AUTOMATED GUIDED VEHICLE WITH SENSORS FOR OBSTACLE AVOIDANCE

A DISSERTATION

Submitted in partial fulfillment of the requirements for the award of the degree

of

MASTER OF TECHNOLOGY

in

ELECTRICAL ENGINEERING

(With Specialization in System Engineering & Operations Research)

By

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CANDIDATE'S DECLARATION

I hereby declare that the work presented in this dissertation entitled "**Automatic Guided Vehicle with Sensors for Obstacle Avoidance**" submitted in partial fulfillment of the requirements for the award of degree of **Master of Technology** in **Electrical Engineering** with specialization in **Systems Engineering and Operation Research,** in the Department of Electrical Engineering, **Indian Institute of Technology Roorkee, Roorkee,** is an authentic record of my own work carried out from June 2005 to June 2006 under the guidance of **Dr. Rajendra Prasad**, Associate Professor, Department of Electrical Engineering, Indian Institute of Technology Roorkee, Roorkee and **Sh. A.K.Chandra**, Associate Director (R&D-Electronics Systems), Nuclear Power Corporation of India Ltd.

I have not submitted the matter embodied in this report for the award of any other degree or diploma.

Date : 2/June/06

Place : Roorkee

(L.SUDERSHAN NAINWAL)

CERTIFICATE

This is to certify that the above statement made by the candidate is true to the best of my knowledge and belief.

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Associate Professor,
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Sudershan

Lalit Sudershan Nainwal

ABSTRACT

The Prototype Design of Automatic Guided Vehicle (AGV) project aspires to construct a vehicle automatically guided with capability to follow the chosen path of travel and avoid collision with obstacle, if any in its path.

In general, the environments where service robots perform tasks are shared with humans. In order to avoid disturbances due to robots, they can be designed to adhere to strict order like tracking on the predefined paths.

This project main objective is to create an AGV that is completely autonomous, the vehicle is capable of receiving sensory inputs, interpreting those inputs to follow the predetermined path and avoid collision with any obstacles without any human intervention.

The intelligence of the system is in the micro controller **AT89C51**. The micro controller takes inputs from the ultrasonic sensor to avoid collision by measuring the proximity of other vehicle or an obstacle and infrared sensors to sense its position relative to the path and steers accordingly to keep the vehicle on its predefined path. Micro controller drive AGV according to its program written in assembley language using two DC motors.

Thus, the AGV is a good platform for robotics. On availability of good sensors, the AGV project can be extended to make a more sophisticated robot in the future.

CONTENTS:

INTRODUCTION

1.1 INTRODUCTION

Robotics is the leading field in Science & Technology which is going to shape the future of the human race. The word "robot' was coined by Karel Capek who wrote a play entitled "R.U.R." or "Rossum's Universal Robots" back in 1921. The base for this word comes from the Czech word 'robotnik' which means 'worker'.

The advantage with robots are that they can be used in hostile environments which are hazardous for humans and for doing repetitive works with precision and speed.

Automatic Guided Vehicle is a mobile robot or Battery-powered driverless vehicle. But basic AGV technology is really not so new. The first AGV was designed in U.S in 1953. Through the years advances in electronics have led to advances in guided vehicles. Vacuum tube technology gave way to transistorized technology and now today microcontroller technology. AGV(Automatic Guided Vehicle) are commonly used for transporting material within a manufacturing, warehousing, or distribution system.

The development of practical and useful unmanned autonomous vehicles continues to present a challenge to researchers and system developers. Two divergent research areas have emerged in the mobile robotics community. In autonomous vehicle robot research, the goal is to develop a vehicle that can navigate at relatively high speeds using sensory feedback in outdoor environments such as fields or roads. These vehicles require massive computational power and powerful sensors in order to adapt their perception and control capabilities to the high speed of motion in complicated outdoor environments. The second area of the research deals with mobile robots that are designed to work in indoor environments or in relatively controlled outdoor environments.

The problem of autonomous navigation of mobile vehicles, or Automated Guided Vehicles (AGV), involves certain complexities that are not usually encountered in other robotic research areas. In order to achieve autonomous navigation, the real-time decision making must be based on continuous sensor information from their environment, rather than off-line planning.

1.2 PROBLEM STATEMENT

This project main objective is to create an AGV that is completely autonomous and can work in dynamic environments. That is, the vehicle will be capable of receiving sensory inputs, interpreting those inputs to follow the predetermined path and avoid collision with any obstacles without any human intervention.

The intelligence of the system is in its micro controller **AT89C51**. The micro controller takes input from the ultrasonic sensor to avoid collision by measuring the proximity of other vehicle or an obstacle and infrared sensors to sense its position relative to the path and steers accordingly to keep the vehicle on its predefined path.

Micro controller drives AGV according to its program written in assembley language using two DC motors.

1.3 ORGANIZATION OF REPORT:

Chapter 1	Provides brief introduction of the topic.
Chapter 2	Provides brief description of some of the methods used for the navigation of AGV.
Chapter 3	Discusses the AGV with sensors and microcontroller to follow pre defined path without any collision.
Chapter 4	Presents the test results and conclusion drawn.

CHAPTER 2

METHODS OF NAVIGATION

Robot navigation is defined as the technique for guiding a mobile robot to a desired destination or along a desired path in an environment characterized by a variable terrain and a set of distinct objects, such as obstacles and landmarks. AGVS are classified into different types based on the navigation which they employ. They are broadly divided into two types based on their navigation technique.

1) Fixed Path AGVS
2) Open Path AGVS

2.1 FIXED PATH SYSTEMS

In general, the environments where service robots perform tasks are shared with humans. In order to avoid disturbances due to robots, they can be designed to adhere to strict order like tracking on the predefined paths. These AGV follow a well-marked continuous path which is either on or buried with in the floor .

But in this method users need to lose some flexibility, as there is need to uninstall or wipe out old path, when new paths are to be laid .However these problems can be overcome by using Open Path Systems.

The different methods are :

2.1.1 Electro Magnetic Guidance System

Electro magnetic guidance in an AGV is based on the fact that an electrical conductor through which an AC current is flowing will create an electromagnetic field around itself. This field is stronger close to the conductor and it reduced with the distance from the conductor.

This field is detected by two inductive coils, these coils generate a differential current as they move away from the magnetic field. The differential current is then used to control the direction of AGV and hence keep it on the route.

Different vehicles can follow similar and overlapping courses as the currents used can be at different frequencies.

Advantages:

(a) More reliable than optical as it cannot be made BLIND

(b) Magnetic codes can be used for different routes with out confusion

Disadvantages:

(a) Disturbance from electromagnetic noise

(b) These signals are weak and easily influenced by other metal parts in vicinity.

(c) It is expensive to change the path, as cable are buried in the floor.

(d) More power consumption as need to flow current through cables.

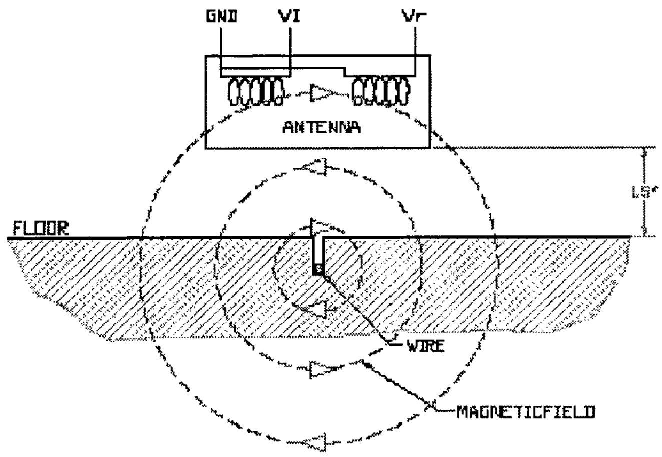


Fig.2.1 Magnetic field and antenna detail

2.1.2 Reflecting Tape Guidance System:

This guidance system is useful in the environment where electrical noise is high, that can make the guide wire system unreliable or when the installation of guide wires in the floor would not be appropriate .Reflecting tape (white tape, metal tape, painting with glass powder on the road course) are set sticked on the route of road way .Any type of light on the lower side of vehicle is reflected and this reflected light signals are sensed by photo sensors under the vehicle. This tape guidance system is superior to the electromagnetic guidance system on the point of flexible path setting, easy path setting and easier to understand the path of the vehicle by the person working nearby. However this path is sensitive to oil, dirt, abrasion.

This method uses reflected light as the medium for detecting the path, a white line or reflective strip is laid down on the floor along the route, the vehicle is expected to follow. Optical sensors are used to detect the reflected light usually a maximum over the line.

A light source usually near the detector is aimed at the floor, when the sensor detects a large increase in reflected light; the sensing circuit changes the logic level of a digital circuit or change the level in an analogue circuit, to follow the line.

Accuracy to detect reflected light depends upon the background, polished backgrounds may look innocent but could reflect sufficient light to swamp detection, a matt background is preferred.

Advantages:

(a) Easily laid tracks

(b) Useable in electromagnetic noisy areas

(c) Tracks require no power and cheap to lie down.

Disadvantages:

(a) Track must be clean

(b) Confusion of multiple paths

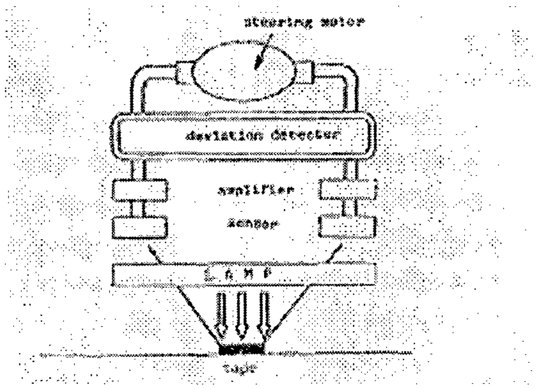


Fig.3.3. Reflecting Tape Guidance System

2.2 OPEN PATH SYSTEM:

This method of guidance is more a matter of self guidance as there are no predetermined routes to follow. The ultrasonic detectors are used to locate objects and map the surroundings of the vehicle, this is to enable vehicle to find its own way to the destination.

This method requires a large amount of processing power to make AGV capable of area mapping. Ultrasonic waves are sound waves with frequency above 20KHz these are transmitted from the ultrasonic emitter, and are detected by an ultrasonic detectors. The detector detects the waves which have been bounced back off of an object. The receiver produces a voltage with amplitude, proportional to the distance of the object from the receiver. A near by object will cause an amplitude lager than that of a distant object.

As distance is a key feature in the ultrasonic principle, objects which are moving provide additional problems.

Advantages:

(a) Requires no path definition.

(b) Able to avoid obstacles collision.

Disadvantages:

(a) Large software programs required to analyze data and calculate evasive maneuvers.

(b) Can operate outside of designated area and interfere in danger zones.

DESIGN OF THE PROTOTYPE

Aims of the dissertation are:-

1 To investigate sensory methods.

2 To design and implement motor drive circuits.

3 To design and implement infrared sensor system.

4 To design and implement ultrasonic sensor system.

5 To program microcontroller AT89C51.

3.1 BRIEF DESCRIPTION:

The intelligence of the system is in the micro controller, the micro controller takes input from the ultrasonic sensor to avoid collision by measuring the proximity of other vehicle or an obstacle and from IR sensors to keep the vehicle on its predefined path.

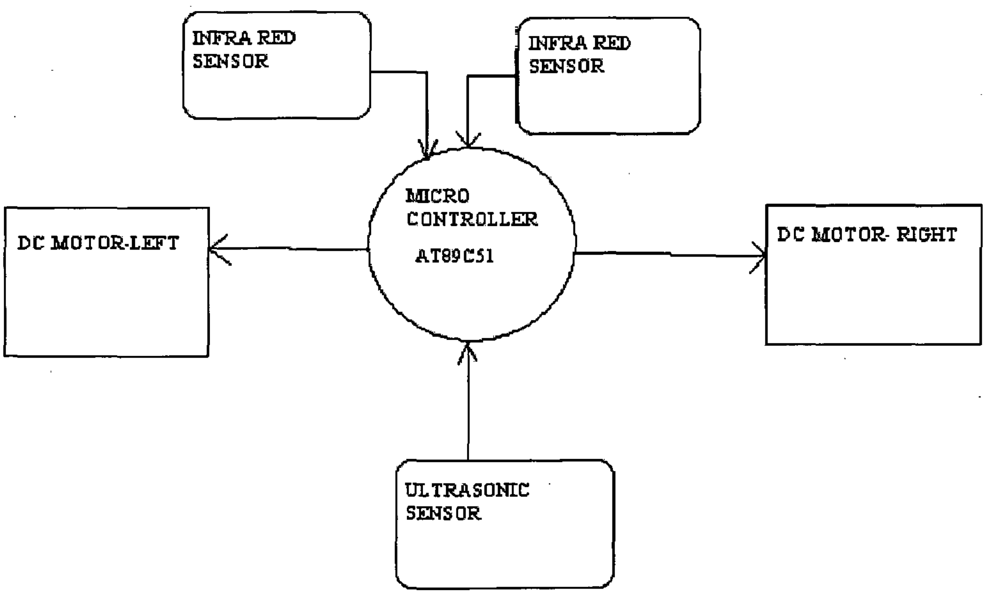


Fig 3.1 Block diagram of AGV

3.2 SENSORS AND COMPARATOR SECTION

3.2.1 Infra red sensors: To detect predefined path.

The robot moves in such a way as to locate itself above a **dark line** drawn on a white surface.

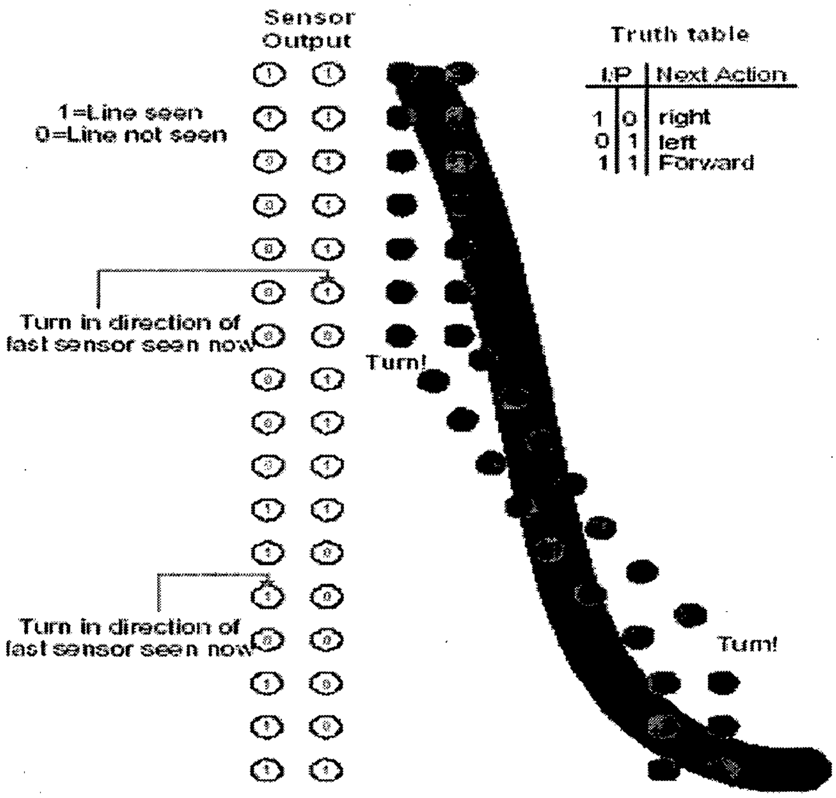


Fig 3.2 AGV following predefined path.

The sensing subsystem consists of two identical parts called Photo Interrupters. Each photo interrupters is made of a light emitting diode (LED) and a phototransistor.

The LED emits infrared light, if the Photo Interrupter passes over a white surface, the infrared light is reflected back and is detected by the phototransistor. This causes large current flow through transistor CE (fig 3.3), through 10 kΩ + 2.2kΩ resistance and hence sensor output is approx. 0V. So inverting terminal have low voltage than non-inverting terminal (non inverting terminal voltage is set by adjusting the potentiometer connected at non-inverting terminal of the comparator) as a result o/p of the comparator will be high.

And on the black surface, CE resistance is high as most of the IR is absorbed by the black surface, that causes small current through (10 +2.2) kΩ resistance, i.e. sensor output is approx. 5V, so inverting terminal has high voltage than non-inverting terminal, as a result o/p of the comparator will be low.

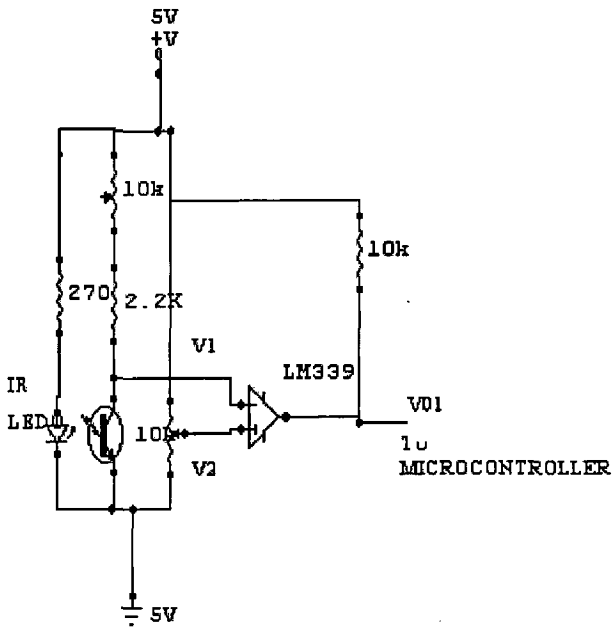


Fig3.3 Infrared sensor and its comparator circuit

Test results:

Signal voltage on the non-inverting terminal of the comparator V2=3.39V

SURFACE-	BLACK	WHITE
V1	4.17V	0V
V01	0.04V	5V

3.2.2 **Ultrasonic sensor**: For obstacle detection:

An ultrasonic sensor consists of a transmitter and a receiver. The transmitter sends ultra sound signal and the reflected ultrasound is received by the receiver, to check for obstacle in the vicinity of AGV. As the distance between AGV and obstacle decreases, receiver output signal amplitude will increase. These generated signals are passed on to the signal conditioning unit ant then to the microcontroller to avoid collision with obstacle.

3.2.2.1 **Transmitter module:** To generate ultra sound signal of 40 KHz

The transmitter module consists of a gated oscillator using NAND Gate IC CD4093, the output of that drives the ultrasonic transducer, ultrasonic transducer is just a very small "speaker" which is designed to generate sound waves at 40 KHz.

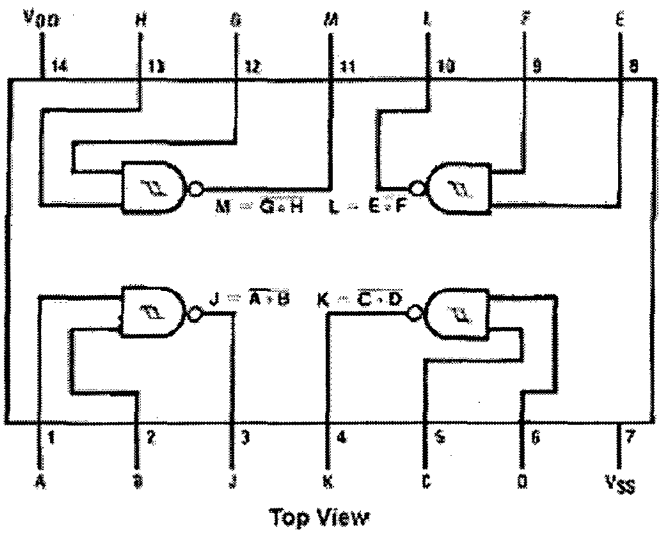


Fig 3.4 NAND Gate IC CD4093B

Schmitt trigger is used as a 40 KHz square-wave oscillator, the circuit consist of 3.3k + 47 K ohm potentiometer and capacitor C6 to set the frequency. 47K ohm potentiometer is for the precise adjustment of the output frequency to the 40KHz. The values for the resistor and capacitor are calculated using the standard RC network equations

Time constant T = R.C

Frequency f=1\RC

Capacitance C=3.3 nf

As f=40kHz

R=1/f C=7.57K ohms.

By varying the 47 k pot, which is in series with 3.3k, value of R=7.57 K ohm is obtained.

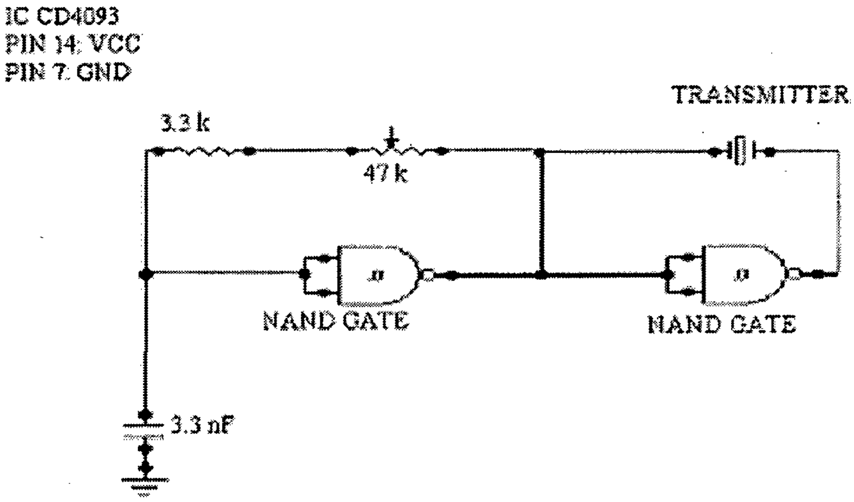


Fig 3.5 Ultra sound transmitter

The Schmitt trigger generates a square wave of 40 kHz, that is made out of phase by using other NAND gate. This out of phase signal and phase signal is applied on the transmitter, which will provide twice the peak-to-peak input voltage than a single-ended driver. The output to the sensor will have a wave form as shown due to the inductive and capacitive components in the sensor.

Output to the transmitter: 40 KHz signal.

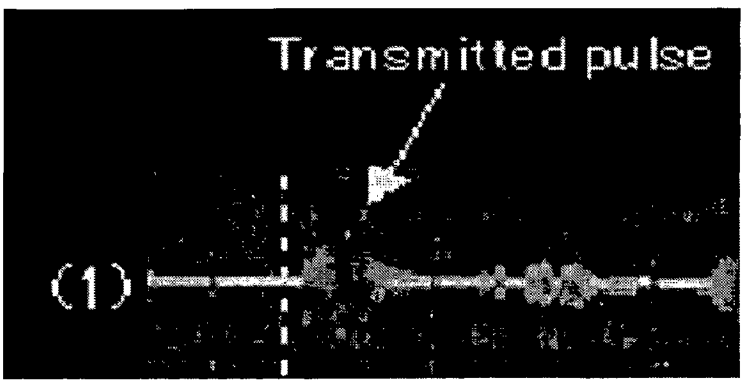


Fig 3.6 40 KHz ultra sound wave

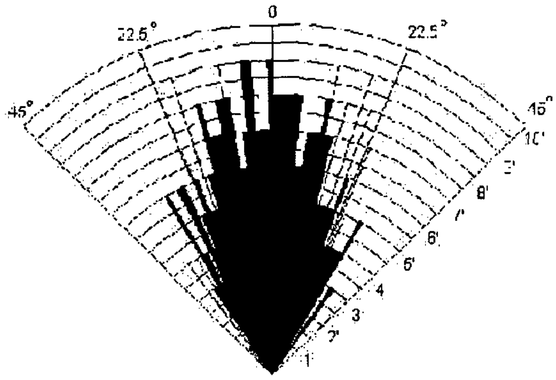
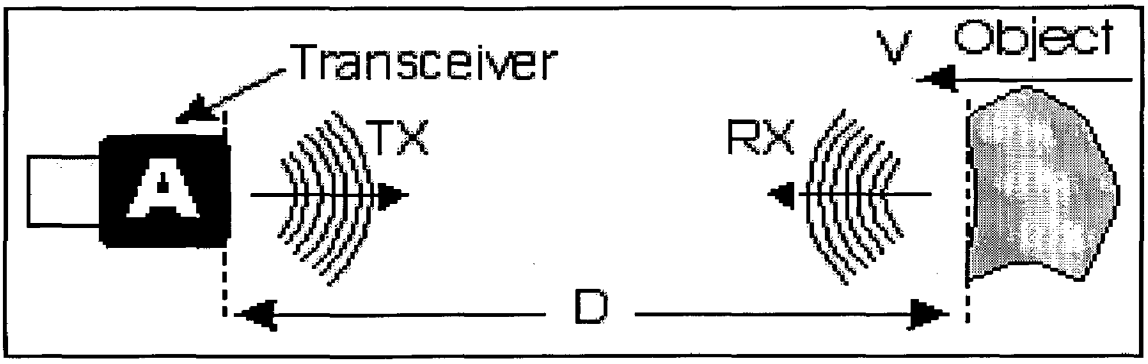


Fig 3.7 Wide beam of the ultrasonic transducer

Transmitter generates 40 KHz ultrasonic signal, if this signal hits any object with in the wide beam of the ultrasonic transducer, it bounce back from the target and vibrates the receivers piezoelectric transducer and generate a low amplitude 40 KHz electric signal.



D: **Distance between receiver and obstacle,** as D decreases amplitude of received ultrasonic signal increases that will increase receiver electric signal output amplitude.

	DISTANCE	RECEIVED O/P AMPLITUDE
CASE A	5 cm	7.7mV
CASE B	20 cm	4.94 mV

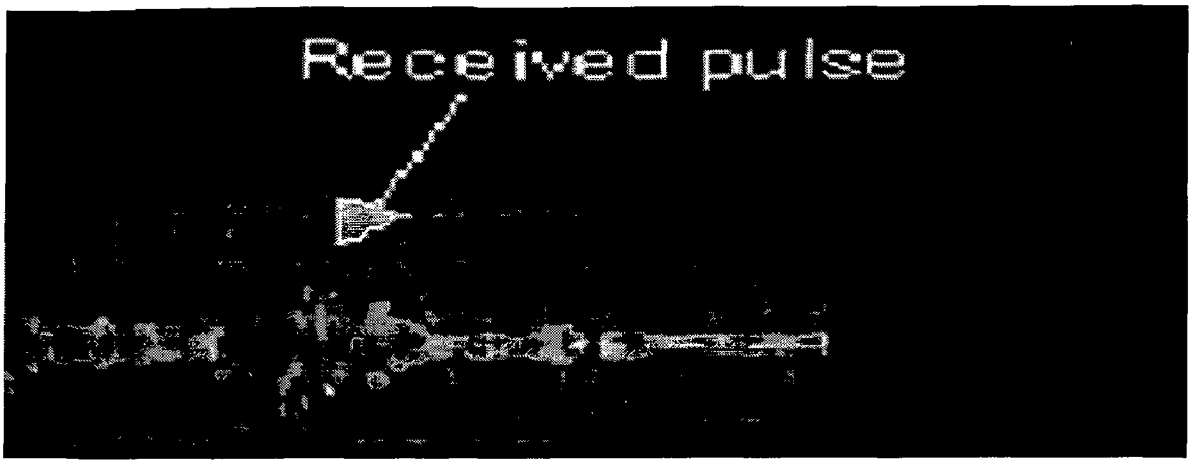


Fig 3.8 Received ultrasound signal

3.2.2.2 Receiver signal conditioning module.

The Receiver signal conditioning module consists of a high gain amplifier built using two CE transistor, which amplifies the 40 KHz electric signal received from the piezoelectric transducer.

Signal amplification circuit

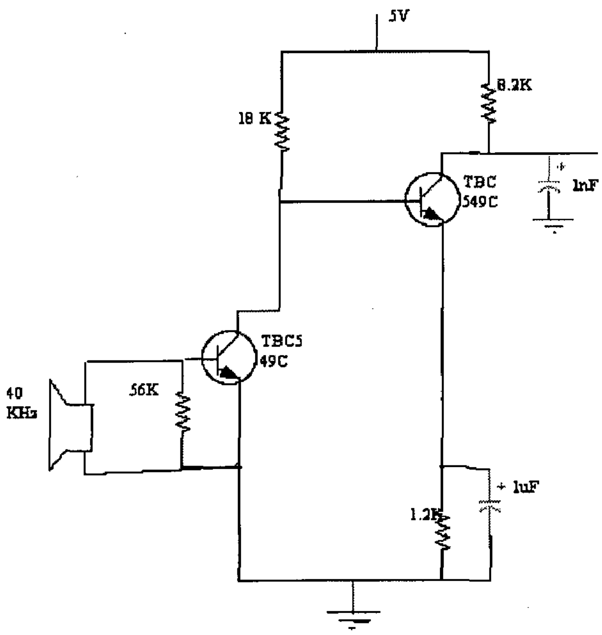


Fig 3.9 Signal amplification circuit

The transmitter parameter at the quiescent point are:

hie: 2K, hfe = 50, hre = $6*10_{-4}$, hoe = 25 uA/V as **$h_{oe}*R_L$= 25*10^{-6} * 8.2K < 0.1** so approximate equation can be used.

In a cascade of stages, the collector resistance of one stage is shunted by the input impedance of the next stage. Hence it is advantageous to start the analysis from last stage.

For the CE second stage: h model

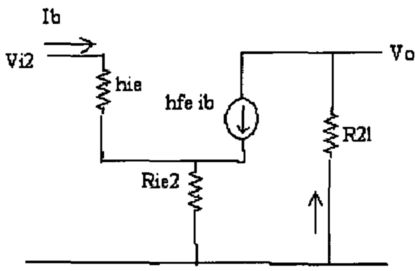


Fig 3.10 h model of second stage CE transistor

Rie2=1.2 K ohm

R_{2L} = 8.2 K ohm

The current gain of the last stage is:

A_{I2}= - hfe=- 50

The input resistance R_{i2} :

R_{i2} = hie + (1+ hfe) Re=2K + (1+50) 1.2K= 63 K ohm.

Voltage gain of the second stage is:

A_{v2}= Vo/V2=-hfe* R_{2L} / R_{i2} = 6.4

For the CE transistor input stage

Current gain:

A_{I1}= -hfe = -50

The input resistance:

R_{i1}= hie = 2KΩ

The effective load on the first stage, its voltage gain and the output impedance.

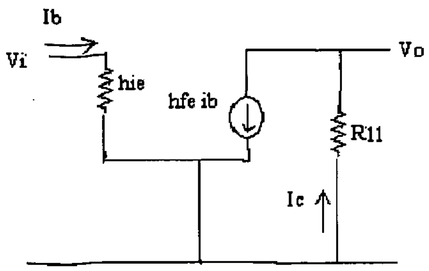


Fig 3.11 h model of first stage CE transistor

R_{L1}= 18k*2k/(18k+2k) = 1.8 KΩ

Voltage gain

Av1= Ai1*Rl1/Ri1 = 45

Voltage gain:

Av=Av1*Av2

Av= 45*6.4=288

Output resistance :

R0=R1L = 8.2 K ohm

3.2.2.3 Rectifier circuit

The amplified output signal is applied to rectifier circuit to generate a DC level proportional to the amplitude of the received echo.

Rectifier circuit consists of a coupling capacitor C4, which is used to remove unwanted low frequency noise. C4=1uf, and C5=450nf, have a value because they are used to couple 40 KHz. D1 and D2 are schottky diode, as there switching time is very small and cutting voltage is 0.3V instead of 0.6V for PN diode, so having good high frequency characteristics.

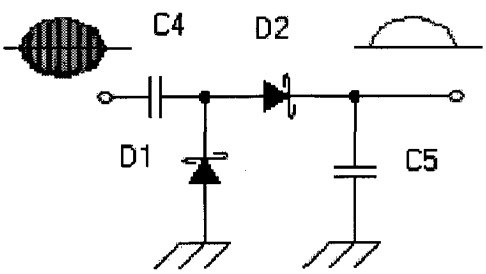


Fig 3.12 Rectifier circuit

The output of the rectifier is fed to the voltage comparator LM339

3.2.2.4 Comparator Circuit

Comparator circuit is used for converting low level analog signals to a high level digital output. The output pull-up resistor should be chosen high enough so as to avoid excessive power dissipation yet low enough to supply enough drive current to switch whatever load circuitry is used on the comparator output. Resistors R1 and R2 are used to set the input threshold trip voltage (V_{REF}) at any value desired within the input common mode range of the comparator.

As the input signal level is lower than the preset voltage of 3.67V set by using 10 Kohm potentiometer, the output at comparator switches to 5V, that determines the echo trigger level (range from 0 to 5V). The output (V_{O1}) of the voltage comparator is applied to micro controller pin 1.2, to avoid collision with obstacle in the vicinity of vehicle.

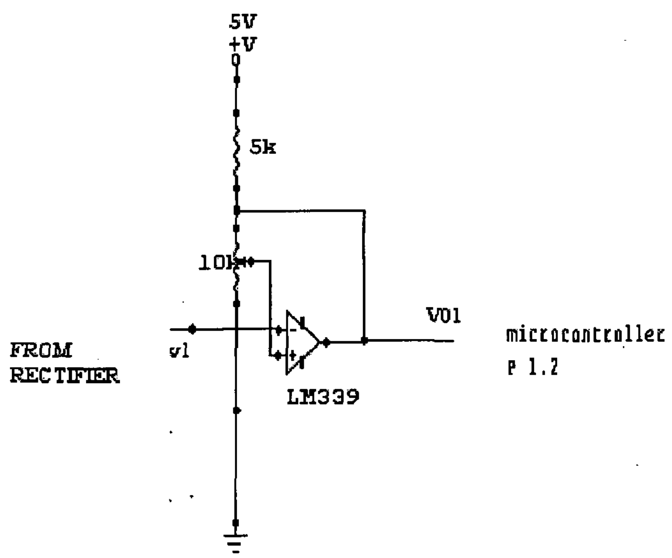


Fig 3.13 Voltage comparator circuit

Test result:

Vref = 3.67 V	No obstacle	Obstacle
V1	1V	4V
V01	5V	0V

3.2.3 Microcontroller module

The signal from the infrared sensors and ultrasound sensor is applied to Pin P1.1, P1.2 and P1.3 of the microcontroller AT89C51.

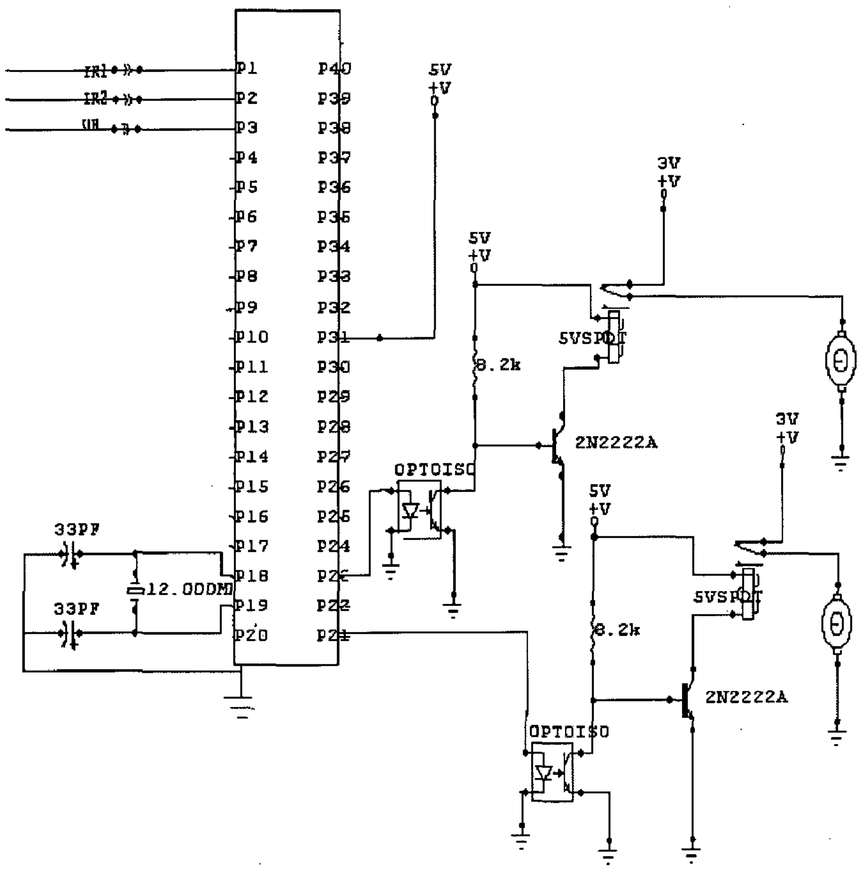


Fig 3.14 Micro Controller module

The microcontroller used is AT89C51, that is a low-power, high-performance CMOS 8-bit microcomputer with 4 Kbytes 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 and pinout. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer.

By combining a versatile 8-bit CPU with Flash on a monolithic chip, the Atmel AT89C51 is a powerful microcomputer which provides a highly flexible and cost effective solution to many embedded control applications.

The AT89C51 provides the following standard features: 4 Kbytes of Flash PEROM, 128 bytes of RAM, 32 I/O lines, two 16-bit timer/counters, a full duplex serial port, on-chip oscillator and clock circuitry.

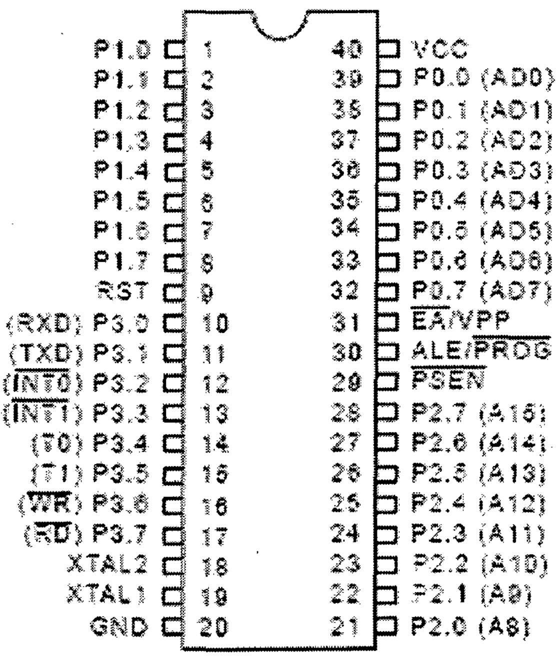


Fig 3.15 Pin Configurations

Pin Description

VCC : Supply voltage.

GND : Ground.

Port 0 :

Port 0 is an 8-bit open drain bidirectional I/O port. As an output port each pin can sink eight TTL inputs. When 1s are written to port 0 pins, the pins can be used as high-impedance inputs. Port 0 also receives the code bytes during Flash programming and outputs the code bytes during program verification.

Port 1:

Port 1 is an 8-bit bidirectional I/O port with internal pullups. Port 1 also receives the low-order address bytes during Flash programming and program verification.

Port 2:

Port 2 is an 8-bit bidirectional I/O port with internal pullups. Port 2 emits the high-order address byte during fetches from external program memory Port 2 also receives the high-order address bits and some control signals during Flash programming and verification.

Port 3:

Port 3 is an 8-bit bidirectional I/O port with internal pullups. Port 3 also serves the functions of various special features of the AT89C51 as listed below:

Port 3 also receives some control signals for Flash programming and programming verification.

RST:

Reset input. A high on this pin for two machine cycles while the oscillator is running resets the device.

ALE/PROG:

Address Latch Enable output pulse for latching the low byte of the address during accesses to external memory. This pin is also the program pulse input (PROG) during Flash programming.

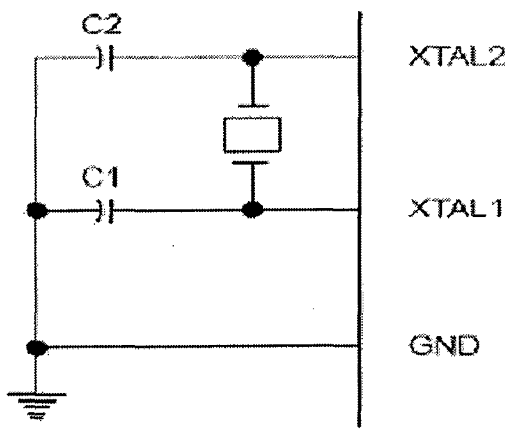
EA/VPP:

External Access Enable. EA must be strapped to GND in order to enable the device to fetch code from external program memory locations starting at 0000H up to FFFFH. EA should be strapped to VCC for internal program executions. This pin also receives the 12-volt programming enable voltage (VPP) during Flash programming,

3.2.3.1 Oscillator circuit:

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. Either a quartz crystal or ceramic resonator may be used.

oscillator connections



C1,C2= 30 pf+/- 10 pf for crystal capacitor

Fig 3.16 Oscillator circuit

3.2.3.2 Programming the Flash Memory

The micro controller AT89C51 is having on-chip Flash memory array in the erased state (that is, it contents = FFH) and ready to be programmed. To program any non-blank byte in the on-chip Flash Memory, the entire memory must be erased using the Chip Erase Mode.

Programming Algorithm: Before programming the microcontroller AT89C51, the address, data and control signals should be set up according to the Flash programming mode table. The programming interface accepts high-voltage (12-

volt) at program enable signal (EA).The AT89C51 code memory array is to be programmed byte-by-byte

To program the AT89C51, take the following steps.

1. Input the desired memory location on the address lines.
2. Input the appropriate data byte on the data lines.
3. Activate the correct combination of control signals.
4. Raise EA/VPP to 12 V for the high-voltage programming mode.
5. Pulse ALE/PROG once to program a byte in the Flash array. The byte-write cycle is self-timed and typically takes no more than 1.5 ms. Repeat steps 1 through 5, changing the address and data for the entire array or until the end of the object file is reached.

Chip Erase: The entire Flash array is erased electrically by using the proper combination of control signals and by holding ALE/PROG low for 10 ms. The code array is written with all "1"s. The chip erase operation must be executed before reprogramming of memory.

Flash Programming Modes Table:

MODE	RST	PSEN	ALE / PROG	EA/Vpp	P2.6	P2.7	P3.6	P3.7
WRITE CODE DATA	H	L	L	H	L	H	H	H
READ CODE DATA	H	L	H	H	L	L	H	H
CHIP ERASE	H	L	L	H	H	L	L	L

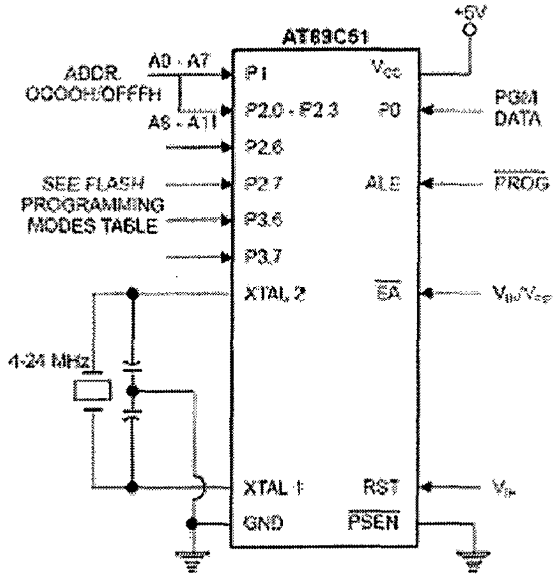


Fig 3.16 Programming the flash memory of AT89C51

3.2.4 Software description

Microcontroller AT89C51 takes inputs from two infrared sensors and one ultrasonic sensor through pins P1.1,P1.2,P1.3 respectively.

Case A: Check, P1.3=1,means there is no obstacle in front of the AGV. Now both infrared sensors check for the position of AGV w.r.t. predefined path.

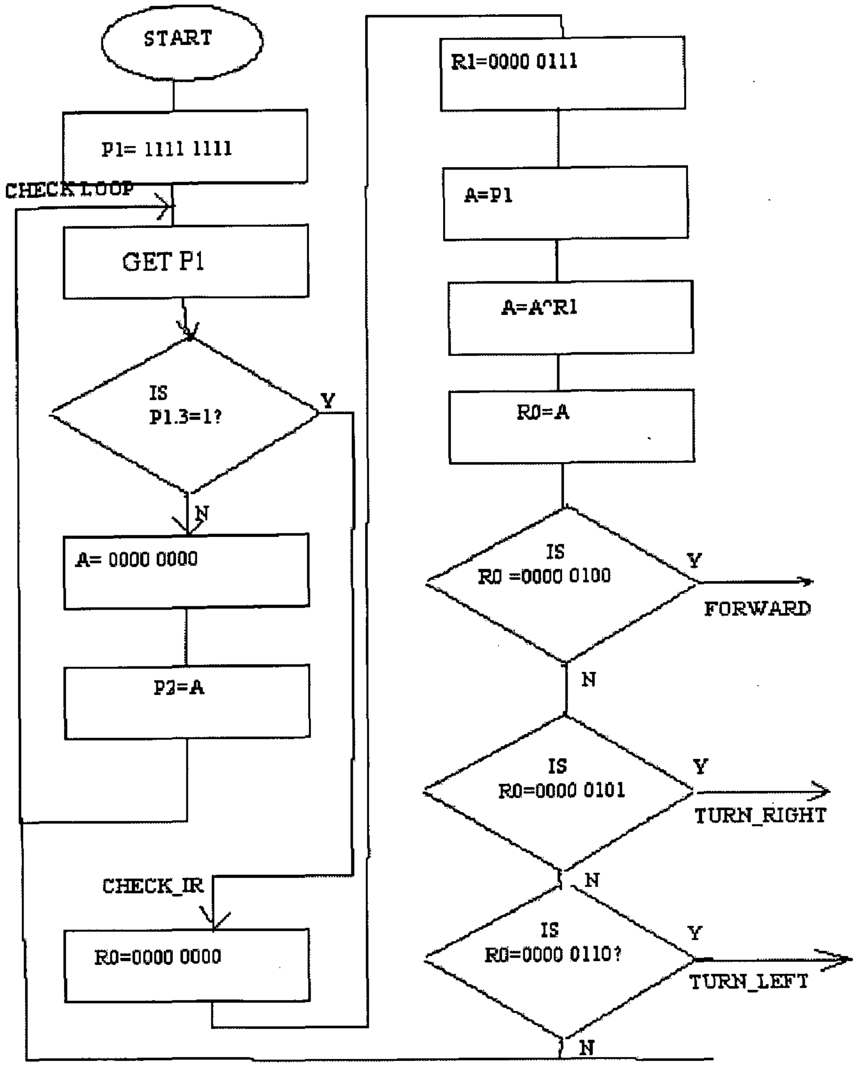
i) If P1.1=0 and P1.2=0, that means AGV is on right path, microcontroller continue to run AGV.

ii) If P1.1=1 and P1.2=0, that shows right wheel is on black surface and left wheel is on white surface, microcontroller turns AGV in right side by stopping right wheel D.C motor.

iii) If P1.1=0 and P1.2=1, that shows left wheel is on black surface and right wheel is on white surface microcontroller turns AGV in left side by stopping left wheel D.C motor.

Case B: if P1.3=0,that shows obstacle is in front of AGV, than microcontroller stops AGV by stopping both left and right D.C motors.

Microcontroller Program Flow Sheet



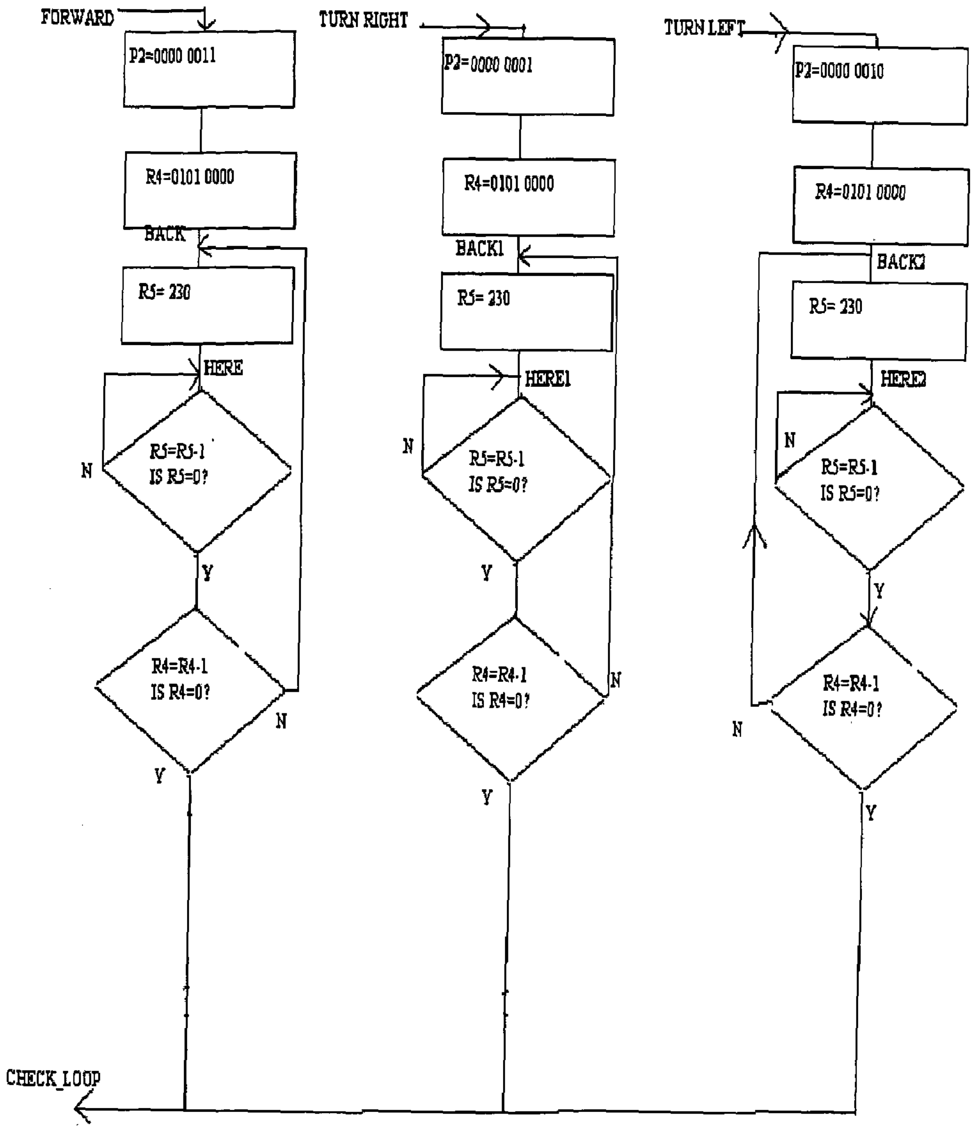


Fig 3.17 Flowchart

Note: Microcontroller Program is Attached As Annexure

3.2.5 OUTPUT MODULE:

The output of microcontroller from pin P23 and P21 is applied to D.C motor through Opto-coupler IC MCT2E, 5 Amp Transistor 2N2222A and Relay.

3.2.5.1 OPTO-COUPLER IC MCT2E:

MCT2E provides optical isolation between microcontroller and the output circuitry. It consist of gallium arsenide diode that is a infra red source optically coupled to a silicon npn transistor.

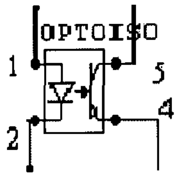


Fig 3.17 Internal circuit of Opto coupler IC MCT2E

3.2.5.2 SHUNT D.C MOTOR:

Specifications:

Operating range: 1.5-3V
Nominal voltage: 3V
No Load:
Speed: 12511rpm
Current: 0.29A
At Max. Efficiency:
Speed: 10012rpm
Current: 1.16A
Torque: 15.7gcm
Output: 1.61W
Eff.: 42.36%

An electric motor is a machine which converts electric energy into mechanical energy. Its action is based on the principle that when a current carrying conductor is placed in a magnetic field, it experiences a mechanical force whose direction is given by Flemings left hand rule and magnitude is

Force: F=BIL,

Here

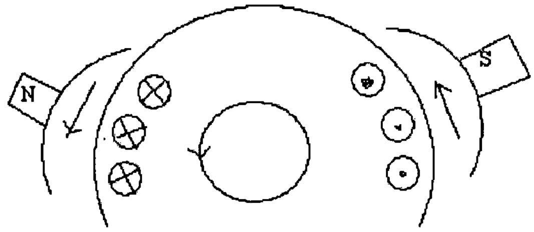
B= magnetic field density

I= current through conductor

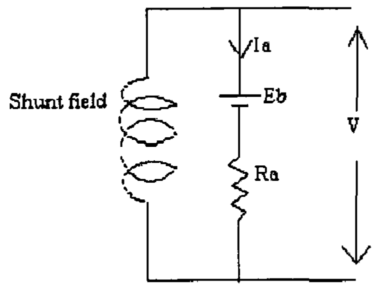
L= length of conductor

As soon as the armature starts rotating, induced emf is produced in armature conductors. The direction of induced emf is given by fleming right hand rule and it is in opposition to the applied voltage.

D.C. Motor



The equivalent circuit of motor:



$$Ia= (V- Eb)/Ra$$

Ra= Armature winding resistance

The applied voltage V has to force current through the armature conductors against this back emf Eb. The electric work done in overcoming this opposition is converted into mechanical energy developed in rotor.

Electric power that produce mechanical torque is = Eb*Ia

Back emf Eb= (ϕ Z P N)/A

Φ= flux per pole (wb)= constant for shunt DC motor.

Z= no. of conductor in rotor armature winding.

P= no. of poles.

N= no. of revolution per second.

A= no. of parallel slots on rotor.

Mechanical torque on rotor is proportional to Ia, as load on rotor increases, N decreases, armature current will increases that will increase torque, a speed is resumed at which current is sufficient to produce a torque to over come the applied shaft torque and the friction torque.

RESULTS AND DISCUSSIONS

The control microcontroller AT89C51 was programmed to read the data from the infrared sensors and ultrasonic sensor and generate output command to the DC motors, to drive AGV on the correct path, without any collision.

The microcontroller AT89C51 was found adequate for the purpose, as the outputs are suitable to drive the output circuit of AGV.

4.1 TEST RESULT:

4.1.1 PATH DETECTION:

Case A: When AGV is on the black surface, AGV will drive in forward direction as transistors will be in cut off region, that will de energize the Relays and connect 3V supply to the DC motor.

Case B: When AGV is on the white surface, AGV will stop as transistors will be in saturation region, that will energize the Relays and disconnect 3V supply with DC motor.

SURFACE	P23/P21	RELAY	D.C. MOTOR
BLACK	1 V	DE-ENERGIZE	ON
WHITE	5 V	ENERGIZE	OFF

The floor background is compensated by tuning the comparator rheostat.

However the floor that it was tested on white paper sheet and occasionally the line detectors not able to trace the black path.

The AGV lost the line if the radius is too small, occasionally it deviate from its predefined path. It is taken care by maintaining path radius greater than 20 cm. we can reduce path radius by reducing the speed of AGV.

4.1.2 OBSTACLE AVOIDANCE:

When no obstacle on the path, AGV will drive in forward direction as transistors will be in cut off region, that will de energize the Relays and connect 3V supply to the DC motor.

When obstacle on the path, is at the distance of 5 cm from AGV, it will stop as transistors will goes to saturation region, that will energize the Relays and disconnect 3V supply with DC motor.

	P23/P21	**RELAY**	**D.C. MOTOR**
NO OBSTACLE	1 V	DE-ENERGIZE	ON
OBSTACLE	5 V	ENERGIZE	OFF

4.2 CONCLUSIONS:

The prototype of AGV is designed and it is seen to follow the pre defined black paths successfully without colliding with obstacle on the path. The infrared sensors and ultrasonic sensor are used to describe the environment to avoid collision with obstacles and to drive the vehicle to the destination. The mobile vehicle navigated in the experimental environment safely.

REFERENCES

[1] "Details on Atmel51, 8-Bit Microcontroller" available at http://www.robotics.com/atmel52.txt.

[2] Instruction Set of industry standard MCS-51.

[3] "Details of microcontroller" available at http://www.seattlerobotics.org/encoder/index.html

[4] A.Ohya A. Osaka and A.Kak, vision based navigation of mobile robot with obstacle avoidance by single camera vision and ultrasonic sensing.Proc of IROS'97, pp 704-711 1997.

[5] www.agvp.com/navigation/types.html.

[6] www.goetting.de "Automation and steering of vehicles in Ports".

Annexure

```
MAIN:
        MOV P1,#0FFH                    ;INITIALISE AS INPUT
CHECK_LOOP:
        JB P1.3,CHECK_IR                ;CHECK OBSTACLE
        MOV A,#00H
        MOV P2,A                        ;YES,STOP VEHICLE;
        JMP CHECK_LOOP                  NO,CHECK VEHICLE ON PREDEFINED PATH
CHECK_IR:
        MOV R0,#0H                      ;INITIATISE REGISTOR R0 =0
        MOV R1,#07H
        MOV A,P1
        ANL A,R1                        ;TAKING ONLY LSB -2 OF PORT1
        MOV R0,A                        ;TAKING TO REGISTOR R0
        CJNE R0,#00000100B,CHECK        ;NO OBSTACLE
        JMP FORWARD                     ;MOVE FORWARD
CHECK:
        CJNE R0,#00000101B,CHECK1       ;CHECK LEFT WHEEL ON
                                         WHITE PAPER
        JMP TURN_RIGHT                  ;IF YES, JUMP RIGHT
CHECK1:
        CJNE R0,#0000110B,CHECK_LOOP    ; CHECK RIGHT WHEEL
                                        ON WHITE PAPER
        JMP TURN_LEFT                   ;IF YES, JUMP LEFT
FORWARD:
        MOV P2,#00000011B
        MOV R4,#50
BACK:
        MOV R5,#230
HERE:
        DJNZ R5,HERE
        DJNZ R4,BACK
        JMP CHECK_LOOP
TURN_RIGHT:
        MOV P2,#00000001B
        MOV R4,#50
BACK1:
        MOV R5,#230
HERE1:
        DJNZ R5,here1
        DJNZ R4,back1
        JMP CHECK_LOOP
TURN_LEFT:
        MOV P2,#00000010B
        MOV R4,#50
BACK2:
        MOV R5,#230
HERE2:
        DJNZ R5,HERE2
        DJNZ R4,BACK2
        JMP CHECK_LOOP
        END
```