A

PROJECT REPORT ON

LINE FOLLOWER ROBOT

Submitted to

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IN
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CERTIFICATE

This is certified that the Project entitled **LINE FOLLOWER ROBOT** is the record of bonafide work done by **ROHIT DADORIYA (0905EC 131137), RISHABH GUPTA (0905EC131132)** and **PUSHPENDRA RAGHUWANSHI (0905EC131125)** under my guidance for the partial Fulfillment of the requirements for the award of the degree of **"Bachel or of Engineering."** To the best of my knowledge, this project is an ori ginal work and has not been submitted anywhere for the award of any degree.

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CERTIFICATE OF APPROVAL

The foregoing project entitled **LINE FOLLOWER ROBOT** is hereby approved as a creditable study of an engineering subject carried out and presented in a manner satisfactory to warrant its acceptance as a pre-req uisite to the degree for which it is submitted. It is understood that by this approval, the undersigned do not necessarily endorse any conclusion or opinion therein, but approve the project for the purpose for which it was submitted.

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Abstract

This paper report describes the techniques for analyzing, designing, controlling and improving the material supply delivery within hospitals. Due to increasing demands for patient supervision, the jobs like supply of food, medicines etc., has become a time consuming process. So, a microcontroller based line following robot carrying medicine can be designed for providing the medicine to the patient whenever they need it. A line follower robot is an electronic system that can detect and follow a line drawn on the floor. The robot uses IR sensors to sense the line, an array of 3 IR LEDs and sensors, facing the ground have been used in this setup. An IR sensor can be fitted near the patient's bed to which connection has been made with the robot too. The switch for it can be activated by the supply person in the microcontroller itself. If the switch is pressed then a flag bit is set in the microcontroller, from which the robot follows the line and reaches near the patient and provide the medicine to the patient. A proximity sensor can be attached with the robot so that it detects any obstacle present in their way and can alarm. The ability to get someone around the clock is the best thing that this system can do. This helps and simplifies the job of material supply and also reduces the manual routine work done by the hospital staff. This technology focuses on the delivery of safe, timely, efficient, effective, patient-centered health care.

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Chapter 1

INTRODUCTION

A line follower robot is basically a robot designed to follow a line or path already pre determined by the user. This line or path may be as simple as a physical white line on the floor or as complex path marking schemes e.g. embedded lines, magnetic markers and laser guide markers. In order to detect these specific markers or 'lines', various se nsing schemes can be employed. These schemes may vary from simple low cost line s ensing circuit to expansive vision systems. The choice of these schemes would be dep endent upon the sensing accuracy and flexibility required. From the industrial point of view, line following robot has been implemented in semi to fully autonomous plants. In this environment, these robots functions as materials carrier to deliver products fro m one manufacturing point to another where rail, conveyor and gantry solutions are n ot possible. Apart from line following capabilities, these robots should also have the c apability to navigate junctions and decide on which junction to turn and which junctio n ignore. This would require the robot to have 90 degree turn and also junction counti ng capabilities. To add on to the complexity of the problem, sensor positioning also pl ays a role in optimizing the robots performance for the tasks mentioned earlier.

Line-following robots with pick- and- placement capabilities are commonly used in m anufacturing plants. These move on a specified path to pick the components from spec ified locations and place them on desired locations. Basically, a line-following robot i s a self-operating robot that detects and follows a line drawn on the floor. The path to be taken is indicated by a white line on a black surface. The control system used must sense the line and man oeuvre the robot to stay on course while constantly correcting t he wrong moves using feedback mechanism, thus forming a simple yet effective close d- loop system.

1.1 Objective of Study

The robot must be capable of following a line.

- It should be capable of taking various degrees of turns
- It must be prepared of a situation that it runs into a territory which has no line to follow.
- The robot must also be capable of following a line even if it has breaks.

- The robot must be insensitive to environmental factors such as lighting and noise.
- It must allow calibration of the line's darkness threshold.
- The robot must be reliable
- Scalability must be a primary concern in the design.
- The color of the line must not be a factor as long as it is darker than the Surroundings

1.2 Problem Defination

In the industry carriers are required to carry products from one manufacturing plant to another which are usually in different buildings or separate blocks. Conventionally, c arts or trucks were used with human drivers. Unreliability and inefficiency in this part of the assembly line formed the weakest link. The project is to automate this sector, u sing carts to follow a line instead of laying railway tracks which are both costly and a n inconvenience

1.3 Project Scope

The robot can be further enhanced to let the user decide whether it is a dark line on a white background or a white line on a dark background. The robot can also be progra mmed to decide what kind of line it is, instead of a user interface. The motor control c ould be modified to steer a convectional vehicle, and not require a differential steering system. The robot could be modified to be a four wheel drive. Extra sensors could be attached to allow the robot to detect obstacles, and if possible bypass it and get back t o the line. In other words, it must be capable predicting the line beyond the obstacle. S peed control could also be incorporated. Position and distance sensing devices could a lso be built in which can transmit information to a mother station, which would be use ful in tracking a lost carrier.

1.4 Block Diagram

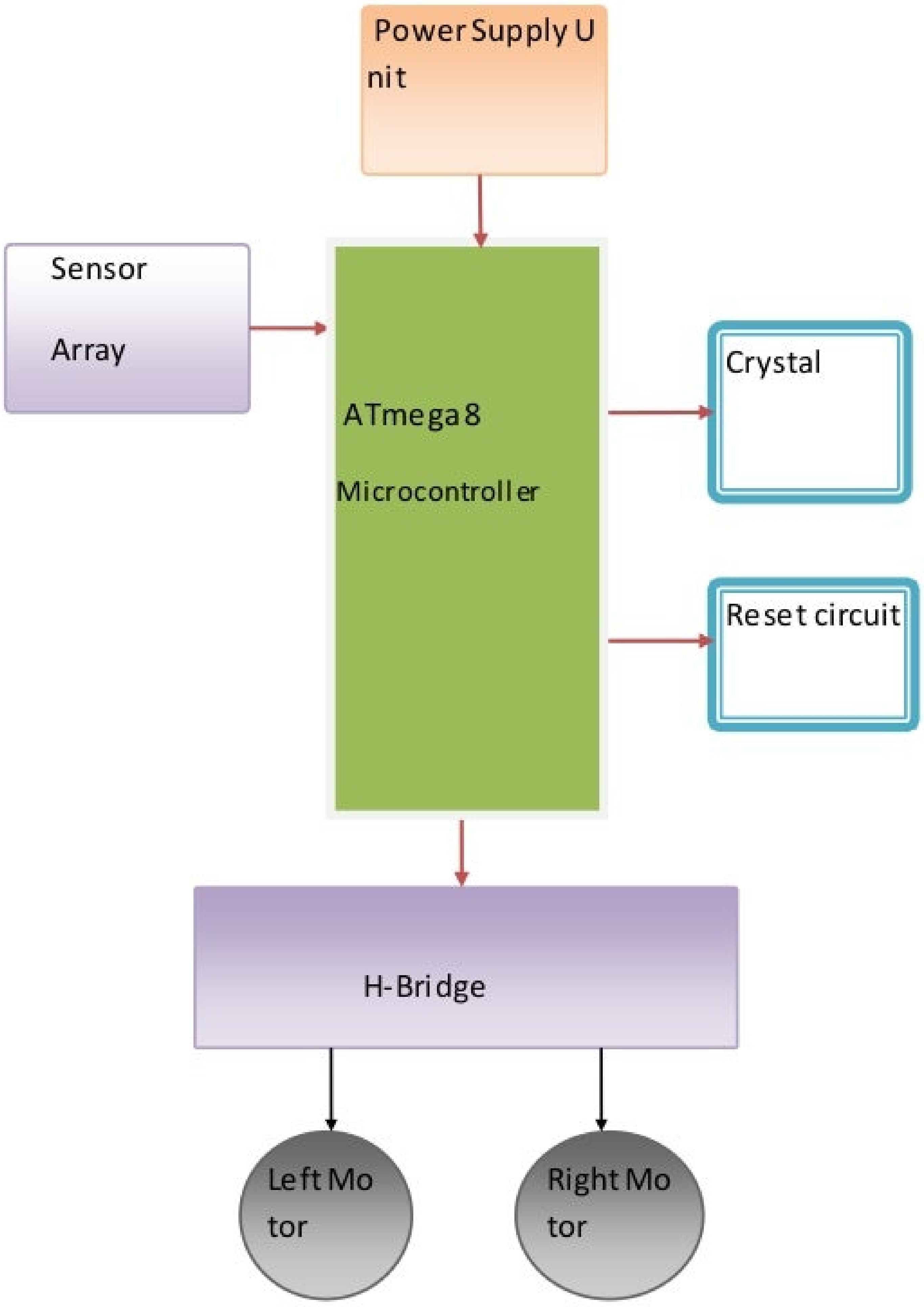

Fig. 1.1 Block Diagram of Line Follower Robot

Chapter 2

LITERATURE SURVEY

In recent years a great deal of time and effort has been spent of developing systems to enable an autonomous robot to follow a marked path using a vision system. Not surpri singly, the majority of this research has been towards modifying, or designing from sc ratch, a full-sized road vehicle so that it can drive on ordinary roads without human su pervision. Due to the large amount of space available in an ordinary road vehicle, high performance computers can be used to perform complex image processing and, typic ally, to maintain a mathematical model of the vehicle and the environment.

Research into autonomous driving using smaller robots typically follows one of two a pproaches. In the first approach a mathematical model of the vehicle and its surroundi ngs is generated, tested in simulation, and then applied to a robot built specifically for the purpose. In the second approach a combination of a visual servoing system and a k inematic model is used, again the robot is typically designed around the solution techn ique. Due to the size of these robots, the processing resources available are quite limit ed so simpler models and techniques, such as visual servoing, are used to reduce the p rocessing load.

2.1 Autonomous Robots

Autonomous robots are independent of any controller and can act on their own. The r obot is programmed to respond in a particular way to an outside stimulus. The bump-a nd-go robot is a good example. This robot uses bumper sensors to detect obstacle. Wh en the robot is turned on, it moves in a straight direction and when it hits an obstacle, t he crash triggers its bumper sensor. The robot gives a programming instruction that as ks the robot to back up, turn to the right direction and move forward. This is its respon se to every bump. In this way, the robot can change direction every time, it encounters an obstacle.

A more elaborate version of the same idea is used by more advanced robots. Robotics create new sensor systems and algorithms to make robots more perceptive and smarter . Today, robots are able to effectively navigate a variety of environments. Obstacle av oidance can be implemented as a reactive control law whereas path planning involves the pre-computation of an obstacle-free path which a controller will then guide a robot along.

Some mobile robots also use various ultrasound sensors to see obstacles or infrared. T hese sensors work in a similar fashion to animal echolocation. The robot sends out a b eam of infrared light or a sound signal. It then detects the reflection of the signal. The robot locates this distance to the obstacles depending on how long it takes the signal t o bounce back.

Some advanced robots also use stereo vision. Two cameras provide robots with depth perception. Image recognition software then gives them the ability to locate, classify v arious objects. Robots also use smell and sound sensors to gain knowledge about its s urroundings

2.2 Working Principle

Robotics is an interesting subject to discuss about and in this advanced world Robots are becoming a part of our life. In this project we are going to discuss about a robot w hich is capable of following a line without the help of any external source.

The Embedded Line following robot uses two motors to control rear wheels and the si ngle front wheel is free. It has 3-infrared sensors on the bottom for detection of black t racking tape. When the middle sensor detects the black color, this sensor output is giv en to the comparator LM358. The output of comparator compares this sensor output w ith a reference voltage and gives an output. The output of comparator will be low whe n it receives an input from the sensor.

We follow a simple logic to implement this project. As we know that black colour is c apable of absorbing the radiation and white colour or a bright colour reflects the radiat ion back. Here we use 3 pairs of IR TX and Rx .The robot uses these IR sensors to sen se the line and the arrangement is made such that sensors face the ground. The output from the sensors is an analog signal which depends on the amount of light reflected ba ck and this analog signal is given to the comparator to produce 0s and 1s.

Internally we have an OTP (one time programmable) processor which is used to contr ol the rotation of the wheels. The rotation of these wheels depends up on the response from the comparator. Let us assume that when a sensor is on the black line it reads 0 a nd when it is on the bright surface it reads 1.

Here we can get three different cases, they are:

1. Straight direction
2. Right curve
3. Left curve

2.2.1 Straight direction

We can expect our robot to move in straight direction when the middle sensors respon se is low and the remaining two sensors response is high. i.e., according to our arrang ement the middle sensor will always be on the line and as the line is black in colour it will not reflect the emitted radiation back and the response of the sensor will be low a nd the response of the remaining two sensors will be high as they will be on the bright surface.

2.2.2 Right curve:

When a right curve is found on the line the responses will change i.e. the response of t he first sensor which is to the right will become low as that sensor will be facing the b lack line and the reaming sensors response will be high. We this data is achieved the c ontrol of the wheels is changed i.e. the right wheel is held and the left wheel is made t o move freely until the response from the middle sensor becomes low. Then the same process repeats again.

2.2.3 Left curve

When a left curve is found on the line the response of the left most sensor will be chan ged from high to low as the sensor will now face the black or the dark surface. Then t he control of the wheel changes i.e. by holding the left wheel and allowing the right wheel to move freely until the middle sensor changes it is response from high to low. The same process continues for all the turns and the robot moves continuously until th e supply is remove.

2.3 Hardware Components

1. IR SENSOR
2. MICROCONTROLLER
3. VOLTAGE REGULATOR
4. COMPARATOR IC
5. MOTOR DRIVER IC
6. POTENTIOMETER

Chapter 3

STEPS IN CIRCUIT DESIGNING

3.1 Circuit Diagram and Explanation

In this Line Follower Robot circuit we have used an IR sensor for detecting the line and a Comparator IC for comparing voltages. Comparator configured in non-inverting mode and 10 K potentiometer is connected at its inverting terminal for adjusting reference voltage and IR receiver's output is directly connected at non-inverting pins of all comparators. One Red LED is connected at output of in the sensor board when this led blinks then it means our sensor is working, then signal goes to microcontroller IC which is programmed and gives the output to the motor driver IC which rotates the motors as per the programming of microcontroller IC.

3.1.1 Block Diagram

The first step is the block diagram which gives an overview of the interconnection among various components. The components are microcontroller (Atmega8), comparator IC (L324), IR Sensors and Motor Driver IC (L293D).

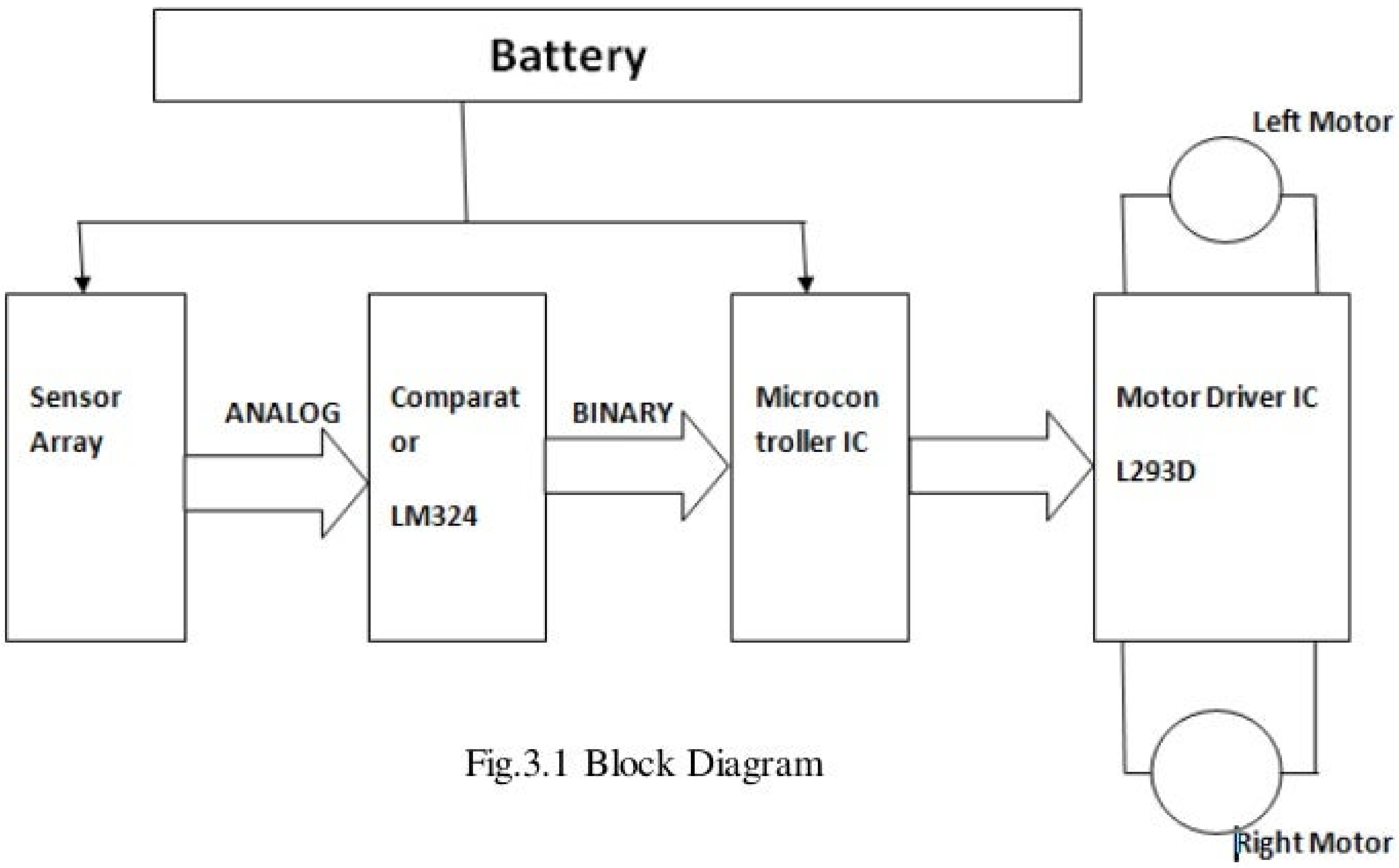

Fig.3.1 Block Diagram

3.1.2 Software Tools

After the block diagram, coding needs to be done. The software used for coding is avr studio4 and the language used for coding is "embedded c".

The program code acts as the decision-maker embedded in the microcontroller i.e. it decides what will be the outputs for particular set of input combination. Programs for the AVR series of microcontrollers can be written in assembly C and AVR Studio etc. We are using winAVR for programming and AVR Studio for simulating (Simulation means debugging the code on software, one can virtually give the input and check the output for that code). In winAVR programmers Notepad we write our C code, after compilation it generates '.hex' file that is a hardware level code.

Source Code

```
#include <mega8.h>
#include <delay.h>
// Declare your global variables here
 int i,j,K;
void main(void)
{
// Declare your local variables here
// Input/Output Ports initialization
// Port B initialization
// Func7=Out Func6=Out Func5=Out Func4=Out Func3=Out Func2=Out Func1=Out
Func0=Out
// State7=0 State6=0 State5=0 State4=0 State3=0 State2=0 State1=0 State0=0
PORTB=0x00;
DDRB=0xFF;
// Port C initialization
// Func6=In Func5=In Func4=In Func3=In Func2=In Func1=In Func0=In
// State6=T State5=T State4=T State3=T State2=T State1=T State0=T
PORTC=0x00;
DDRC=0x00;
// Port D initialization
// Func7=In Func6=In Func5=In Func4=In Func3=In Func2=In Func1=In Func0=In
// State7=T State6=T State5=T State4=T State3=T State2=T State1=T State0=T
PORTD=0x00;
DDRD=0x00;
// Timer/Counter 0 initialization
// Clock source: System Clock
```

```
// Clock value: Timer 0 Stopped
TCCR0=0x00;
TCNT0=0x00;
// Timer/Counter 1 initialization
// Clock source: System Clock
// Clock value: Timer1 Stopped
// Mode: Normal top=0xFFFF
// OC1A output: Discon.
// OC1B output: Discon.
// Noise Canceler: Off
// Input Capture on Falling Edge
// Timer1 Overflow Interrupt: Off
// Input Capture Interrupt: Off
// Compare A Match Interrupt: Off
// Compare B Match Interrupt: Off
TCCR1A=0x00;
TCCR1B=0x00;
TCNT1H=0x00;
TCNT1L=0x00;
ICR1H=0x00;
ICR1L=0x00;
OCR1AH=0x00;
OCR1AL=0x00;
OCR1BH=0x00;
OCR1BL=0x00;
// Timer/Counter 2 initialization
// Clock source: System Clock
// Clock value: Timer2 Stopped
// Mode: Normal top=0xFF
// OC2 output: Disconnected
ASSR=0x00;
TCCR2=0x00;
TCNT2=0x00;
OCR2=0x00;
```

```
// External Interrupt(s) initialization
// INT0: Off
// INT1: Off
MCUCR=0x00;
// Timer(s)/Counter(s) Interrupt(s) initialization
TIMSK=0x00;
// USART initialization
// USART disabled
UCSRB=0x00;
// Analog Comparator initialization
// Analog Comparator: Off
// Analog Comparator Input Capture by Timer/Counter 1: Off
ACSR=0x80;
SFIOR=0x00;
// ADC initialization
// ADC disabled
ADCSRA=0x00;
// SPI initialization
// SPI disabled
SPCR=0x00;
// TWI initialization
// TWI disabled
TWCR=0x00;
while (1)
    {
    i=PINC.4;
    j=PINC.3;
    K=PINC.2;
        if(i==1&&j==0&&K==1)
    {
    PORTB=0x06;
    delay_ms(200);
    }
    else if(i==0&&j==1&&K==0)
```

```
{
PORTB=0x06;
delay_ms(200);
}
else if(i==1&&j==1&&K==0)
{
PORTB=0x02;
delay_ms(200);
}
else if(i==1&&j==1&&K==1)
{
PORTB=0x04;
delay_ms(200);
}
else if(i==0&&j==0&&K==1)
{
PORTB=0x04;
delay_ms(200);
}
else if(i==0&&j==1&&K==1)
{
PORTB=0x04;
delay_ms(200);
}
else if(i==0&&j==0&&K==0)
{
PORTB=0x06;
delay_ms(200);
}
else if(i==1&&j==0&&K==0)
{
PORTB=0x02;
delay_ms(200);
}
```

// Place your code here

}

}

3.1.3 Schematic Diagram

After coding schematic diagram is drawn on protious 8 professional and the schematic diagram is shown below. Using protious we will simulate the project and check if it works properly. So that we can perform the hardware implementation of the project.

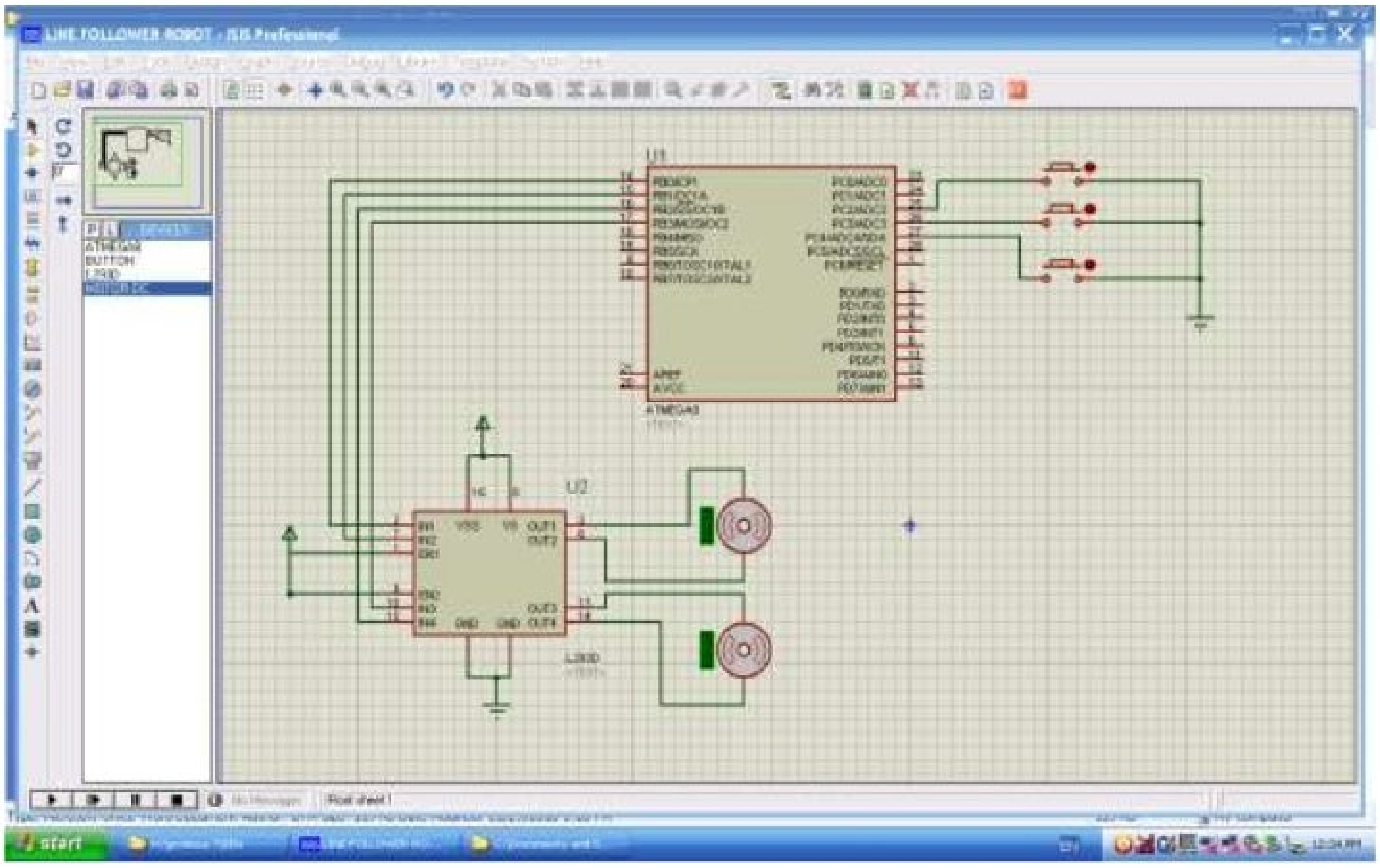

Fig.3.2 Schematic Diagram of Line Follower Robot

3.1.4 PCB Designing

Fourth step is designing the PCB layout using PCB Express software. In the PCB express software, choose the different IC's and other components from the component manager and draw a clean PCB layout. The PCB layout of line follower robot is given as :

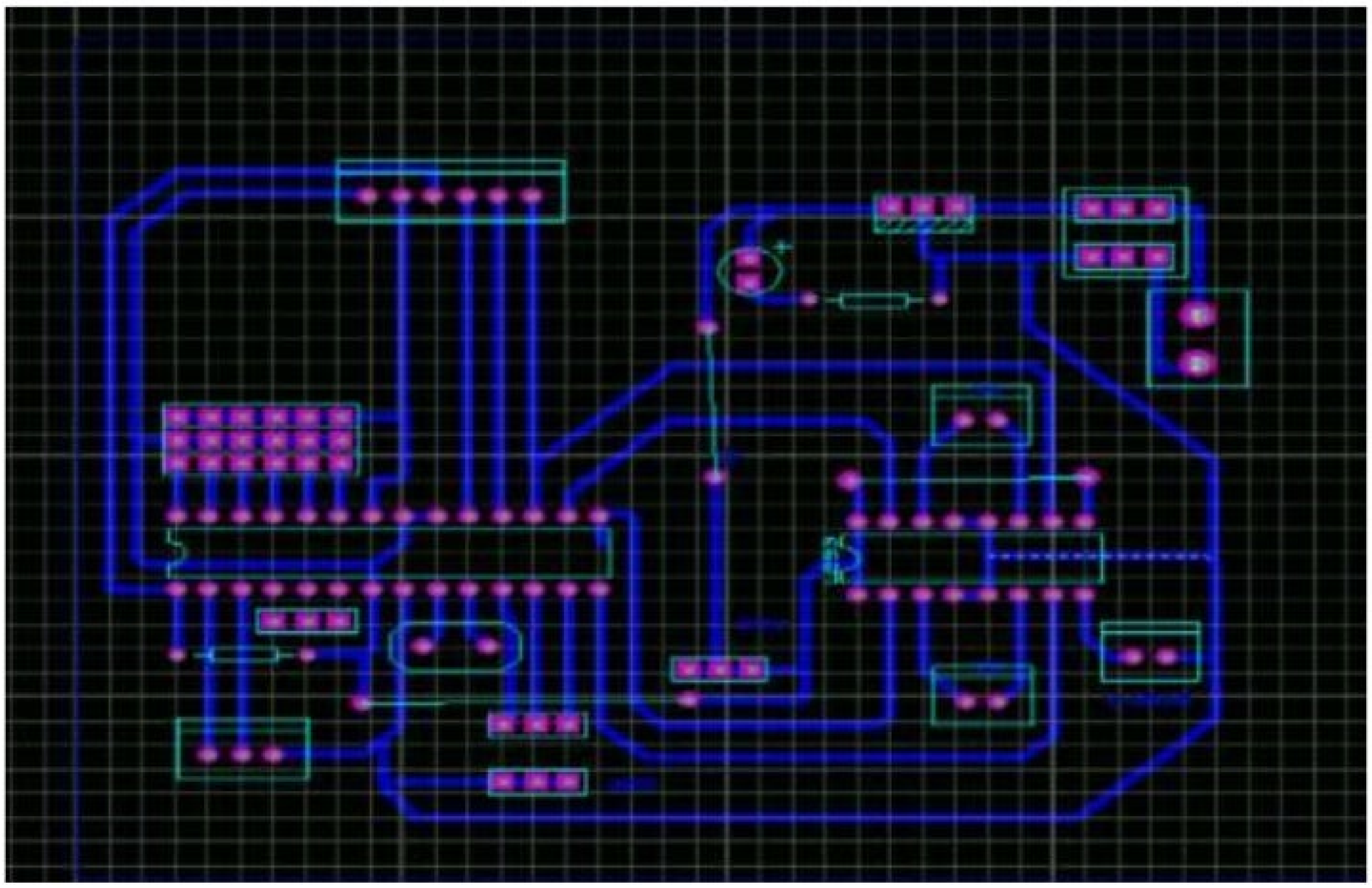

Fig.3.3 PCB Layout of Line Follower Robot

3.1.5 Pressing

After the PCB layout is done, take its printout on a glossy A4 size sheet using a LASE R printer and print it on the copper clad board (CCD) Using press method. Due to whi ch the diagram on the glossy paper will stick to the board.

3.1.6 Etching

After pressing the glossy paper on the PCB board, now dip that printed circuit board i n $FeCl_3$ for one hour and this whole process is known as Etching.

3.1.7 Drilling and Shouldering

After taking out the PCB from the ferric chloride solution, now PCB is ready for Drill ing. Drilling is the process in which small holes are made in the PCB for fixing the co mponents. The size of hole is about 0.8mm and the machine is used for drilling is call ed Drilling machine.

After the drilling process now fix all the components in the holes andthen to fix the co mponents permanently we shouldering process, in which a wire, made of tin and lead is heated by a shouldering machine so that it melts and components become stick to th e board permanently.

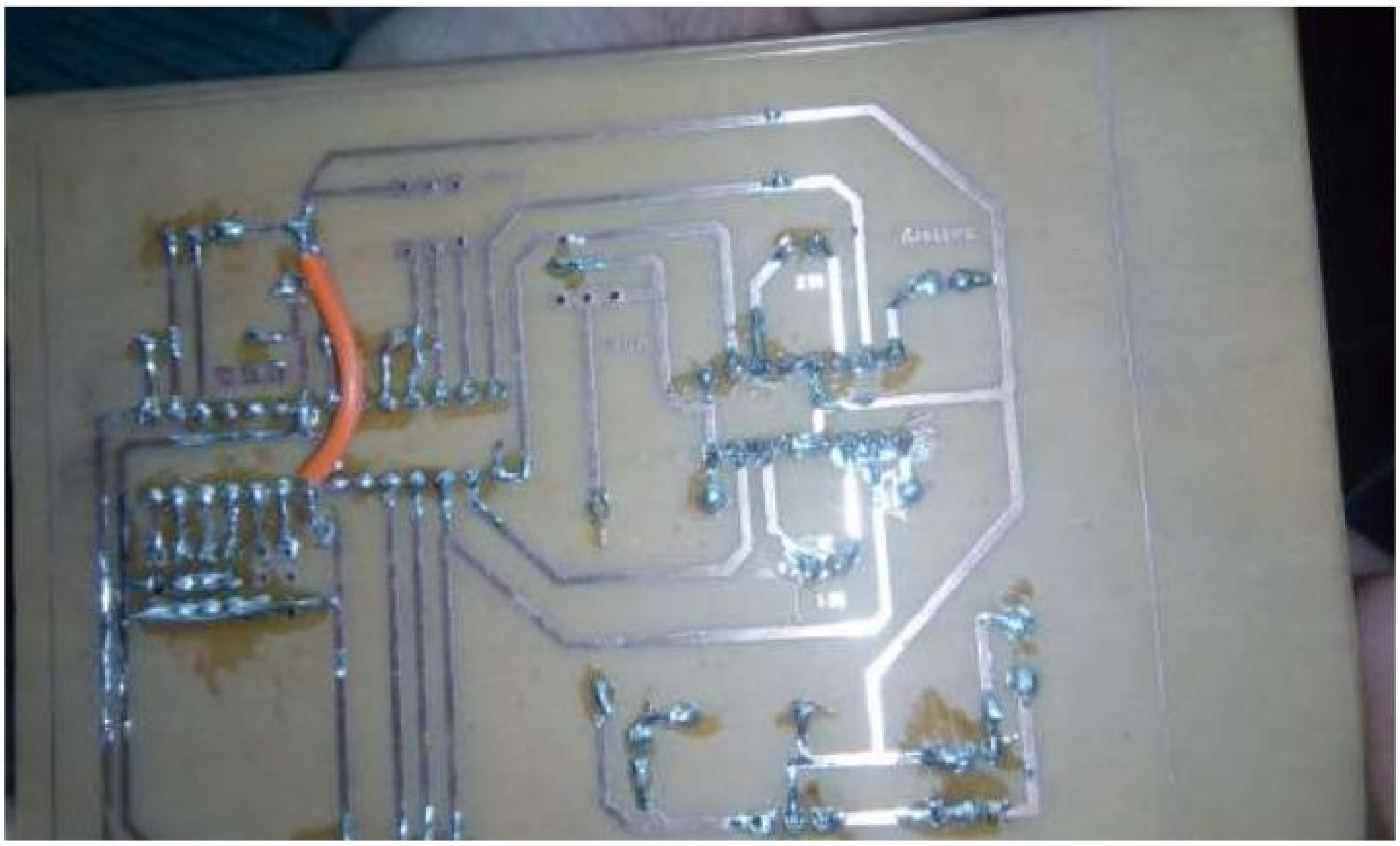

Fig.3.4 PCB after Drilling and Shouldering

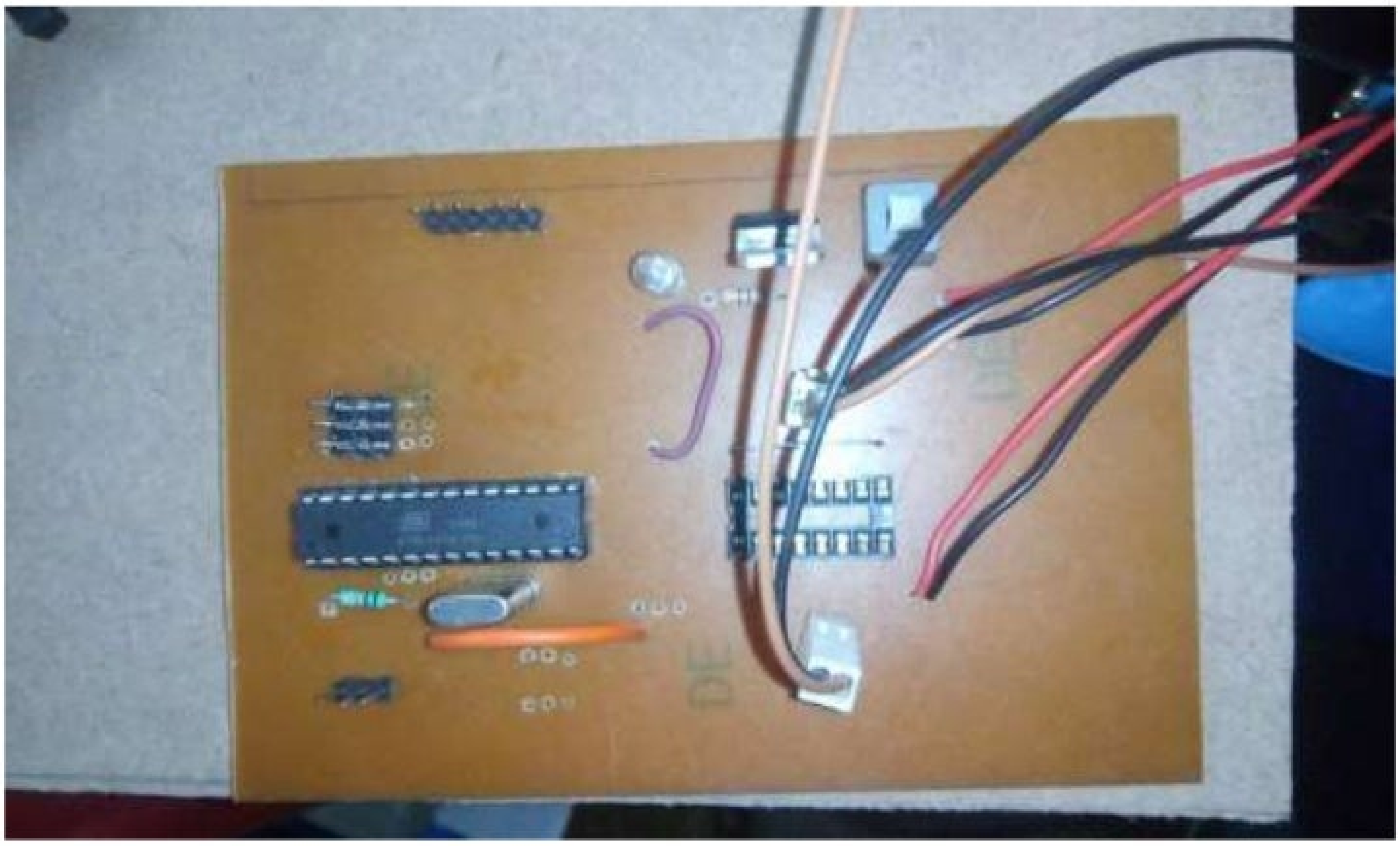

Fig.3.5 PCB after fixing the Components

Chapter 4

RESULT & DISCUSSION

Our project is an innovative idea of intelligent system which has basically line detecti on feature and will provide help in various fields like hospitals and service sectors. Th e sensors in this system are a type of infrared sensor that senses the line and gives the feedback to the microcontroller unit.

1. The battery activates the circuit.
2. The sensor transmitter transmits the frequency, which reflects from the surface. Sensor receiver receives the reflected frequency and gives it to the microcontroller.
3. The 8051 microcontroller processes it and gives the signal to motor driver IC.
4. Motor driver IC rotates the motors as per the signal receive and then the wheels rotates.

4.1 Result

The objective of the line following robot is to follow a line on its given path which is obtained for which it uses IR sensors which detects the line and sends the information to LM324 comparator and then to H bridge which controls the working of the wheel's . Microcontroller controls the other operations.

4.2 Discussions

Research shows that number of patients died because of few numbers of trained medi cal staff. Shortage of nurses is 'killing thousands a year': Patients in overstretched hos pitals developing fatal complications which could have been cured. A lot of hospitals have stopped recruiting nurses and medical personnel since 2005 and 2006. From the past two years there is an increasing trend of recruiting more doctors than the nurses. I f sufficient number of nurses based on the patient numbers visiting a hospital can be r ecruited then the number of deaths can be estimated decreases by 10 %.

Contrasting conditions

Countries	Expenditure on health as % of GDP		Hospital beds	Nurses	Physicians
	Government	Private	Per 10,000 population		
Germany	7.8	2.7	82	108	35
UK	7.2	1.5	34	103	21
USA	7.3	7.9	31	98	27
Japan	6.7	1.6	138	41	21
Russia	3.1	1.7	97	85	43
Brazil	3.7	4.7	24	65	17
South Africa	3.3	4.9	28	41	8
Thailand	3.0	1.1	22	15	3
China	2.0	2.3	41	14	14
Vietnam	2.8	4.4	29	10	12
India	1.4	2.8	9	13	6
Global median	5.0	3.3	24	28	12

Figure 4.1 World health statistics, WHO 2013

The above table (fig4.1) shows that the availability of nurses and physicians is very low in India compared to that of the Global median. So there is a high need of supervision of the nurses or attendants towards the monitoring of patients rather than concentrating on the supply of medicines, food etc. This leads to the need for implementing other alternative for those activities. This is the situation where the Automated Guided Vehicle (AGV) can be implemented for the delivery of the material supply to patients. In this paper we considered the use of a line follower robot for the above specified problem.

Recommended Solution

Automation is recommended in the material supply delivery system. The benefits of using the automation techniques in hospitals are as follows:

The average nurse walks roughly 5 miles per shift of work. Much of this travel time is not spent travelling from one patient to the next to apply hands-on, bedside care. Unfortunately, most of the walking is spent in the pursuit of hunting for and gathering medical supplies, collecting and executing physician orders, and performing registration and discharge tasks. These routine and mundane tasks can be performed by robots now. Thanks to the robot solution, quality of care improves through efficiency.

Nurses can now claim more time during their shift to spend on patient care. In fact, the robot allows for a redefinition of ‘patient care.’ Whereas historically, gathering supplies, coordinating meals and medications, and various forms of paperwork and documentation were considered ‘patient care’, now these administrative and logistical tasks can be defined and assigned to what they truly are. And nurses can get back to the highly-skilled interpersonal clinical tasks that they have been trained for, and that patients really need in order to heal. Quality of care improves through increased staff satisfacti on.

Medical errors have been a major cost to the healthcare delivery system. First and fore most, there is a human cost. Medical errors have caused death, dismemberment, and minor injuries.

4.3 Advantages & Disadvantages

Advantages

- Robot movement is automatic.
- Fit and Forget system.
- Cost effective.
- Simplicity of building

Disadvantages

- LFR follows a black line about 1 or 2 inches in width on a white surface.
- LFR are simple robots with an additional sensors placed on them.
- Needs a path to run either white or black since the IR rays should reflect from the particular path.
- Slow speed and instability on different line thickness or hard angles.

4.4 Applications

- Guidance system for industrial robots moving on shop floor etc.
- Industrial applications.
- Home applications.

Chapter 5

CONCLUSION AND FUTURE SCOPE OF WORK

5.1 Conclusion

In this project we have studied and implemented a Line Following Robot using a Micr ocontroller for blind people. The programming and interfacing of microcontroller has been mastered during the implementation.

The cost of health care in India greatly depends upon the land and location of building , the infrastructure and facilities and skilled staff required to maintain the expensive m achinery. In a country like India, where the population in humongous and the resource s are scarce, it becomes highly difficult to set up such extensive projects in every locat ion. So what this system provides is an alternate to the existing system with robotic m achinery, which can handle tasks with lower per capita cost and better accuracy

5.2 Future Scope

Smarter versions of line followers are used to deliver mails within office building and deliver medications in a hospital.

This technology has been suggested for running buses and other mass transit systems and may end up as a part of autonomous cars navigating the freeway.

Line following robot based materials supply system can play a vital role in the field of hospitality. Line following robot’s application over electronics engineering can’t be u nderestimated. In India many people show reluctance to get admitted in a hospital bec ause of cost issues. The cost for cure can be reduced by using the robots in governmen t and private hospitals. It can be very beneficial for the patients as well. Also, monitori ng of every patient is very difficult for the nurses, given the fact that there are very fe w of them. So a camera can be placed in the line following robot, from which the stat us for every patients can be handle from a single room. In the bed of the patient an acc elerometer can be placed from which if a patient have a heart attack then that device c an operate an alarm circuit. A GSM module can be placed with the line following rob ot so that if any untoward incident occurs then that system can make a call to the doct or, it also helps the doctors for remote diagnosis of patients even when he is away fro m hospital by remote presence. The line follower robots can also be improvised by usi ng RFID tags so that accuracy of the system increases. Robotics is very big field for t he new innovation and research. By using the robot in real time applications, a health care system can be manage in an effectively way.

Chapter 6

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APPENDIX

7.1 IR Sensors

An Infra-Red sensor detects Infra-Red light/white light from a particular object/lin e and then converts light energy to electrical energy. An IR sensor pair consists of an emitter and a detector. The emitter is blue in color and the detector can be grey, black or white in color.

2.2.1.1 IR Emitter:

An infra-red emitter is a Light Emitting Diode (LED) made from Gallium Arsenide . It detects IR energy at a wavelength of 880nm and emits the same. The infrared p hototransistor acts as a transistor with the base voltage determined by the amount o f light hitting the transistor. Hence it acts as a variable current source. Greater amo unt of IR light cause greater currents to flow through the collector-emitter leads. The variable current traveling through the resistor causes a voltage drop in the pull-up resistor. This voltage is measured as the output of the device.

2.2.1.2 IR Detector:

An infra-red detector is a photo detector. It detects IR energy emitted by the emitte r and converts it into electrical energy. The main principle involved in the conversi on of light energy to electrical energy is photoelectric effect.The output is taken at negative terminal of IR detector. The output can be taken to a microcontroller eithe r to its ADC (Analog to Digital Converter) or LM 339 can be used as a comparator

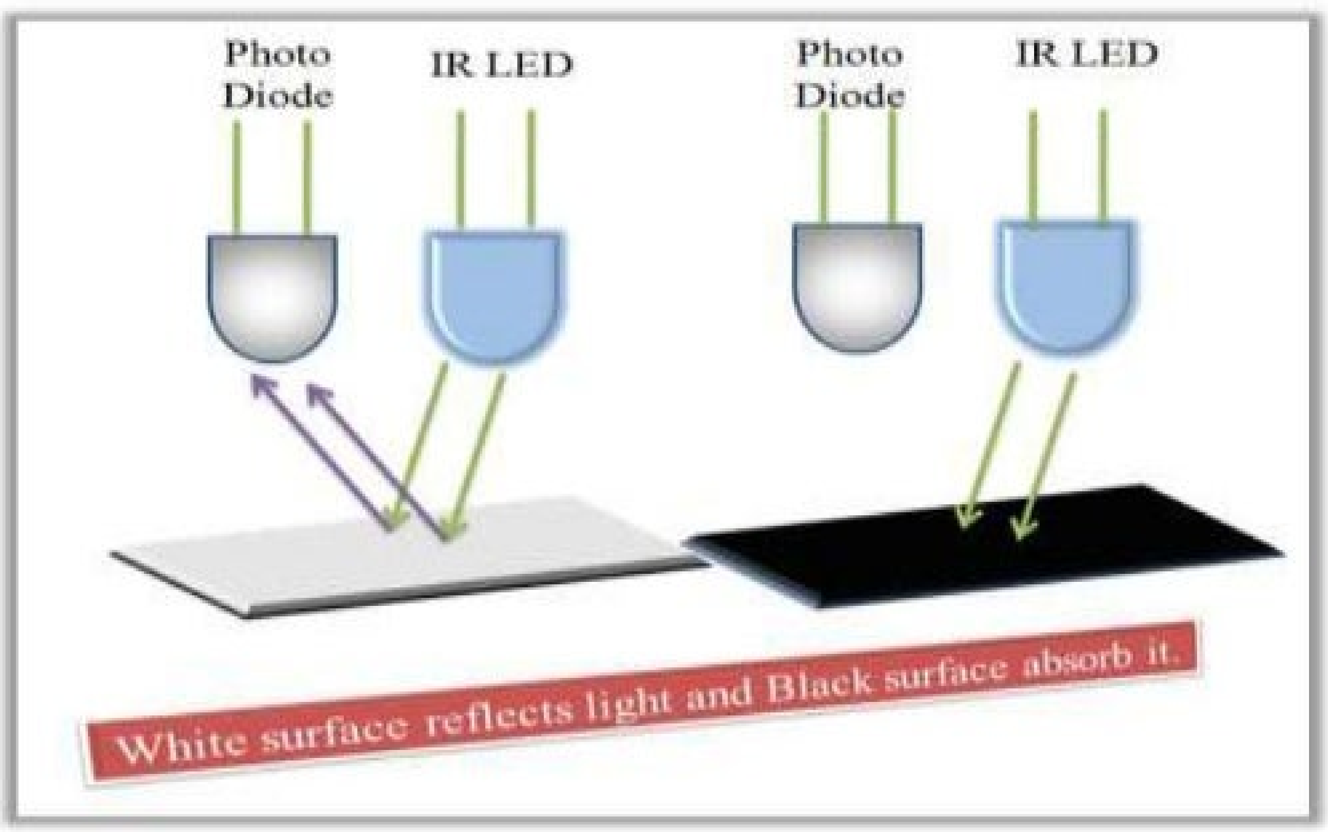

Fig: 7.1 IR Sensor

7.2 ATmega 8 Microcontroller

The ATmega 8 is a low-power, high-performance CMOS 8-bit microcontroller wit h 4K bytes of programmable Flash memory and erasable read only memory (PER OM). The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry- standard MCS-51 instruction set a nd pin out. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a ver satile 8-bit CPU with Flash on a monolithic chip, the Atmel ATmega 8 is a powerf ul microcontroller which provides a highly-flexible and cost-effective solution to many embedded control applications.

7.2.1 Pin Configurations

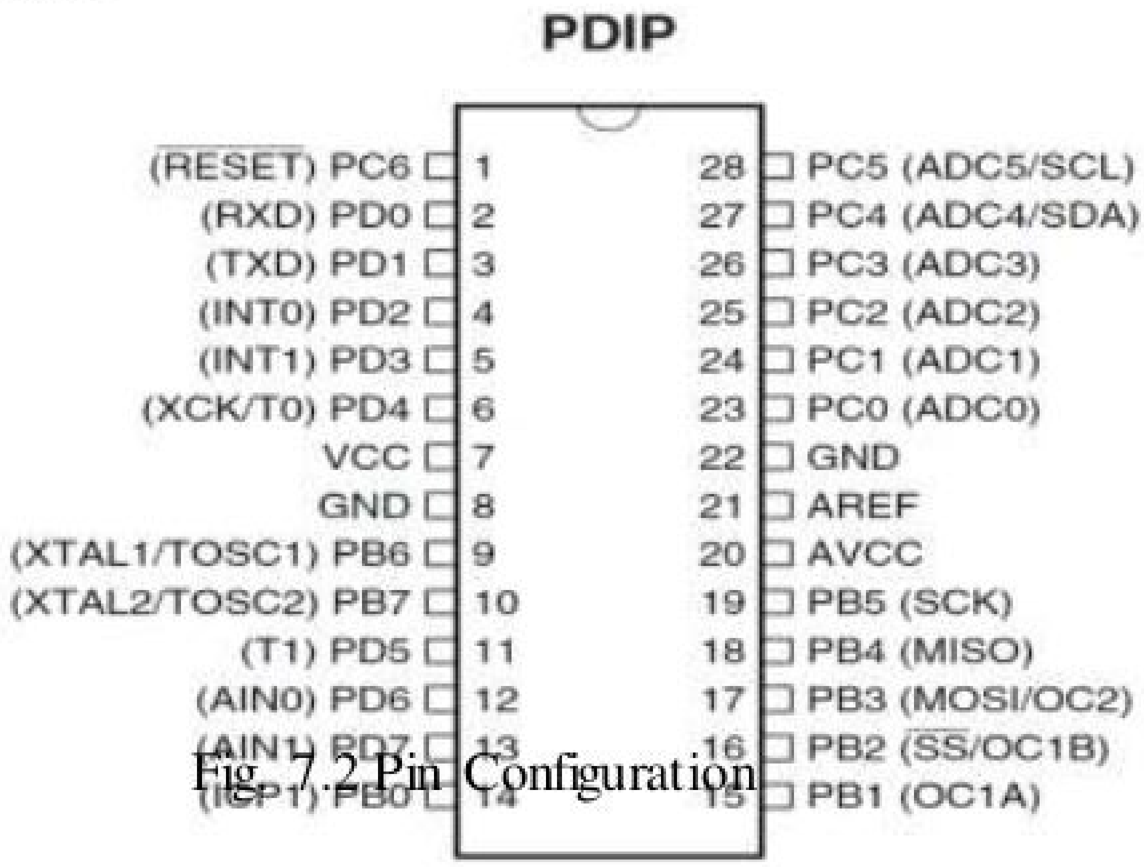

Fig. 7.2 Pin Configuration

7.2.2 Standard Features

- 4K bytes of Flash,
- 128* 8 bits of internal RAM,
- 32 programmable I/O lines,
- Full static operation: 0Hz to 24 MHz
- Three level program memory Lock
- two 16-bit timer/counters,
- a six-vector two-level interrupt architecture,

7.3 Voltage Regulator

A voltage regulator is an electrical regulator designed to automatically maintain a c onstant voltage level. It converts a positive voltage (7-29V) to +5 volts. Heat sink provided in the center to release heat generated due to drop across the IC. Input voltage of about 5 to 18 V is given, Ground is 0 V and regulated output of +5V. It may use an electromechanical mechanism, or passive or active electronic components. Depending on the design, it may be used to regulate one or more AC or DC voltages. There are two types of regulator:

- Positive Voltage Series (78xx)
- Negative Voltage Series (79xx)

78xx: '78' indicate the positive series and 'xx' indicates the voltage rating. Suppose 7805 produces the maximum 5V. '05' indicates the regulator output is 5V.
79xx: '78' indicate the negative series and 'xx' indicates the voltage rating. Suppose 7905 produces the maximum -5V. '05' indicates the regulator output is -5V.

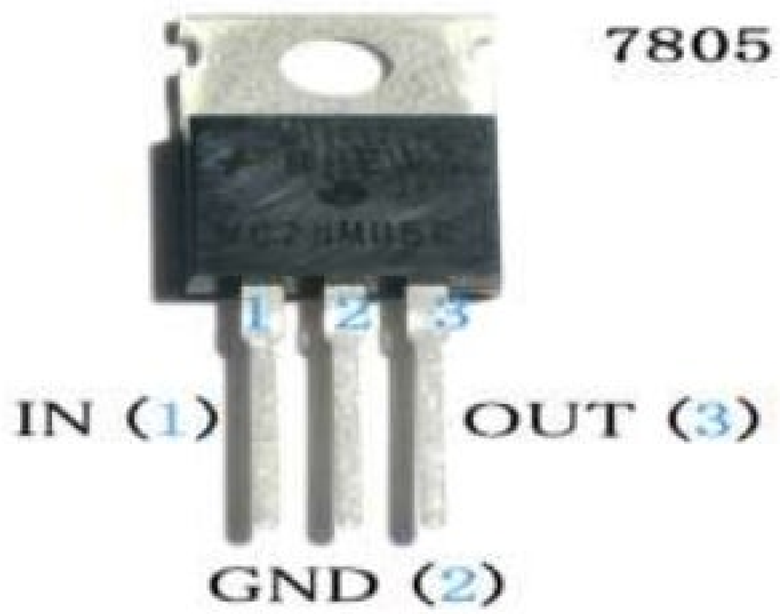

Fig: 7.3 Voltage Regulator

7.4 Comparator IC

The LM358 IC is a great, low power and easy to use dual channel op-amp IC. It is designed and introduced by national semiconductor. It consists of two internally frequency compensated, high gain, independent op-amps. This IC is designed for specially to operate from a single power supply over a wide range of voltages. The LM358 IC is available in a chip sized package and applications of this op amp include conventional op-amp circuits, DC gain blocks and transducer amplifiers. LM358 IC is a good, standard operational amplifier and it is suitable for your needs. It can handle 3-32V DC supply & source up to 20mA per channel. This op-amp is apt, if you want to operate two separate op-amps for a single power supply. It's available in an 8-pin DIP package.

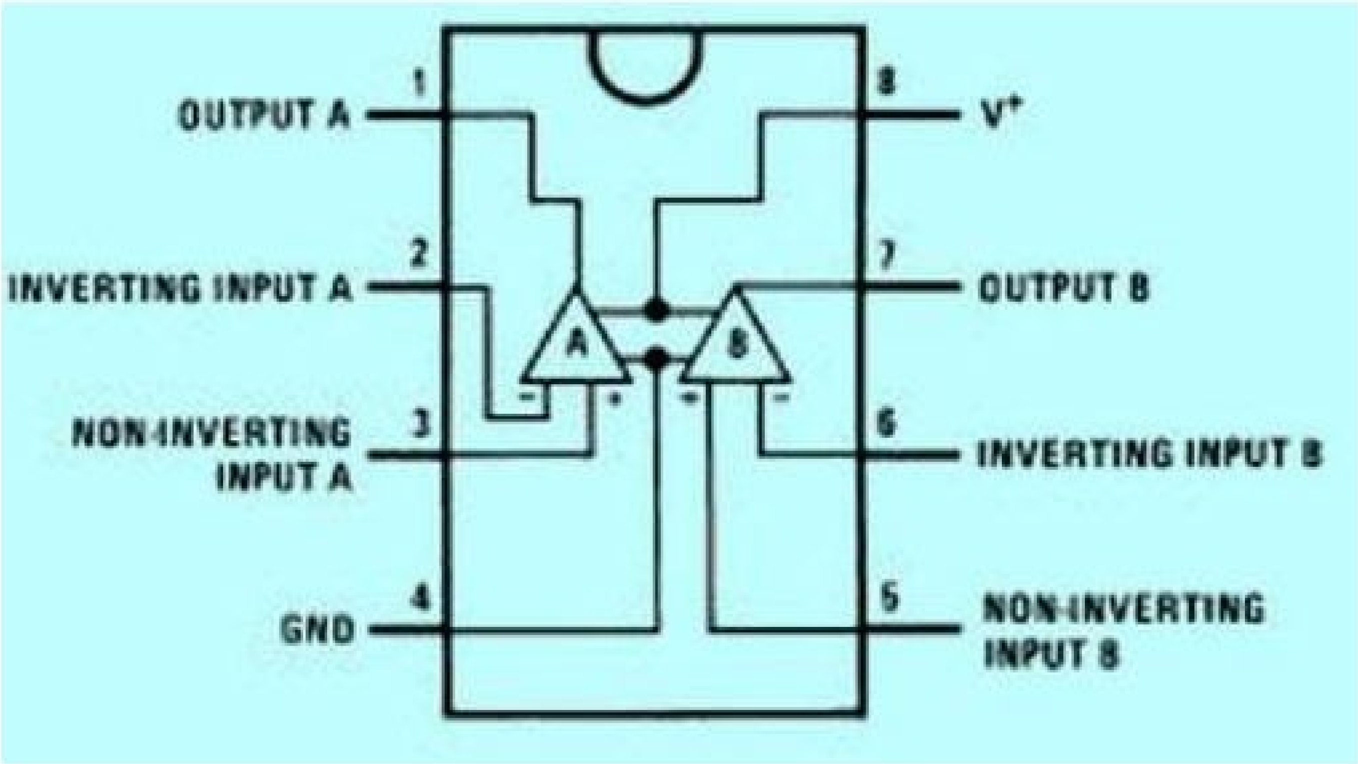

Fig.7.4 pin diagram of LM 358 IC

7.5 Motor Driver IC

This is a Motor driver IC that can drive two motors simultaneously. Motors are arr anged in a fashion called H-Bridge. An H-bridge is an electronic circuit which ena bles DC electric motors to be run forwards or backwards. These circuits are often u sed in robotics. H-bridges are available as integrated circuits, or can be built from d iscrete components.

The two basic states of a H-bridge. The term "H-bridge" is derived from the typical graphical representation of such a circuit. An H-bridge is built with four switches (solid-state or mechanical). When the switches S1 and S4 (according to the first fig ure) are closed (and S2 and S3 are open) a positive voltage will be applied across t he motor. By opening S1 and S4 switches and closing S2 and S3 switches, this volt age is reversed, allowing reverse operation of the motor.

Using the nomenclature above, the switches S1 and S2 should never be closed at th e same time, as this would cause a short circuit on the input voltage source. The sa me applies to the switches S3 and S4. This condition is known as shoot-through.

The switching property of this H-Bridge can be replaced by a Transistor or a Relay or a MOSFET or even by an IC. Here we are replacing this with an IC named L29 3D as the driver whose description is as given below. The Device is a monolithic i ntegrated high voltage, high current four channel driver designed to accept standar d DTL or TTL logic levels and drive inductive loads as and switching power transi stors. To simplify use as two bridges each pair of channels is equipped with an ena ble input. A separate supply input is provided for the logic, allowing operation at a lower voltage and internal clamp diodes are included. This device is suitable for us e in switching applications at frequencies up to 5 kHz. The L293D is assembled in a 16 lead plastic package which has 4 center pins connected together and used for h eat sinking The L293D is assembled in a 20 lead surface mount which has 8 center pins connected together and used for heat sinking.

Fig. 7.5 Motor Driver IC

7.5.1 Operation

The H-Bridge arrangement is generally used to reverse the polarity of the motor, b ut can also be used to 'brake' the motor, where the motor comes to a sudden stop, a s the motors terminals are shorted, or to let the motor 'free run' to a stop, as the mot or is effectively disconnected from the circuit. The following table summarizes ope ration.

S1	**S2**	**S3**	**S4**	**Result**
1	0	0	1	Motor moves right
0	1	1	0	Motor moves left
0	0	0	0	Motor free runs
0	1	0	1	Motor brakes

Table: 7.6 H-bridge switch operation

7.5.2 Pin Connections

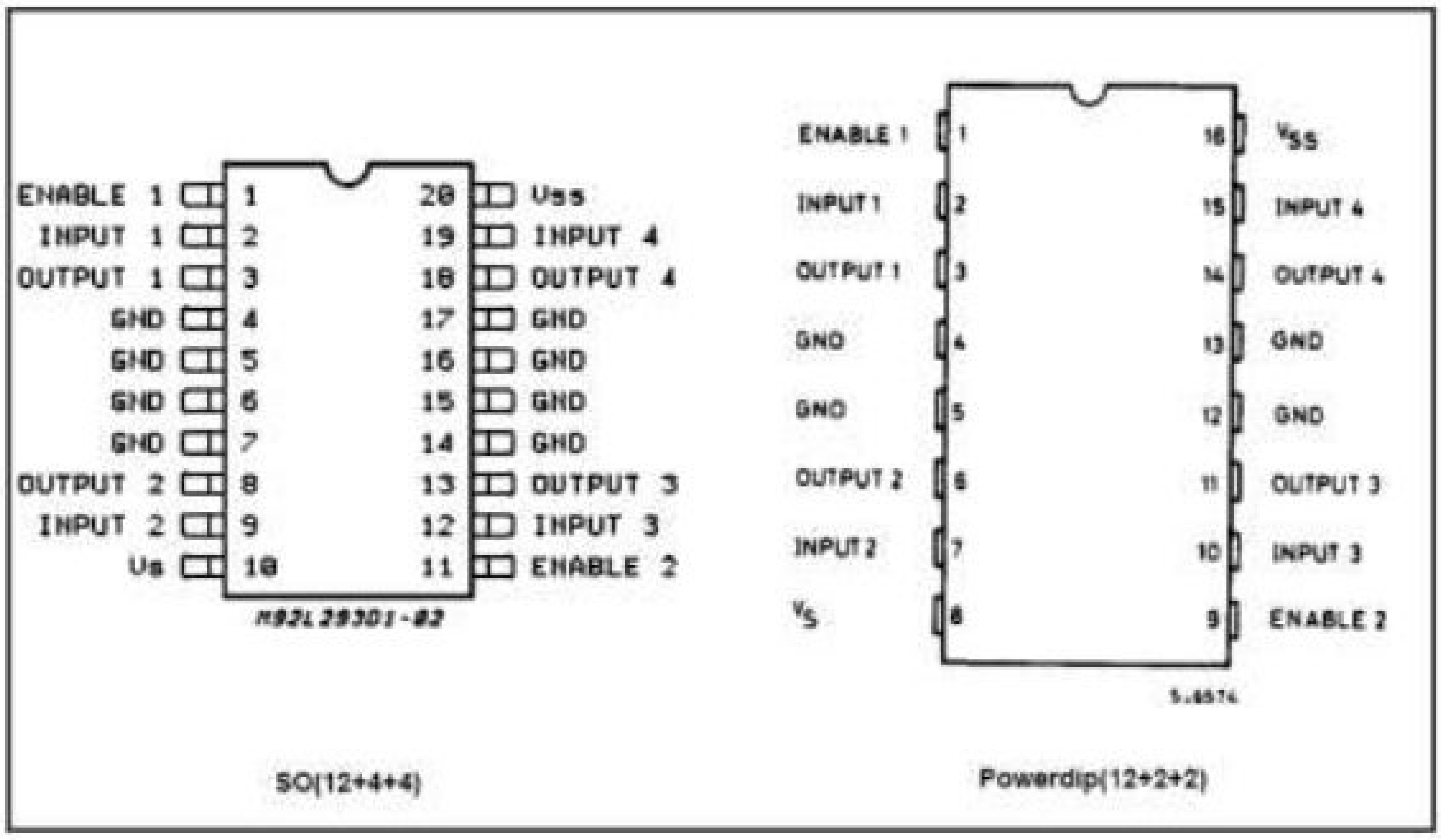

Fig: 7.7 pin configuration of L293D

7.5.3 Features

- 600ma output current capability per channel
- 1.2A peak output current (non repetitive)
- Enable facility over temperature protection
- high noise immunity
- internal clamp diodes

7.6 Potentiometer

Potentiometer is a variable resistor which is used to vary the resistance by rotating the shaft. Potentiometers are available from 100 ohm to 470Kohm (or more).Potent iometer is a voltage divider. If we connect lead A to Vcc and lead B to ground then you get voltages from 0 to Vcc at lead W. Mainly Potentiometer are used to gener ate reference voltage for LM324.

\Fig. 7.8 Potentiometer