Design and Project Laboratory

Laboratory report submitted for the partial fulfillment
of the requirements for the degree of

Bachelor of Technology
in
Electronics and Communication Engineering

by

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Chapter 1

Project 1: Line Follower Robot

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1.1 List of Components used

Table 1.1: List of Components

S.No.	Component	Specification/ Model No.
1	Transformer/DC Source	12V,5V
2	Diode	1N4007
3	Comparator IC	LM358
4	Resistance	220kΩ
4	Motor Driver Module	L298N
5	IR Sensor Module	LM393
6	LED	
7	DC Motor	
8	Potentiometer	

1.2 Introduction

A Line Follower Robot is an autonomous robotic system designed to follow a predefined path, typically a black line on a white surface or vice versa. It is widely used in industrial automation, material handling, and educational robotics.

This project implements a Line Follower Robot using an L298N motor driver module without a microcontroller. Instead of an Arduino, the system uses operational amplifiers (comparators) to process signals from Infrared (IR) sensors, which detect the line and control the movement of the robot.

The L298N motor driver module plays a crucial role in driving the two DC motors efficiently. It receives signals from the comparator circuit, which determines whether the robot should move forward, stop, or turn based on sensor readings. By utilizing simple analog electronics, this design eliminates the need for programming, making it a cost-effective and straightforward solution for autonomous navigation.

This approach to line following robots demonstrates an efficient and practical way to develop autonomous movement using hardware-based logic, making it ideal for beginners and enthusiasts looking to understand basic robotics concepts. [3]

1.3 Working Principle of Sensor

1.3.1 Introduction

An **Infrared (IR) sensor** is an electronic device that detects infrared radiation from objects in its field of view. It operates based on the principles of infrared emission and reflection. The sensor typically consists of an **IR transmitter (LED)** and an **IR receiver (photodiode or phototransistor)**.

1.3.2 Working Principle

1. **Emission of IR Rays:** The IR transmitter (IR LED) emits infrared light, which is invisible to the human eye. This infrared radiation travels through the air and may encounter an object.

2. **Reflection and Absorption:** If an object is present in front of the sensor, it reflects some or all of the infrared rays. The amount of reflected IR light depends on the object's surface characteristics. Light-colored or reflective surfaces reflect more IR, while dark surfaces absorb more.

3. **Detection by IR Receiver:** The IR receiver (a photodiode or phototransistor) detects the reflected infrared light. When IR light falls on the receiver, its electrical resistance changes, generating an output signal.

4. **Signal Processing and Output:** The output signal from the receiver is processed using an electronic circuit (such as a comparator or microcontroller). The sensor provides a digital or analog output, depending on the circuit design, to indicate the presence or absence of an object.

1.3.3 Types of IR Sensors

- **Active IR Sensors:** Consist of both an IR emitter and receiver. Work based on reflection or interruption of the IR beam. Used in proximity sensors, obstacle detection, etc.

- **Passive IR (PIR) Sensors:** Detect infrared radiation emitted by warm objects (e.g., humans, animals). Commonly used in motion detection applications.

1.3.4 Applications of IR Sensors

- Obstacle detection in robotics
- Automatic door opening systems
- Line-following robots
- Motion detection and security systems
- Temperature measurement and remote controls

1.4 Actuator Used

1.4.1 LM358 Comparator (Signal Processing for Sensors)

The **LM358** is an operational amplifier used as a comparator in the line follower robot. Its role includes:

- Receiving signals from infrared (IR) sensors or Light Dependent Resistors (LDRs).
- Comparing the sensor output voltage with a reference voltage.
- Outputting a **LOW (0V)** signal when a black line is detected and **HIGH (5V)** when a white surface is detected.
- Sending processed signals to the microcontroller or motor driver.

Pin Number	Pin Name	Description
1	Output A	Output of Operational Amplifier A
2	Inverting Input A	Inverting Input of Op-Amp A
3	Non-Inverting Input A	Non-Inverting Input of Op-Amp A
4	Vcc (GND)	Ground (Negative Power Supply)
5	Non-Inverting Input B	Non-Inverting Input of Op-Amp B
6	Inverting Input B	Inverting Input of Op-Amp B
7	Output B	Output of Operational Amplifier B
8	Vcc (+)	Positive Power Supply

Table 1.2: LM358 IC Pinout Table

Pin Number	Pin Name	Description
1	Enable A (ENA)	Enables PWM signal for Motor A
2	Input 1 (IN1)	Input for Motor A (Direction Control)
3	Input 2 (IN2)	Input for Motor A (Direction Control)
4	Ground (GND)	Ground (Common with power supply)
5	Ground (GND)	Ground (Common with power supply)
6	Output 1 (OUT1)	Motor A Output Terminal 1
7	Output 2 (OUT2)	Motor A Output Terminal 2
8	Vcc (Motor Supply)	Supply Voltage for Motors (Up to 35V)
9	Enable B (ENB)	Enables PWM signal for Motor B
10	Input 3 (IN3)	Input for Motor B (Direction Control)
11	Input 4 (IN4)	Input for Motor B (Direction Control)
12	Ground (GND)	Ground (Common with power supply)
13	Ground (GND)	Ground (Common with power supply)
14	Output 3 (OUT3)	Motor B Output Terminal 1
15	Output 4 (OUT4)	Motor B Output Terminal 2
16	5V (Logic Supply)	Logic Power Supply (5V for internal circuit)

Table 1.3: L298N Motor Driver Pinout Table

1.4.2 L298N Motor Driver Module (Motor Control)

The **L298N** is an H-bridge motor driver that manages the speed and direction of the DC motors. It operates as follows:

- Receives signals from the microcontroller or LM358 comparator.
- Adjusts the rotation of the motors based on sensor input.
- Controls the speed of the motors using Pulse Width Modulation (PWM).

1.4.3 DC Motors (Movement of the Robot)

The **DC motors** are responsible for the movement of the robot. Their behavior is controlled by the L298N motor driver as follows:

- **Both motors move forward** $\Rightarrow$ Robot moves straight.
- **Right motor stops, left motor moves** $\Rightarrow$ Robot turns right.
- **Left motor stops, right motor moves** $\Rightarrow$ Robot turns left.
- **Both motors stop** $\Rightarrow$ Robot stops.

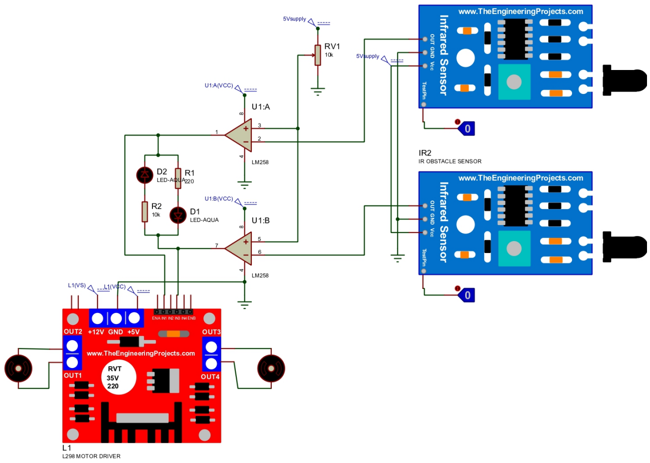

Figure 1.1: Circuit Diagram of Line Follower

1.5 Circuit Diagram and Explanation

1.5.1 IR Obstacle Sensors

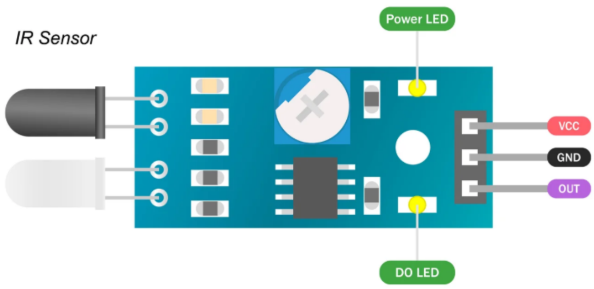

Figure 1.2: IR Sensor
[1]

- Two **IR sensors** are used in the circuit.
- Each sensor has three pins:
  - **Vcc (5V)**: Connected to the **5V supply**.
  - **GND**: Connected to **ground**.
  - **OUT**: The **output** signal of each sensor is connected to the **inverting inputs** (pins **2** and **6**) of the **LM358** comparator.

1.5.2 Operational Amplifier (LM358)

- The **LM358** contains **two comparators** (U1:A and U1:B).
- **Non-inverting inputs (Pin 3 & Pin 5)** receive signals from the IR sensors.
- **Inverting inputs (Pin 2 & Pin 6)** receive a **reference voltage** set by a **10k potentiometer (RV1)**.
- **Comparator Outputs (Pin 1 & Pin 7)**:
  - When an obstacle is detected, the comparator output changes state.

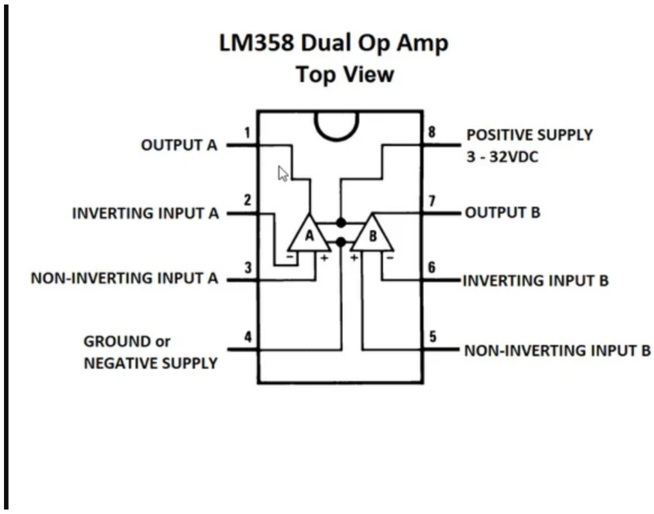

Figure 1.3: LM358 Pin Diagram
[2]

- **D1 (LED-AQUA) and D2 (LED-AQUA)** are connected via **R1 (220Ω) and R2 (10kΩ)** to indicate detection.

1.5.3 Motor Driver (L298N)

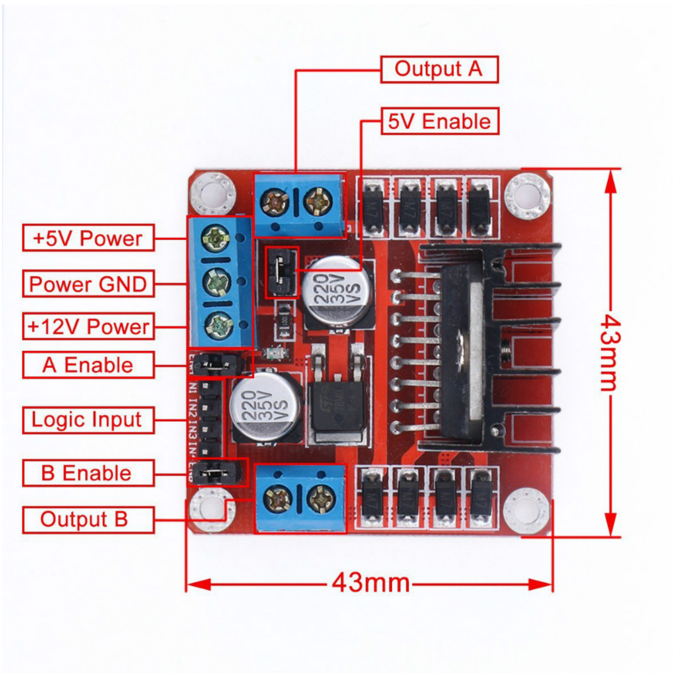

Figure 1.4: L298N Motor Driver Module

- The **L298N motor driver module** controls **two DC motors**.
- **Power Connections**:
  - **+12V**: Motor power supply.
  - **+5V**: Logic supply for the internal circuit.
  - **GND**: Connected to the common ground of the circuit.
- **Inputs from LM358**:

  - The outputs of the **LM358 comparator (Pin 1 Pin 7)** are connected to the **input pins of the L298N motor driver**.
  - These inputs determine the motor direction and movement.

- **Motor Outputs**:
  - **OUT1 & OUT2** control **Motor 1**.
  - **OUT3 & OUT4** control **Motor 2**.

1.5.4 Summary

1. **IR sensors detect obstacles** and send signals to the **LM358 comparators**.
2. **LM358 compares** the sensor output with a reference voltage.
3. **Comparator outputs** control the **L298N motor driver** inputs.
4. **L298N drives two motors** based on the comparator output.

This setup is commonly used in **autonomous robots**, **line-following robots**, or **obstacle-avoiding robots**.

1.6 Working of Project

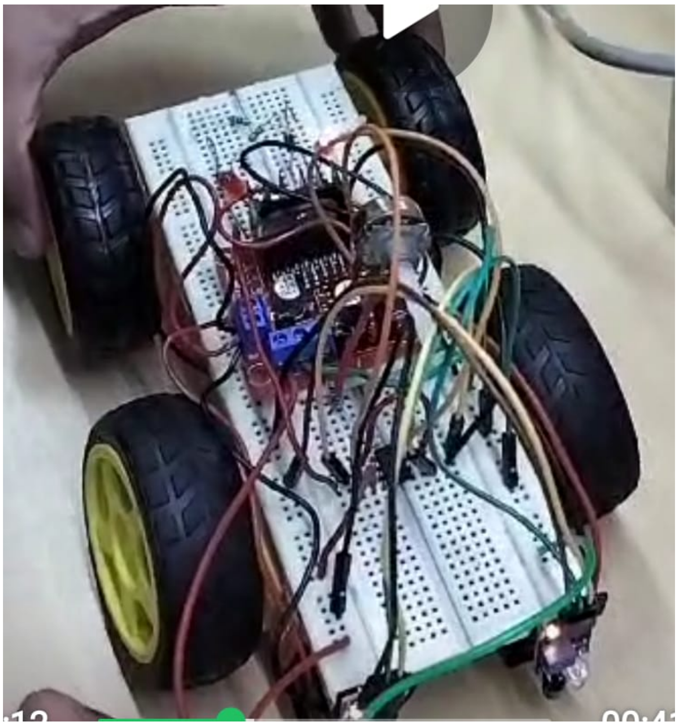

Figure 1.5: Line Follower Bot

1.6.1 IR Sensor Functionality

The IR sensors detect the surface color:

- **Black Surface**: Sensor output is **LOW** (5V).
- **White Surface**: Sensor output is **HIGH** (0V).

1.6.2 LM358 Comparator Operation

The LM358 consists of two operational amplifiers functioning as comparators:

- The non-inverting input (+) is connected to a reference voltage set by a potentiometer (RV1).
- The inverting input (-) is connected to the IR sensor output.
- If the sensor detects black, the comparator output is **LOW**.
- If the sensor detects white, the comparator output is **HIGH**.

1.6.3 Motor Control using L298N

The L298N motor driver receives signals from the LM358 comparators and drives the motors accordingly:

Left Sensor	**Right Sensor**	**Left Motor**	**Right Motor**
White (1)	White (1)	Forward	Forward
Black (0)	White (1)	Stop/Slow	Forward
White (1)	Black (0)	Forward	Stop/Slow
Black (0)	Black (0)	Stop	Stop

Table 1.4: Motor control based on sensor readings

1.7 Conclusion

1. We have learned the skill of designing and implementing a line follower robot using LM358 and L298N. Through this project, we have gained hands-on experience in working with sensors, operational amplifiers, and motor drivers, enhancing our understanding of autonomous robotics.
2. We have analyzed the project by understanding the working of IR sensors, comparators, and motor drivers. The role of each component in detecting and responding to a line-following path was examined, and we evaluated the circuit's performance in various conditions.
3. Future scope of the project includes improving sensor accuracy by using advanced IR modules, implementing PID control for smoother navigation, and integrating AI-based algorithms to enhance decision-making capabilities. Additionally, wireless control and obstacle detection features can be incorporated for greater functionality.

Bibliography

[1] ADIY. IR Sensor Module with Pot, February 2025.

[2] Kapil Kumar. LM358 IC and Its Applications, May 2022.

[3] Lavanya R. How to make line following robot without using microcontroller, October 2021.