# IMPLEMENTING LINE DETECTION AND FOLLOWING USING LM358

**ECB1204 - ANALOG INTEGRATED CIRCUIT**

**A PROJECT REPORT**

***Submitted by***


**SAMUEL JERRY B**

**SRI NARAEN N S**

**ROHAN MOORTHY S**

**AHMED A**


***in partial fulfillment for the award of the degree***

***of***

**BACHELOR OF ENGINEERING**

***in***

**ELECTRONICS AND COMMUNICATION ENGINEERING**


**K.RAMAKRISHNAN COLLEGE OF TECHNOLOGY**

(An Autonomous Institution, Affiliated to Anna University Chennai and Approved by AICTE, New Delhi)

**SAMAYAPURAM, TIRUCHIRAPPALLI – 621 112**


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# K. RAMAKRISHNAN COLLEGE OF TECHNOLOGY (AUTONOMOUS)

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## BONAFIDE CERTIFICATE

Certified that this project report titled **"IMPLEMENTING LINE DETECTION AND FOLLOWING USING LM358"** is the bonafide work of **SAMUEL JERRY B (2303811710621093), SRI NARAEN N S (2303811710621104), ROHAN MOORTHY S (2303811710621091), AHMED A (2303811710621301)** who carried out the project under my supervision. Certified further, that to the best of my knowledge the work reported herein does not from part of any other project report or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

| | |
|---|---|
| **SIGNATURE** | **SIGNATURE** |
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| **HEAD OF THE DEPARTMENT** | **SUPERVISOR** |
| Assistant Professor | Assistant Professor |
| Department of Electronics and Communication Engineering | Department of Electronics and Communication Engineering |
| K Ramakrishnan College of Technology (Autonomous) | K Ramakrishnan College of Technology (Autonomous) |
| Samayapuram – 621 112 | Samayapuram – 621 112 |

Submitted for the viva-voce examination held on ………………

**INTERNAL EXAMINER** **EXTERNALEXAMINER**

# DECLARATION

We jointly declare that the project report on **IMPLEMENTING LINE DETECTION AND FOLLOWING USING LM358** is the result of original work done by us and best of our knowledge, similar work has not been submitted to **“ANNA UNIVERSITY CHENNAI”** for the requirement of Degree of **BACHELOR OF ENGINEERING**. This project report is submitted on the partial fulfillment of the requirement of the award of Degree of **BACHELOR OF ENGINEERING**.

**Signature**

SAMUEL JERRY B

SRI NARAEN N S

AHMED A

ROHAN MOORTY S

Place: Samayapuram

Date:

# ACKNOWLEDGEMENT

It is with great pride that we express our gratitude and in-debt to our institution **K. Ramakrishnan College of Technology (Autonomous)**, for providing us with the opportunity to do this project.

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# CHAPTER 1

## PROBLEM STATEMENT

In today's rapidly advancing technological world, robotics has become a cornerstone of innovation, automation, and education. However, despite its importance, access to robotics learning is often hindered by the high cost, complexity, and technical expertise required for most robotic systems. Line-following robots, for example, are widely used in academic and industrial contexts to demonstrate principles of automation, control systems, and real-time navigation. Unfortunately, these systems often rely on microcontrollers, advanced sensors, and complex programming, which may deter beginners and hobbyists from engaging in hands-on learning.

The challenge lies in creating a robotic system that is both affordable and accessible while retaining essential functionality. Students, particularly in resource-limited educational institutions, need a platform to learn robotics that does not require prior knowledge of programming or microcontroller-based electronics. The lack of such solutions has created a gap between theoretical learning and practical application, limiting opportunities for innovation and skill development.

To address this issue, the project proposes designing a LumoTrack Bot that operates purely on analog components, such as operational amplifiers, transistors, and IR sensors, eliminating the need for microcontrollers. This design is cost-effective, easy to assemble, and provides a foundational understanding of robotics and control systems. By focusing on simplicity and functionality, this project aims to bridge the gap between affordability and accessibility in robotics education.

## 1.1 BACKGROUND OF THE WORKING

Line-following robots have long been used as an entry point into robotics and automation due to their simple yet effective functionality. Traditional designs often rely on microcontrollers like Arduino, Raspberry Pi, or PIC, which offer flexibility and precision for controlling motor speeds and sensor data processing. These microcontroller-based systems are highly programmable and suitable for complex tasks but come with challenges like higher costs, increased complexity, and the requirement for programming knowledge. While these systems are ideal for advanced users, they pose significant barriers for beginners and educators looking for cost-effective, easy-to-implement solutions for robotics learning.

In recent years, there has been a growing interest in designing analog robots that eliminate the need for microcontrollers, focusing instead on operational amplifiers, transistors, and simple sensors like IR modules. Such designs aim to simplify robot functionality while retaining core features like path-following and obstacle detection. Analog designs, though less flexible, are highly accessible and cost-effective, making them ideal for educational use. Previous research and prototypes have shown that basic automation tasks, such as line-following, can be effectively achieved using analog circuits, highlighting the potential of these systems as affordable and beginner-friendly alternatives to microcontroller-based designs. This project builds upon these ideas to create a robust and low-cost Tiny Line Follower Robot using analog components.

# CHAPTER 2

## DESIGN PROCEDURE

The **Line Follower Robot** uses two LEDs and LDRs (Light Dependent Resistors) to detect the line. Here is the updated design procedure:

Identify the robot's basic functionality, such as line-following capability, sensor accuracy, and motor control based on light intensity detection. Choose essential components including:

- LEDs and LDRs for line detection.
- Operational amplifier (LM358) for comparing the sensor readings.Transistors (SS8550) for amplifying control signals to drive the motors.
- DC motors for propulsion and direction adjustment.
- Resistors and capacitors for voltage and signal stabilization.
- Battery for power up the circuit

The 2 LEDs emit light, and the LDRs detect the reflection of light from the surface, allowing the system to distinguish between the black line (low reflection) and the surrounding white surface (high reflection).

The operational amplifier (LM358) is used to compare the signals from the LDRs and generate the necessary output to control the motors via the transistors. Chassis and Mechanical Design: Design a lightweight and stable chassis to mount all components, ensuring proper placement for optimal sensor readings and effective movement.

Assemble all components: LEDs and LDRs positioned near the surface for optimal line detection, the motors mounted for movement, and the wiring setup to connect the components as per the circuit diagram.

Test the robot on a track with a defined path. Adjust the LDR positioning and motor speeds as needed to ensure smooth, accurate line-following behavior.

## 2.1 DETAILED EXPLANATION OF COMPONENTS

### 2.1.1 LED

Figure 2.1 LED

LEDs (Light Emitting Diodes) are used as the light source in the Tiny Line Follower Robot. Positioned close to the surface, the LEDs emit visible light onto the track. When the light hits the surface, it reflects differently depending on the surface's color. White surfaces reflect more light, while black surfaces absorb most of it. This varying reflectivity is crucial for distinguishing the line from the surrounding area. LEDs are chosen for their low power consumption, durability, and cost-effectiveness, making them an excellent choice for this application.

### 2.1.2 LDR

Figure 2.2 LDR

LDRs are the sensors used to detect the intensity of light reflected from the surface. When the light from the LEDs hits the LDR, its resistance changes based on the amount of light received. On a white surface with high reflectivity, the resistance of the LDR decreases, producing a higher voltage. Conversely, on a black surface with low reflectivity, the resistance increases, resulting in a lower voltage. These voltage changes are processed by the operational amplifier to determine the robot's position on the track. LDRs are a simple and cost-effective choice for detecting light intensity in this application.

### 2.1.3 OPERATIONAL AMPLIFIER (LM358)


Figure 2.3 Op-Amp

The LM358 is used as a comparator to process the signals from the LDRs. It compares the voltage generated by the LDRs with a predefined reference voltage and outputs a signal to indicate whether the robot needs to adjust its path. By acting as the decision-making component, the op-amp determines the necessary correction for the motors to guide the robot back to the line. Its simplicity and energy efficiency make it ideal for this analog-based robot design.

### 2.1.4 TRANSISTORS (SS8550)

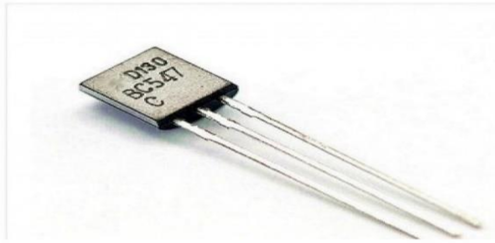


Figure 2.4 Transistor

The SS8550 PNP transistors are used in the robot's circuit to control the DC motors. These transistors act as switches, allowing current to flow to the motors based on the signal received from the operational amplifier. When the op-amp detects a deviation from the line, the corresponding SS8550 transistor is activated, enabling the motor to adjust the robot's path. The SS8550 is ideal for this application due to its ability to handle higher currents and its efficiency in low-power circuits, ensuring reliable motor control during operation.

### 2.1.5 GEAR MOTORS

Figure 2.5 Gear motor

Gear Motor motors are the driving force of the robot, powering its wheels to ensure movement. Their speed and direction are controlled by the amplified signals from the transistors, enabling the robot to adjust its path based on the LDR readings. These motors provide sufficient torque for smooth navigation and are energy-efficient, making them ideal for this compact robot.

### 2.1.6 RESISTORS

Figure 2.6 Resistor

Resistors play a crucial role in stabilizing and controlling the current flow within the circuit. In the Tiny Line Follower Robot, resistors are used in combination with the LDRs to form a voltage divider circuit. This allows the varying resistance of the LDR to be converted into a voltage signal, which is processed by the operational amplifier. Additionally, resistors are used to limit the current flowing through the LEDs and transistors, preventing damage to these components. Their precise values are carefully chosen to ensure optimal performance and stability of the circuit.

### 2.1.7 DIODES

Figure 2.8 Diode

Diodes are used in the Tiny Line Follower Robot to protect the circuit and ensure current flows in the desired direction. In motor control circuits, diodes act as flyback diodes, preventing voltage spikes generated when the motors are turned off from damaging other components like transistors. These voltage spikes are a natural by  product of the motor's inductive load, and the diodes safely redirect the excess energy. Additionally, diodes can be used in the power supply section to prevent reverse polarity connections, safeguarding the entire circuit.

### 2.1.8 POWER SUPPLY


Figure 2.9 Power Supply

A 6V battery powers all the components, including the LEDs, LDRs, operational amplifier, transistors, and motors. The battery provides stable energy for continuous operation. Proper connections and adequate battery capacity ensure the robot runs efficiently without interruptions.

### 2.1.9 SWITCH

Figure 2.10 Switch

Switches are included in the circuit to provide manual control, such as turning the robot on or off. A simple toggle or push-button switch is connected to the power supply, enabling the user to easily control the system's operation. Switches may also be used to reset certain parts of the circuit or to change modes if additional functionality is incorporated. They are an essential component for user interaction and convenience in managing the robot's operation.

## 2.3 CALCULATION

Battery Configuration

Parallel: Total voltage = 3.7V (constant), but the current capacity doubles, providing longer operation time.

Power Supply Calculation

Parallel Connection at 3.7V):
If your circuit draws the same 0.5A:

P=3.7×0.5=1.85WP = 3.7 × 0.5 = 1.85WP=3.7×0.5=1.85W

While the voltage remains 3.7V, the doubled current capacity extends runtime.

Resistor for LED:
To limit the current through the LED and prevent damage:
R = (V_battery - V_LED) / I_LED

For example:

- Vbattery = 7.4V
- VLED = 2V
- ILED = 20mA=0.02AI

R = (7.4 - 2) / 0.02 = 270Ω

Resistor for LDR Circuit:

The voltage divider generates a voltage signal for the op-amp:

V out = V battery × (R LDR / (R LDR + R fixed))

- V battery=7.4V
- R LDR=10kΩR
- R fixed=20kΩ:

  V out = 7.4 × (10 / (10 + 20)) = 2.47V.

Resistor for Transistor Base:

To limit the base current of the transistor:

R base = (V opamp – V BE) / I base

- V opamp = 5V
- VBE = 0.7V
- I collector=0.5A,
- h FE=100
- I base=I collector/h FE=0.5/100=0.005A
- R base= (5 - 0.7) / 0.005 = 860Ω
- A resistor close to 860Ω

## 2.3. CIRCUIT DIAGRAM

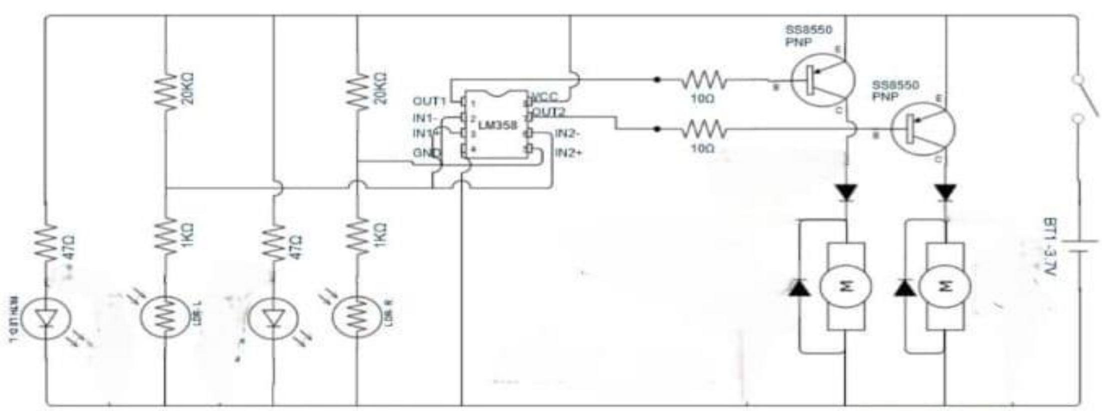


Figure 2.13 Circuit diagram of line follower robot

# CHAPTER 3

## COST OF THE COMPONENTS

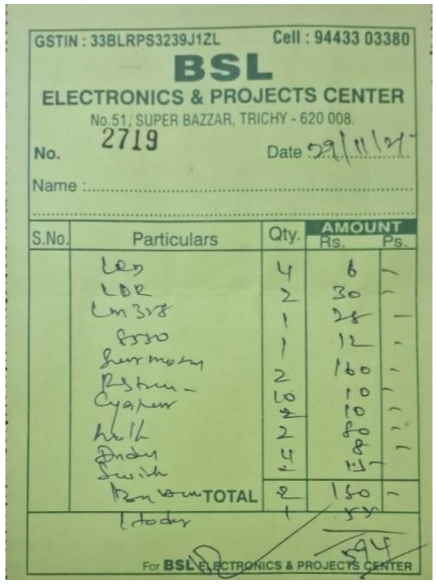


Figure 3.1 Bill of the components

| S.No | NAME OF THE COMPONENT | QUANTITY | AMOUNT |
|---|---|---|---|
| 1 | LEDs | 2 | 3 |
| 2 | LDRs | 2 | 30 |
| 3 | Operational Amplifier (LM358) | 1 | 28 |
| 4 | Transistors (BC547) | 2 | 12 |
| 5 | Gear Motors | 2 | 160 |
| 6 | Resistors | 8 | 8 |
| 7 | Wheels | 2 | 80 |
| 8 | Diodes | 4 | 8 |
| 9 | Switch | 1 | 15 |
| 10 | Batteries | 2 | 180 |

Table 3.1 Cost and Quantity of the Components

# CHAPTER 4

## RESULT AND DISCUSSION

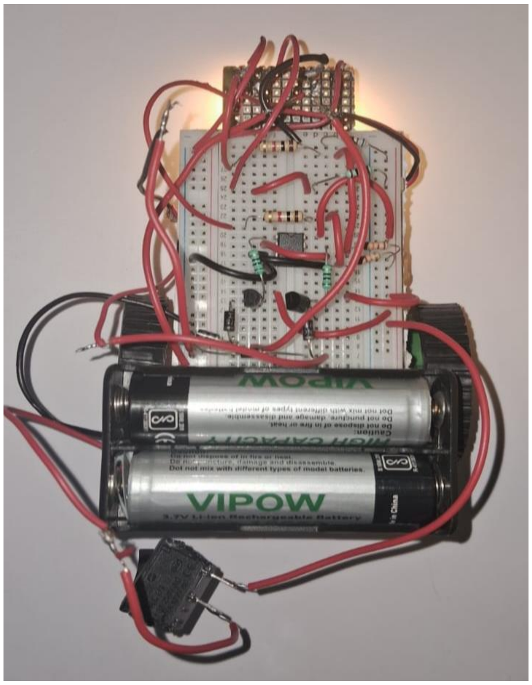


Figure 4.1 DEMO OF LINE DETECTION

The Line Detection and Follower was successfully implemented using LEDs and LDRs to detect the path, along with an operational amplifier and other analog components for control. During testing, the robot demonstrated reliable line-following behavior on a flat, well-lit surface. The following observations were made

The robot performed well on surfaces with clear contrast between the black line and the white background. However, its performance declined slightly on reflective or uneven surfaces, where the light intensity detected by the LDRs varied inconsistently. Adjustments to the placement and alignment of the sensors improved performance in such conditions.

The robot's response time was quick, allowing it to correct its direction effectively when deviating from the line. The analog circuit design, with no microcontroller, ensured minimal delay in processing signals from the LDRs. The system functioned optimally in indoor environments with controlled lighting. Bright ambient light or shadows occasionally caused false readings, highlighting the need for careful calibration of the LEDs and LDRs to enhance robustness against such factors. The use of a 6V power supply enabled efficient operation, with the robot running for extended periods without significant power loss. The inclusion of capacitors helped stabilize the power supply, especially during motor operation.

The analog circuit design proved to be stable, with all components functioning as intended. The use of resistors with precise values ensured proper current flow and voltage levels, contributing to the overall reliability of the system.

The results confirmed that the robot's analog design is effective for basic line-following tasks. The use of LEDs and LDRs in place of IR sensors demonstrated that the system could achieve the desired functionality without significant cost or complexity. However, the robot's performance is sensitive to surface reflectivity and ambient lighting conditions, which could be mitigated with improved sensor housings or filters.

The robot serves as an excellent educational tool, showcasing how analog circuits can be used for real-time automation. Future enhancements, such as integrating better environmental adaptability and optimizing sensor alignment, would further improve its performance and broaden its application. Overall, the project successfully achieved its goal of creating a simple, cost-effective robot for line-following tasks.

## 4.1 APPLICATIONS

Ideal for teaching fundamental robotics concepts, including sensors, analog circuits, and control systems.

Helps students and hobbyists gain hands-on experience in building and programming robotic systems.

Can serve as a prototype for automated line-following systems used in manufacturing or logistics. Applicable in conveyor systems for material handling or sorting tasks.

Useful in robots for predefined path navigation in warehouses or small-scale industrial environments. Can be adapted for robotic vacuum cleaners or guided delivery robots.

## 4.2 ADVANTAGES

The use of analog components, such as LEDs, LDRs, and operational amplifiers, eliminates the need for expensive microcontrollers, reducing overall cost.

Operates on a 6V battery with low power consumption, ensuring longer operation times.

The analog circuit ensures immediate response to sensor inputs, providing smooth and efficient line-following performance.

# CHAPTER 5
# CONCLUSION

Line Detection and Follower project successfully demonstrated the use of analog components, such as LEDs, LDRs, operational amplifiers, and transistors, to achieve line-following functionality. The robot effectively followed a predefined path, showcasing its capability as a simple, cost-effective solution for basic automation tasks. Its design eliminates the need for microcontrollers, making it accessible and affordable for students, hobbyists, and educators.

The project highlighted the effectiveness of analog circuits in real-time applications, providing a practical platform to learn fundamental concepts in robotics and electronics. While the robot performed well under controlled conditions, its sensitivity to environmental factors such as lighting and surface variations pointed to areas for future improvement. Enhancements like better sensor shielding, advanced calibration, and environmental adaptability could significantly expand its applications.

In conclusion, the Line Detection and Follower project serves as an excellent educational tool, bridging the gap between theoretical knowledge and practical implementation. It lays the foundation for further exploration and innovation in analog robotics, promoting accessible learning and creativity in automation technologies.