Command Based Line Following Robot using RF Technology

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ABSTRACT

This research paper demonstrates a prototype development of an Intelligent Command Based Line Follower Robot (LFR) using Radio Frequency (RF) Technology. Mostly the LFR are build by using microcontroller chips. One of the basic and most fundamental problems with LFR based upon microcontroller chips is that they are preprogrammed. Due to these preprogramming limitations LFR cannot accept any instruction and command in real time from outside users other than what is already fixed. The proposed prototype systems is designed and demonstrated to recognize, understand and modify the actual performance and the movements of the robot following the path by getting information in real time from three Light Dependent Resistor (LDR) sensors via Parallel Port Interface Circuit (PPIC) connected to PC. A computer program is implemented in C-language to accept user commands and also control the robot autonomously according to the received signals.

***Keywords*: Line Following Robot, Radio Frequency, command based, RF Transmitters, RF Receivers**

1. Introduction

LFR is a tool or machine that can follow a specified path. Historically the most LFR are build using the microcontroller chips (Roman et al. 2006; Nolfi .and Floreano, 2001). The chip is preprogrammed and embedded within the robot. One of the basic problems with microcontroller based designs is the acceptance of commands from the user in real time from outside world.

The second problem with LFR is wired connections, and the length of wire is the main constraint. As the length of a wire increases, the signal strength attenuate and along with signal strength attenuation delay in timings also increases. To overcome these problems, RF is used as it provides a convenient way of transmitting signals without conductors and hence eliminating the attenuation and time delay. The current approach solves the problem of controlling LFR with the added functionality of command mode. The command mode LFR is controlled using PC based instructions developed in C-programming language. Some work based on Radio Frequency Identification (RFID) systems has been reported in (Finkenzeller, 2003; Microchip Micro Guide). In these systems RFID tang is attached to receive and send information to and from a remote control device. The Strength of these RFID systems is that they can overcome line of sight problem as well as line loss and limitations. So far RF based line following robots are build as given in (Willem, 2011). But they are not implemented to be controlled via PC. The proposed prototype RF based LFR has been build and it is controlled with Personal Computer (PC).

2. System Development

Two different RF chips have been used for transmitting and receiving the signals between the robot and the PC. The RF of 35 MHz is used for controlling robot movement and 27MHz for transmission of information.

The construction of a command based LFR using RF technology, a RF based Car of 35 MHz was selected that works as a robot. The reasons for selecting this type of RF car are:

a. It works on wireless system
b. Easy to assemble, configure and control
c. Low cost

The main advantage of using RF technology is that it does not require line of sight, which makes this device more useful as compared to one that uses the wired or infrared based wireless technology.

The elements involved during the physical design of robot are:

2.1 Transmission

The direction of a robot was controlled by RF remote of 35MHz via PC. A transmission of robot is conformed to two wheels (i.e. left and right), coupled with two direct current motors separately as shown in Fig.1.

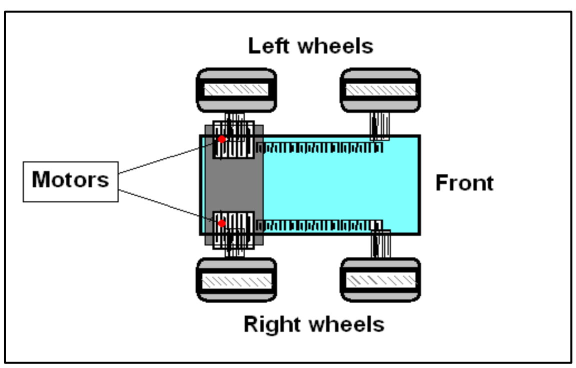

Fig.1. Transmission system and Wheel location

The operation for robot control is shown in Table 1. Allowed moments are:

a. Forward direction
b. Backward direction

c. Right (clockwise)
d. Left (counter clockwise)
e. 360 degrees rotation

Table 1: Operation Table for robot movement

A	B	C	Function
1	0	1	Forward
1	1	0	Right (Clockwise)
0	1	1	Left (Anti-Clockwise)
0	0	0	Error
1	1	1	No Line Detected
0	1	0	White Track

2.2 Direct current motor control

The robot movements involve two motors i.e. Left motor and Right motor. The power of these motors is controlled via RF transmitter which is connected at PPIC. Speed and turning of the robot is controlled from PC using received information from LDR sensor values i.e. A, B, and C as shown in Table 2.

Table 2: Operation Table of Motors

A	B	C	Signal	Right Motor	Left Motor
1	0	1	S1+S2	1	1
0	1	1	S2	0	1
1	1	0	S1	1	0

The movement of the robot is controlled from PC's four data out pins via PPIC i.e. Data0, Data1, Data2 and Data3. The PC pins configuration of PPIC and their description are shown in Table 3.

a. To move the robot in forward direction the Relay number 1 and 2 are triggered, this makes the transmitter to generate signals S1 and S2.
b. To move the robot in backward direction the Relay number 3 and 4 are triggered, to generate signals S3 and S4.
c. To move the robot in the right direction (clockwise), then the Relay number 1 is triggered to generate signal S1.
d. And finally, to move the robot in the left direction (counter clockwise), then the Relay number 2 is triggered to generate signal S2.

The PC Pin Configuration of Robot Movement is mentioned in Table 3. The series of relays are connected to PC via PPIC to PP. In PC there are four PP Data out pins i.e. Data 0, Data 1, Data 2 and Data 3, which are connected to PPIC and from these four data signals four switches of RC transmitter are operated i.e. S1, S2, S3 and S4 respectively. And three Data input pins of

PC i.e. Data A, Data B, and Data C are used to receive the sensor information from sensor receiver circuit i.e. S8, S9, and S10 respectively. And finally PC pins from 18 to 25 are grounded.

Table 3: PC Pin Description of PPIC

PC Pin #	Description	Relay #	Signal #
2	Data 0	1	S1
3	Data 1	2	S2
4	Data 2	3	S3
5	Data 3	4	S4
10	Data In A	5	S8
11	Data In B	6	S9
12	Data In C	7	S10
18-25	Ground	GND	-

Table 4: Pin Configuration of Robot Movement

PC Pin #	Operated Relay #	Transmitted Signal #
2	1	S1
3	2	S2
4	3	S3
5	4	S4
18-25	Grounded	Common

2.3 Command based LFR using RF Prototype Architecture

Fig.2 shows the LFR architecture, where PC, PPIC, transmitter for RC Car, Sensor Receiver Circuit, Sensor transmitter and RC Car can be observed.

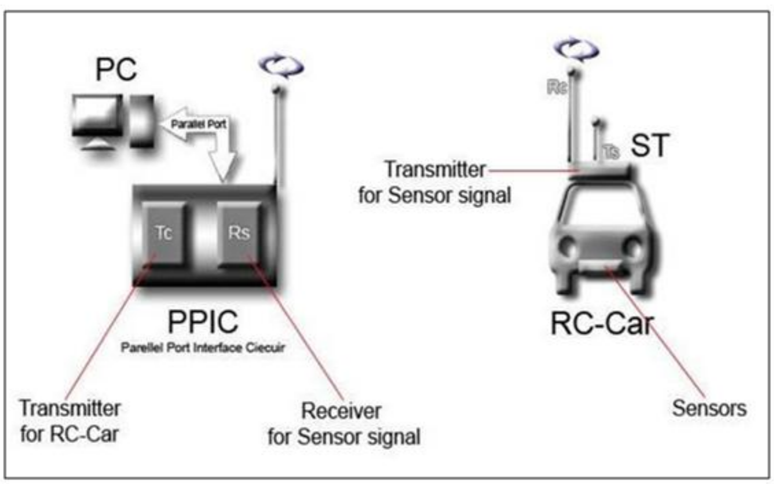

Fig.2. Prototype Architecture

2.4 Sensor Placement

Sensors are place at the front bumper of a robot. The main objective of the robot is to position its B (middle) sensor on the tape line and other two sensors A (left) and C (right) off the tape line. If the tape line ever ventures past these two extreme sensors, then the robot corrects by turning in the appropriate direction to maintain tracking. Sensors are positioned between 1/16" to 1/8" above the ground as shown in Fig.3.

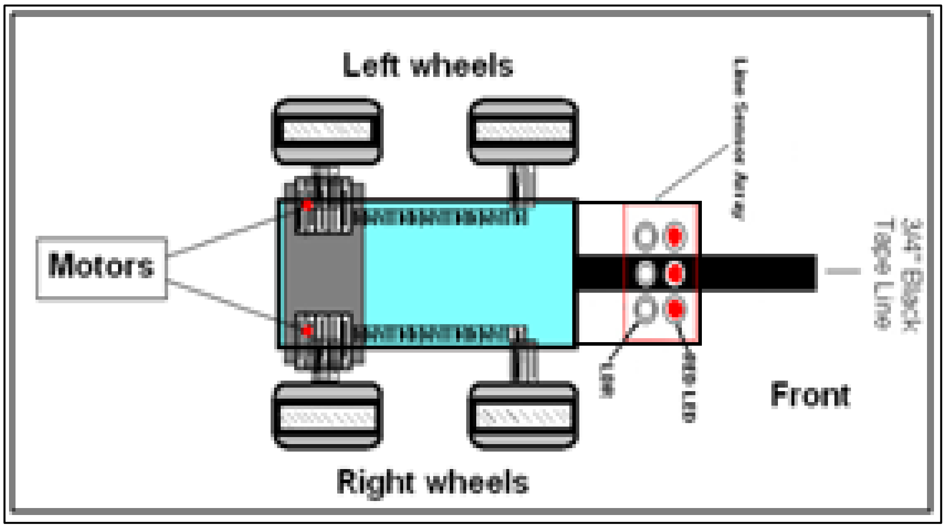

Fig.3. Sensor Placement (LDR's & LED's)

2.4.1 Sensor Spacing

The sensors are arranged according to Fig.4 to get optimal results and this spacing work well for ¾" width tape lines.

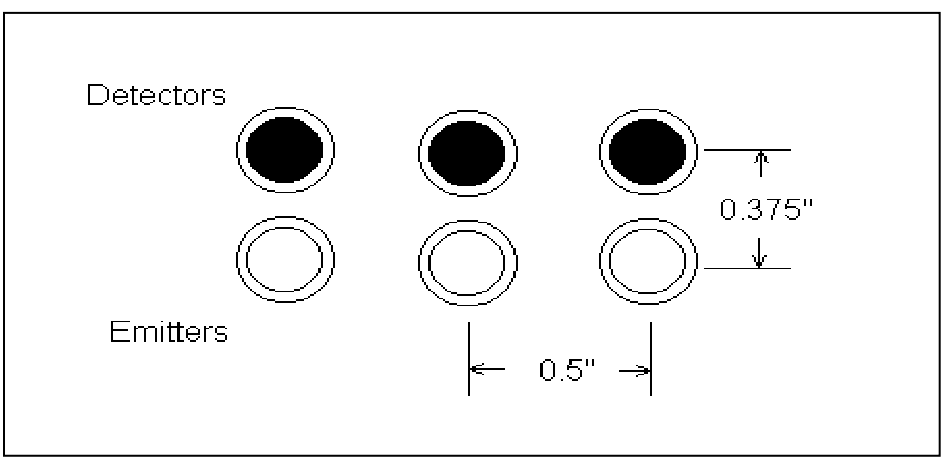

Fig.4. Sensor Spacing

2.4.2 Sensor array

The sensor on the left is named as A, the middle sensor as B and the right sensor as C. When the sensor reads A=1, B=0 and C=1, then it is assumed that robot is on the tape at center point and ready to move the robot in forward direction.

The PC decides the next move according to the algorithm given below which tries to position the robot such that L and R both read 1 and the M reads 0. These conditions are shown in Table 5.

Table 5: Sensor Array conditions

A: Left	B: Middle	C: Right
1	0	1

Desired state A = C = 1 and B = 0.

2.4.3 Sensor Transmission

The Red LED is used to transmit the light on the tape (line) and the LDR is used to sense the reflected light of LED as shown in the Fig.5. The output of the sensors is an analog signal which depends on the amount of light reflected back. This analog signal is sent by RF based transmitter of 27MHz which transmits these signals to sensor receiver circuit which is connected to PPIC.

Then PPIC fed these three signals to PC via three PC input pins as mentioned in Table 3. Table 6 shows the description of Sensors transmitted signal and Table 7 shows the pin description of Sensor received signals at PC.

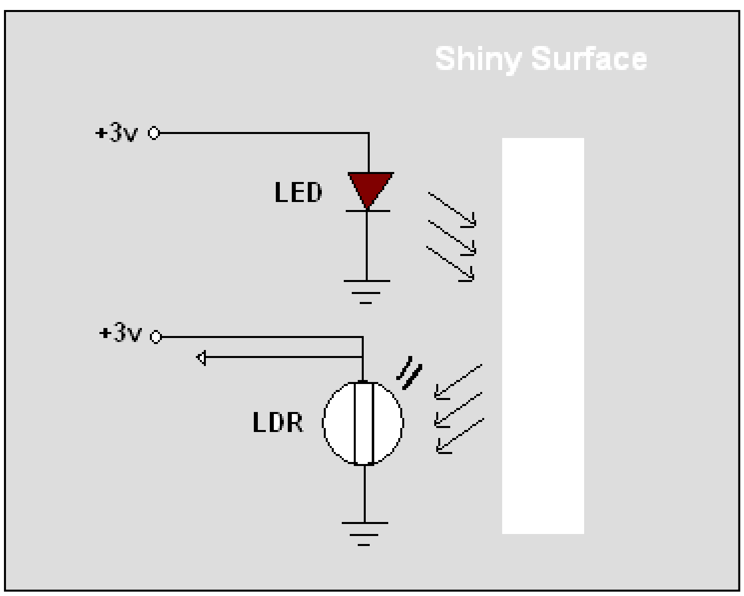

Fig.5. Circuit Diagram of Sensor circuit for the Red LED (Emitter) and LDR (Detector)

Table 6: Sensors Transmitted Signal

Sensor #	Transmitted Signal
LEFT	S6
MIDDLE	S7
RIGHT	S5

Table 7: Sensors Received Signal to PC

Received Signal	Relay #	PC Pin #
S8	5	10
S9	6	11
S10	7	12

2.5 LFR Programming Description

To implement this section of prototype, a C-Programming language is used. The program achieves three sensors monitoring, controlling robot movement and acceptance of user commands. The flowchart for the software is shown in Fig.6.

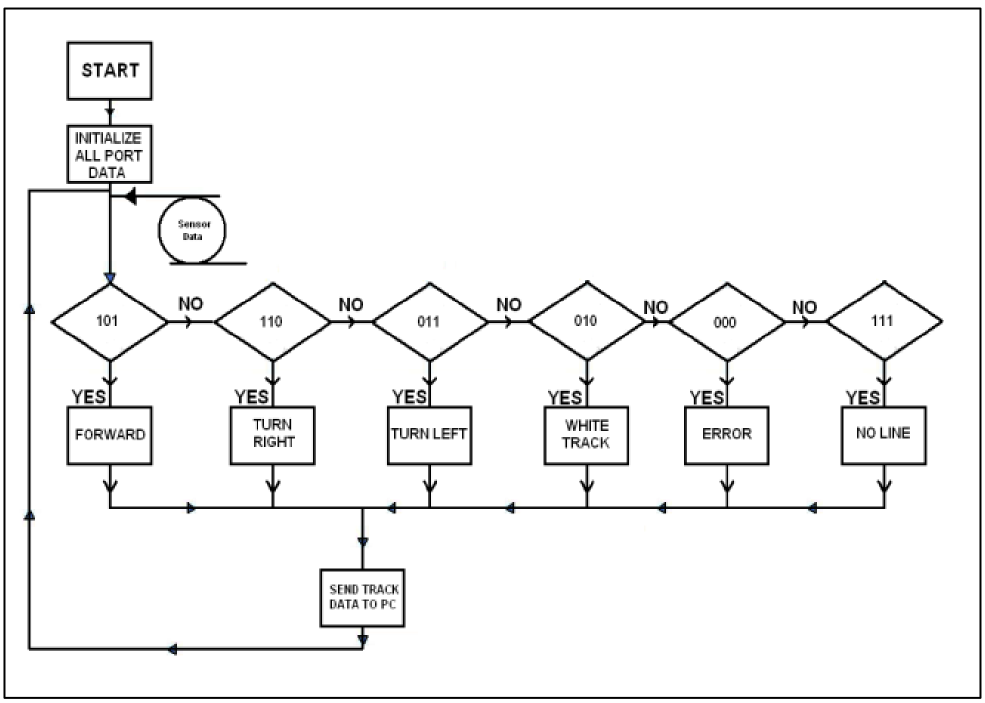

Fig.6. PC software flowchart

2.5.1 Curve Line Analysis

The action of a robot is decided according to received signals via PPIC through sensor receiver circuit. The robot movement according to Curve Line behavior of the Robot is shown in Fig.7.

- If A (Left Sensor) reads 1, B (Middle Sensor) reads 0, and C (Left Sensor) reads 1, then the S1 and S2 signals are generated from RC transmitter and the robot moves in forward direction as shown in Fig.7 case: 1.
- In contrast if A (Left Sensor) reads 1, B (Middle Sensor) reads 1, and C (Left Sensor) reads 0, then the S2 signal is generated from RC transmitter and the robot moves in right (Clockwise) direction as shown in Fig.7case: 2.
- And finally if the Robot moves in the left direction (anticlockwise), then the Relay number 2 is triggered, to generate signal S2 as shown in Fig.7 case: 4.

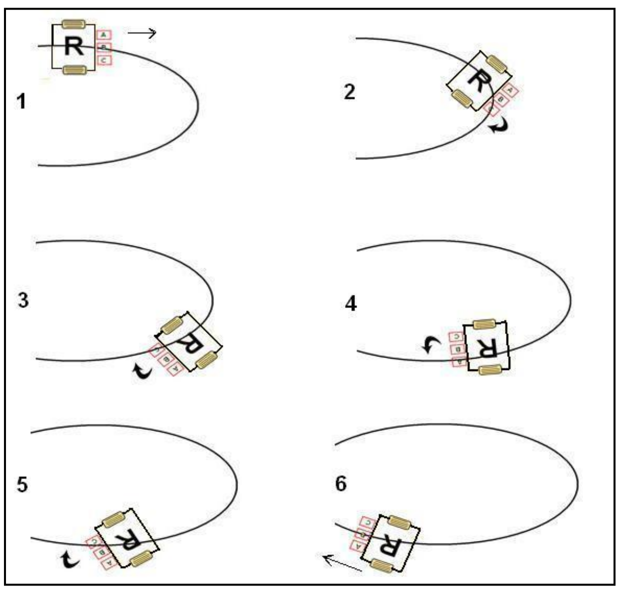

Fig.7.Curve Line behavior of the Robot

2.5.2 Prototype Algorithm for Autonomous control

Following algorithm is designed to control the robot autonomously and decides the next move of the robot via received information from sensors.

1. IF A = left sensor which reads 1,
C = right sensor which reads 1,
B = middle sensor which reads 0,
Then Move in the Forward Direction.

2. IF A <= 0, B > 0 and C > 0,
Then Move in Anti-clockwise (left)
3. IF A > 0, B > 0 and C <= 0,
Then Move in Clockwise (right)
4. IF A > 0, B > 0 and C > 0,
Then output Line Lost
5. IF A <= 0, B <= 0 and C <= 0,
Then output ERROR
6. Repeat step 1 to 5

2.6 Overall circuit diagram for the prototype model

The final circuit diagram for the command based LFR using RF technology is shown in two parts, Fig.8 shows PPIC circuit with RC Car Transmitter and Sensor Receiver circuit and Fig.9 shows the Sensor Transmitter circuit.

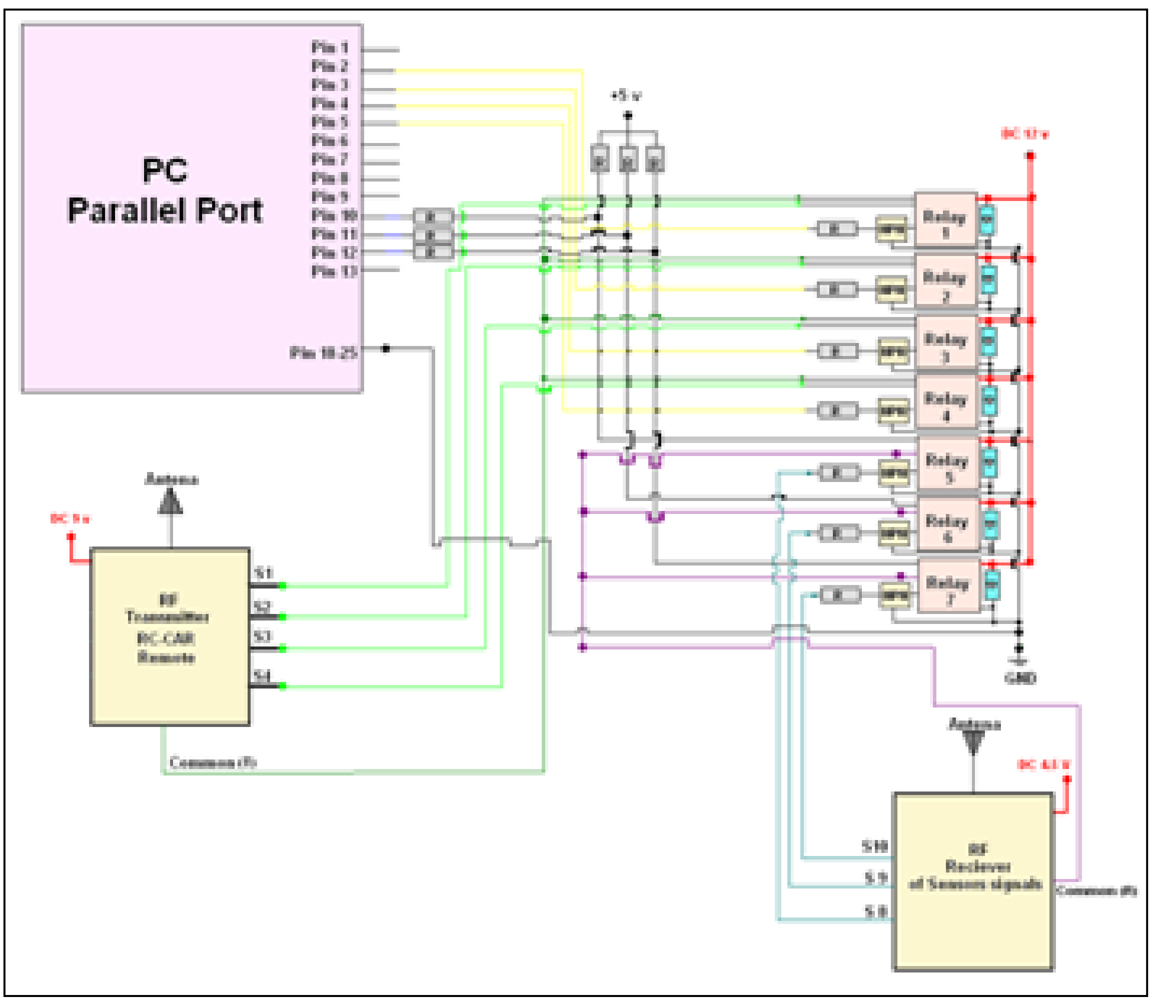

Fig.8. PPIC circuit with RC Car Transmitter and Sensor Receiver circuit

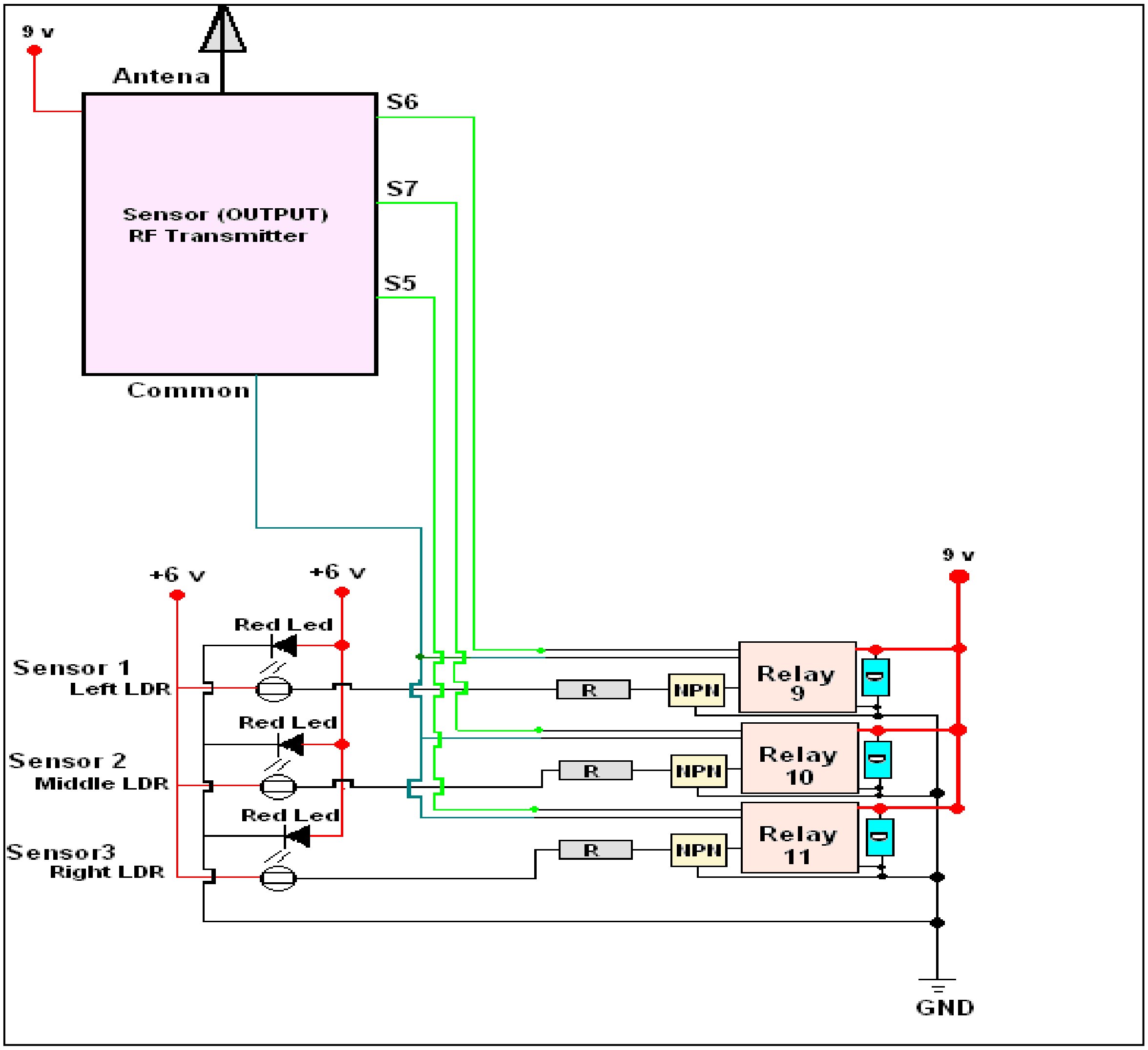

Fig.9. Sensor Transmitter circuit

7. Conclusions And Recommendations

The problem with microcontroller based LFR's was the acceptance of commands from the user in real time environment, so this problem was solved by the replacing the microcontroller with PC to provide additional facility. To overcome this problem RF was used to provide a convenient way of transmitting signals without conductors and hence eliminating the attenuation and time delay. These additional facilities provide users to control the robot wirelessly as well as it allows user to work at such places which are too dangerous to explore.

Further range finder modules (ultrasonic or infrared) and a gripper could be used. Such modules will allow variety of different and more complex algorithms to be implemented on the robot. Furthermore, adding a gripper will allow more sophisticated algorithms to be implements in robot to carrying objects, play soccer and various industrial applications.

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