PATH FOLLOWER ROBOTIC CAR USING RF TAG

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CERTIFICATE

This is to certify that the work entitled, **"Path Follower Robotic Car Using RF tag"** submitted by Khushboo Saxena, Ankita Prasad and Sachin Malviya in partial fulfillment for the award of degree Bachelor of Technology in Electronics and Communication Engineering of Jaypee University of Information Technology has been carried out under my supervision. This work has not been submitted partially or wholly to any other University or Institute for the award of this or any other degree or diploma.

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This work is the result of dedication of many individuals without whom it would not appear in its present form. We give our sincere thanks to the following people.

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This work is dedicated to our families and friends, without whom none of this would have been even possible.

Khushboo Saxena

Sachin Malviya

Ankita Prasad

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List of Abbreviations

Abbreviations	Full Forms
IC	Integrated Circuit
RF	Radio Frequency
LED	Light Emitting Diode
AC	Alternating Current
DC	Direct Current
HF	Higher Frequency
CE	Common Emitter
TTL	Transistor-transistor Logic
CMOS	Complementary Metal Oxide Semiconductor
PMOS	P-type Metal Oxide Semiconductor
RAM	Random-access Memory
ROM	Read-only Memory
EPROM	Erasable-programmable read-only Memory
ADC	Analog to Digital Converter
GND	Ground
RST	Reset
UART	Universal Asynchronous Receiver-Transmitter

ABSTRACT

Thousands of fatal accidents leading to injuries and deaths occur very frequently on the roads. This has increased the mortality rate to a greater extent. Apart from this they also lead to negative economic impact. Platooning is another area of concern. Thereby, leading to heavy congestion on the roads creating unnecessary delays. Safe, secure and relaxed driving on roads is what every individual and traffic policemen wants. Development of various kinds of robotic vehicles is on the verge of exponential growth. Automation of cars and other vehicles is the only solution for the concerns above mentioned.

Path follower robotic car using RF tag is one of the concepts in the field of automation which has not yet been fully developed to its extent. The aim of our project is to explore the concept thereby producing a practical sample (non commercial).

The basic concept of the project includes maneuvering the robot on the black path which is detected by the infrared sensor array in the main circuitry. Its input (voltage) is given to the comparator wherein it's compared with reference voltage and accordingly it drives the microcontroller which keeps the continuous check on the path of the car. Any obstacle is detected by the RF tag which further gives instructions to the microcontroller. Thus here we present our efforts to give a robot a human-like property of responding to stimuli.

CHAPTER 1: INTRODUCTION

The theory and design of mobile robotic cars are the subjects of much research in universities and companies around the world. One major application is the design of cars and trucks that drive themselves. Why automate the driving task? One of the major reasons is safety. According to the U.S. department of transportation in 2000 there was approximately 6,394,000 police reported motor vehicle traffic crashes, resulting in 3,189,000 injuries and 41,821 lives lost. Many accidents are caused by human error.

Human driving error may be caused by a number of factors. During long drives on the highway, the driver must constantly monitor the road conditions and react to them over an extended period of time. Such constant attentiveness is tiring and the resulting fatigue may reduce the driver's reaction time. Additionally the driver may be distracted by talking with other passengers, tuning the radio, or using a cell phone. Such distractions may also lead to accidents.

Other applications of mobile robotic cars involve sending them where humans cannot or should not go. NASA has programs that develop robots to navigate other planets. It is safer and less expensive to send a relatively small, mobile robot to harsh environment of Mars than to develop transportation and living quarters for several astronauts. Similarly, mobile robots can enter burning buildings to locate someone or something. They can navigate battle-fields to search for mines. They can seek out and deactivate bombs. The usefulness of these little machines is limited only by our imagination!

1.1 Brief Introduction of the Project

The Project deals with automatic car driving which helps in avoiding accidents. A particular program is fed in the microcontroller and it sends the message to the decoders and the converters, which helps drive the model. Robotics is a fascinating subject-more so, if one has to fabricate a robot himself. The field of robotics encompasses a number of engineering disciplines such as electronics, electrical, structural, pneumatics and mechanical.

The structural part involves use of frames, beams, linkages, axles etc. The mechanical parts / accessories comprise various types of gears (spurs, crowns, bevels, worms and differential gear systems), pulleys, belts and drive systems. Pneumatics plays a vital role in generating specific pushing and pulling movements such as simulating arms or leg movements.

Pneumatics grippers are also used with advantage in robotics because of their simplicity and cost effectiveness. The electrical items include DC & stepper motors, actuators, electrical grips, clutch and their control. The electronic part involves remote control, sensors, their interface circuitry and a microcontroller for all over control.

Our design consists of a microcontroller and several sensors mounted on the vehicle to gather information about the vehicle and broadcast the information through a transmitter. The key focus would be to detect mechanical motions of the car and its surrounding conditions through the use of Infrared distance sensor. The information gathered is then encoded using a microcontroller and sent through a transmitter.

1.2 Background

There is very little background math required for this Project other than the usual expected out of an ECE junior. The primary focus of mathematical calculations is the wired communications: the data transfer rates, the timing, the data encoding. Although background in error control code theory would be helpful, it is not entirely necessary.

1.3 Logical Structure

Our design Project consists of two major components, the car (transmitting end) and the home base (receiving end). The wired telemetry system was designed as a stand-alone system consisting devices that can be attached to any moving object to detect its distance from surrounding stationary objects.

1.4 Block Diagram

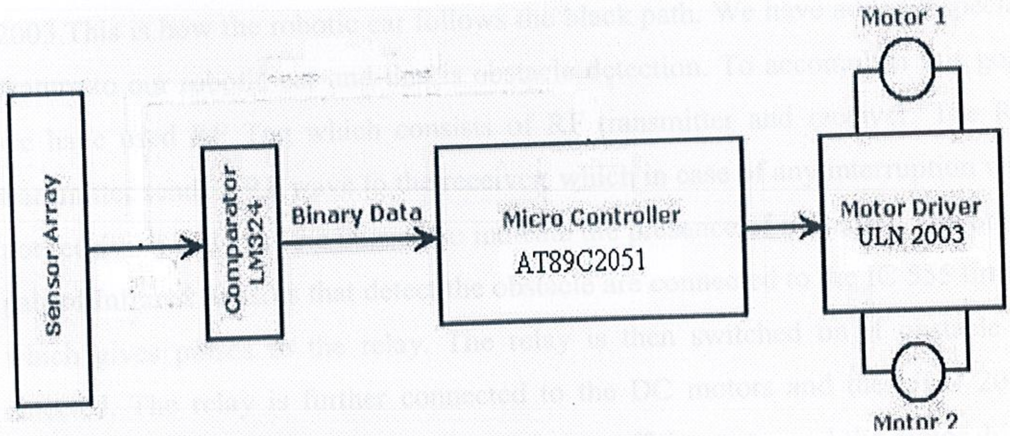

Fig 1.1: Block Diagram

CHAPTER 2: HARDWARE DESCRIPTION

2.1 Basic working of the project

We are presenting an element- **PATH FOLLOWER ROBOTIC CAR** that can be controlled using primarily the infrared mode. The infrared mode has the advantage of adequate range up to 200m with proper alignment besides being in front. On the other hand, an IR remote would function over a limited range of about 3m.

The car follows a black path on a white surface, which is sensed by Infrared Sensors. If the infrared sensor senses the black path, then the resistance in the infrared receiver circuitry becomes high and minimum current flows. The difference in the resistance is sensed and sent to the microcontroller AT89C2051 via LM324 IC which is an Schmitt Triggered IC as shown in the fig 2. Accordingly the microcontroller issues instructions to the DC motor drive ULN 2003.This is how the robotic car follows the black path. We have added a special feature to our robotic car and that is obstacle detection. To accomplish this goal we have used RF Tag which consists of RF transmitter and receiver. The RF transmitter sends a RF wave to the receiver, which in case of any interruption will not receive it and start the buzzer (to indicate the presence of obstacle). The other pair of Infrared Sensors that detect the obstacle are connected to the IC 555 timer, which gives pulses to the relay. The relay is then switched on if obstacle is detected. The relay is further connected to the DC motors and the ULN 2003 motor drive. On interruption, the relay switches off the motor and the motor drive that drives the wheels. Thus the car stops.

In this Project we use IC 89C2051 as a main microcontroller and with the help of this microcontroller we move the data on the LED matrix. In addition with 89C2051 microcontroller we use LM324 & IC555 as a speed controller.

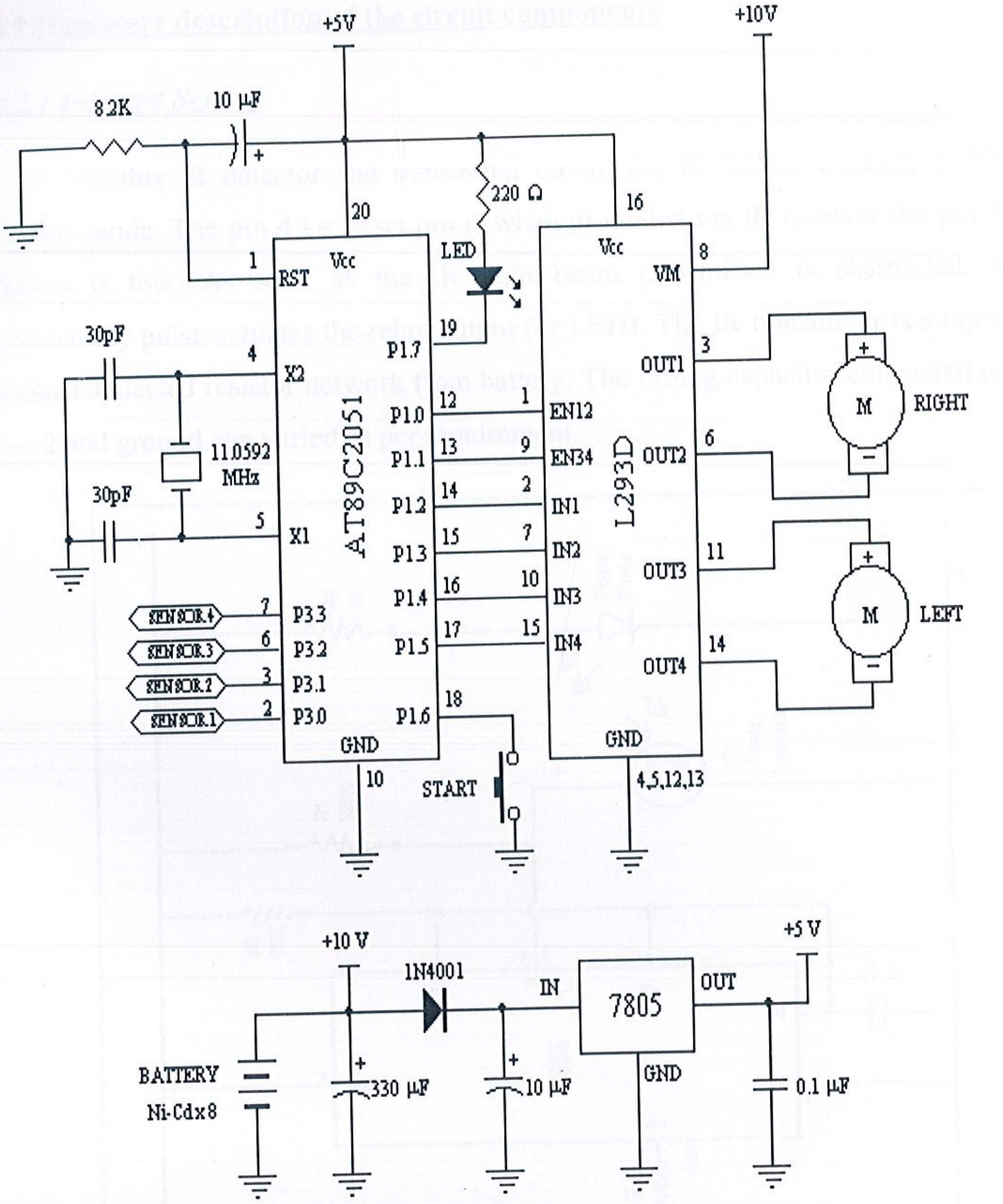

Fig 2.1: Main Circuit Diagram

2.2 Hardware description of the circuit components

2.2.1 Infrared Sensor

In this IR detector and transmitter circuit the IC 555 is working under astable mode. The pin 4 i.e. reset pin is when grounded via IR receiver the pin 3 output is low. As soon as the IR light beam transmitted is obstructed, a momentary pulse actuates the relay output (or LED). The IR transmitter is simple series connected resistor network from battery. The timing capacitor connected to pin 2 and ground can varied as per requirement.

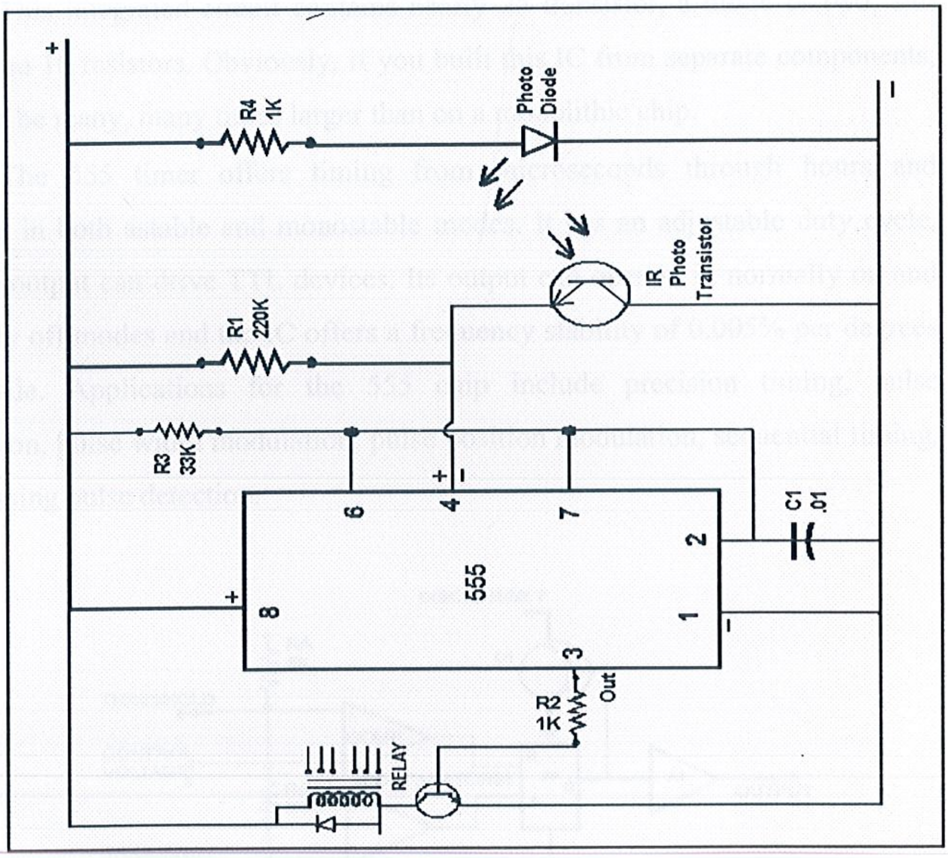

Fig 2.2: IR Sensor

2.2.2 *555 Timer Integrated Circuit*

The 555 integrated circuit is an extremely versatile timer that can be used in many different applications. This IC is a monolithic timing circuit that is a highly stable controller capable of producing accurate time delays or oscillations. Additional terminals are producing provided for triggering or resetting if desire. For a stable operation as an oscillator, the free running frequency and the duty cycle are both accurately controlled with two external resistors and one capacitor. The circuit may be triggered and reset on falling waveforms, and the output structure can source or sink up to 200ma or drive TTL Circuits.

This integrated circuit contains nearly 25 transistor, a diode or two, and more than 10 resistors. Obviously, if you built this IC from separate components, it would be many, many times larger than on a monolithic chip.

The 555 timer offers timing from microseconds through hours and operates in both astable and monostable modes. It has an adjustable duty cycle, and the output can drive TTL devices. Its output can operate in normally on and normally off modes and the IC offers a frequency stability of 0.005% per degrees centigrade. Applications for the 555 chip include precision timing, pulse generation, pulse width modulation, pulse position modulation, sequential timing, and missing pulse detection.

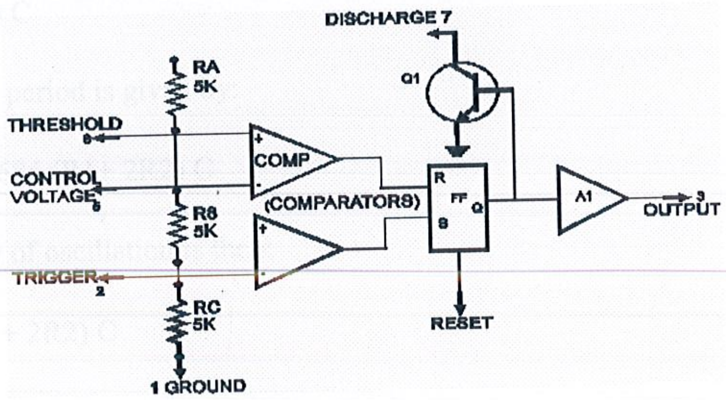

Fig 2.3: 555 Timer IC

There are two modes in which 555 timer IC works. They are:

a) Astable Mode

b) Monostable Mode

❖ IC 555-Astable Operation

If the circuit is connected as shown in figure 2.3 (pins 2 and 6 connected). It will trigger itself and free run as a multivibrator. The external capacitor charges through R1 and R2 and discharges through R2 only. Thus, the duty cycle may be precisely set by the ratio of these two resistors. In this mode of operation the capacitor charges and discharges between 1/3 Vcc and 2/3 Vcc. As in the triggered mode, the charge and discharges times, and therefore, the frequency are independent of the supply voltage. Figure 2.4 shows the actual waveforms generated in this mode of operation. In the following fig 2.4 we have taken R1 and R2 as Ra and Rb respectively.

The charge time (output high) is given by:

$t1= 0.685 (R1 + R2) C$

And the discharge time (output low) by:

$t2= 0.685 (R2) C$

Thus, the total period is given by:

$T= t1 + t2= 0.685 (R1+ 2R2) C$

The frequency of oscillation is then:

$f = 1.46 / (R1 + 2R2) C$

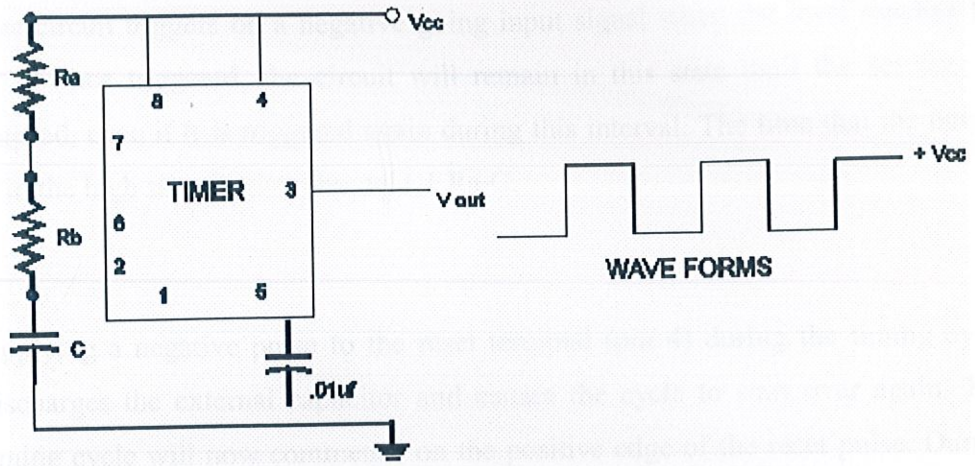

Fig 2.4: 555 Timer in Astable Mode and its output waveform

❖ IC 555-Monostable Operation

In the monostable mode of operation, the timer functions as a one shot. Referring to figure the external capacitor is initially held discharged by a transistor inside the timer. Upon applications of a negative trigger pulse to pin 2, the flip-flop is set, which releases the short circuit across the external capacitor and drives the output high. The voltage across the capacitor increases exponentially with the time constant, t which is given by:

$$t = Ra\ C$$

When the voltage across the capacitor equals 2/3 VCC, the comparator resets the flip-flop, which, in turn, discharges the capacitor rapidly and drives the output to its low state. Figure 2.5 shows the actual waveforms generated in this mode of operation.

The circuit triggers on a negative going input signal when the level reaches 1/3 Vcc. Once triggered, the circuit will remain in this state until the set time is elapsed, even if it is triggered again during this interval. The time that the output is in the high state is given by: t= 1.1 Ra C.

Applying a negative pulse to the reset terminal (pin 4) during the timing cycle discharges the external capacitor and causes the cycle to start over again. The timing cycle will now commence on the positive edge of the reset pulse. During the time the reset pulse is applied, the output is driven to its low state.

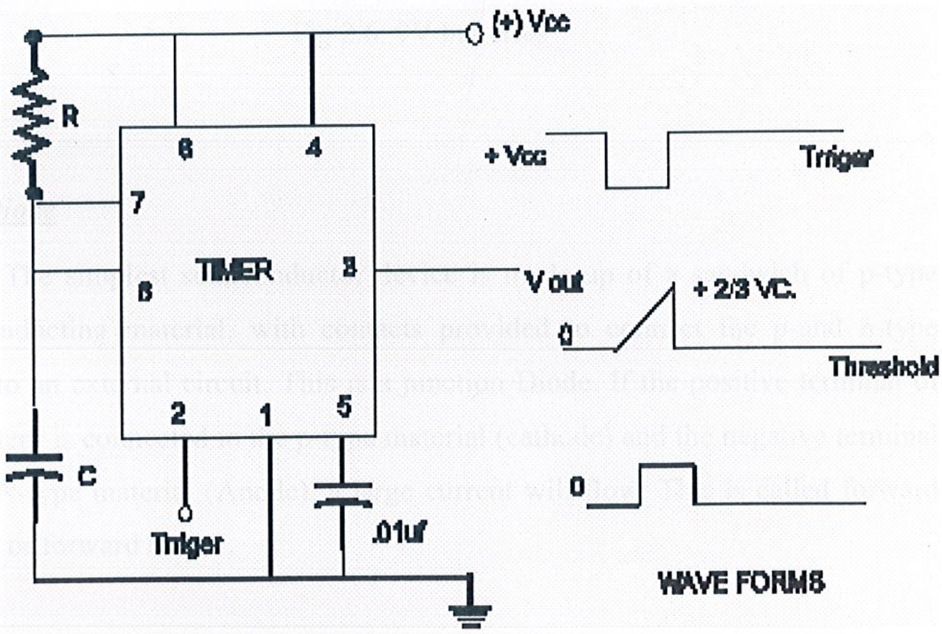

Fig.2.5: 555 Timer in monostable mode and its output waveform

2.2.3 *Power Supply*

We have used six 9 volt batteries in the whole project. These batteries are 0% cadmium and 0% mercury 6F22 dc batteries for transistor radios as shown in figure 2.6 below:

Fig 2.6: 9V batteries

2.2.4 *Diode*

The simplest semiconductor device is made up of a sandwich of p-type semiconducting material, with contacts provided to connect the p-and n-type layers to an external circuit. This is a junction Diode. If the positive terminal of the battery is connected to the p-type material (cathode) and the negative terminal to the N-type material (Anode), a large current will flow. This is called forward current or forward biased.

If the connections are reversed, a very little current will flow. This is because under this condition, the p-type material will accept the electrons from the negative terminal of the battery and the n-type material will give up its free electrons to the battery, resulting in the state of electrical equilibrium since the n-type material has no more electrons. Thus there will be a small current to flow and the diode is called Reverse biased.

Thus the Diode allows direct current to pass only in one direction while blocking it in the other direction. Power diodes are used in converting AC into DC. In this, current will flow freely during the first half cycle (forward biased) and practically not at all during the other half cycle (reverse biased). This makes the diode an effective rectifier, which convert ac into pulsating dc. Signal diodes are used in radio circuits for detection. Zener diodes are used in the circuit to control the voltage.

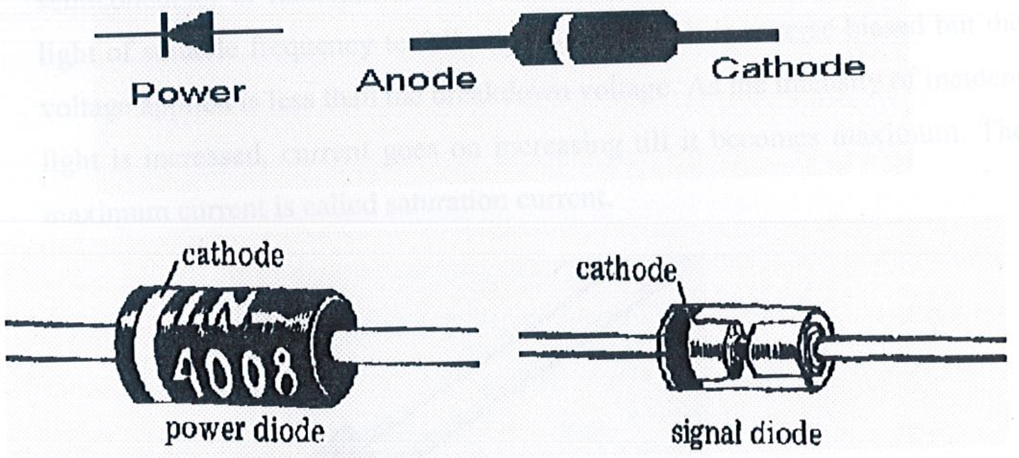

Fig 2.7: Power Diodes and Signal Diodes

Some common types of diodes that are used in our project are:

a) **Zener Diodes:** A zener diode is specially designed junction diode, which can operate continuously without being damaged in the region of reverse break down voltage. One of the most important applications of zener diode is the design of constant voltage power supply. The zener diode is joined in reverse bias to dc through a resistance R of suitable value.

Fig: 2.8 Zener Diode

b) **Photo Diodes:** A photo diode is a junction diode made from photo-sensitive semiconductor or material. In such a diode, there is a provision to allow the light of suitable frequency to fall on p-n junction. It is reverse-biased but the voltage applied is less than the breakdown voltage. As the intensity of incident light is increased, current goes on increasing till it becomes maximum. The maximum current is called saturation current.

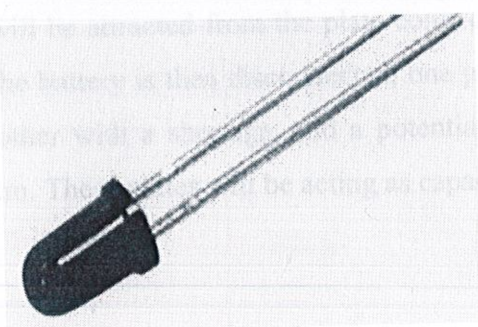

Fig 2.9: Photo Diode

c) Light Emitting Diode (LED): When a junction diode is forward biased, energy is released at the junction diode is forward biased; energy is released at the junction due to recombination of electrons and holes. In case of silicon and germanium diodes, the energy released is in infrared region. In the junction diode made of gallium arsenate or indium phosphide, the energy is released in visible region. Such a junction diode is called a light emitting diode or LED.

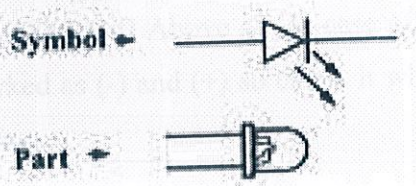

Fig 2.10: Light Emitting Diodes

2.2.5 Capacitors

It is an electronic component whose function is to accumulate charges and then release it. To understand the concept of capacitance, consider a pair of metal plates which all are placed near to each other without touching. If a battery is connected to these plates the positive pole to one and the negative pole to the other, electrons from the battery will be attracted from the plate connected to the positive terminal of the battery. If the battery is then disconnected, one plate will be left with excess of electrons, the other with a shortage, and a potential or voltage difference will exists between them. These plates will be acting as capacitors.

Capacitors are of two types: -

a) **Fixed type** like ceramic, polyester, electrolytic capacitors-these names refer to the material they are made of aluminum foil.

b) **Variable type** like gang condenser in radio or trimmer. In fixed type capacitors, it has two leads and its value is written over its body and variable type has three leads. Unit of measurement of a capacitor is farad denoted by the symbol F. It is a very big unit of capacitance. Small unit capacitor are pico-farad denoted by pf (1pf=1/1000, 000,000,000 f) Above all, in case of electrolytic capacitors, its two terminal are marked as (-) and (+) so check it while using capacitors in the circuit in right direction.

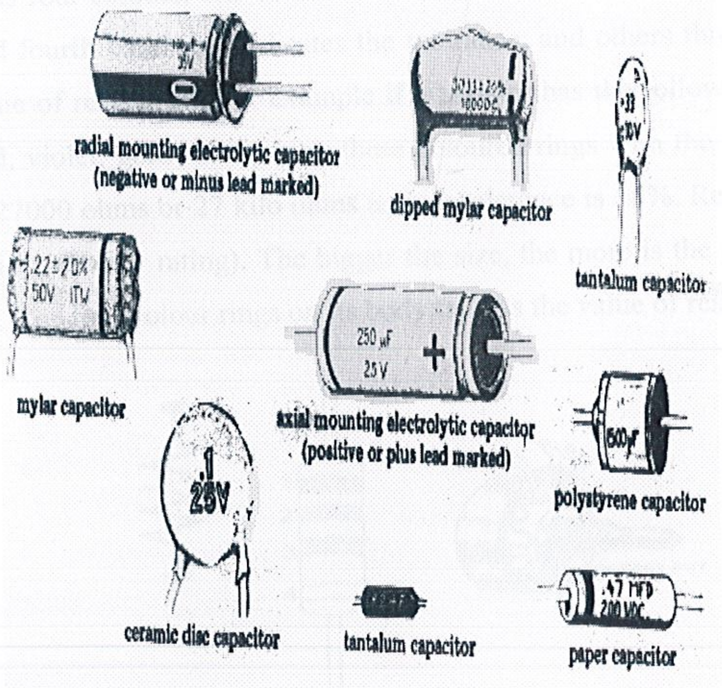

Fig 2.11: Types of Capacitors

2.2.6 ***Resistors***

Resistance is the opposition of a material to the current. It is measured in Ohms (Ω). All conductors represent a certain amount of resistance, since no conductor is 100% efficient. To control the electron flow (current) in a predictable manner, we use resistors. Electronic circuits use calibrated lumped resistance to control the flow of current. Broadly speaking, resistor can be divided into two groups viz. fixed & adjustable (variable) resistors. In fixed resistors, the value is fixed & cannot be varied. In variable resistors, the resistance value can be varied by an adjuster knob. It can be divided into (a) Carbon composition (b) Wire wound (c) Special type. The most common type of resistors used in our projects is carbon type. The resistance value is normally indicated by colour bands. Each resistance has four colours, one of the bands on either side will be gold or silver, this is called fourth band and indicates the tolerance, and others three band will give the value of resistance. For example if a resistor has the following marking on it say red, violet, gold. Comparing these coloured rings with the colour code, its value is 27000 ohms or 27 kilo ohms and its tolerance is ±5%. Resistor comes in various sizes (Power rating). The bigger the size, the more is the power rating of 1/4 watts. The four colour rings on its body tells us the value of resistor value.

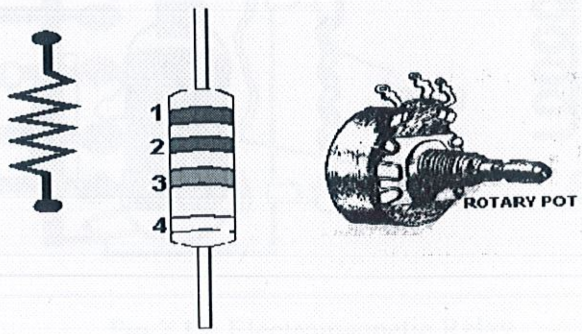

Fig 2.12: Resistor

2.2.7 *Relay*

Relay is a common, simple application of electromagnetism. It uses an electromagnet made from an iron rod wound with hundreds of fine copper wire. When electricity is applied to the wire, the rod becomes magnetic. A movable contact arm above the rod is then pulled toward the rod until it closes a switch contact. When the electricity is removed, a small spring pulls the contract arm away from the rod until it closes a second switch contact. By means of relay, a current circuit can be broken or closed in one circuit as a result of a current in another circuit.

Relays can have several poles and contacts. The types of contacts could be normally open and normally closed. One closure of the relay can turn on the same normally open contacts; can turn off the other normally closed contacts.

Relay requires a current through their coils, for which a voltage is applied. This voltage for a relay can be DC low voltages upto 24V or could be 240V a.c.

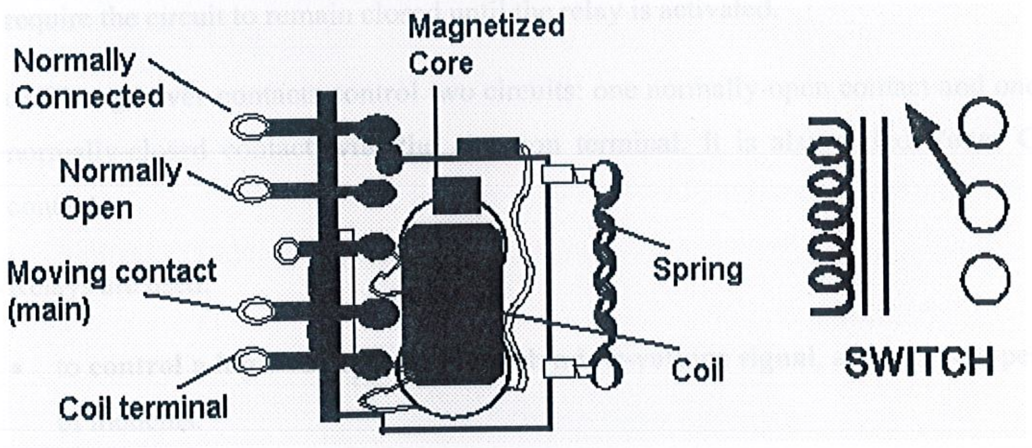

Fig 2.13: Electromagnetic Relay

A **relay** is an electrical switch that opens and closes under control of another electrical circuit. In the original form, the switch is operated by an electromagnet to open or close one or many sets of contacts. It was invented by Joseph Henry in 1835. Since a relay is able to control an output circuit of higher power than the input circuit, it can be considered, in a broad sense, to be a form of electrical amplifier.

These contacts can be either:

a) **Normally-Open (NO)** contacts connect the circuit when the relay is activated; the circuit is disconnected when the relay is inactive. It is also called **Form A** contact or "make" contact. Form A contact is ideal for applications that require to switch a high current power source from a remote device.

b) **Normally-closed (NC)** contacts disconnect the circuit when the relay is activated; the circuit is connected when the relay is inactive. It is also called **Form B** contact or "break" contact. Form B contact is ideal for applications that require the circuit to remain closed until the relay is activated.

c) **Change-over** contacts control two circuits: one normally-open contact and one normally-closed contact with the common terminal. It is also called **Form C** contact.

Relays are used:

- to **control a high-voltage circuit with a low-voltage signal**, as in some types of modems.
- to **control a high-current circuit with a low-current signal**, as in the starter solenoid of an automobile.
- to **detect and isolate faults on transmission and distribution lines** by opening and closing circuit breakers (protection relays).

- to **isolate the controlling circuit from the controlled circuit** when the two are at different potentials, for example when controlling a mains-powered device from a low-voltage switch. The latter is often applied to control office lighting as the low voltage wires are easily installed in partitions, which may be often moved as need change. They may also be controlled by room occupancy detectors in an effort to conserve energy,
- to perform **logic functions**. For example, the boolean AND function is realised by connecting NO relay contacts in series, the OR function by connecting NO contacts in parallel. The change-over or Form C contacts perform the XOR (exclusive or) function. Similar functions for NAND and NOR are accomplished using NC contacts. Due to the failure modes of a relay compared with a semiconductor, they are widely used in safety critical logic, such as the control panels of radioactive waste handling machinery.
- to perform **time delay functions**. Relays can be modified to delay opening or delay closing a set of contacts. A very short (a fraction of a second) delay would use a copper disk between the armature and moving blade assembly. Current flowing in the disk maintains magnetic field for a short time, lengthening release time. For a slightly longer (up to a minute) delay, a dashpot is used. A dashpot is a piston filled with fluid that is allowed to escape slowly. The time period can be varied by increasing or decreasing the flow rate. For longer time periods, a mechanical clockwork timer is installed.

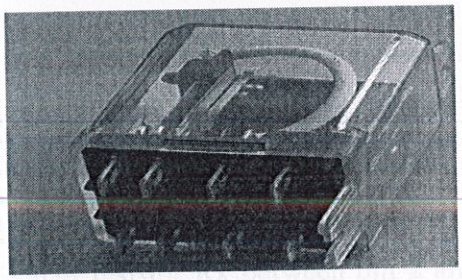

Fig 2.14: Relay

2.2.8 7805: 3-Terminal Voltage Regulators

One can get a constant high-voltage power supply using inexpensive 3-terminal voltage regulators through some simple techniques described below. Depending upon the current requirement, a reasonable load regulation can be achieved. Line regulation in all cases is equal to that of the voltage regulator used.

Advantages of this voltage regulator are: simplicity, low cost, and practically reasonable regulation characteristics. For currents of the order of 1A or less, only one zener and some resistors and capacitors are needed.

The operation of the schematic in fig 2.15 where 78XX is a 3-terminal voltage regulator is described below.

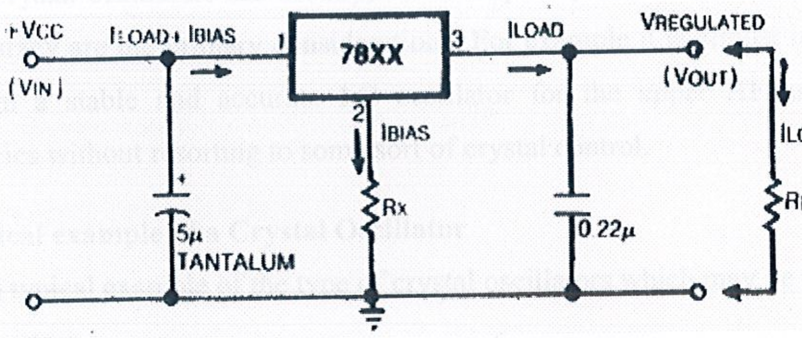

Fig 2.15: Schematic for obtaining low-voltage regulated output using 3-terminal voltage regulators.

Rectified and filtered unregulated voltage is applied at VIN and a constant voltage appears between pins 2 and 3 of the voltage regulator. The distribution of two currents in the circuit (IBIAS and ILOAD) is as shown in the fig 2.15. These voltage regulators have a typical bias current of 5 mA, which is reasonably constant. By inserting a small resistor Rx between pin 2 and ground, the output voltage varies widely in many cases.

By this method voltage increment of 5 to 10 per cent is practically feasible. However, if a high-value resistance is used to obtain a higher output voltage, a slight variation in bias current will result in wide variation of the output voltage.

2.2.9 ***Crystal Oscillator***

Crystal oscillators are oscillators where the primary frequency determining element is a quartz crystal. Because of the inherent characteristics of the quartz crystal the crystal oscillator may be held to extreme accuracy of frequency stability. Temperature compensation may be applied to crystal oscillators to improve thermal stability of the crystal oscillator.

Crystal oscillators are usually, fixed frequency oscillators where stability and accuracy are the primary considerations. For example it is almost impossible to design a stable and accurate LC oscillator for the upper HF and higher frequencies without resorting to some sort of crystal control.

A practical example of a Crystal Oscillator

This is a typical example of the type of crystal oscillators which may be used for say converters.

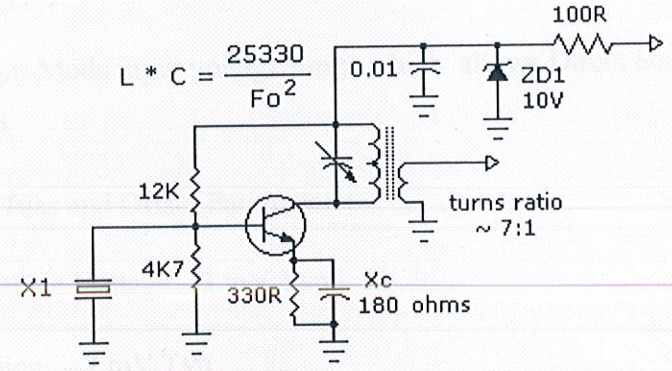

Fig 2.16: Schematic of a crystal oscillator

The transistor could be a general purpose type with a Ft of at least 150 MHz for HF use. A typical example would be a 2N2222A.

The turn's ratio on the tuned circuit depicts an anticipated nominal load of 50 ohms. This allows theoretical 2K5 ohms on the collector. If it is followed by a buffer amplifier we would be able to maintain the typical 7:1 turn's ratio. We have included a formula for determining L and C in the tuned circuits of crystal oscillators. We have taken the value of L a reactance of around 250 ohms. We have made C a smaller trimmer in parallel with a standard fixed value.

2.2.10 <u>LM124, LM124A, LM224, LM224A, LM324, LM324A: Comparators</u>

We have used the comparator LM324 in our project. Its features are stated below:

- 2-kV ESD Protection (K-Suffix Devices)
- Wide Supply Range:
  - Single Supply --3 V to 32 V
  - Or Dual Supplies --1.5 V to 16 V
  - Low Supply-Current Drain Independent of Supply Voltage -- 0.8 mA Typ
  - Common-Mode input voltage range which allows Direct Sensing near Ground
- Low Input Bias and Offset Parameters:
  - Input Offset Voltage --3 mV Typ
  - A Versions --2 mV Typ
  - Input Offset Current --2 nA Typ

- Input Bias Current -- 20 nA Typ
- A Versions --15 nA Typ
- Differential Input Voltage Range equals Maximum Rated Supply Voltage 32 V
- Open-Loop Differential Voltage Amplification --100 V/mV Type

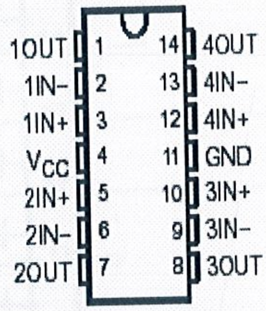

Fig 2.17: Pin out Diagram of LM324

2.2.11 IC – ULN 2003: Motor Driver

The ULN2003 is high voltage, high current Darlington array each containing seven open collector Darlington pairs with common emitters. Each channel rated at 500mA and can withstand peak currents of 600mA. Suppression diodes are included for inductive load driving and the inputs are pinned opposite the outputs to simplify board layout.

Package:

2003A is supplied in 16 pin plastic DIP packages with a copper lead frame to reduce thermal resistance.

Specifications of ULN2003A: 6 – 15V

CMOS

PMOS

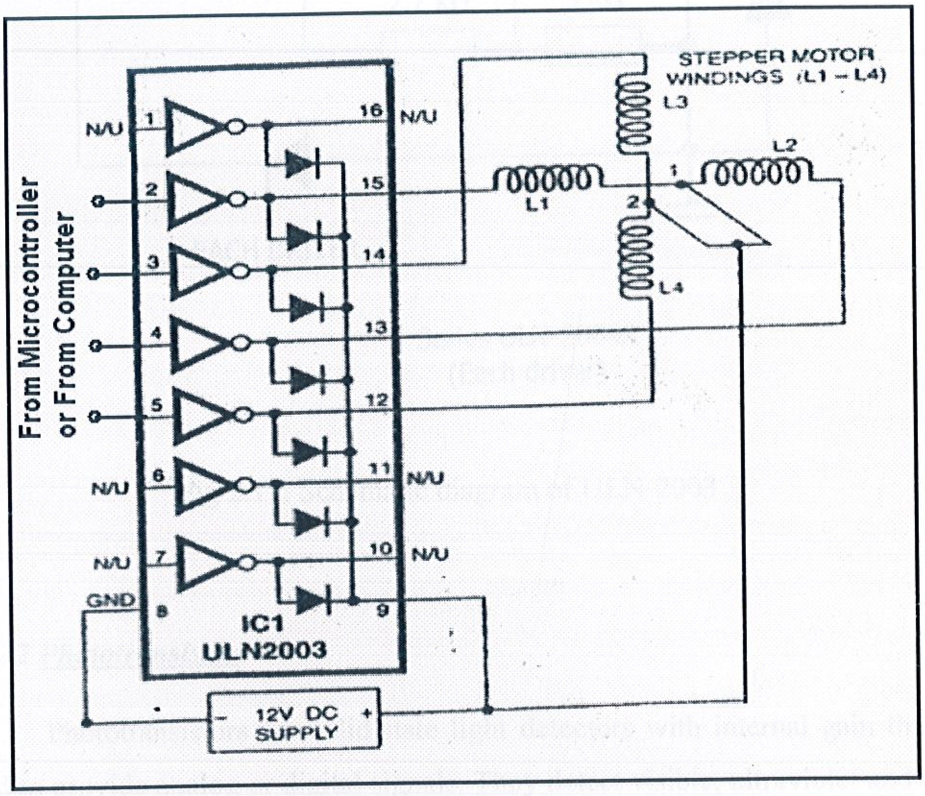

Fig 2.18: Example showing use of ULN-2003 to drive stepper motor

Application of ULN-2003:

These versatile devices are useful for driving a wide range of loads including solenoids, relays, DC motors; LED displays filament lamps, thermal print heads and high power buffers.

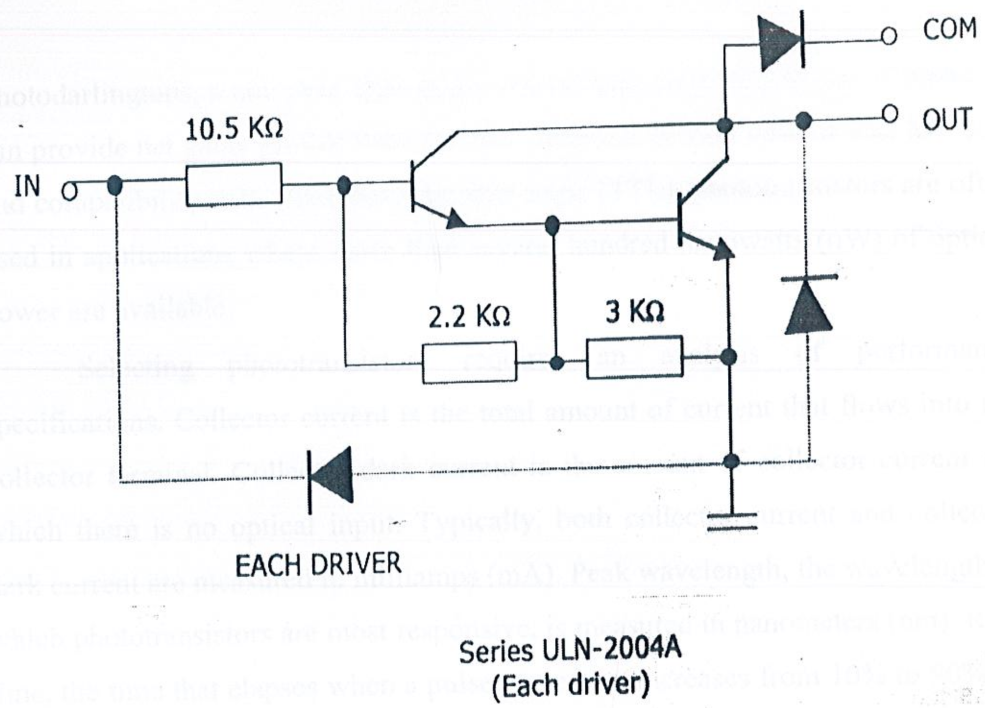

Fig 2.19: Schematic diagram of ULN-2003

2.2.12 Phototransistor

Phototransistors are solid-state light detectors with internal gain that are used to provide analog or digital signals. They detect visible, ultraviolet and near-infrared light from a variety of sources and are more sensitive than photodiodes, semiconductor devices that require a pre-amplifier. Phototransistors feed a photocurrent output into the base of a small signal transistor. For each illumination level, the area of the exposed collector-base junction and the DC current gain of the transistor define the output. The base current from the incident photons is amplified by the gain of the transistor, resulting in current gains that range from hundreds to several thousands. Response time is a function of the capacitance of the collector-base junction and the value of the load resistance.

Photodarlingtons, a common type of phototransistor, have two stages of gain and can provide net gains greater than 100,000. Because of their ease of use, low cost and compatibility with transistor-transistor logic (TTL), phototransistors are often used in applications where more than several hundred nanowatts (nW) of optical power are available.

Selecting phototransistors requires an analysis of performance specifications. Collector current is the total amount of current that flows into the collector terminal. Collector dark current is the amount of collector current for which there is no optical input. Typically, both collector current and collector dark current are measured in milliamps (mA). Peak wavelength, the wavelength at which phototransistors are most responsive, is measured in nanometers (nm). Rise time, the time that elapses when a pulse waveform increases from 10% to 90% of its maximum value, is expressed in nanoseconds (ns). Collector-emitter breakdown voltage is the voltage at which phototransistors conduct a specified (nondestructive) current when biased in the normal direction without optical or electrical inputs to the base. Power dissipation, a measure of total power consumption, is measured in milliwatts (mW). Other performance specifications for phototransistors include spectral range, fall time, acceptance angle, and operating temperature.

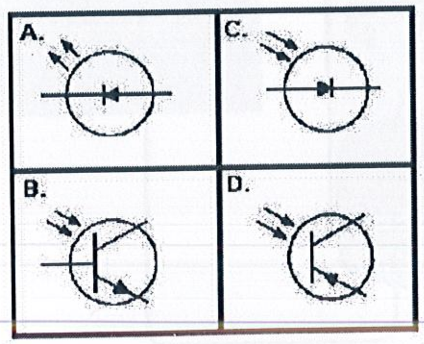

Fig 2.20(a): Phototransistor

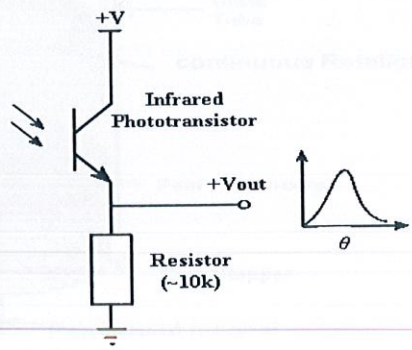

Fig 2.20(b): Working of Phototransistor

2.2.13 *DC Motor*

Faradays used Oersted's principle that electricity could be used to produce motion, to build the world first electric motor in 1821. Ten years later, using the same logic in reverse, Faraday was interested in getting the motion produced by Oersted's experiment to be continuous, rather then just a rotatory shift in position. In his experiments, Faraday thought in terms of magnetic lines of force. He visualized how flux lines existing around a current carrying wire and a bar magnet. He was then able to produce a device in which the different lines of force could interact and produce continuous rotation. The basic Faraday's motor uses a free-swinging wire that circles around the end of a bar magnet. The bottom end of the wire is in a pool of mercury, which allows the wire to rotate while keeping a complete electric circuit.

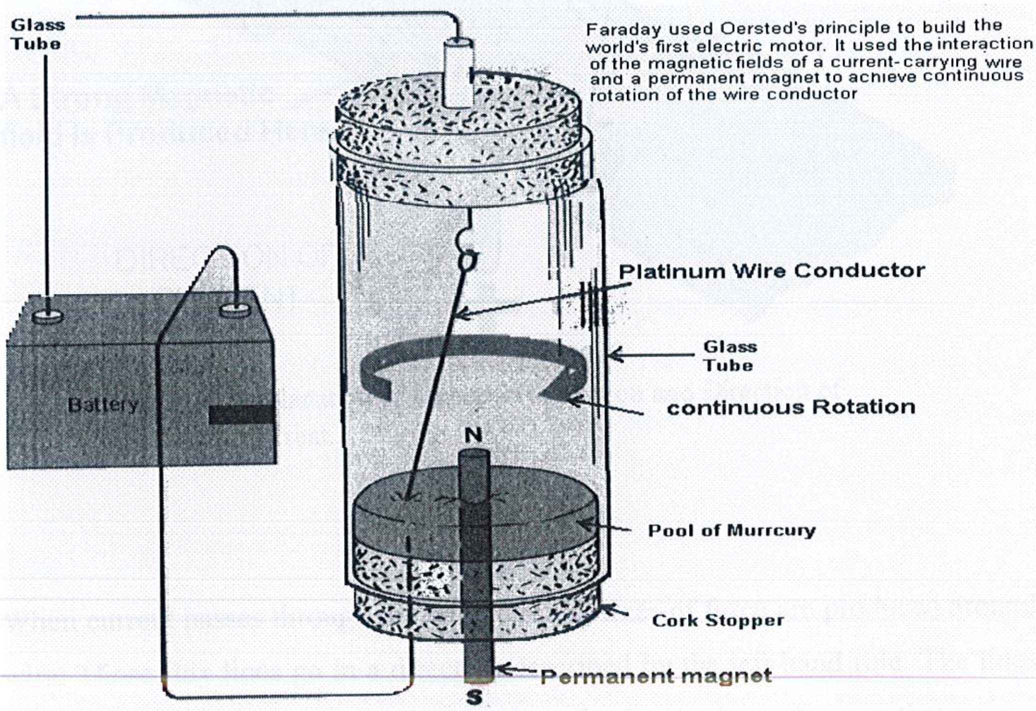

Fig 2.21: Basic Motor Action

Although Faraday's motor was ingenious, it could not be used to do any practical work. This is because its drive shaft was enclosed and it could only produce an internal orbital motion. It could not transfer its mechanical energy to the outside for driving an external load. However, it did show how the magnetic fields of a conductor and a magnet could be made to interact to produce continuous motion. Faraday's motor orbited its wire rotor must pass through the magnet's lines of force.

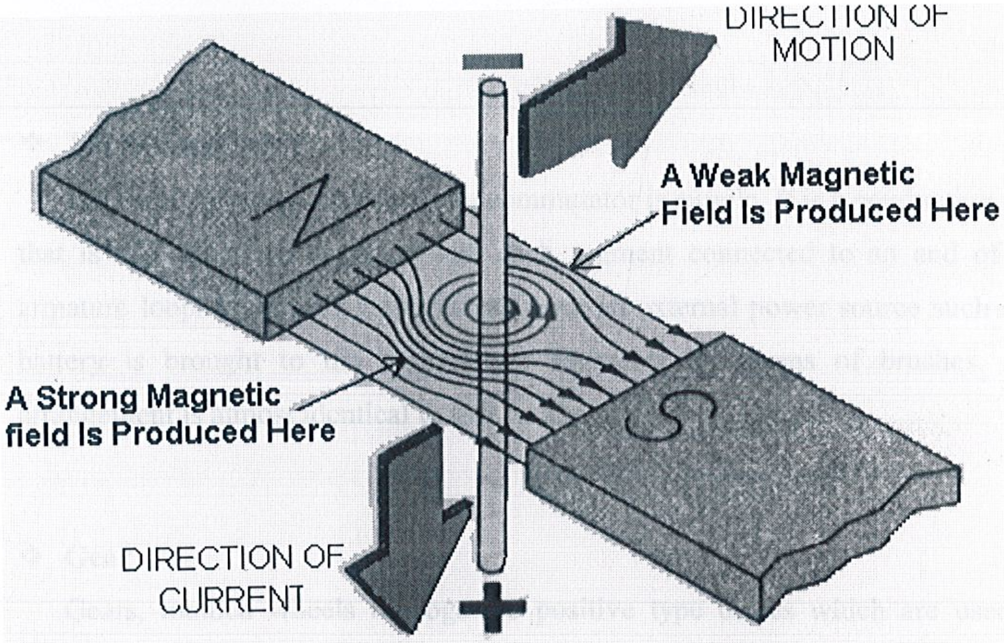

Fig 2.22: Explanation of Direction of Motion and Direction of Current.

When current passes through the wire, circular lines of force are produced around wire. Those flux lines go in a direction described by the left-hand rule. The lines of force of the magnet go from the N pole to the S pole. It can be seen that on one side of the wire, the magnetic lines of force are going in the opposite direction as a result the wire, s flux lines oppose the magnet's flux line since flux lines takes the path of least resistance, more lines concentrate on the other side of the wire conductor, the lines are bent and are very closely spaced. The lines tend to straighten and be wider spaced. Because of this the denser, curved field pushes the wire in the opposite direction.

The direction in which the wire is moved is determined by the right hand rule. If the current in the wire went in the opposite direction, the direction of its flux lines would reverse, and the wire would be pushed the other way.

❖ The Commutator

For the single-loop armature, the commutator is simple. It is a conducting ring that is split into two segment with each segment connected to an end of the armature loop. Power for the armature from an external power source such as a battery is brought to the commutator segments by means of brushes. The arrangement is almost identical to that for the basic dc generator.

❖ Gear

Gears, toothed wheels or cogs are positive type drives which are used to transmit motion between two shafts or a shaft and a component having linear motion, by meshing of two or more gears. They have advantage over other drives like chains, belts etc. in case of precision machines where a definite velocity ratio is of importance and also in case where the driver and the follower are in close proximity; the downside is that gears are more expensive to manufacture and their operating cost is also relatively high.

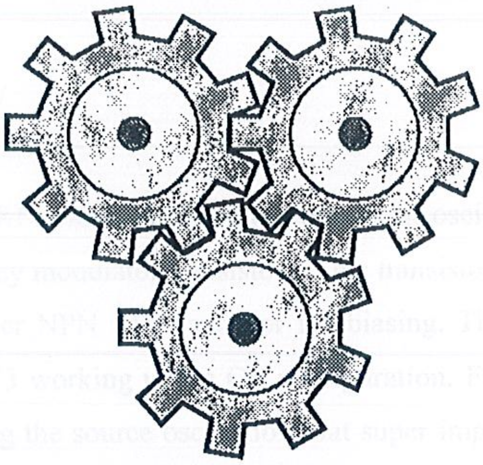

Fig 2.23: Gears

Gears of differing size are often used in pairs for a mechanical advantage, allowing the torque of the driving gear to produce a larger torque in the driven gear at lower speed, or a smaller torque at higher speed. The larger gear is known as a wheel and the smaller as a pinion. This is the principle of the automobile transmission, allowing selection between various mechanical advantages. The ratio of the rotational speeds of two meshed gears is called the Gear ratio.

2.2.14 RF Tag

❖ **RF Transmitter Module**

In the project the RF remote transmitter contain an oscillator comprises one BF-194 (radio frequency modulator transistor). This transistor is coupled with CE configuration with other NPN 548 transistor for biasing. The basic oscillator is formed by transistor T3 working under CE configuration. From the collector an LC circuit is generating the source oscillation that super imposes to the T-2 base from its emitter follower circuit. R2 provides biasing VCC to T3. R1 and LED indicate the power 'on' while pressing the key. The basic modulation circuit comprises T-1, R-6, C-2 and a trimmer variable capacitor. By changing the IFT at the T3 collector (LC circuit) we can change frequency for transmission. Varying trimmer at collector of T-1 can do the range and alignment between transmitter and receiver. A 9V portable battery powers the whole unit.

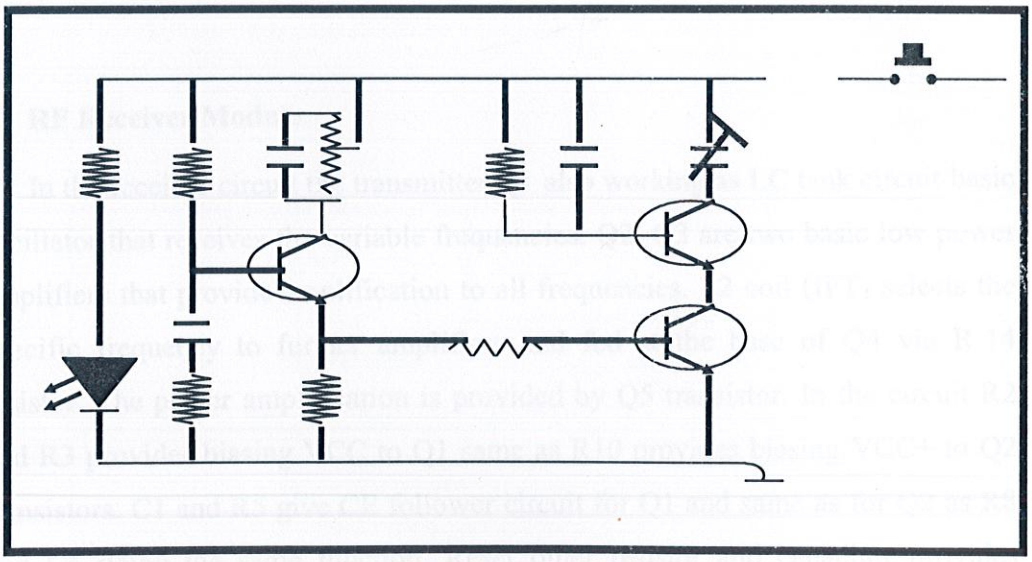

Fig 2.24: RF Transmitter Module

COMPONENTS USED:

RESISTANCE

R1	-	100Ω
R2	-	330K
R3, R4, R5	-	2K7
R6	-	47K

CAPACITORS

C1	-	.022
C2, C3	-	.001

TRANSISTOR

T1	-	BF494
T2	-	BC548

❖ **RF Receiver Module**

In the receiver circuit the transmitter Q1 also working as LC tank circuit basic oscillator that receives the variable frequencies. Q2, Q3 are two basic low power amplifiers that provide amplification to all frequencies. L2 coil (IFT) selects the specific frequency to further amplifiers and fed at the base of Q4 via R-14 resistor. The power amplification is provided by Q5 transistor. In the circuit R2 and R3 provides biasing VCC to Q1 same as R10 provides biasing VCC+ to Q2 transistors. C1 and R5 give CE follower circuit for Q1 and same as for Q2 as R8 and C6 doing the same function. Reset other resistor and capacitor provides necessary biasing VCC and frequency cut off function at different stages of the circuit.

Finally from Q5 the driver unit is given output to the buzzer or any other connected device to operate that unit.

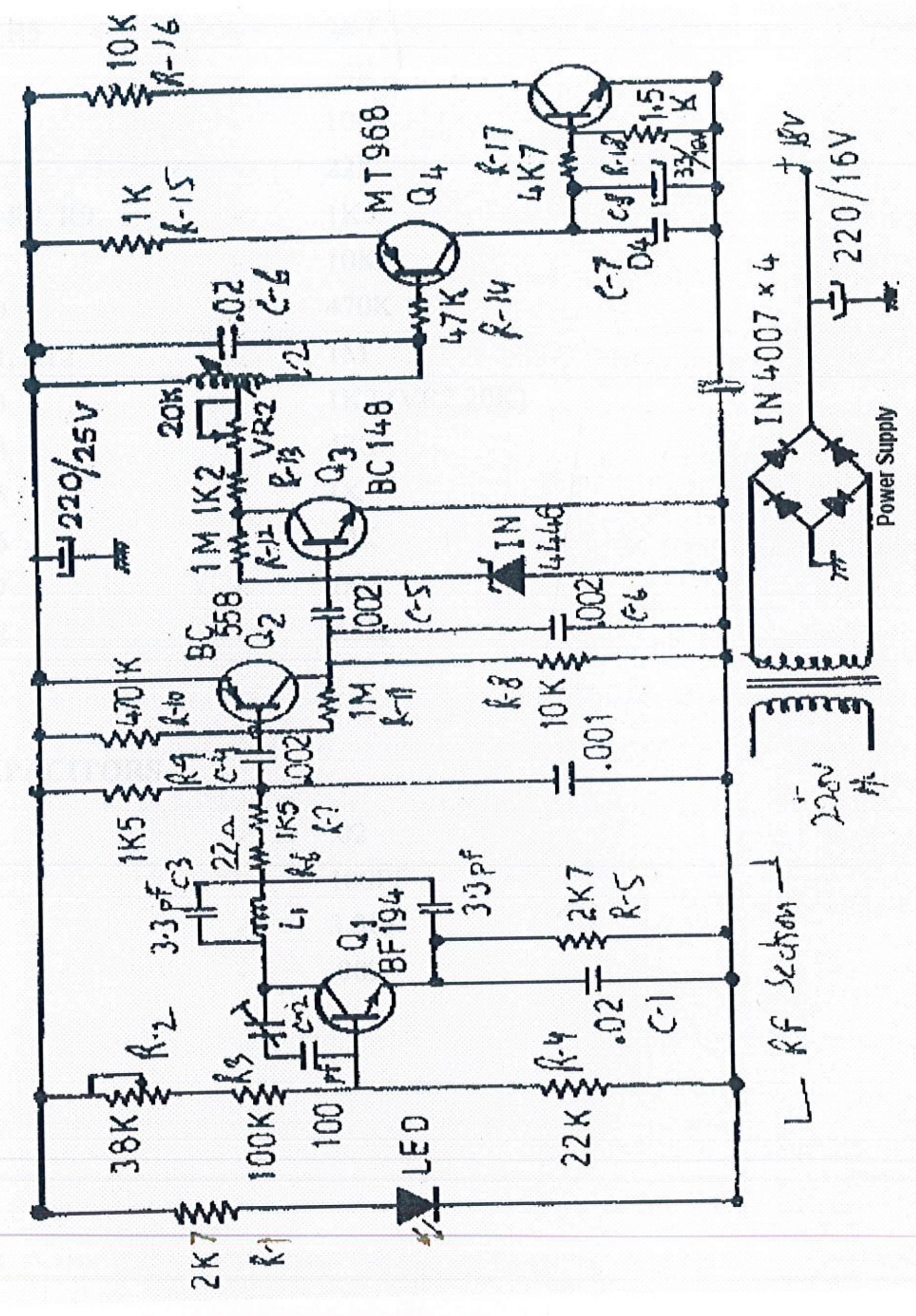

Fig 2.25: RF Receiver Module

COMPONENTS USED:

RESISTANCE

R1, R5	-	2K7
R2	-	38K
R3	-	100K
R4	-	22K
R6, R7, R9	-	1K5
R8	-	10K
R10	-	470K
R11, R12	-	1M
R13	-	1K2 (VR2 20K)
R14	-	47K
R15	-	1K
R16	-	10K
R17	-	4K7
R18	-	1.5K

CAPACITORS

C1	-	.02
C2	-	100Pf
C3	-	3.3Pf
C4	-	.002

CHAPTER 3: MICROCONTROLLER AT89C2051

The invention of the transistor, or semiconductor, was one of the most important developments leading to the personal computer revolution.

The transistor, which essentially functions as a solid-state electronic switch, replaced the much less suitable vacuum tube because the transistor was so much smaller and consumed significantly less power. A computer system built with transistors was much smaller, faster, and more efficient than a computer system built with vacuum tubes.

In 1959, engineers at Texas Instruments invented the *integrated circuit* (IC), a semiconductor circuit that contains more than one transistor on the same base (or substrate material) and connects the transistors without wires. The first IC contained only six transistors.

With the evolution of IC came the most important technological invention of the recent times that is the *microprocessor*. These microprocessors contain no RAM, no ROM, and no I/O ports on the chip itself which gives them the advantage of versatility as designer can decide on the amount of above mentioned things for the task at hand. But the addition of external RAM, ROM, and I/O ports makes these systems bulkier and much more expensive. That's why we have used *Microcontroller*.

A microcontroller has a CPU (a microprocessor) in addition to a fixed amount of RAM, ROM, I/O ports, and a timer all on a single chip. This makes them ideal for many applications in which cost and space are critical. Microcontrollers are used for specific purposes at hand. In our project, we have used AT89C2051 microcontroller.

3.1 Description of AT89C2051 Microcontroller

The AT89C2051 is a low-voltage, high-performance CMOS 8-bit microcomputer with 2K bytes of Flash programmable and erasable read only memory (PEROM). The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry-standard MCS-51 instruction set. By combining a versatile 8-bit CPU with Flash on a monolithic chip, the Atmel AT89C2051 is a powerful microcomputer which provides a highly-flexible and cost-effective solution to many embedded control applications.

The AT89C2051 provides the following standard features: 2K bytes of Flash, 128 bytes of RAM, 15 I/O lines, two 16-bit timer/counters, a five vector two-level interrupt architecture, a full duplex serial port, a precision analog comparator, on-chip oscillator and clock circuitry. In addition, the AT89C2051 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port and interrupt system to continue functioning. The power-down mode saves the RAM contents but freezes the oscillator disabling all other chip functions until the next hardware reset.

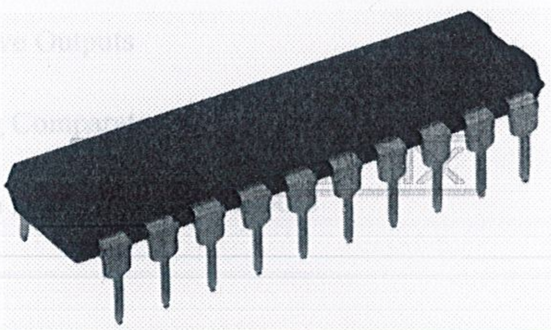

Fig 3.1: AT89C2051 microcontroller

3.2 Features

- 8-bit Microcontroller with 2K Bytes Flash
- Compatible with MCS-51™ Products
- 2K Bytes of Reprogrammable Flash Memory
- Endurance: 1,000 Write/Erase Cycles
- 2.7V to 6V Operating Range
- Fully Static Operation: 0 Hz to 24 MHz
- Two-level Program Memory Lock
- 128 x 8-bit Internal RAM
- 15 Programmable I/O Lines
- Two 16-bit Timer/Counters
- Six Interrupt Sources
- Programmable Serial UART Channel
- Direct LED Drive Outputs
- On-chip Analog Comparator
- Low-power Idle and Power-down Modes

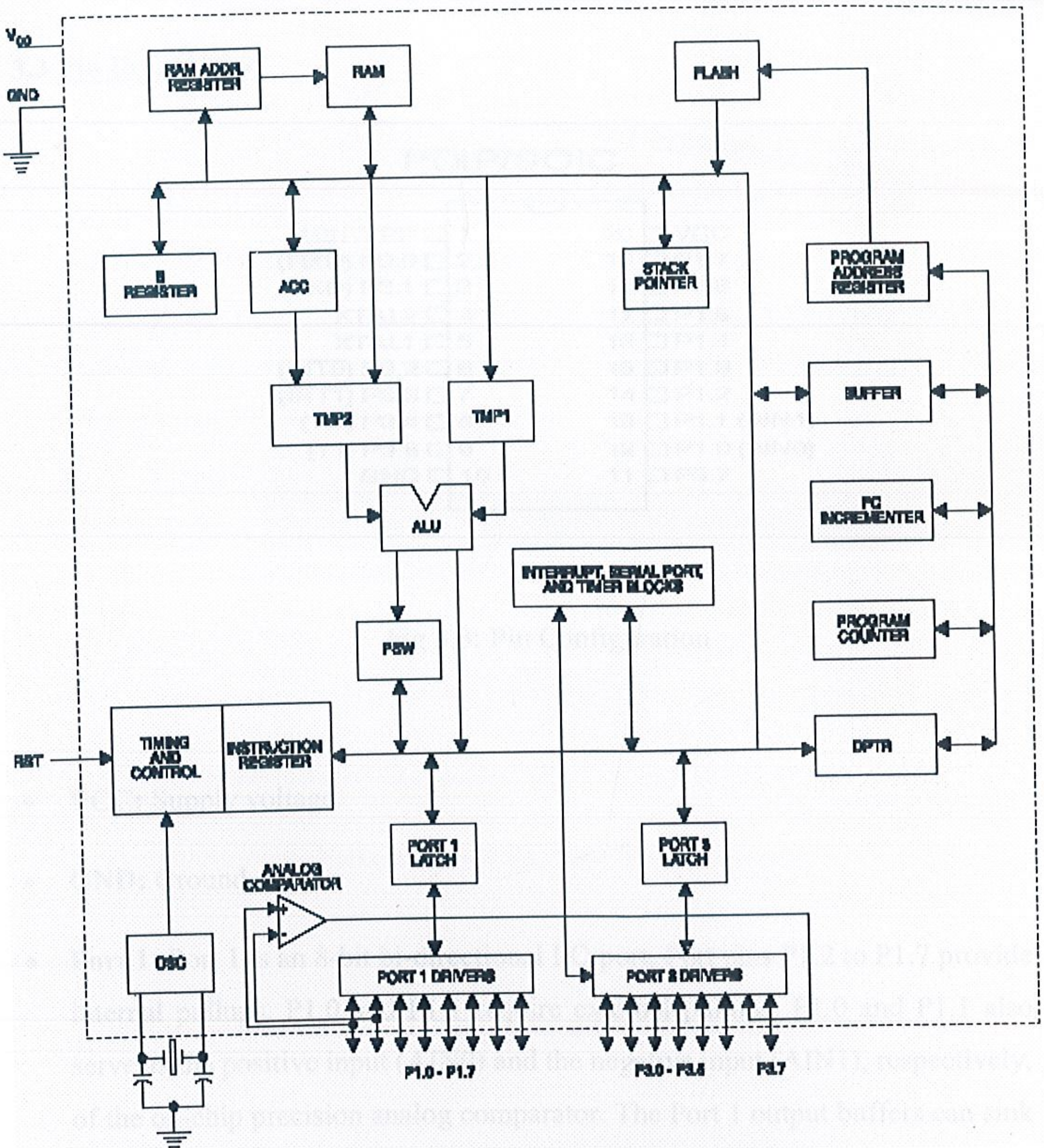

Fig 3.2: Block Diagram of Microcontroller

3.3 Pin Description

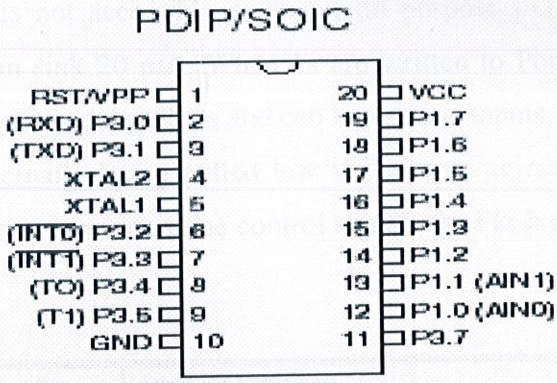

Fig 3.3: Pin Configuration

- **VCC:** Supply voltage.

- **GND:** Ground.

- **Port 1:** Port 1 is an 8-bit bi-directional I/O port. Port pins P1.2 to P1.7 provide internal pullups. P1.0 and P1.1 require external pullups. P1.0 and P1.1 also serve as the positive input (AIN0) and the negative input (AIN1), respectively, of the on-chip precision analog comparator. The Port 1 output buffers can sink 20 mA and can drive LED displays directly.

  When 1s are written to Port 1 pins, they can be used as inputs. When pins P1.2 to P1.7 are used as inputs and are externally pulled low, they will source current because of the internal pullups. Port 1 also receives code data during Flash programming and verification.

- **Port 3:** Port 3 pins P3.0 to P3.5, P3.7 are seven bi-irectional I/O pins with internal pullups. P3.6 is hard-wired as an input to the output of the on-chip comparator and is not accessible as a general purpose I/O pin. The Port 3 output buffers can sink 20 mA. When 1s are written to Port 3 pins they are pulled high by the internal pullups and can be used as inputs. As inputs, Port 3 pins that are externally being pulled low will source current because of the pull-ups. Port 3 also receives some control signals for Flash programming and verification.

Port Pin	Alternate Functions
P3.0	RXD (serial input port)
P3.1	TXD (serial output port)
P3.2	$\overline{\text{INT0}}$ (external interrupt 0)
P3.3	$\overline{\text{INT1}}$ (external interrupt 1)
P3.4	T0 (timer 0 external input)
P3.5	T1 (timer 1 external input)

Table 3.1: Port Pins and their Functions

- **RST:** Reset input. All I/O pins are reset to 1s as soon as RST goes high. Holding the RST pin high for two machine cycles while the oscillator is running resets the device. Each machine cycle takes 12 oscillator or clock cycles.
- **XTAL1:** Input to the inverting oscillator amplifier and input to the internal clock operating circuit.
- **XTAL2:** Output from the inverting oscillator amplifier.

❖ **Oscillator Characteristics:** XTAL1 and XTAL2 are the input and output, respectively, of an inverting amplifier which can be configured for use as an on-chip oscillator, as shown in figure 3.4(a). Either a quartz crystal or ceramic resonator may be used. To drive the device from an external clock source, XTAL2 should be left unconnected while XTAL1 is driven as shown in figure 3.4(b).

There are no requirements on the duty cycle of the external clock signal, since the input to the internal clocking circuitry is through a divide-by-two flip-flop, but minimum and maximum voltage high and low time specifications must be observed.

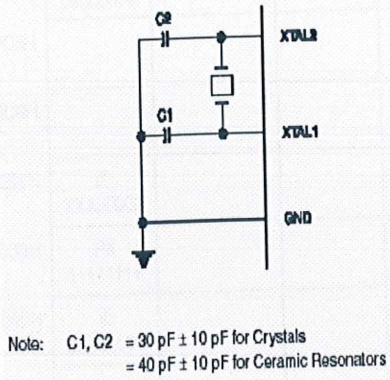

Fig 3.4(a): Oscillator Connections

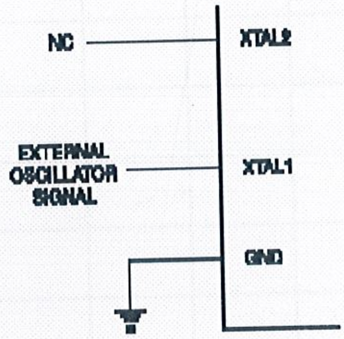

Fig 3.4(b): External clock drive Configuration

❖ **Special Function Registers:** A map of the on-chip memory area called the Special Function Register (SFR) space is shown in the table 3.2 below. Note that not all of the addresses are occupied, and unoccupied addresses may not be implemented on the chip. Read accesses to these addresses will in general return random data, and write accesses will have an indeterminate effect.

User software should not write 1s to these unlisted locations, since they may be used in future products to invoke new features. In that case, the reset or inactive values of the new bits will always be 0.

0F8H									0FFH
0F0H	B 00000000								0F7H
0E8H									0EFH
0E0H	ACC 00000000								0E7H
0D8H									0DFH
0D0H	PSW 00000000								0D7H
0C8H									0CFH
0C0H									0C7H
0B8H	IP XXX00000								0BFH
0B0H	P3 11111111								0B7H
0A8H	IE 0XX00000								0AFH
0A0H									0A7H
98H	SCON 00000000	SBUF XXXXXXXX							9FH
90H	P1 11111111								97H
88H	TCON 00000000	TMOD 00000000	TL0 00000000	TL1 00000000	TH0 00000000	TH1 00000000			8FH
80H		SP 00000111	DPL 00000000	DPH 00000000				PCON 0XXX0000	87H

Table 3.2: AT89C2051 SFR Map and Reset values

3.4 Instructions

- **Branching instructions:** LCALL, LJMP, ACALL, AJMP, SJMP, JMP @A+DPTR These unconditional branching instructions will execute correctly as long as the programmer keeps in mind that the destination branching address must fall within the physical boundaries of the program memory size (locations 00H to 7FFH for the 89C2051). Violating the physical space limits may cause unknown program behavior. CJNE [...], DJNZ [...], JB, JNB, JC, JNC, JBC, JZ, JNZ with these conditional branching instructions the same rule above applies. Again, violating the memory boundaries may cause erratic execution. For applications involving interrupts the normal interrupt service routine address locations of the 80C51 family architecture have been preserved.
- **MOVX-related instructions, Data Memory:** The AT89C2051 contains 128 bytes of internal data memory. Thus, in the AT89C2051 the stack depth is limited to 128 bytes, the amount of available RAM. External DATA memory access is not supported in this device, nor is external PROGRAM memory execution. Therefore, no MOVX [...] instructions should be included in the program. A typical 80C51 assembler will still assemble instructions, even if they are written in violation of the restrictions mentioned above. Program Memory Lock Bits On the chip are two lock bits which can be left unprogrammed (U) or can be programmed (P) to obtain the additional features listed in the table below:

Program Lock Bits	LB1	LB2	Protection Type
1	U	U	No program lock features.
2	P	U	Further programming of the Flash is disabled.
3	P	P	Same as mode 2, also verify is disabled.

Note: 1. The Lock Bits can only be erased with the Chip Erase operation.

Table 3.3: Lock Bit Protection Mode

- **Idle Mode:** In idle mode, the CPU puts itself to sleep while all the onchip peripherals remain active. The mode is invoked by software. The content of the on-chip RAM and all the special functions registers remain unchanged during this mode. The idle mode can be terminated by any enabled interrupt or by a hardware reset.P1.0 and P1.1 should be set to "0" if no external pullups are used, or set to "1" if external pullups are used. It should be noted that when idle is terminated by a hardware reset, the device normally resumes program execution, from where it left off, up to two machine cycles before the internal reset algorithm takes control. On-chip hardware inhibits access to internal RAM in this event, but access to the port pins is not inhibited. To eliminate the possibility of an unexpected write to a port pin when Idle is terminated by reset, the instruction following the one that invokes Idle should not be one that writes to a port pin or to external memory.

- **Power-down Mode:** In the power down mode the oscillator is stopped, and the instruction that invokes power down is the last instruction executed. The on-chip RAM and Special Function Registers retain their values until the power down mode is terminated. The only exit from power down is a hardware reset. Reset redefines the SFRs but does not change the on-chip RAM. The reset should not be activated before VCC is restored to its normal operating level and must be held active long enough to allow the oscillator to restart and stabilize. P1.0 and P1.1 should be set to "0" if no external pullups are used, or set to "1" if external pullups are used.

3.5 Programming the Microcontroller

- **Programming the Flash:** The AT89C2051 is shipped with the 2K bytes of on-chip PEROM code memory array in the erased state (i.e., contents = FFH) and ready to be programmed. The code memory array is programmed one byte at a time. Once the array is programmed, to re-program any non-blank byte, the entire memory array needs to be erased electrically.
- **Internal Address Counter:** The AT89C2051 contains an internal PEROM address counter which is always reset to 000H on the rising edge of RST and is advanced by applying a positive going pulse to pin XTAL1.
- **Programming Algorithm:** To program the AT89C2051, the following sequence is followed.

  a) Power-up sequence: Apply power between VCC and GND pins. Set RST and XTAL1 to GND.

  b) Set pin RST to "H". Set pin P3.2 to "H".

c) Apply the appropriate combination of "H" or "L" logic levels to pins P3.3, P3.4, P3.5 and P3.7 to select one of the programming operations shown in the PEROM Programming Modes table 3.4. To Program and Verify the array:

d) Apply data for Code byte at location 000H to P1.0 to P1.7.

e) Raise RST to 12V to enable programming.

f) Pulse P3.2 once to program a byte in the PEROM array or the lock bits. The byte-write cycle is self-timed and typically takes 1.2 ms.

g) To verify the programmed data, lower RST from 12V to logic "H" level and set pins P3.3 to P3.7 to the appropiate levels. Output data can be read at the port P1 pins.

h) To program a byte at the next address location, pulse XTAL1 pin once to advance the internal address counter. Apply new data to the port P1 pins.

i) Repeat steps e) through h), changing data and advancing the address counter for the entire 2K bytes array or until the end of the object file is reached.

j) Power-off sequence: set XTAL1 to "L" , set RST to "L"

k) Turn VCC power off.

❖ **Data Polling:** The AT89C2051 features Data Polling to indicate the end of a write cycle. During a write cycle, an attempted read of the last byte written will result in the complement of the written data on P1.7. Once the write cycle has been completed, true data is valid on all outputs, and the next cycle may begin. Data Polling may begin any time after a write cycle has been initiated.

- **Ready/Busy:** The Progress of byte programming can also be monitored by the RDY/BSY output signal. Pin P3.1 is pulled low after P3.2 goes high during programming to indicate BUSY. P3.1 is pulled High again when programming is done to indicate READY.

- **Program Verify:** If lock bits LB1 and LB2 have not been programmed code data can be read back via the data lines for verification:

  a) Reset the internal address counter to 000H by bringing RST from "L" to "H".

  b) Apply the appropriate control signals for Read Code data and read the output data at the port P1 pins.

  c) Pulse pin XTAL1 once to advance the internal address counter.

  d) Read the next code data byte at the port P1 pins.

  e) Repeat steps c) and d) until the entire array is read. The lock bits cannot be verified directly. Verification of the lock bits is achieved by observing that their features are enabled.

- **Chip Erase:** The entire PEROM array (2K bytes) and the two Lock Bits are erased electrically by using the proper combination of control signals and by holding P3.2 low for 10 ms. The code array is written with all "1"s in the Chip Erase operation and must be executed before any nonblank memory byte can be re-programmed.

- **Reading the Signature Bytes:** The signature bytes are read by the same procedure as a normal verification of locations 000H, 001H, and 002H, except that P3.5 and P3.7 must be pulled to a logic low.

The values returned are as follows:

- (000H) = 1EH indicates manufactured by Atmel
- (001H) = 21H indicates 89C2051

❖ Programming Interface

Every code byte in the Flash array can be written and the entire array can be erased by using the appropriate combination of control signals. The write operation cycle is selftimed and once initiated, will automatically time itself to completion.All major programming vendors offer worldwide support for the Atmel microcontroller series. Please contact your local programming vendor for the appropriate software revision.

Mode		RST/VPP	P3.2/$\overline{PROG}$	P3.3	P3.4	P3.5	P3.7
Write Code Data[1][3]		12V	¯_/¯	L	H	H	H
Read Code Data[1]		H	H	L	L	H	H
Write Lock	Bit - 1	12V	¯_/¯	H	H	H	H
	Bit - 2	12V	¯_/¯	H	H	L	L
Chip Erase		12V	¯_/¯ (2)	H	L	L	L
Read Signature Byte		H	H	L	L	L	L

Notes: 1. The internal PEROM address counter is reset to 000H on the rising edge of RST and is advanced by a positive pulse at XTAL 1 pin.
2. Chip Erase requires a 10 ms $\overline{PROG}$ pulse.
3. P3.1 is pulled Low during programming to indicate RDY/$\overline{BSY}$.

Table 3.4: Flash Programming Modes

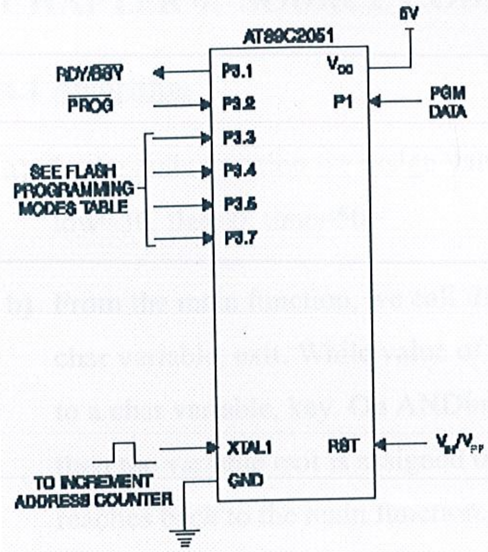

Fig 3.5(a): Programming Flash memory

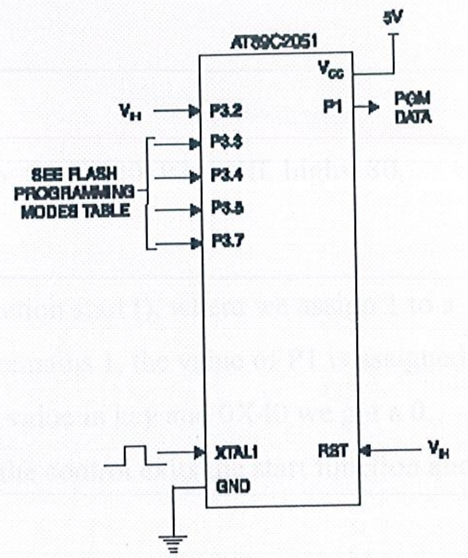

Fig 3.5(b): Verifying Flash memory

CHAPTER 4: SOURCE CODING

4.1 Algorithm

a) In the main function we assign values to: P1=0X40, P3=0Xff, high= 80, low=30, flag=0, time=50.

b) From the main function, we call the function start (), where we assign 1 to a char variable, exit. While value of exit remains 1, the value of P1 is assigned to a char variable, key. On ANDing the value in key and 0X40 we get a 0, then the variable exit is assigned 0 and the control exits the start function and reaches back to the main function.

c) In the main function, the control switches to the never ending while loop in which we assign P3 the value obtained by ORing the value previously stored in P3 and 0X0f. Then it calls the function Run ().

d) In Run (), we AND the value of sensors with 0X01. If we get a 0 then TurnRight function is called and flag is assigned 1.

e) TurnRight function allows us to assign P1= 0X68 and increases the speed of right wheel by incrementing the variable speedright by 5. Speedleft is assigned the value stored in variable low, with delay introduced.

f) Now if in the function RUN (), the value obtained by ANDing the value stored in sensors and 0X08 is 0 then TurnLeft function is called.

g) In TurnLeft, we increment the value of variable speedright by 5 and the value of speedleft is assigned low. Delay is introduced.

h) The control comes back to the RUN function. Now if the value in sensors is equal to 0X09 then forward function is called and the variable high is sent as argument. At forward function, value stored in variable high is received in the variable speed.

i) In the Forward function, the value of speed right is increased to speed plus 10, and speedleft is assigned the value of variable speed. Delay is introduced.

j) Now in the RUN function if the value stored in sensors is equal to 0X0b or the value in sensors is equal to 0X0d and flag is equal to 0 then the function Forward is called and the variable low is sent as argument.

4.2 Flowchart

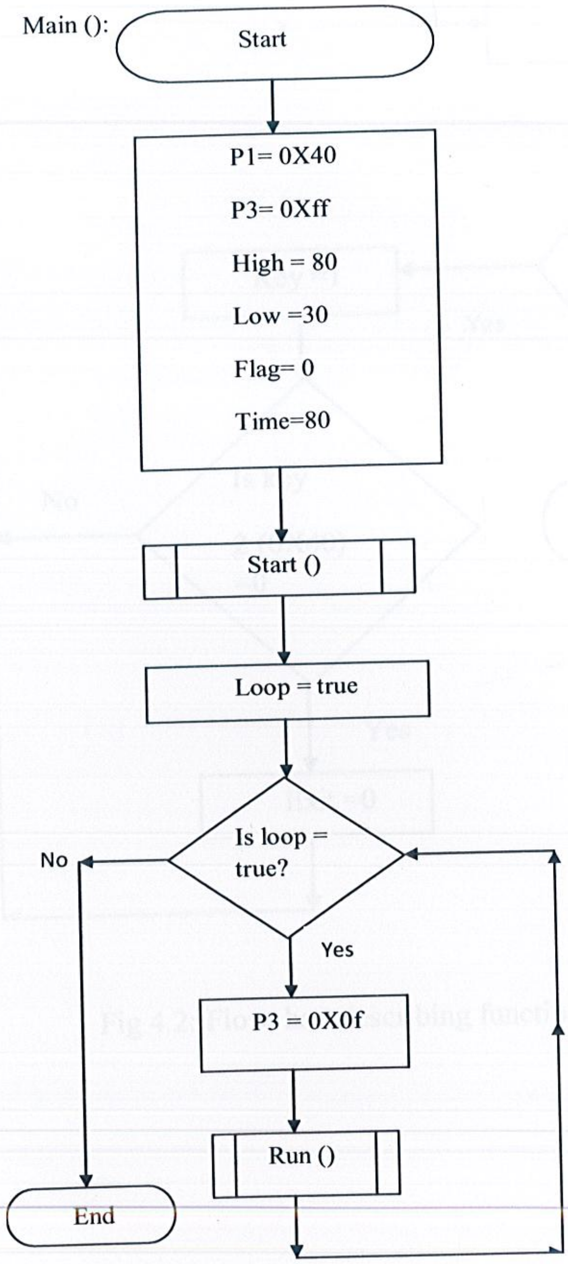

Fig 4.1: Flowchart describing function main ()

Start ():

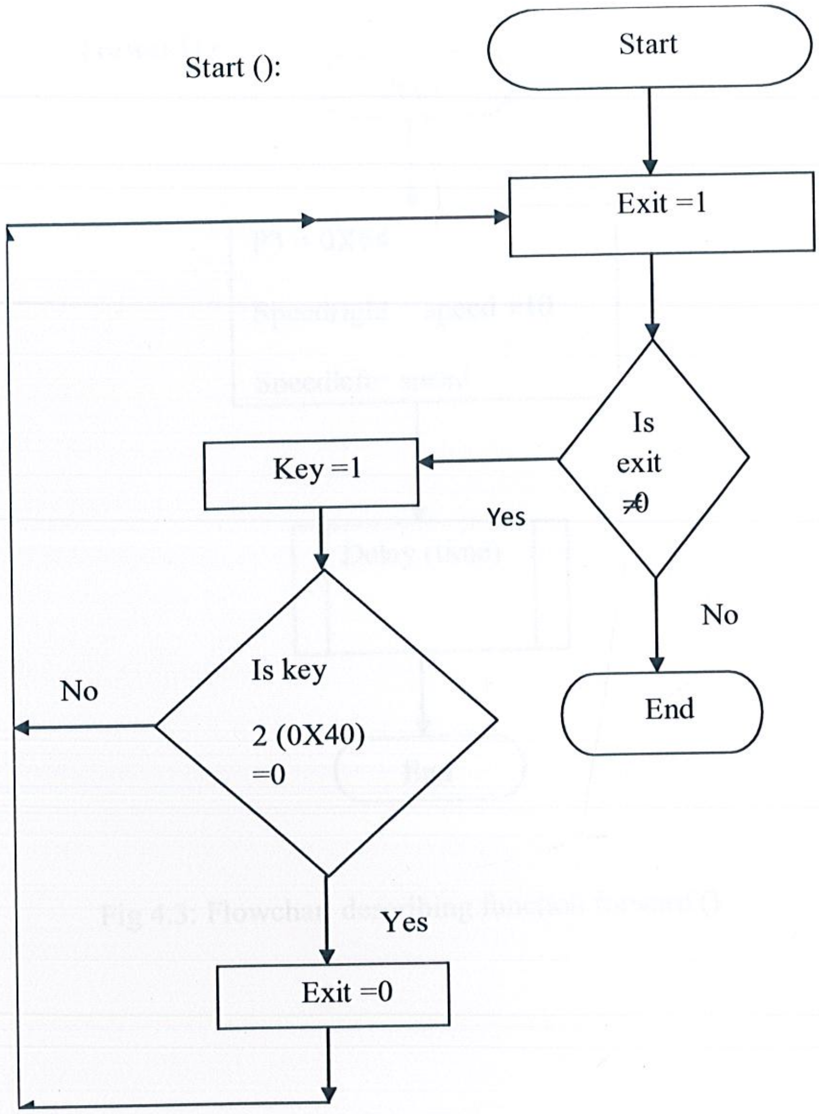

Fig 4.2: Flowchart describing function start ()

Forward ():

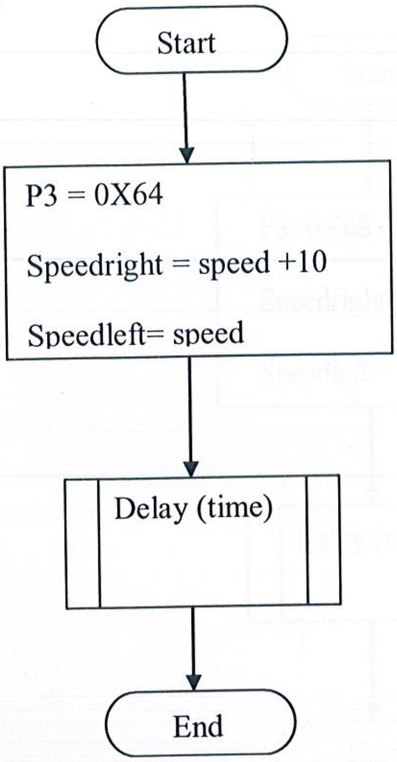

Fig 4.3: Flowchart describing function forward ()

TurnRight ():

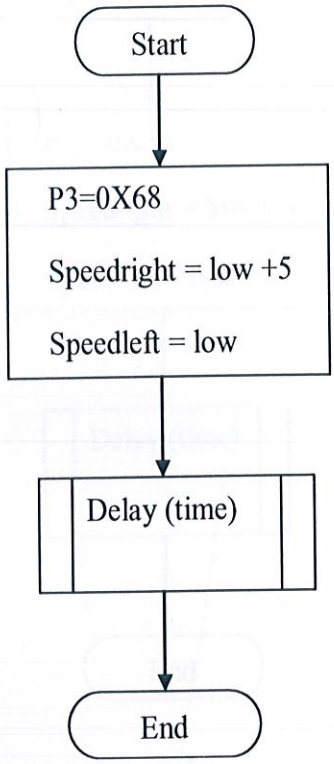

Fig 4.4: Flowchart describing function TurnRight ()

TurnLeft ():

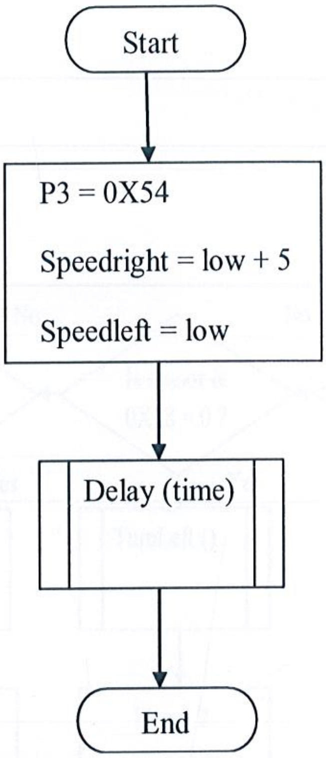

Fig 4.5: Flowchart describing function TurnLeft ()

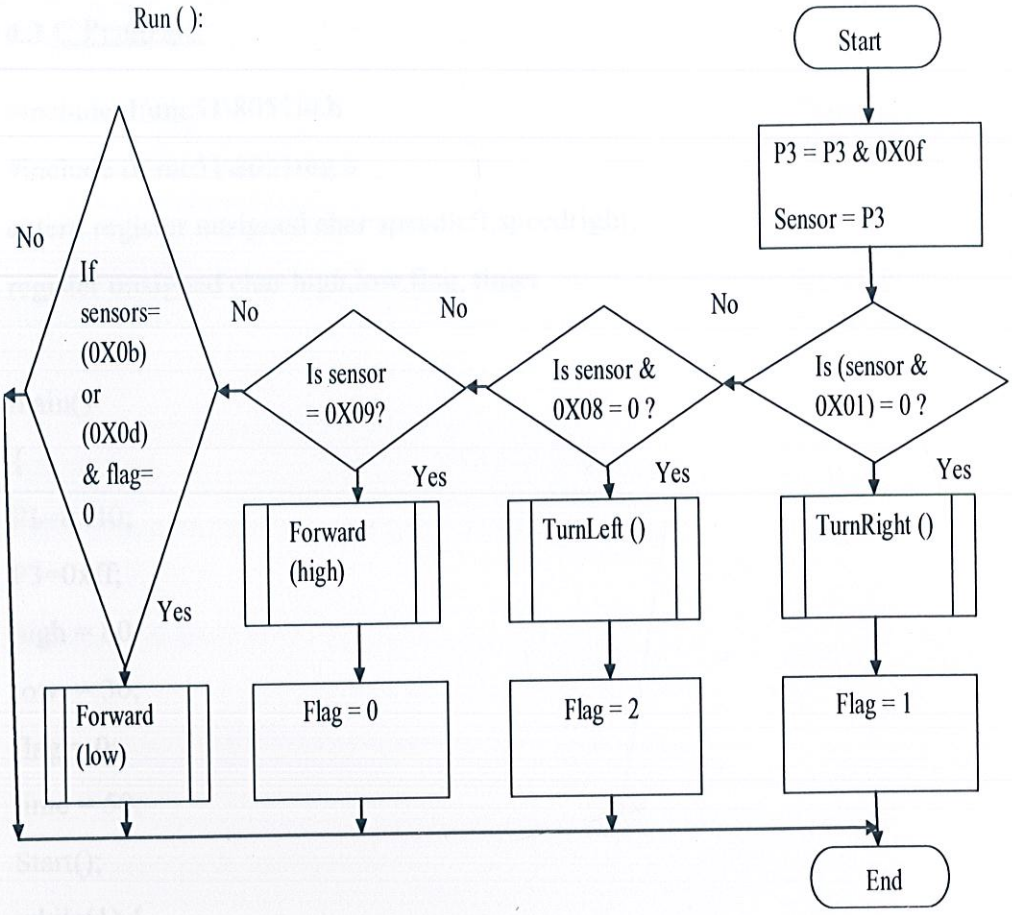

Fig 4.6: Flowchart describing function Run ()

4.3 C Program

```
#include d:\mc51\8051io.h
#include d:\mc51\8051reg.h
extern register unsigned char speedleft,speedright;
register unsigned char high,low,flag, time;

main()
{
P1=0x40;
P3=0xff;
high = 80;
low  = 30;
flag = 0;
time = 50;
Start();
while(1) {
P3|= 0x0f;
Run();
}
}

Start()
{
char exit,key;
exit =1;
while(exit)
```

```
{
key = P1;
if((key & 0x40)==0) exit=0;
}
}

Run()
{
char sensors;
sensors = (P3 &=0x0f);

if((sensors & 0x01)==0) {
TurnRight();
flag = 1;      }

else  if((sensors & 0x08)==0) {
TurnLeft();
flag = 2;          }
else  if(sensors == 0x09)    {
Forward(high);
flag = 0; }
else  if(((sensors==0x0b)||(sensors==0x0d))&&(flag==0))
Forward(low);

}
```

```
Forward(char speed)
{
P1=0x64;
speedright = speed+10;
speedleft  = speed;
delay(time);
}

TurnRight()
{
P1=0x68;
speedright = low+5;
speedleft  = low;
delay(time);
}

TurnLeft()
{
P1=0x54;
speedright = low+5;
speedleft  = low;
delay(time);
}
```

CHAPTER 5: FUTURE SCOPE

5.1 Applications

- *A guard robot:* The bot can be set to guard a corridor in homes and offices. Equipping it with a long range wireless camera would really be a good idea so that it can transmit images to a control centre placed at a remote or nearby location
- *An exploring bot*: The bot can be operated in manual mode from a remote control state(e.g. a pc) and can be used to work in tight or hazardous places (like pipes, mines and so on) and places that humans can't explore on their own.
- *A serving bot*: In offices or college cafeterias the bot can be used to serve meals, beverages and so on.
- *As an agricultural bot*: The bot can be equipped with more powerful machinery and then can be set to work on small fields e.g. to clear grass, harvest crops etc.

5.2 Possible Improvements

- Use of camera will help in analyzing the path and will provide a view to the robot user.
- Use of differential steering with gradual change in wheel speeds.
- Use of Hysteresis in sensor circuit using LM339.
- Use of ADC so that the exact position of the line can be interpolated.
- Use of wheelchair or three wheel drive to reduce traction.
- General improvements like using a low dropout voltage regulator, lighter chassis etc.

CHAPTER 6: CONCLUSION

Our efforts in this project have been concentrated on designing a system that can be used to develop a robot that can fit into a number of applications and also be cost effective as far as possible so as to provide an effective solution to the applied fields. The RF tag used along with the microcontroller that is programmed for the path follower robotic car in this project has given a hint towards the potential of designing an even better robotic system which when equipped with more advanced components can prove to be an effective and cheap solution to a variety of applications that are either handled by humans or left undiscovered.

SNAPSHOTS OF OUR PROJECT

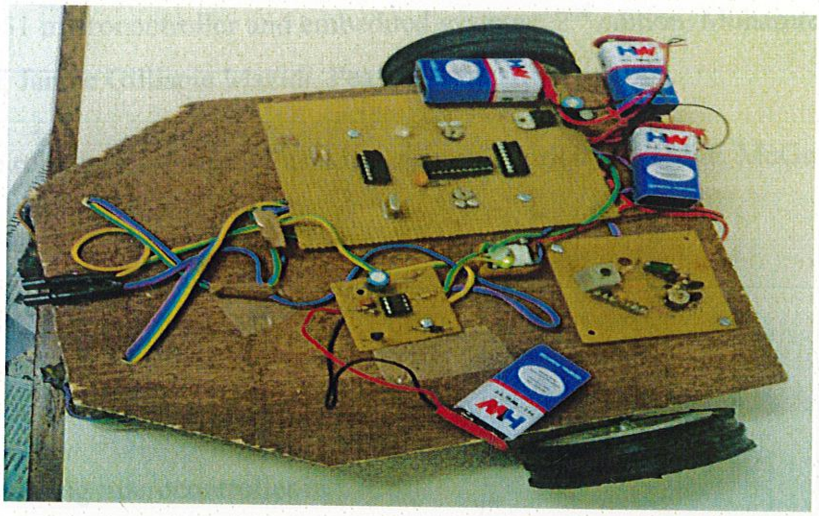

Fig 6.1: Top View of Path Follower Robotic Car

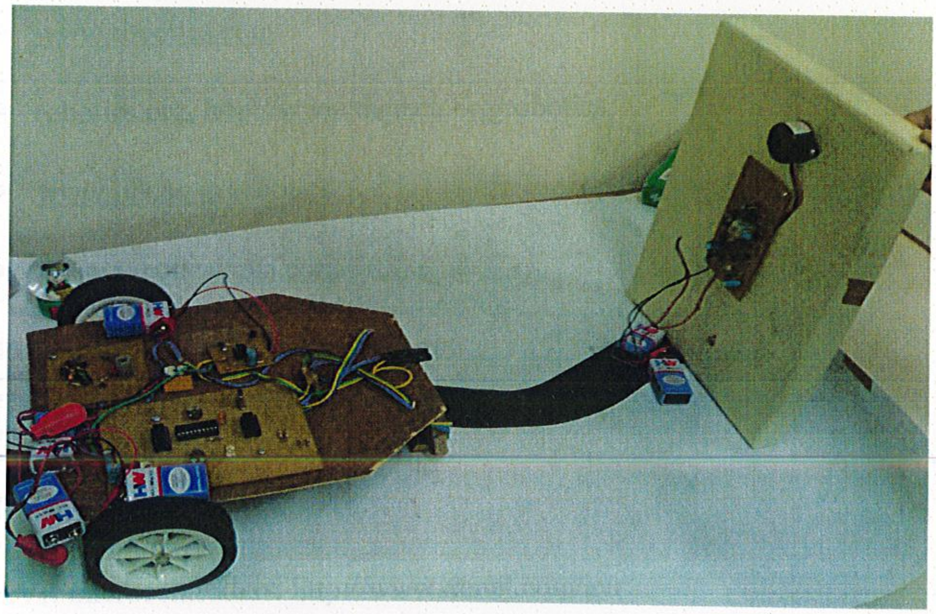

Fig 6.2: Robotic Car Following the Black Path

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  - www.iitk.ac.in robotics
  - www.roboticsindia.com
  - www.robotics_platform.eu.com
  - www.google.com
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