# Design and Fabrication of Line Follower Robot

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## ABSTRACT

Line follower robot is a robo car that can follow a path. The path can be visible like a black line on the white surface (or vice-verse). It is an integrated design from the knowledge of Mechanical, Electrical and Computer engineering. This paper presents a 700gm weight of a 9W LDR sensor based line follower robot design and fabrication procedure which always directs along the black mark on the white surface. The electromechanical robot dimension is $7 \times 5 \times 2.5$ cubic inches with a cost of BDT 1150. This low cost fundamental electronic component based line sensing robot can carry a load of about 500gm without getting off the line.

**Key Words**: Line Follower, Robot, Electromechanical.



## 1 INTRODUCTION

In the early 1800's mechanical puppets were first built in Europe, just for entertainment value. And these were called robots since their parts were driven by linkage and cams and controlled by rotating drum selectors. In 1801 Joseph Maria Jacquard made the next great change and invented the automatic draw loom. The draw looms would punch cards and was used to control the lifting of thread in fabric factories. This was the first to be able to store a program and control a machine. After that there were many small changes in robotics.

The first industrial robots were Unimates developed by George Devol and Joe Engelberger in the late 50's and early 60's. The first patent was by Devol but Engelberger formed Unimation which was the first market robots. So Engelberger has been called the "father of robotics". For a while the economic viability of these robots proved disastrous and thing slowed down for robotics. But the industry recovered and by the mid-80's robotics was back on track.

George DevolJr, in 1954 developed the multi jointed artificial arms which lead to the modern robots. But mechanical engineer Victor Scheinman developed the truly flexible arm known as the Programmable Universal Manipulation Arm (PUMA) [1]. In 1950 Isaac Asimov came up with laws for robots and these were:

i. A robot may not injure a human being, or through inaction allow a human being to come to harm.

ii. A robot must obey the orders given it by human beings, except where such orders would conflict with the first law.

iii. A robot must protect its own existence as long as such protection does not conflict with the first or second law.[2]

Mobile Robotics moved into its own in 1983 when Odetics introduced this six-legged vehicle which was capable of climbing over objects. This robot could lift over 5.6 times its own weight parked and 2.3 times it weight moving. [3]

In 2000 Sony unveils humanoid robots, the Sony Dream Robots (SDR) at Robodex. SDR is able to recognize 10 different faces, expresses emotion through speech and body language, and can walk on flat as well as irregular surfaces.

In 2005 the Korean Institute of Science and Technology (KIST), creates HUBO, and claims it is the smartest robot in the world. This robot is linked to a computer via a high-speed wireless connection; the computer does all of the thinking for the robot.

**Line follower**

Line follower is a machine that can follow a path. The path can be visible like a black line on a white surface (or vice-versa) or it can be invisible like a magnetic field. [4]

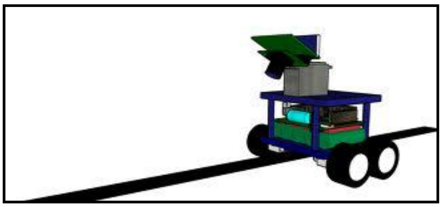


*Fig: Line follower robot*

**Application area**

Line followers can be used to deliver mail within an office building and deliver medications in a hospital. The technology has been suggested for running buses and other mass transit systems, and may end up as part of autonomous cars navigating the freeway. The line follower can be used in guidance system for industrial robots moving on shop floor. An example might be in a warehouse where the robots follow 'tracks' to and from the shelves they stock and retrieve from. A line follower robot can be used in military as spy kids or in many other applications.



## 2 Design and Fabrication

**Block Diagram**

Once the main configuration is chosen, the first thing to do seems to be to make a functional block diagram. Although it might grow or change later, I always like to have "the big picture" available. As Microsoft Visio is design software that it decides to make a Block Diagram in Visio. Just looking at this drawing really gets brings up a host of ideas and questions. Hardware, logic, motor control and many other thoughts come rushing in. I need to slow down and compartmentalized.

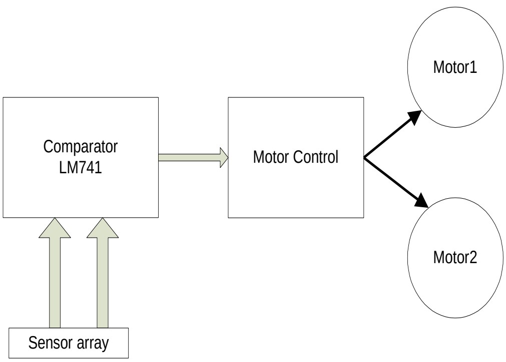



*Fig: Block diagram of line follower robot*

Since this project is the basic of beginner's robotics projects. The robot which is be able to follow a line on the ground without getting off the line too much. The robot has sensors installed underneath the front part of the body and two DC motors drive wheels moving forward. A circuit inside takes input signal from sensors and controls the speed of wheels' rotation. The control is done in such a way that when a sensor senses a black line, the motor slows down or even stops. Then the difference of rotation speed makes it possible to make turns.

**Line sensing**

The basic principle of the line follower robot actually almost the same as the light follower robot, but instead of tracking the light the LFR sensor is used to track the line. Therefore by differentiating the line color and its surrounding (black over white or vice verse) any light sensitive sensor could be used to navigate the robot to follow this track.

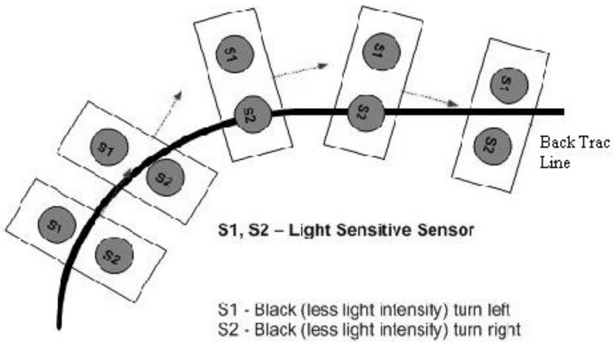



*Fig: Module of Line Sensing*

## 3 Complete Circuit Diagram

In the line follower Robot when the sensor is above the white surface, the light reflected. Hence the LDR resistance decreases and the signal voltage is about 1.1V across the LDR terminal results high signal to the op-amp comparator to turn on the motor.

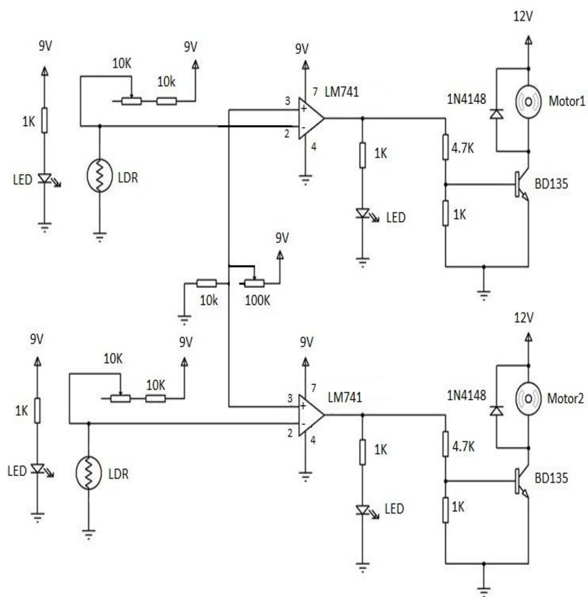



*Fig: Circuit Diagram of line follower Robot*

On the other hand when light falls into black surface then there is no light reflection or small reflection. So the LDR resistance increases and the signal voltage is about 2.7V across the LDR terminal results low signal to the op-amp comparator to turn off the motor. The two motor runs when light reflect through the white surface.
When a black line finds by the sensors then the corresponding motor turns off. The experimental values are :
Here, the sensor output voltage at white surface =1.1V. The sensor output voltage at black surface =2.7V. The reference voltage = (1.1+2.7)/2=1.9V
So, when the sensor voltage is less than the reference voltage, then comparator signal is high and when the voltage is higher than the reference voltage then comparator signal is low. This high and low signal switches the transistors to turn on or turn off the motors.

## 4 CIRCUITS

**Line sensor**

For the line follower robot the line sensors are made using LDR and white LED.A 1K resistor across the LED.A series connection of 10K resistor and 10K variable are with the LDR . After soldering the image of the line sensor is shown below. It is powered by 9V battery.

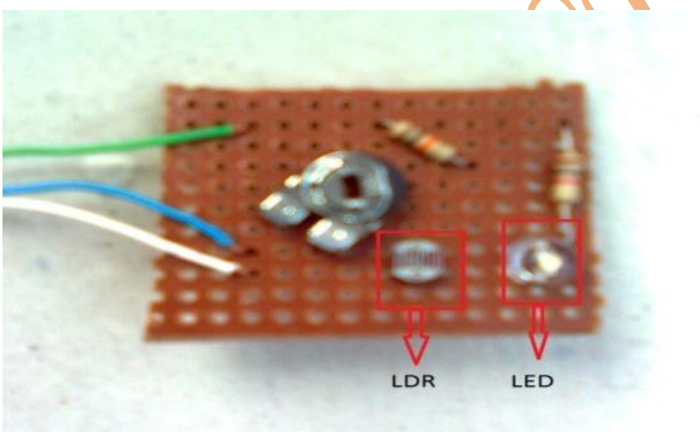
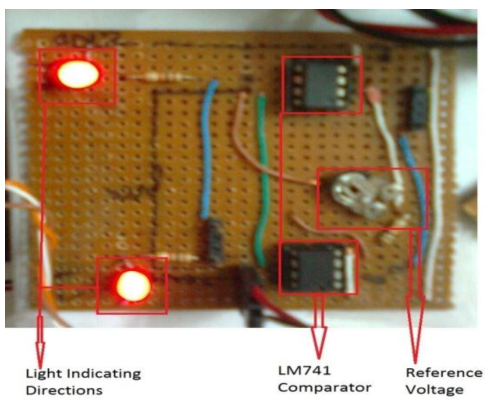



*Fig: Line sensor*

**Comparator circuit**

The comparator using LM741 op-amps, compare the sensor signal, with a reference voltage supplied in the pin no 3. So there the output signal is either high or low to drive the transistor based motor control circuit.

*Fig: Comparator circuit*



**Motor control Circuit**

In this line follower robot the motors are controlled by small power transistor BD135.There is a 4.7KΩ and 1KΩ resistor divider across the base of the transistor. Where high signal voltage from the op-amp is approximately 5.9V turns the base emitter junction in forward bias and the low signal voltage from the op-amp is approximately 1.8V also known as offset voltage which is not enough to turn on the base emitter junction. So the motor is off.

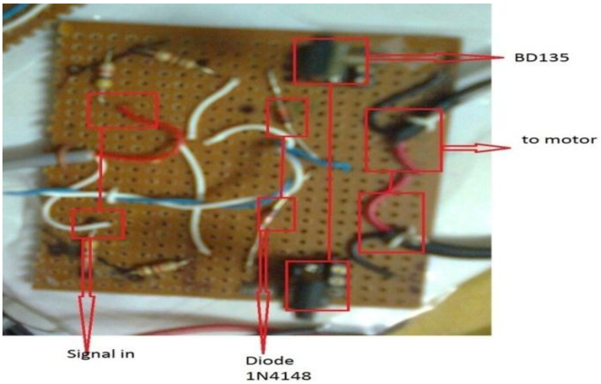
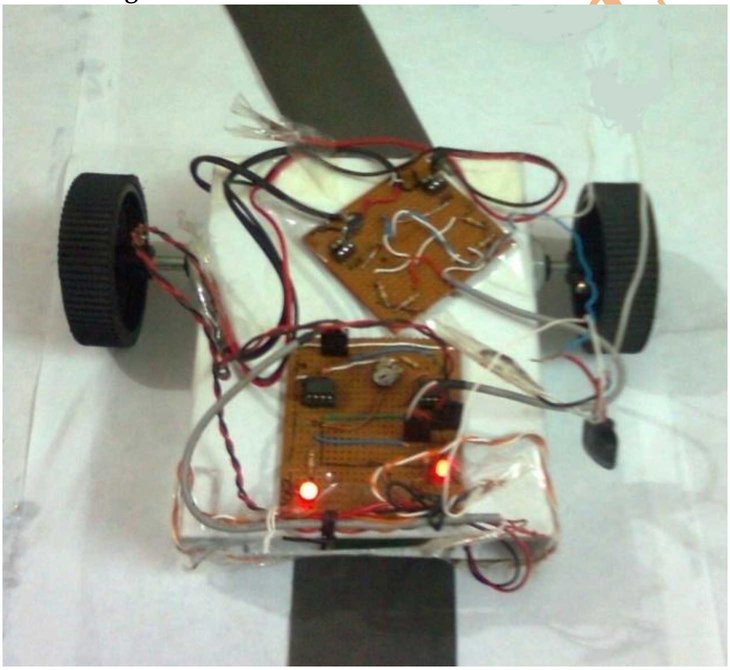



*Fig: Motor control Circuit*

**Robot Image**



## 5 Cost and Power Calculation

Power

| | | |
|---|---|---|
| 1. Maximum power by the motors | 300mA*12V *2 | 7.2W |
| 2. Power absorbed by LEDs | 10mA*9V*4 | 0.36W |
| 3.Power consumed by op-amps | 100mA*9*2 | 1.8W |
| Maximum Power needed | | 9.36W |

So the maximum power needed for this Robot is 9.36 W.

Cost for fabrication

| Equipments | Quantity | Cost |
|---|---|---|
| Dc geared motor | 2 | 700 |
| Mechanical body | 1 | 200 |
| Vero Board | 2 | 50 |
| Led and resistors | - | 50 |
| Op-amp LM741 | 2 | 20 |
| Transistor | 2 | 15 |
| Others | - | 100 |
| Total | | 1135 |

For the line follower robot the highest cost is about BDT 1135.

## 6 CONCLUSIONS

The Line follower robot works successfully to track on the black line. Above the white surface (art paper) there are some black lines in different directions. The robot still good enough to sense the line and follows the track. Also the robot is capable to carry some load likely 500gm.

## 7 FUTURE WORK

The line follower robot is made by op-amps and transistors, where the motor is directly on or off using the signal of the comparator. Now the techniques can be replaced by PWM using more sensor, microcontroller and H-Bridge motor controller IC i.e. L293D. I want to try it earlier but failure in some cases. I have compiled some programs of microcontroller. Also instead of LDR it can be used phototransistor whose response is much better than LDR. There are 2 line sensors used here so the fluctuation of line is a fact. Using more than 2 sensor likely 5 sensor array may be used to detect the black line quickly. Also using microcontroller it can draw the reverse direction as well as obstacle avoiding turning the motor 180º. The block diagram may be represented as follows. Also using color sensors the robot can sense different colors. It can be used in the robotic game competition and other fields.

So the development features in brief:

- Appling PWM technique
- Use of Microcontroller
- Use of color sensor
- Obstacle avoiding

## REFERENCES

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