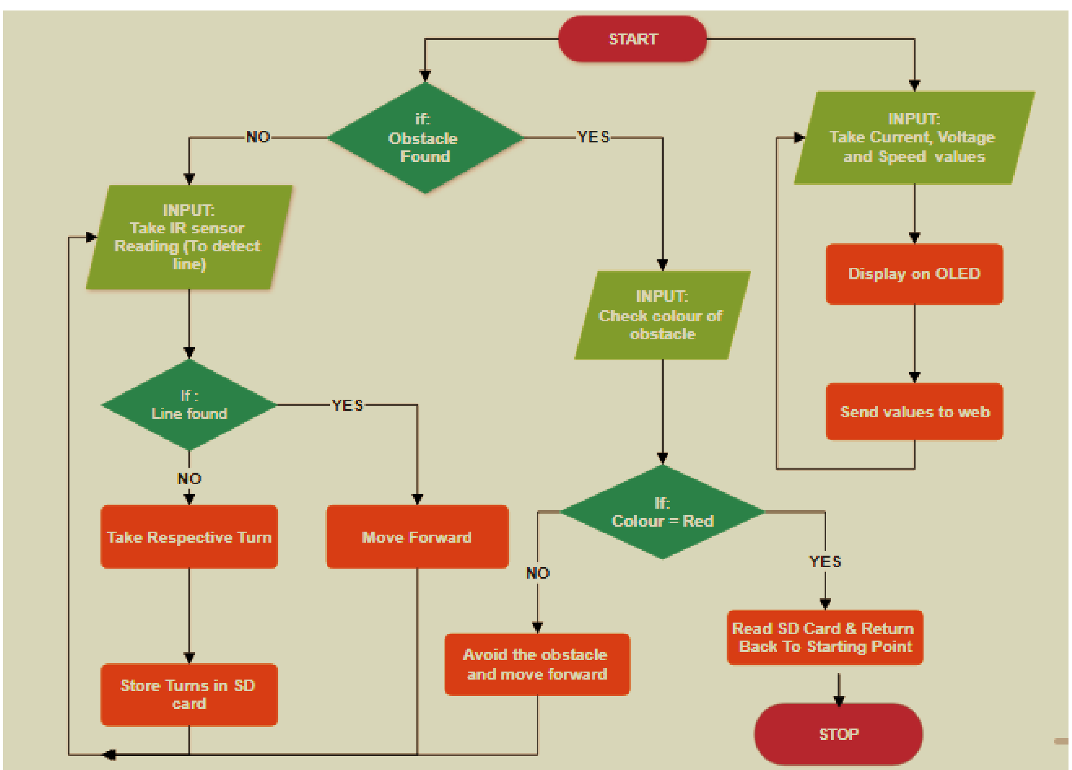
Chapter 2-Product Design:

2.1 Block Diagram:

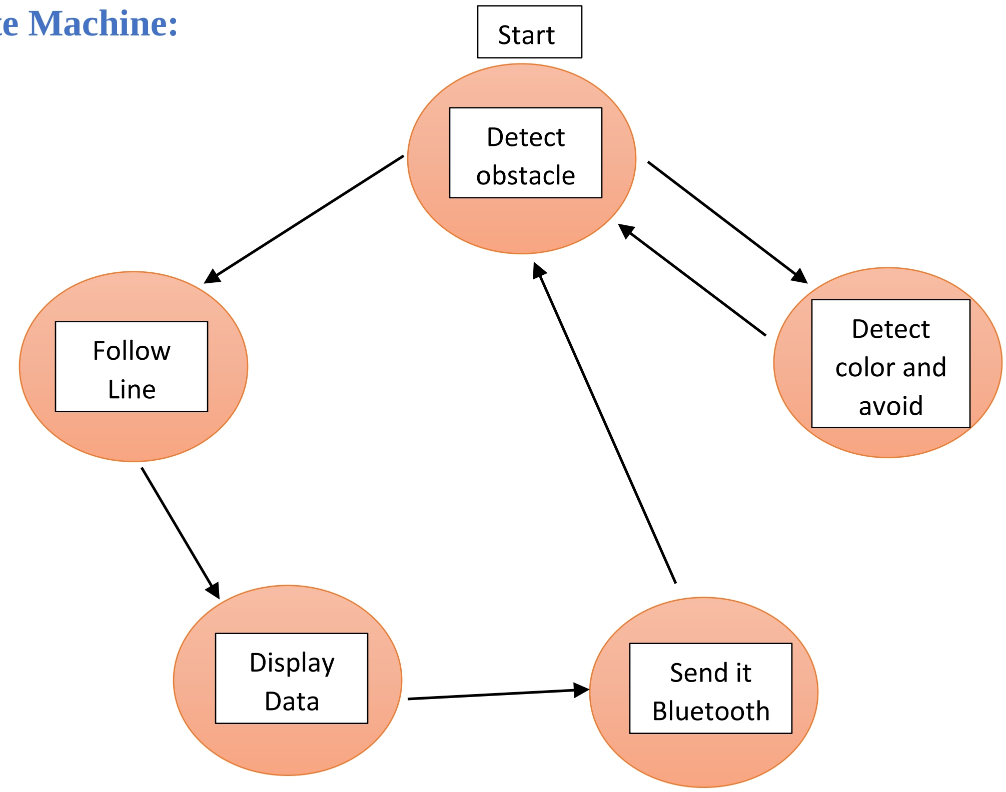
The block diagram of Our robot is as follow:



2.2 Flow Chart:



2.3 State Machine:



Chapter 3- Electronics Design and Sensor Selections:

3.1 Component Selection:

3.1.1 Component List:

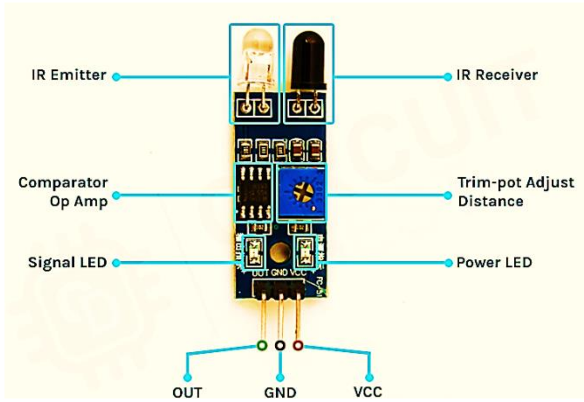
Components:

- ESP32
- battery
- IR sensor module
- IR encoder/ speed sensor
- Ultrasonic Sensor
- Color sensor
- SD card module
- Current sensor
- Voltage sensor.
- OLED display
- Motor driver module.
- Car casing
- Motor + wheels

3.1.2 Sensor Description:

IR Sensor:

IR sensor detect if the car is on the black line or not. IR Sensor module has an Infrared transmitter led and an Infrared receiver LED. Transmitter LED transmit the IR rays, if the object reflects the rays, the Receiver LED receive the ray and give a signal 1 or 0 to the microcontroller and if object absorb the ray the receiver LED will not receive the rays back, so it will give opposite signal to microcontroller.

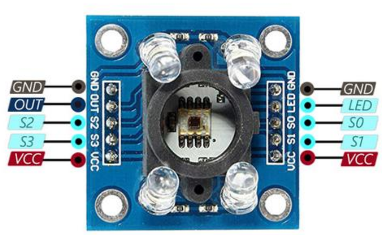


Ultrasonic Sensor:

Ultrasonic Sensor the measure the distance of object using an ultrasonic sound wave. By using this sensor, we can detect the obstacle in the path of the car at a specific distance.

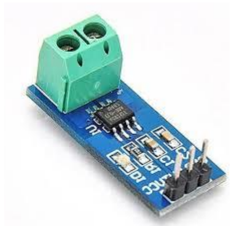
Color Sensor:

Color Sensor detect the frequency of red, green, and blue color. We can detect any color by the frequency of color ad perform specific task on a specific color.



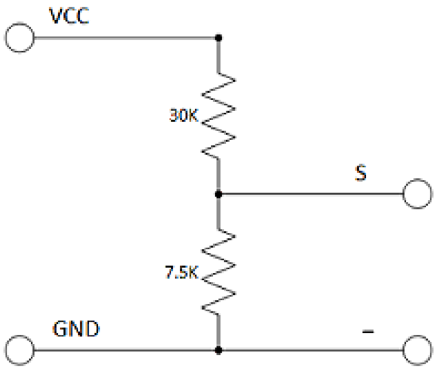
Current Sensor:

Current sensor tells the value of current passing through the circuit. It is connected in series with the circuit.

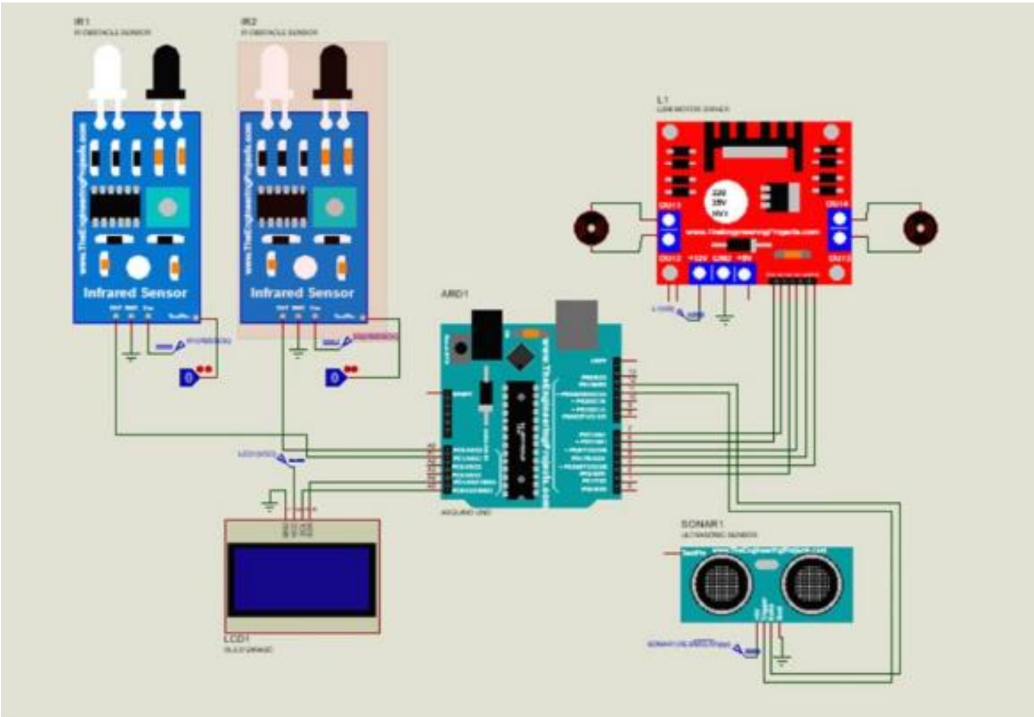


Voltage Sensor:

Voltage Sensor tells the voltage across the circuit. It is connected in parallel with the component or circuit. Voltage sensor can also be made using a voltage divider circuit.

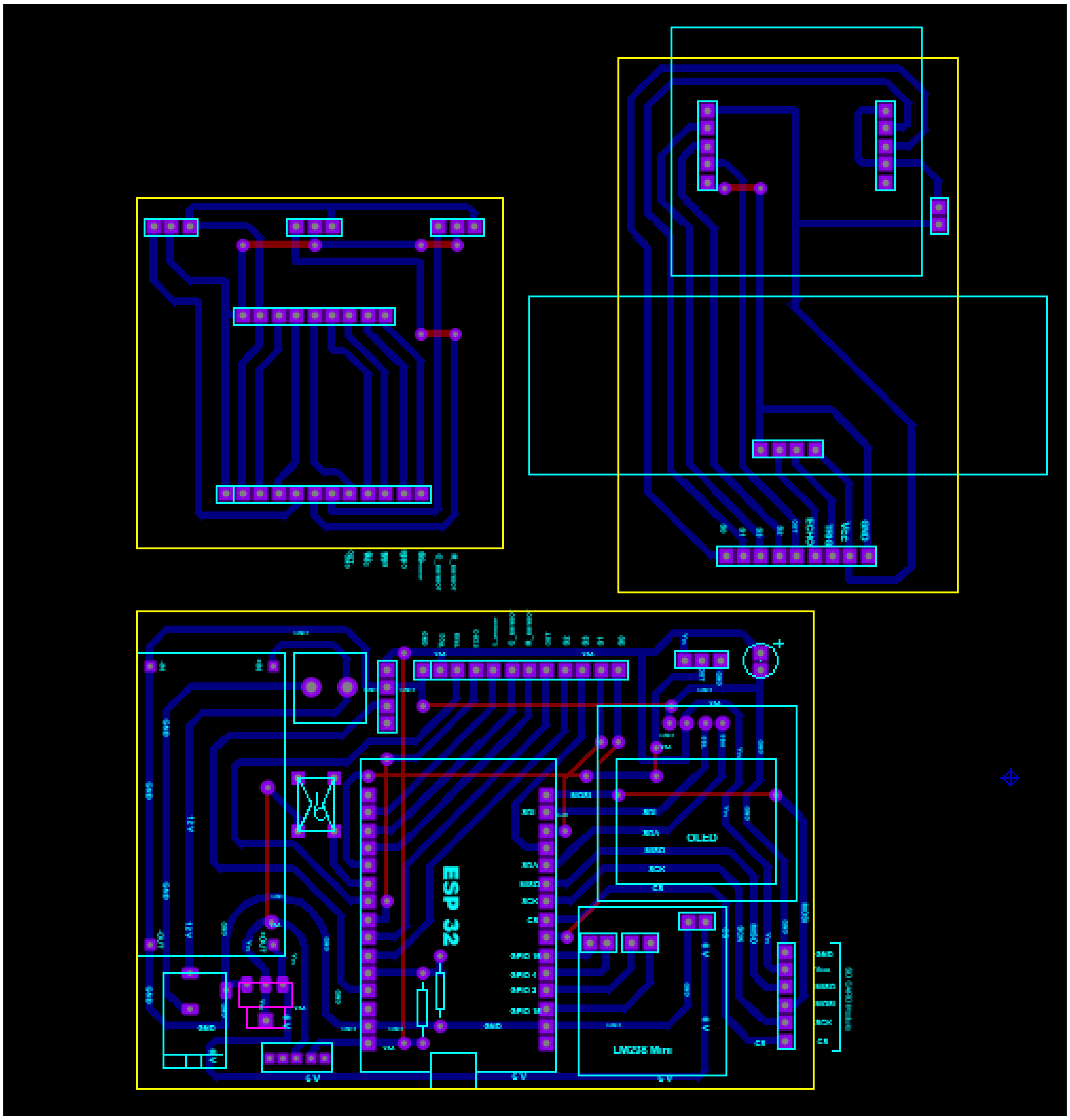


3.2 Schematic:

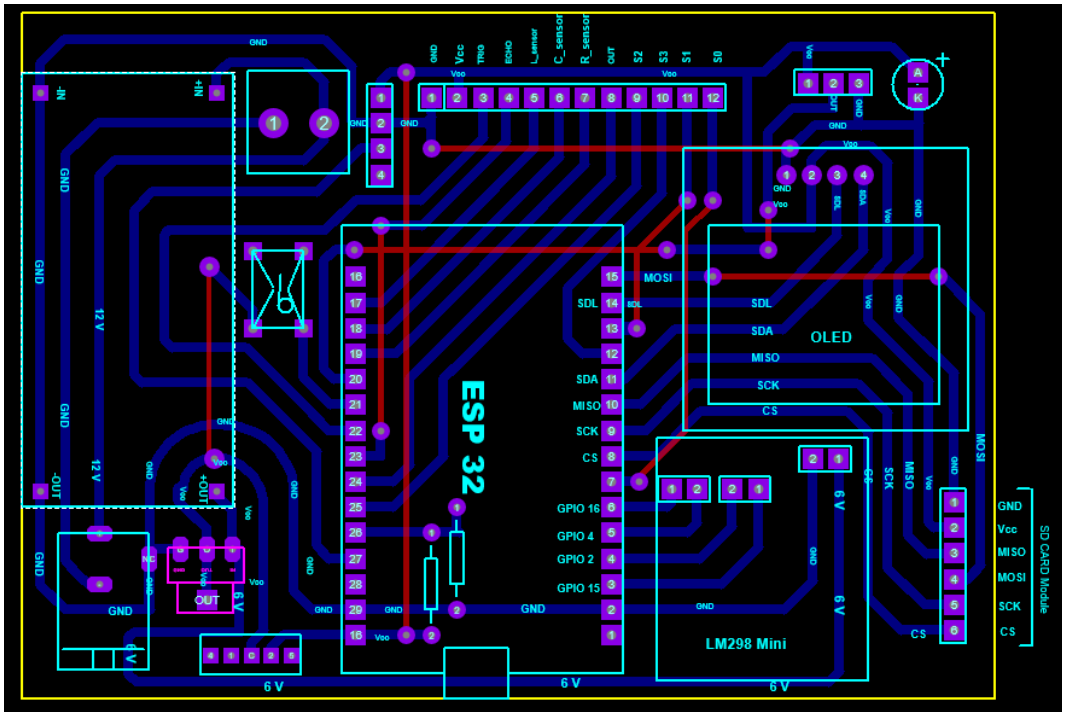


3.3 PCB Design:

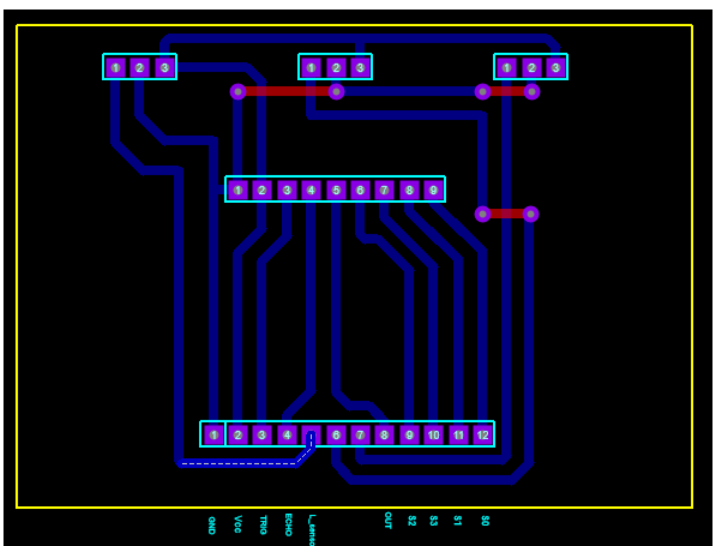
The PCB is designed in three parts and all of them will be connected to the each other to complete the circuit.

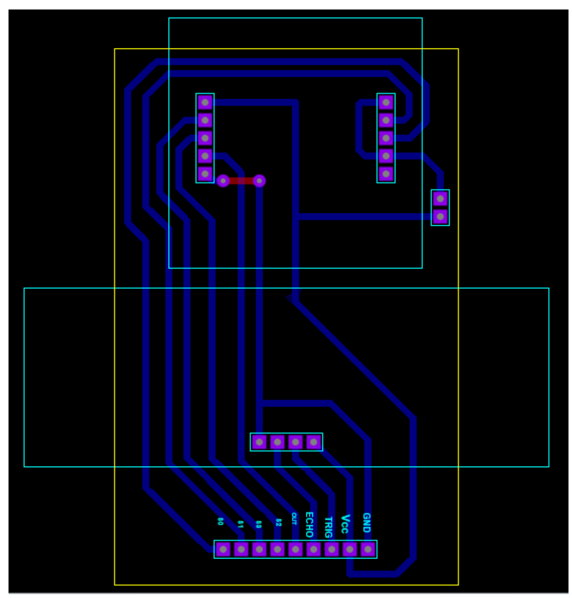


The following design has the voltage sensor, current sensor, IR encode Sensor and a buck converter, motor driver, SD card and an OLED display connected to ESP 32.



These are the PCBs of the front sensors that will follow the line and detect the obstacle. it includes IR sensors, Ultrasonic sensor, Color sensor.





Chapter 4: Software and firmware Design:

4.1 Input / Output Pins:

- IR Sensors (GPIO 36, GPIO 39, GPIO 34)
- Ultrasonic Sensor (GPIO 33, GPIO 25)
- Color Sensor (GPIO 17, GPIO 1, GPIO 3 , GPIO 26 , GPIO 27)

- Motor Driver (GPIO 16, GPIO 4, GPIO 2, GPIO 15)
- Current Sensor (GPIO 35)
- Voltage Sensor (GPIO 14)
- IR Encoder Sensor (GPIO 12)

4.2 Controller selection:

- ESP 32 WRROM, WITH built-in WIFI and Bluetooth module.

4.3 Software Used:

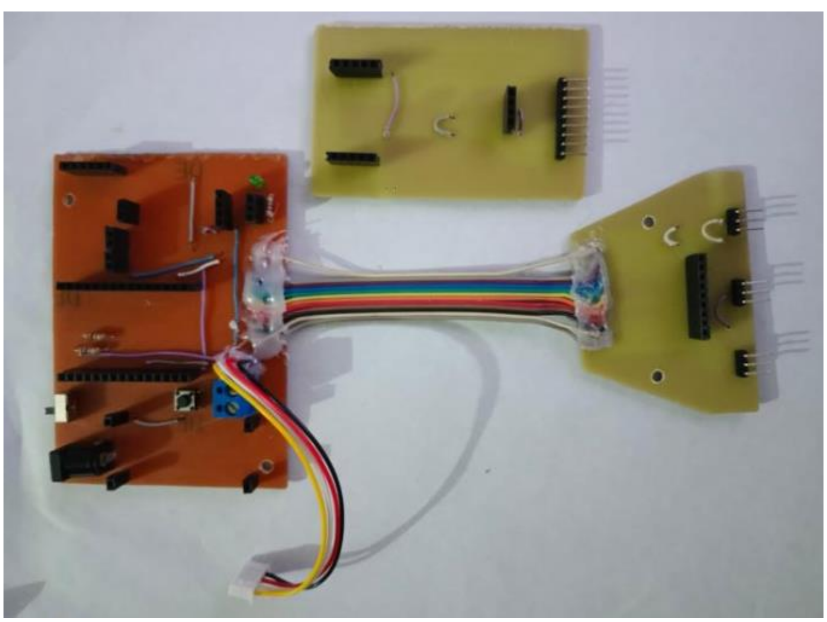
- For PCB AND schematic designing we use Proteus 8.13 Software
- For Coding we use Arduino Ide Software.

Chapter 05 System Test Phase:

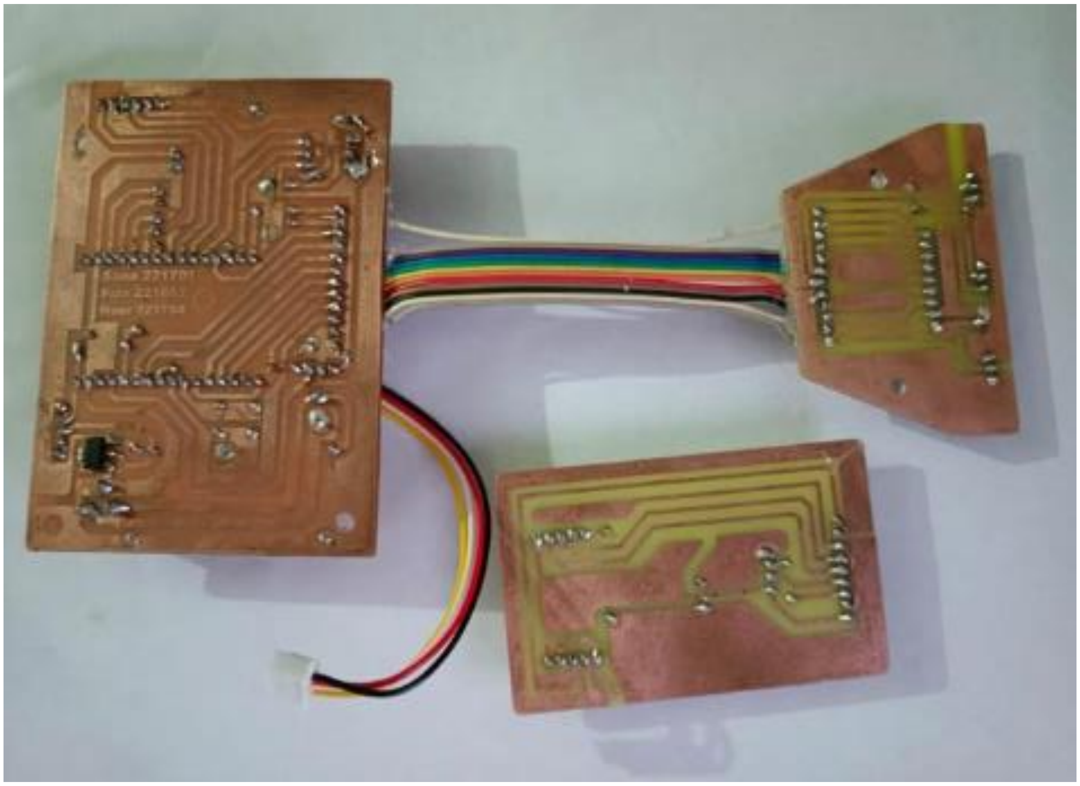
5.1 Project Actual Pictures:

PCB

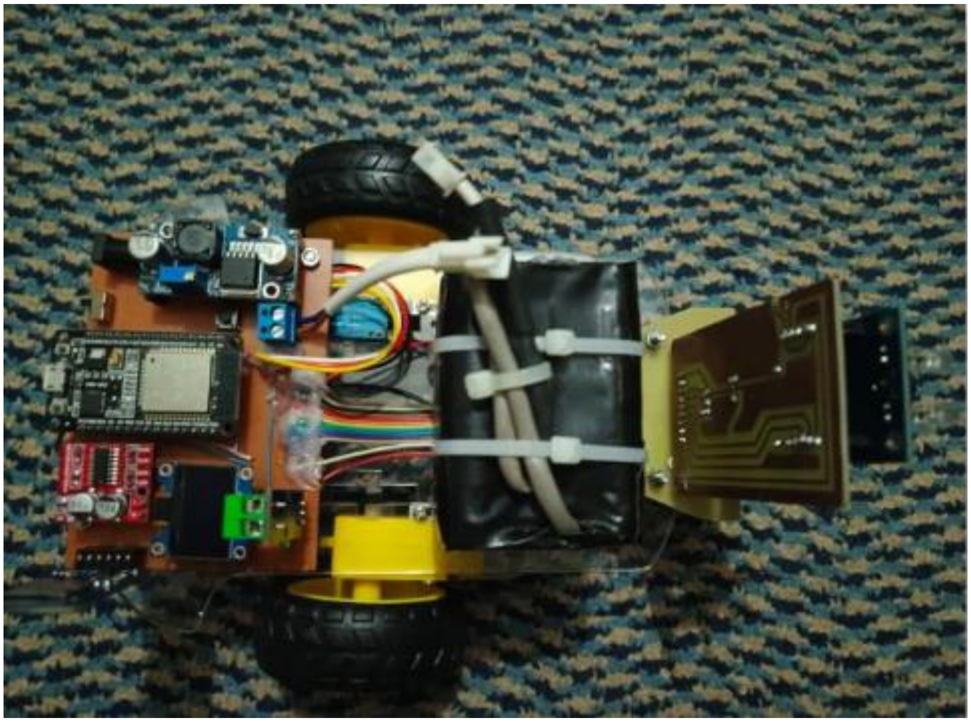
Top side:

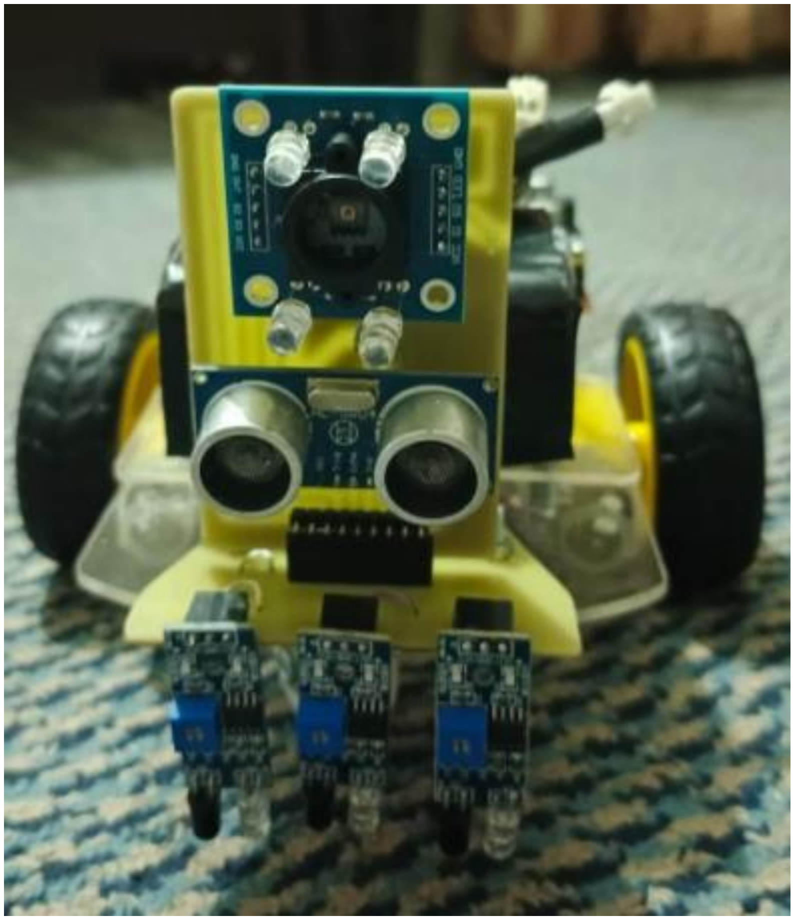


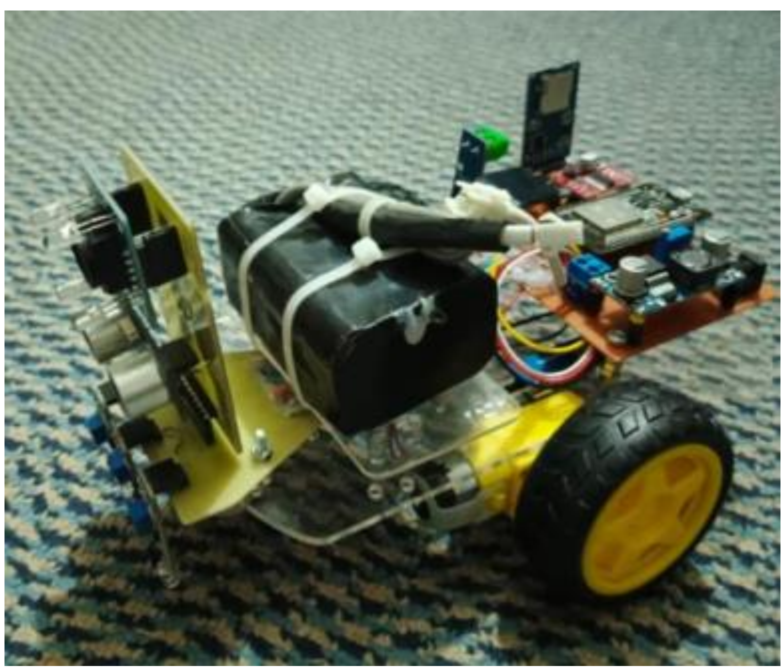
Copper Side:



Final Project Pictures:







Chapter 6 Applications And conclusion

6.1 Applications in the future world of robotics:

- At our current stage, we're crafting this technology on a small scale, envisioning its potential future integration into advanced automotive systems.
- Our project integrates two distinct technologies: line-following and obstacle avoidance, laying the groundwork for broader applications in vehicular automation.
- Industrial Automation: Implementing the LFR technology in factories can optimize material handling processes by efficiently navigating through production lines while avoiding obstacles.
- Autonomous Delivery Systems: Utilizing LFR-equipped vehicles can enhance delivery services by autonomously navigating through urban environments, avoiding obstacles, and memorizing delivery routes for increased efficiency.
- Agricultural Robotics: LFR-enabled robots can assist in precision farming tasks, such as crop monitoring and harvesting, by navigating through fields, avoiding obstacles, and memorizing optimal paths for subsequent operations.

6.2 Conclusion:

Our project successfully integrated both line-following and obstacle avoidance functionalities, showcasing a versatile and efficient robotic system and also sending the data to the web using IOT. By employing sensor fusion and effective algorithmic design, we achieved seamless navigation in diverse environments. Through rigorous testing and iteration, we ensured robust performance and reliability in real-world scenarios. This project underscores the importance of interdisciplinary collaboration and creative problem-solving in robotics engineering. Overall, our achievement signifies a significant step forward in the development of autonomous systems with practical applications in various fields.

Appendix

Connections of sensors: