Implementation Of Autonomous Line Follower Robot

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***Abstract* - The line follower is an autonomous robot that detects and follows a line. The path may be visible like a black line on a white surface or may be reverse of that or it can be invisible like a magnetic field. A close loop control system is used in the robot. The robot must sense a line and maneuvers accordingly to stay on course while correcting the wrong moves using feedback mechanism thus forming a simple but yet effective closed loop System [1]. The robot is designed to follow very tight curves as the data from the sensors are continuous in nature. This robot is simple but effective having straightforward design to perform line following task.**

Index Terms – Feedback, Autonomous, Comparator, LDR,LED.

I. INTRODUCTION

Robots are electromechanical machines having ability to perform tasks or actions on some given electronic programming. Line follower robots are mobile robots having ability to follow a line very accurately having an onboard hardwired control circuit. As mechanical ways of performing various tasks have been discovered and the development of mechanics and complex mechanisms still going on in full swing, the necessity of automatic machines is ever increasing. Initially machinery was mainly used for repetitive functions. But with the development of science and technology more complex machines have been developed. In order to develop a stable and useful fast line following robot proper study and accurate model regarding electronics and steering mechanism is very much necessary [2]. For model design and improving performance, proper stability analysis is required. The basic operations of the line follower are capturing line position with sensors mounted at front end of the robot and steer the robot to track the line with steering mechanism. The line sensing process requires high resolution and high robustness [3]. Two motors are used for governing wheel's motion. Practical applications of a line follower include automated cars running on roads with embedded magnets; guidance system for industrial robots moving on shop floor etc [4][5][6].

II. BLOCK DIAGRAM

The robot uses LED and LDR sensors to sense the line. Two LEDs (Tx) and sensors (Rx), facing the ground has been used in this setup. The output of the sensors is an analog signal which depends on the amount of light reflected back, this analog signal is given to the comparator to produce 0s and 1s which are then fed to the logic circuit whose output is then passed through a diode matrix and then given to the driver circuits and finally to driving motors. Let's see all the system in detailed manner.

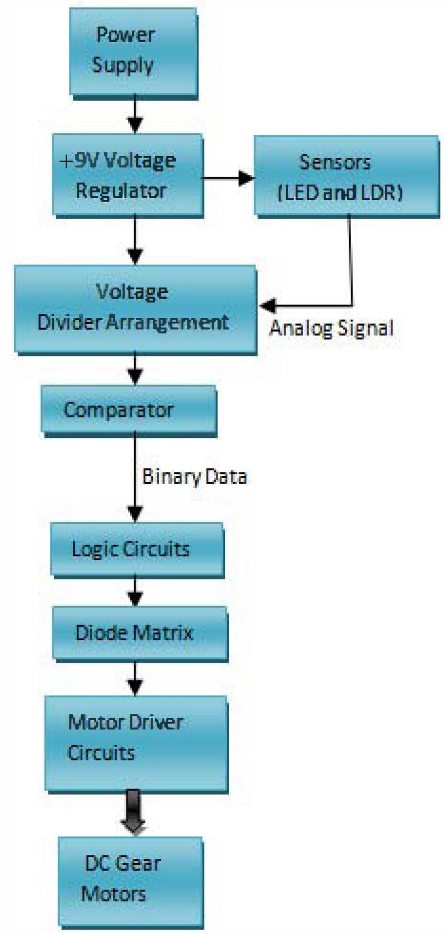

Fig.1 Block diagram of the line follower robot.

III. SENSORS

It has been observed that to attain efficient line following for any track not more than two sensors are needed on either sides of the line. As light energy hits a surface, some portion of it is scattered or absorbed and rest of the energy is reflected. Different surfaces scatter, absorb and reflect light in different portions. Black surface will absorb more light than a white surface, and a shiny smooth white surface will reflect more energy than a rough surface. The intensity of the reflected light will be sensed by the receiver.

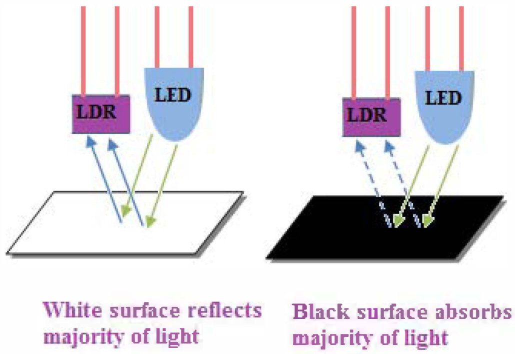

Fig.2 Sensor arrangement.

For this robot LED is used as light source and LDR is used as light sensor. When light falls on white surface the resistance of the LDR is decreased while black surface results in higher resistance. A good sensor will have low resistance in presence of light and a very large resistance in absence of light. This property of light and LDR is used to build the line follower.

IV. Algorithm

The sensor's resistance and voltage divider arrangement are used to generate ADC values of each sensor. The generated digital values are processed and used to drive the motors to follow the track.

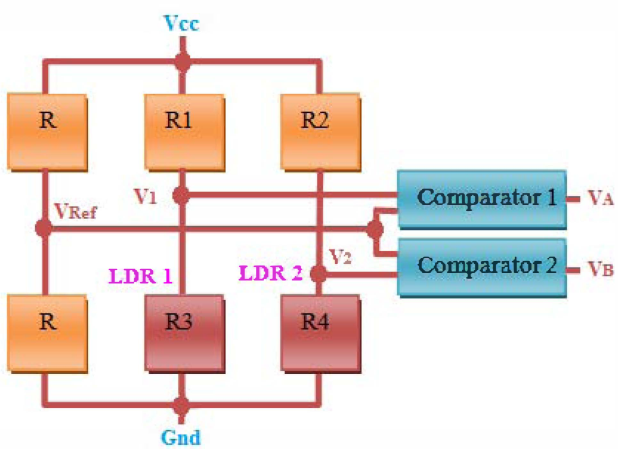

Fig.3 Voltage divider and comparator arrangement.

Applying voltage divider rule the corresponding voltages of different points are found as

$$V_{Ref}=\frac{Vcc.R}{2R}$$

$$V_1=\frac{Vcc.R3}{(R1+R3)}$$

$$V_2=\frac{Vcc.R2}{(R2+R4)}$$

$V_A=V_1 \sim V_{Ref}$

$V_B=V_2 \sim V_{Ref}$

No.	Status	V_A	V_A	Command	Left Motor	Right Motor
(1)	$V_1<V_{Ref}$ $V_2<V_{Ref}$	0	0	Stop	Stop	Stop
(2)	$V_1<V_{Ref}$ $V_2>V_{Ref}$	0	1	Right	Forward	Backward
(3)	$V_1>V_{Ref}$ $V_2<V_{Ref}$	1	0	Left	Backward	Forward
(4)	$V_1>V_{Ref}$ $V_2>V_{Ref}$	1	1	Go	Forward	Forward

Table.1 Different conditions for movement.

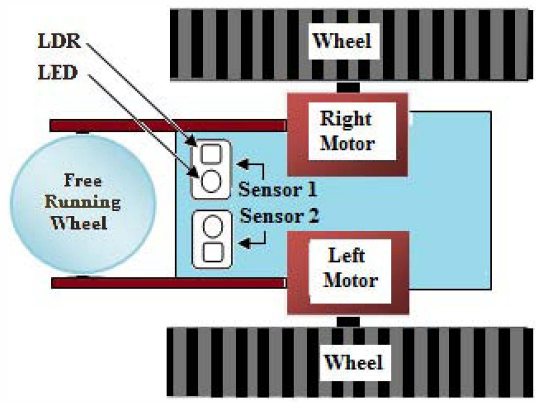

Fig.4 Bird view of the robot.

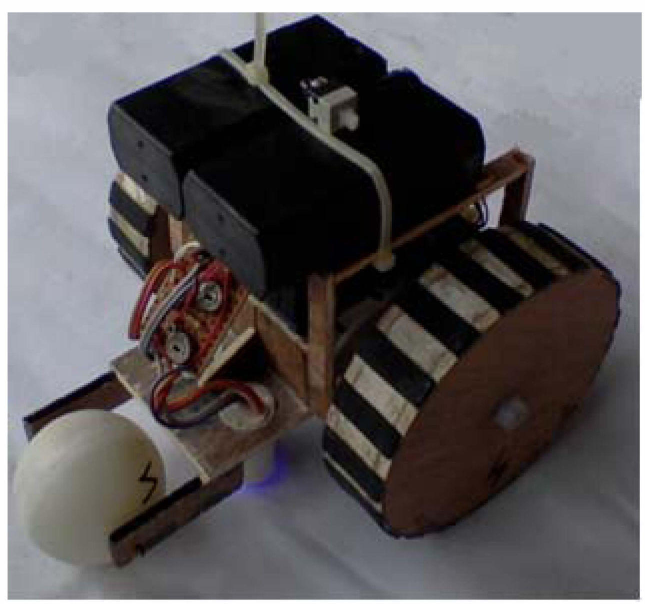

Fig. 5 Actual photo of the robot.

V. Motor Interface and Control Circuit

1) Voltage Regulator:

The brightness of the LED changes linearly with voltage change that's why to provide constant light regulated voltage source is preferable. In this case +9V voltage regulator is used.

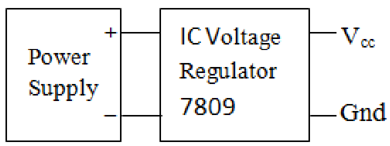

Fig.6 Voltage regulator arrangement.

2) Voltage Divider And Comparator:

A simple bridge network is used as voltage divider to produce reference voltage. Voltages across sensors are V_1 and V_2. Variable resistors are used in series with the LDR for fine tuning of color. The voltages V_1, V_2 and V_{Ref} are fed to comparators to produce digital data V_A and V_B.

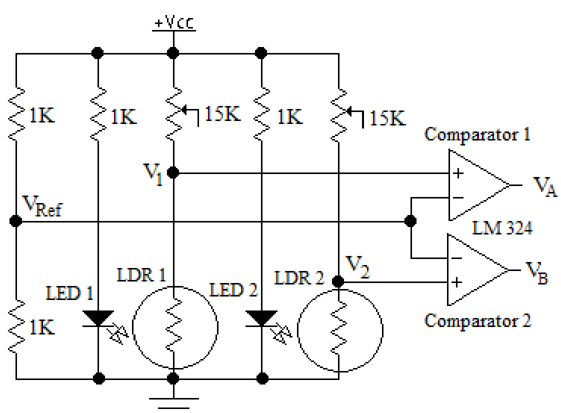

Fig.7 Voltage divider and comparator circuit.

3) Logic Circuit:

The logic circuit works as the brain of the robot having two NOT gates and three AND gates. It produces digital information of the robot's current position which is a direct equivalent of the sensor's analog output and expected movement depending on current position. The robot gets four basic instructions from this part i.e. when to go forward or stop, when to turn in which direction (right or left).

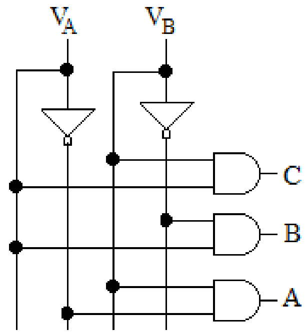

Fig.8 Logic circuit.

4) Diode Matrix:

The logic circuit gives instructions of movement and the diode distributes those data to the right and left driving motor drivers. Every output of logic circuit drives two motors simultaneously. The arrangement of the diode matrix is given below. Let 'P' and 'Q' are the inputs of the right motor and 'R' and 'S' are inputs of the left motor. When 'C' is high it means that the robot is on the line so 'R' and 'Q' are high and the robot moves forward. When 'B' is high it means the robot is out of the track on the right side so it needs to turns left, then 'Q' and 'S' are high. Similarly 'P' and 'R' are high when the robot needs to turn right.

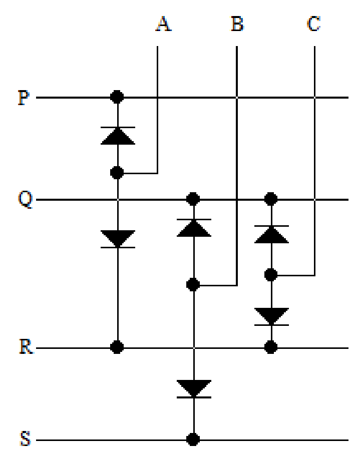

Fig.9 Diode matrix.

5) Motor Driver:

A detailed driver circuit is shown in the following figure. In this circuit the primary elements are 6V relays. Relays are electromechanical switches that can switch between two circuits. Here when voltage is applied, say to input 'S', it's concerning relay will switch from ground to Vcc which applies voltage to the left DC motor and finds ground through other relays. So the use of the relay based driver circuit gives a very low resistance path to the motors. Relays help provide much greater current to the motors than semiconductor driver circuits. This circuit provides built in dynamic motor breaking ability which is very much necessary for sharp turning for a line follower.

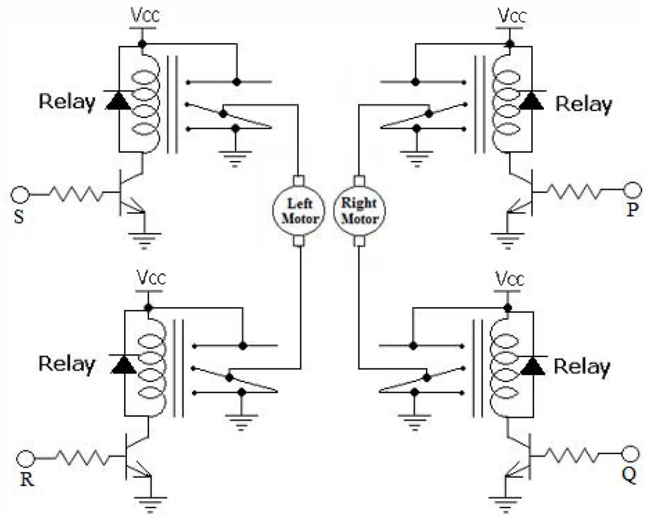

Fig.10 Relay based driver circuit.

6) Driving And Steering Mechanism:

Steering mechanism has to be efficient for a line follower robot. Two DC geared motors are connected, one to each of the two drive wheels at the right and at the left of the robot's base. Those two motors are responsible of driving the robot backward and forward as well as steering in any required direction. When both the motors revolve clockwise the robot goes forward and for steering one motor revolves opposite to another. A free running wheel is set in front of the robot.

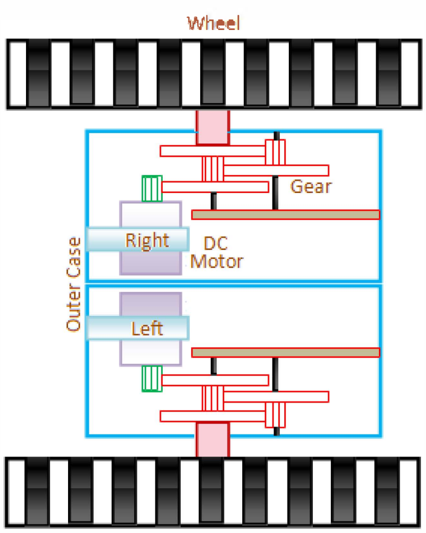

Fig.11 Motor arrangement for driving.

6) Line width and color:

The line width and color is an important factor for an efficient line following robot. If the line width is less than minimum line width required or if the line color is not properly tuned then the robot will not be able to track and follow the line. The line width must be at least equal to the separation between the sensors. Once any particular color is tuned, the position of the sensors (height from line) must not be changed.

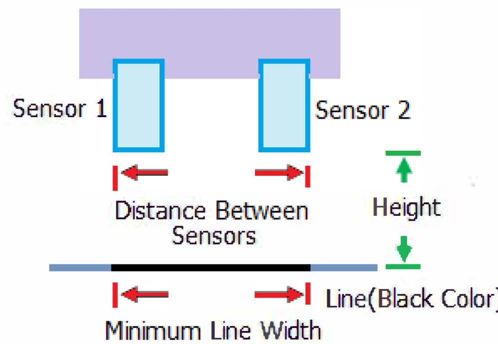

Fig.12 Sensor placement.

7) Turning Angle:

Turning angle of the robot depends mainly on the speed and motor breaking. Larger turning angle and efficient motor breaking mechanism are required for greater speed. The robot presented here has moderate speed of about $0.2ms^{-1}$. The minimum turning angle is 110^0. Any angle less than 110^0 will lead the robot missing the line.

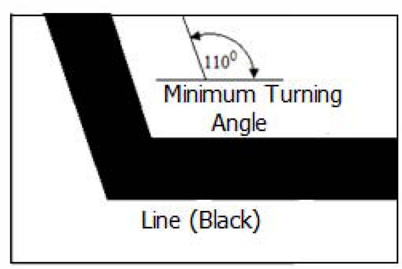

Fig.13 Line showing minimum turning angle.

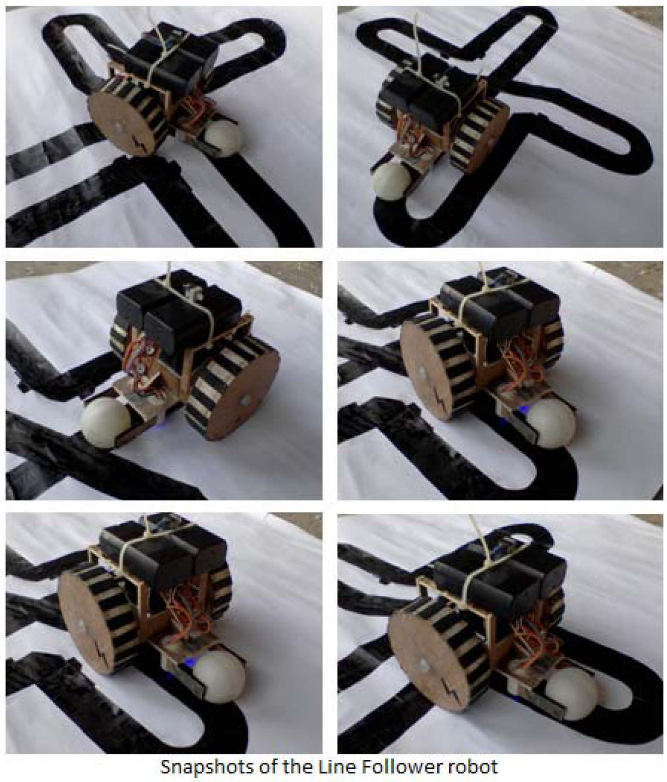

Fig. 14 Robot is following black line.

VII. Conclusion

The idea of the robot which has been presented in this paper employs instructions from sensors and on board logic circuits to achieve its physical movement. One of its significant attribute is controlling efficiently with very much accuracy. It does not use complex algorithms for line following applications. Controlling process has been made automatic by straightforward controlling mechanism. Simple basic electronics is used instead of costly microcontrollers which made it very much cost effective. Further modification of this robot includes additional sensors like sonar and infrared [7] so that the robot will be able to follow a line having the ability to avoid obstacle.

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