Design and Implementation of a Maze Solving Robot



A report submitted to the department of Electrical and Electronic Engineering, Sonargaon University (SU), Dhaka, in partial fulfillment of the requirements for award of the degree of Bachelor of Science in Electrical and Electronic Engineering

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DECLARATION

It is declared hereby that this thesis paper or any part of it has not been submitted to anywhere else for the award of any degree.

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CERTIFICATION

This is to certify that this project entitled "**Design and Implementation of a Maze Solving Robot"** is done by the following students under my direct supervision. This project work has been carried out by them in the laboratories of the Department of Electrical and Electronic Engineering under the Faculty of Engineering, Sonargaon University (SU) in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering.

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ACKNOWLEDGEMENT

The report titled as on "**Design and Implementation of a Maze Solving Robot**" has been prepared to fulfill the requirement of our practicum program. In the process of doing and preparing our practicum report, we would like to pay our gratitude to some persons for their enormous help and vast co-operation.

At first, we would like to show our gratitude to the University authority to permit us to do our practicum. Specially, we would like to thank to our honorable teacher **MD. Iqbal Kabir ,** Lecturer, Department of Electrical & Electronics Engineering, Sonargaon University (SU), Dhaka, for his valuable and patient advice, sympathetic assistance, co-operation, contribution of new idea. Deep theoretical and hardware knowledge & keen interest of our supervisor in this field influenced us to carry out this project. His endless patience, scholarly guidance, continual encouragement, constant and energetic supervision, constructive criticism, valuable advice, reading many inferior draft and correcting them at all stage have made it possible to complete this project.

Finally, we would like to thanks again to the respected **Vice- Chancellor of SU,**

Professor Dr. Md. Abul Bashar also thanks to **Head of Department of SU,**

Electrical & Electronics Engineering, Professor Dr. M. Bashir Uddin because they are designated such an environment for learning through which we got the opportunity to acquire knowledge under Bsc in EEE program, and that will be very helpful for our prospective career.

We are, indeed, grateful to all those from whom we got sincere cooperation and help for the preparation of this report

ABSTRACT

An autonomous robot system which exists in physical world, can sense its environment and act on the inputs to achieve some goals without any human intervention.

Maze solving problem is a very old problem, but still now it is considered as an important field of robotics. The main aim of this project is to make an Arduino based efficient autonomous maze solver robot. For solving the maze, the robot will need to follow the path on the maze which it does by using the ultra-sonic sensor. In this work we have used a microcontroller (Arduino UNO) to control the whole process. There are two methods by which we can solve the maze i.e. the default left and default right algorithm. We have used the default left algorithm for solving the maze where the robot takes a right turn wherever possible. A 7.5V battery is supplying the required power. The robot hence trained will be able to solve the maze without any intervention. The algorithm which can be used to find an optimal solution for the same, which it does by following the path of cells backwards to the start once the finish location is found is also discussed in this work. In this project Hardware development, software development and maze construction had been done. For performance testing, the robot will implement to solve the maze.

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List of Abbreviation

PWM	Pulse Width Modulation
PVC Board	polymerizing vinyl chloride Board
EEPROM	Electrically Erasable Programmable Read-Only Memory
SRAM	Static Random Access Memory
AC	Alternative Current.
DC	Direct Current

CHAPTER 1

INTRODUCTION

1.1 Introduction:

An autonomous robot system which exists in physical world, can sense its environment and act on the inputs to achieve some goals without any human intervention. An autonomous robot is a category of robot that can perform task intelligently without any human assistance [1]. Maze solving robot one of the most popular autonomous robot. It is small self-reliant robot that can solve a maze from an unknown starting positing to the center area of the maze in the shortest possible time. A maze solving robot make multiple runs in a maze, first it creates a map of the maze layout and store it in its memory, then run through a shortest path [2]. A maze is a network of paths, typically from an entrance to exit.The concept of maze approximately thousand years old [3]. Which was invented in Egypt. From then, many mathematicians made various algorithms to solve the maze. Now a days, maze solving problem is an important field of robotics. It is based on one of the most important areas of robot, which is "Decision Making Algorithm". Cause, this robot will be placed in unknown place, and it requires to have a good decision-making capability. There are many types of maze solving robot using various type of algorithms. In this project, the system design of maze solving robot consist obstacle avoidance ultrasonic sensor and then sensor will detect the wall. Solve the maze, this robot will apply wall flowing algorithms such as left-hand process.

1.2 Background:

The problem of solving a maze is approximately 47 years old but, it is still considered an important field of robotics. One of the most important area of robot on which is based in decision making algorithm [4]. It is simply defined a robot which will be placed in an unknown environment and it required having a good decision-making capability to find the way out using its programmed algorithm. In the middle of the 20th century, maze solving problems become an important field of robotics [5]. In the year of 1972, editors of IEEE Spectrum magazine came up with the concept of micro-mouse which is a small microprocessor-controlled vehicle with self-intelligence and capability to navigate a critical maze [6][7]. Then in May 1977, the fast US Micro mouse contest, called "Amazing Micro

mouse Maze Contest" was announced by IEEE Spectrum. From then, this type of contest became more popular, and many types of maze solving robots are developed every year. In the year 1999, Michael Gims, Sonja Lenz and Dirk Becker from University of East London developed a micro mouse. They used a non-graph theory algorithm, Wall Following Algorithm. Chang Yuen Chung, a student of University Technology Malaysia (UTM) designed a micro mouse using Flood Fill Algorithm. His robot was designed in three layers so that the robot looks more compact and smaller size. Chang Yuen Chung claimed that this Flood Fill Algorithm is able to find the shortest path but more memory is required for execution [8].

1.3 Objectives:

a) To design and construct a low-cost maze solving robot.
b) To develop the programmed of the robot for assessing the performance of the maze solving robot.
c) To solve the maze by programming the robot.

1.4 Methodology:

a) Collection of information from different books, internet and manuals.
b) Collection of components from local market.
c) To design and build the Arduino based hardware of maze robot.
d) To design and build a small maze.

CHAPTER 2

System Architecture

2.1 Working principle:

The electronic subsystem of the robot consists of many components such as microcontroller IC, motor driver IC, battery, voltage booster, gear motor, transistor, power switch, and various types of registers, capacitors. The robot is programmed in such a way to drive maze. Besides that, ultra-sonic sensor is placed on its left side, right side and front side to notifies the distance of any obstacles. AS its travels the program are using solve the maze called ‘‘left hand method’. Ultra-sonic sensor measure distance by sending out by a sound wave at a specific frequency and listening for that sound by bounce back. The robot takes decision as per the programmed has implemented and it also robot continuously takes reading from the sensor for the purpose of analyzing them to takes decision about which direction have to go. The direction left has highest priority. If the robot turn left it goes that direction. If the robot can't turn left it goes to straight. If robot can't go left or straight then it goes to right. If there is no place to go then it goes reverse. It does so until the maze solved.

2.2 Block Diagram of Maze Solving Robot:

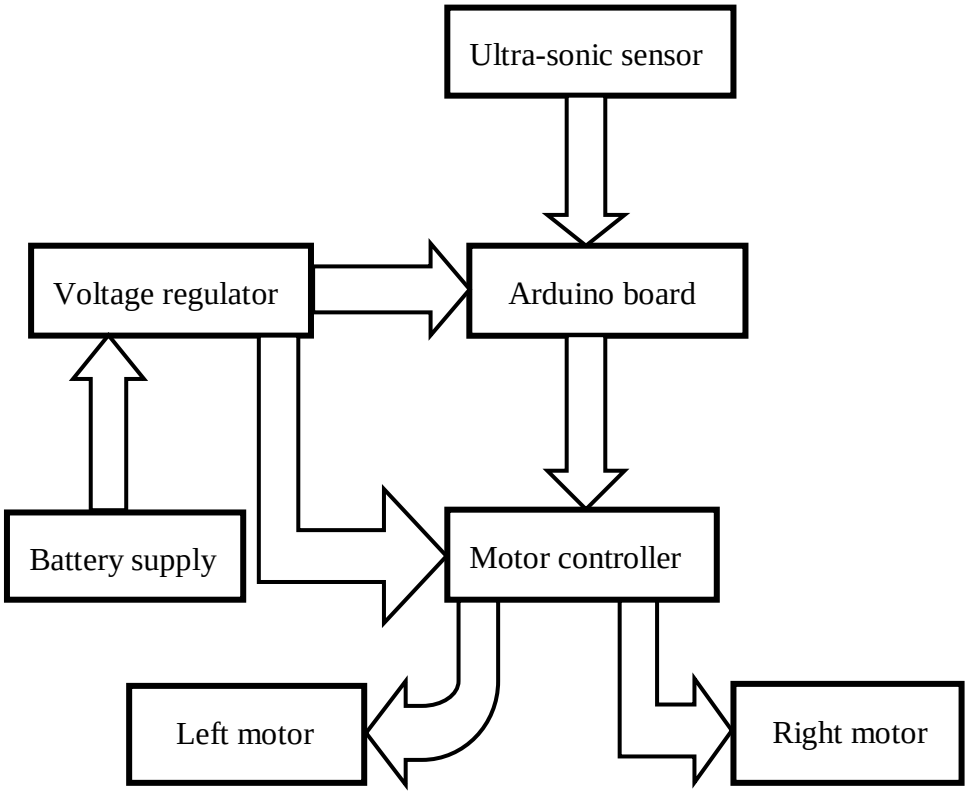


Figure 2.1:Block Diagram of a Maze Solving Robot

2.3 Circuit Diagram of a Maze Solving Robot:

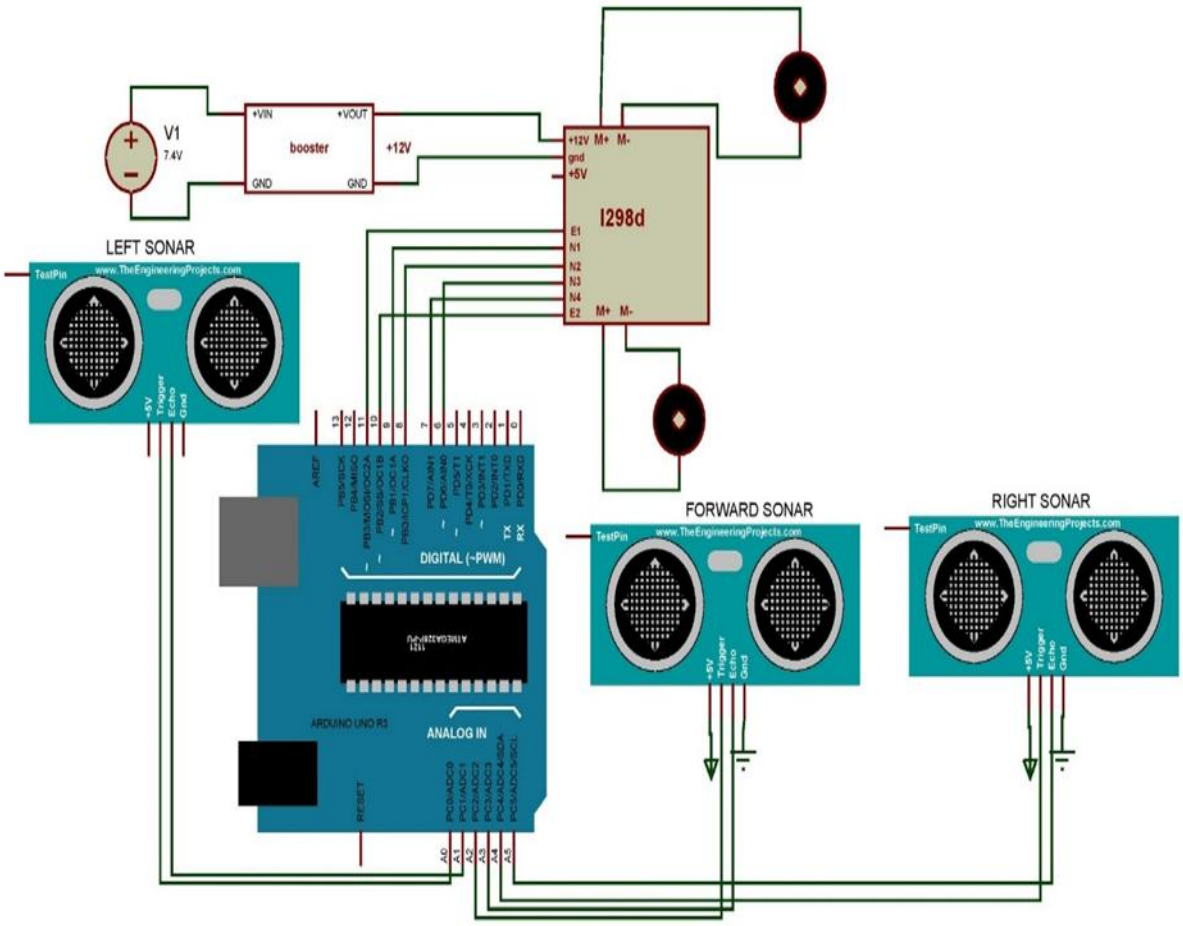


Figure: 2.2: Circuit Diagram of a Maze Solving Robot

2.4 Application:

Now a day's robots are widely used in various critical and dangerous find. This project is based on decision making algorithms. So, it can be used in various intelligent fields. It can be used as a rescue operation, navigation problems, search operation, medical attention, military search and rescue, etc.

There are many cases that are like mazes where humans could get lost in. This robot can find its way out again. It can also be used in too small or dangerous cave where human can't enter. Not only the caves, but also in a big shopping mall, it's possible that one can lose track of the Paths. This robot can be used as a guide in that case too

2.5 List of Components with Price:

The total cost of this project is 9560 tk. It is very cheap price for a robot. Mobile robot requires a chassis for assembling all equipment. The cost of the chassis which is used in this project is only 1200 tk. The price of Arduino Uno with Atmega-328p IC is 1000 tk. Ultrasonic sonar (HR-SR04) has been used in this project. Per sensor cost is only 120 tk. But other sensors are more expensive. Two DC motors with wheels cost only 2400 tk. Price of motor controller is 800 tk. A li poly battery is used to minimize the cost. It takes only 2000 tk.

Table 2.1: The Used Parts List and the Total Cost of the Project.

S/N	**Name**	**Quantity**	**Price (Tk)**	**Market Price (Tk)**
1	Robot frame	1	1200	Tk12000/=
2	Atmega-328 IC	1	800	
3	L298D IC	1	1000	
4	Gear motor	2	2400	
5	Battery	1	2000	
6	Ultrasonic sensor	3	360	
7	PVC board	1	1000	
8	Booster circuit	1	300	
9	Miscellaneous		500	
Total=		**Tk9560/=**		

CHAPTER 3

Arduino UNO

3.1 Arduino UNO

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button [9]. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter. "Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; for a comparison with previous versions, see the

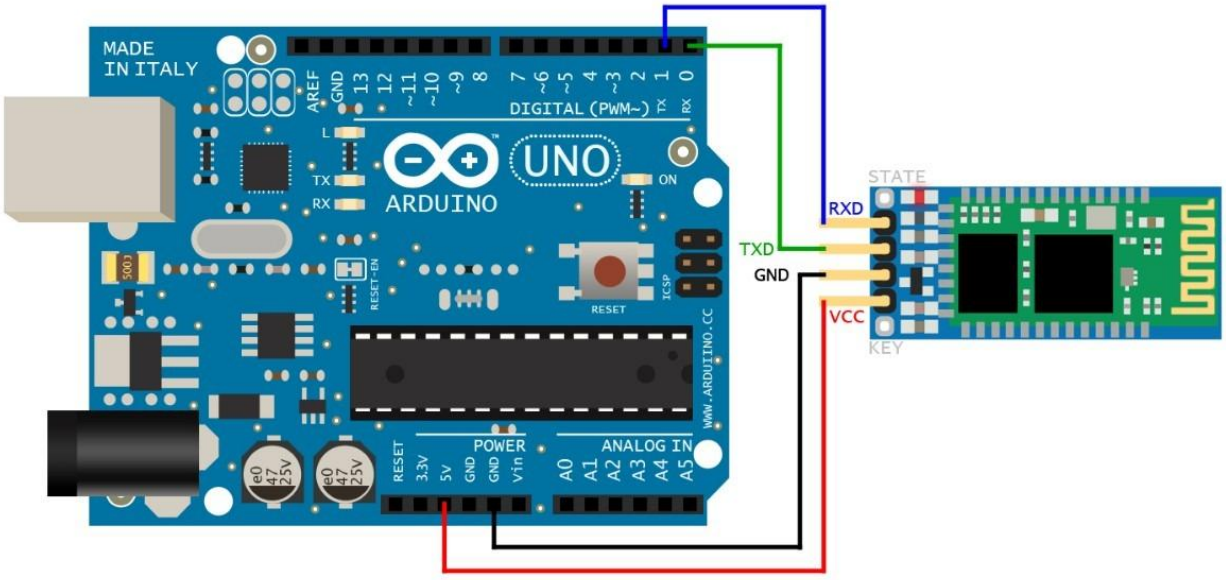


Figure 3.1: Arduino Board

3.2 Technical Specification:

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB of which 0.5 KB used by boot loader
SRAM	2KB
EEPROM	1KB
Clock Speed	16 MHz

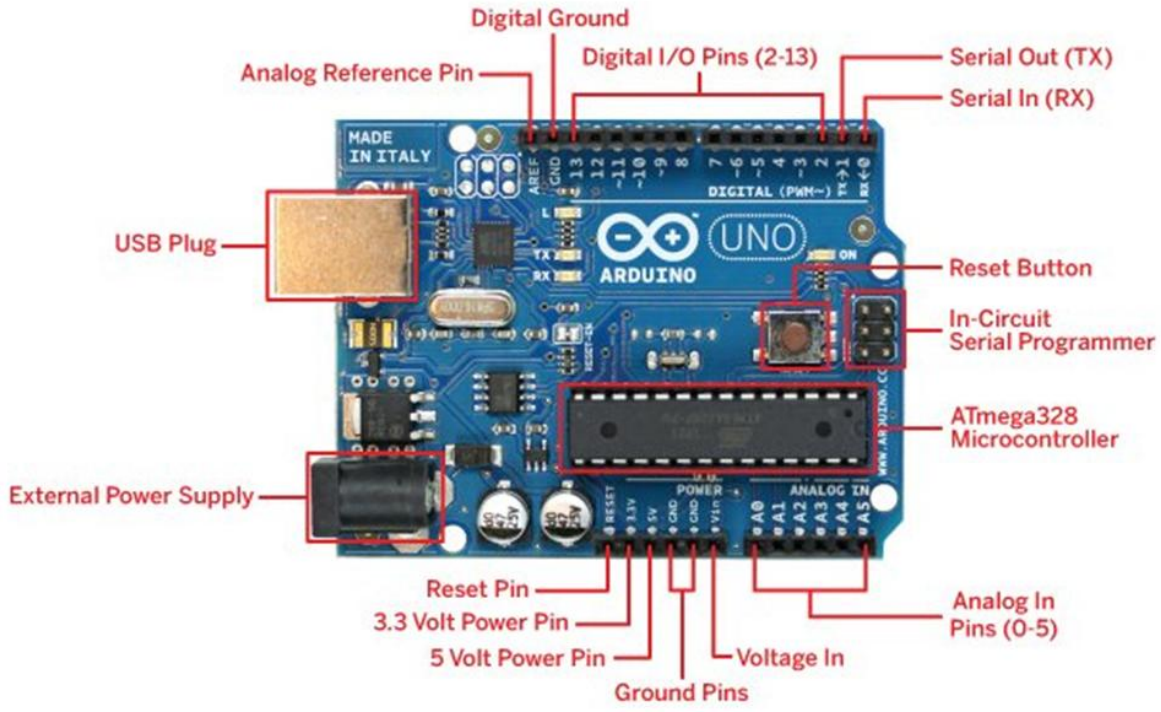


Figure 3.1: Arduino UNO Board Pin Description

3.3 Power:

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically.

External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the GND and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The power pins are as follows:

- Vin. The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- 5V. The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply.
- 3V3. A 3.3-volt supply generated by the on-board regulator. Maximum current draw is 50mA.
- GND. Ground pins. 6-Watt 12 Volt solar panel is lightweight, waterproof, and designed for long term outdoor use in any environment. The panel uses polycrystalline solar cells.

3.4 Memory:

The Atmega328 has 32 KB of flash memory for storing code (of which 0,5 KB is used for the boot loader); It has also 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library

3.5 Input and Output:

Each of the 14 digital pins on the Uno can be used as an input or output, using pin Mode (), digital Write (), and digital Read () functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40mA and has an internal pull-up resistor (disconnected by default) of 20-50 k ohms. In addition, some pins have specialized functions:

a) Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. T These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.

b) External Interrupts: 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attach Interrupt () function for details.

c) PWM: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analog Write () function.

d) SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication, which, although provided by the underlying hardware, is not currently included in the Arduino language.

e) LED: 13. There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

f) The Uno has 6 analog inputs, each of which provide 10 bits of resolution (i.e. 1024 different values). By default, they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analog Reference () function. Additionally, some pins have specialized functionality:

g) I2C: 4 (SDA) and 5 (SCL). Support I2C (TWI) communication using the Wire library. There are a couple of other pins on the board.

h) AREF. Reference voltage for the analog inputs. Used with analog Reference.

i) Reset. Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

3.6 Communication:

The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega8U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '8U2 firmware uses the standard USBCOM drivers and no

external driver is needed. However, on Windows, an *.inf file is required. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1). A Software Serial library allows for serial communication on any of the Uno's digital pins. The ATmega328 also support I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus; see the documentation for details. To use the SPI communication, please see the ATmega328 datasheet.

3.7 Programming:

The Arduino Uno can be programmed with the Arduino software. Select "Arduino Uno from the Tools > Board menu (according to the microcontroller on board for the download purpose). For details, see the reference and tutorials video.

The ATmega328 on the Arduino Uno comes preburned with a boot loader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files).

You can also bypass the boot loader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header; see these instructions for details. The ATmega16U2 (or 8U2 in the rev1 and rev2 boards) firmware source code is available. The ATmega16U2/8U2 is loaded with a DFU boot loader, which can be activated by:

- On Rev1 boards: connecting the solder jumper on the back of the board (near the map of Italy) and then resetting the 8U2.
- On R ev2 or later boards: there is a resistor that pulling the 8U2/16U2 HWB line to ground, making it easier to put into DFU mode.

You can then use Atmel's FLIP software (Windows) or the DFU programmer (Mac OS X and Linux) to load a new firmware. Or you can use the ISP header with an external programmer (overwriting the DFU boot loader). See this user-contributed tutorial for more information.

3.8 Automatic (Software) Reset:

Rather than requiring a physical press of the reset button before an upload, the Arduino Uno is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2/16U2 is connected to the reset line of the ATmega328via a 100 Nano farad capacitor. When this line is asserted (taken

low), the reset line drops long enough to reset the chip [10]. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the boot loader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload. This setup has other implications. When the Uno is connected to either a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For thefollowing half-second or so, the boot loader is running on the Uno. While it is programmed to ignore malformed data (i.e. anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is opened [11]. If a sketch running on the board receives one-time configuration or other data when it first starts, make sure that the software with which it communicates waits a second after opening the connection and before sending this data. The Uno contains a trace that can be cut to disable the auto-reset. The pads on either side of the trace can be soldered together to re-enable it. It's labeled "RESET-EN". You may also be able to disable the auto-reset by connecting a 110-ohm resistor from 5V to the reset line; see this forum thread for details.

3.9 USB Over Current Protection:

The Arduino Uno has a resettable poly fuse that protects your computer's USB ports from shorts and over current. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. If more than 500 mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed [12].

3.10 Physical Characteristics:

The maximum length and width of the Uno PCB are 2.7 and 2.1 inches respectively, with the USB connector and power jack extending beyond the former dimension. Four screw holes allow the board to be attached to a surface or case. Note that the distance between digital pins 7 and 8is 160 mil (0.16"), not an even multiple of the 100-mil spacing of the other pins.

3.11Block Diagram of Microcontroller:

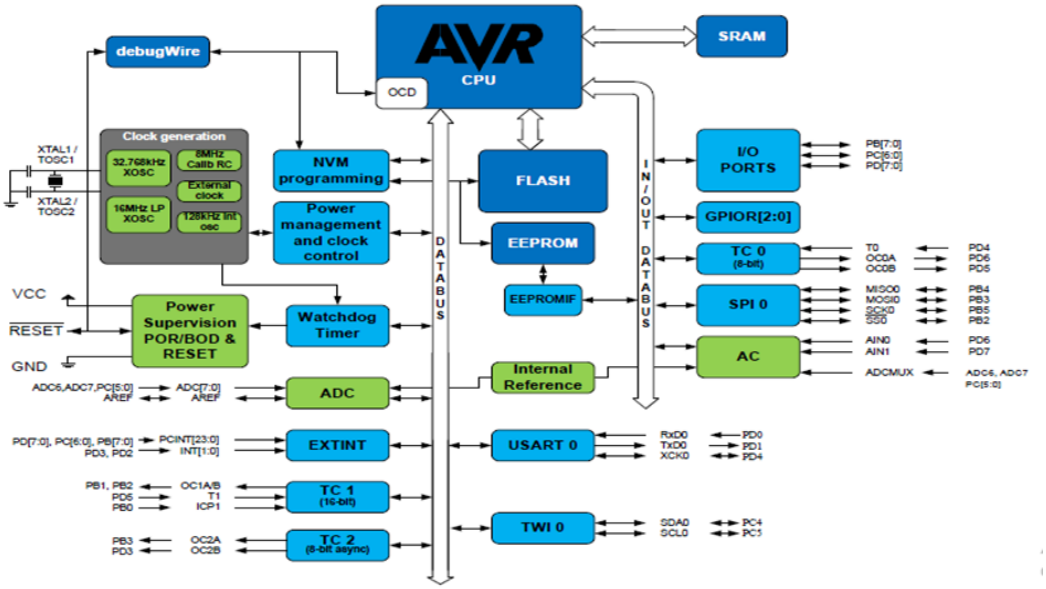


Figure 3.3: Block Diagram of Microcontroller Atmega-328 IC

3.12 Pin Configuration:

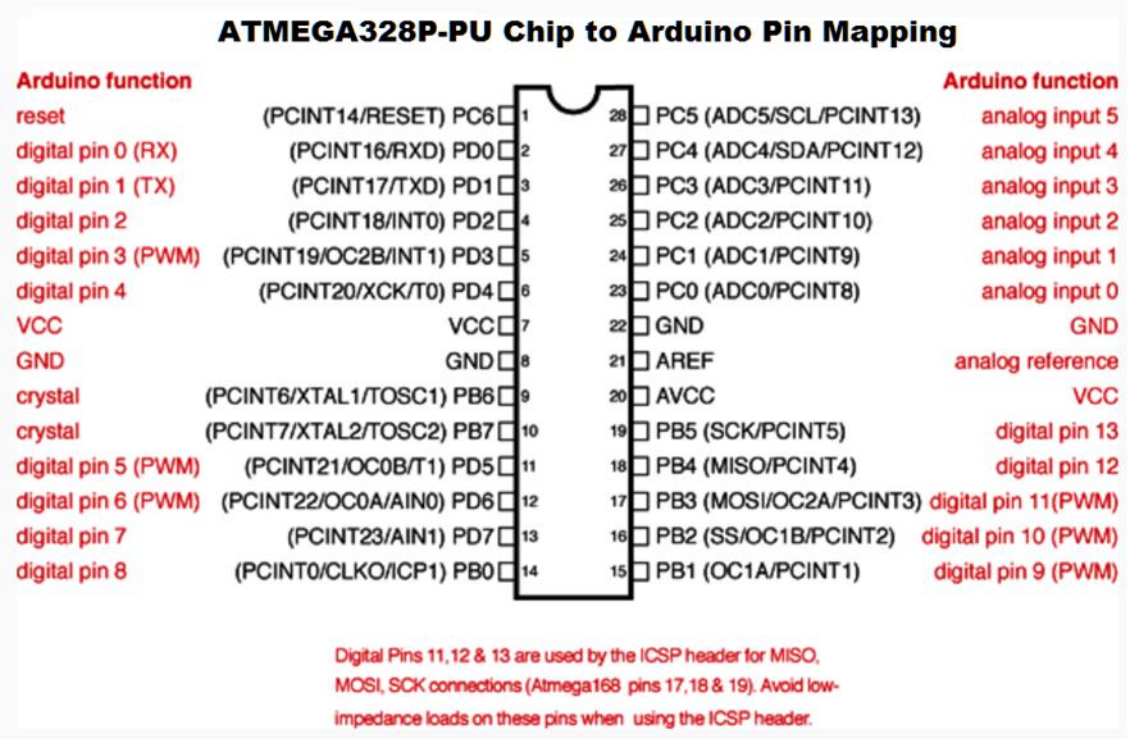


Figure: 3.4: Pin Configuration of Microcontroller Atmega-328

3.13 Pin Descriptions:

- **VCC:** Digital supply voltage.
- **GND:** Ground.
- **Port B (PB [7:0]) XTAL1/XTAL2/TOSC1/TOSC2**

Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running. Depending on the clock selection fuse settings, PB6 can be used as input to the inverting Oscillator amplifier and input to the internal clock operating circuit. Atmel ATmega328/P [DATASHEET] Atmel-42735B-ATmega328/P Datasheet_Complete-11/2016 17 Depending on the clock selection fuse settings, PB7 can be used as output from the inverting Oscillator amplifier. If the Internal Calibrated RC Oscillator is used as chip clock source, PB [7:6] is used as TOSC [2:1] input for the Asynchronous Timer/Counter2 if the AS2 bit in ASSR is set.

Port C (PC [5:0]):

Port C is a 7-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The PC [5:0] output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tri-stated when a reset condition becomes active, even if the clock is not running.

PC6/RESET

If the RSTDISBL Fuse is programmed, PC6 is used as an I/O pin. Note that the electrical characteristics of PC6 differ from those of the other pins of Port C. If the RSTDISBL Fuse is unprogrammed, PC6 is used as a Reset input. A low level on this pin for longer than the minimum pulse length will generate a Reset, even if the clock is not running. Shorter pulses are not guaranteed to generate a Reset. The various special features of Port C are elaborated in the Alternate Functions of Port C section.

Port D (PD [7:0])

Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D pins are tri-stated when a reset condition becomes active, even if the clock is not running.

AVCC

AVCC is the supply voltage pin for the A/D Converter, PC [3:0], and PE [3:2]. It should be externally connected to VCC, even if the ADC is not used. If the ADC is used, it should be connected to VCC through a low-pass filter. Note that PC [6:4] use digital supply voltage, VCC.

AREF

AREF is the analog reference pin for the A/D Converter.

ADC [7:6] (TQFP and VFQFN Package Only)

In the TQFP and VFQFN package, ADC [7:6] serves as analog inputs to the A/D converter. These pins are powered from the analog supply and serve as 10-bit ADC channels.

CHAPTER 4

Ultra-SonicSensor HC-SR04

4.1 Picture of Ultra-Sonic Sensor:

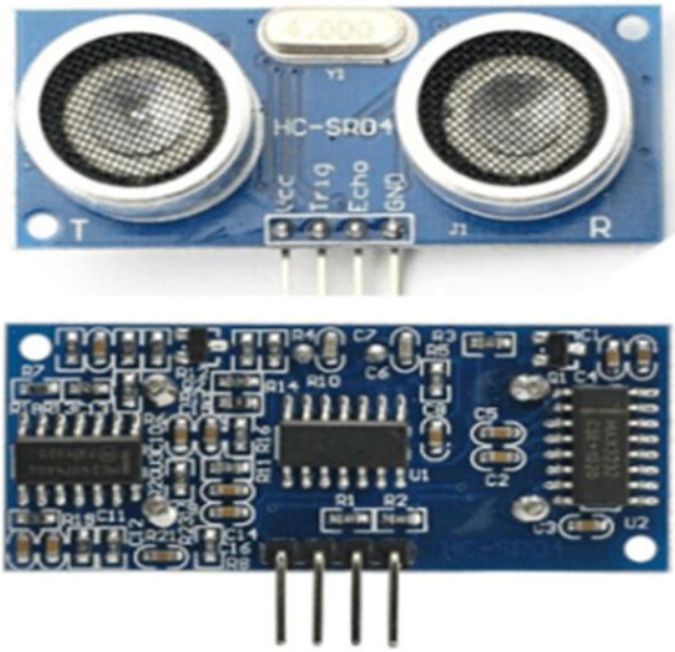


Figure 4.1: Ultra -Sonic Sensor HC-SR04 [13]

4.2 Feature:

- Operating voltage: +5V
- Operating current: < 15mA
- Measuring distance: 2 cm to 400 cm
- Accuracy: 3 mm
- Measuring angle covered:<15º.
- Operating frequency: 40Hz
- Compact and light weight
- High reliability
- Pulse in/out communication
- Low power consumption
- High sensitivity

4.3Application fields

- Used to avoid and detect obstacles with robot like biped robot, obstacle avoider robot, path finding robot etc.
- Used to measure the distance within a wide range of 2cm to 400cm.
- Can be used to map the objects surrounding the sensor by rotating it.

4.4 Circuit Diagram

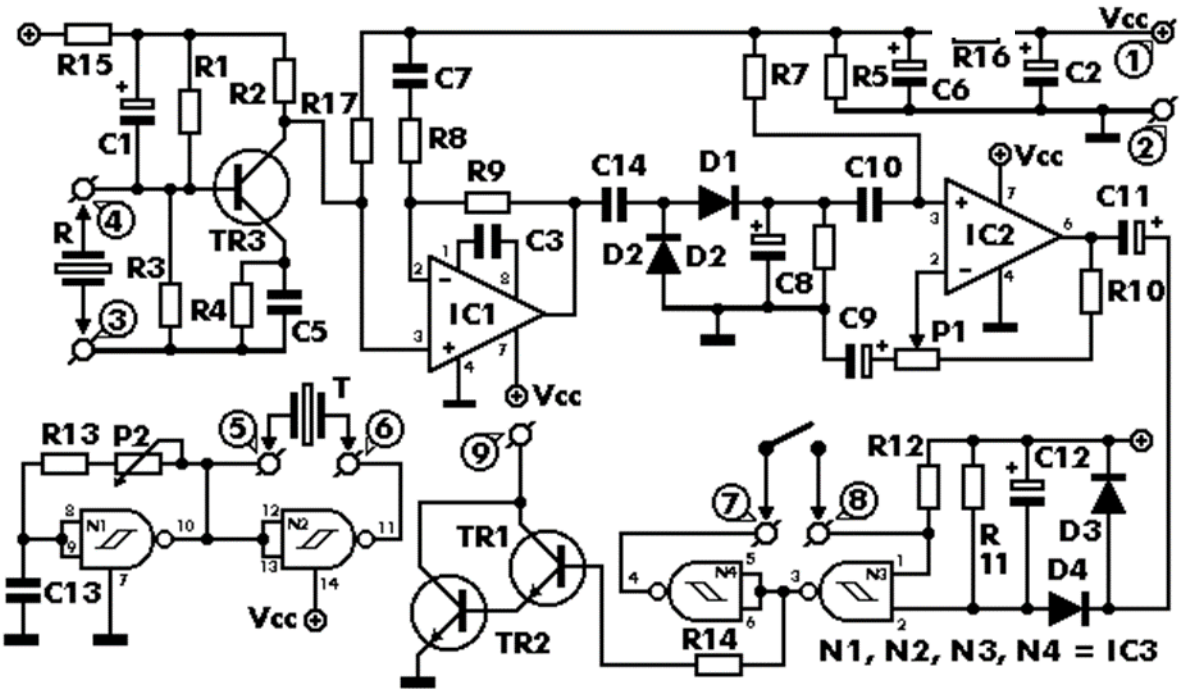


Figure 4.2: Circuit Diagram of HC-SR04

4.5 Working Principle:

As shown above the HC-SR04 Ultrasonic (US) sensor is a 4-pin module, whose pin names are Vcc, Trigger, Echo and Ground respectively. This sensor is a very popular sensor used in many applications where measuring distance or sensing objects are required. The module has two eyes like projects in the front which forms the Ultrasonic transmitter and Receiver [14]. The distance can be calculated with the following formula:Distance L = 1/2 × T × C.

Where L is the distance, T is the time between the emission and reception, and C is the sonic speed. (The value is multiplied by 1/2 because T is the time for go-and-return distance.)

The Ultrasonic transmitter transmits an ultrasonic wave, this wave travels in air and when it gets objected by any material it gets reflected back toward the sensor this reflected wave is observed by the Ultrasonic receiver module as shown in the picture below

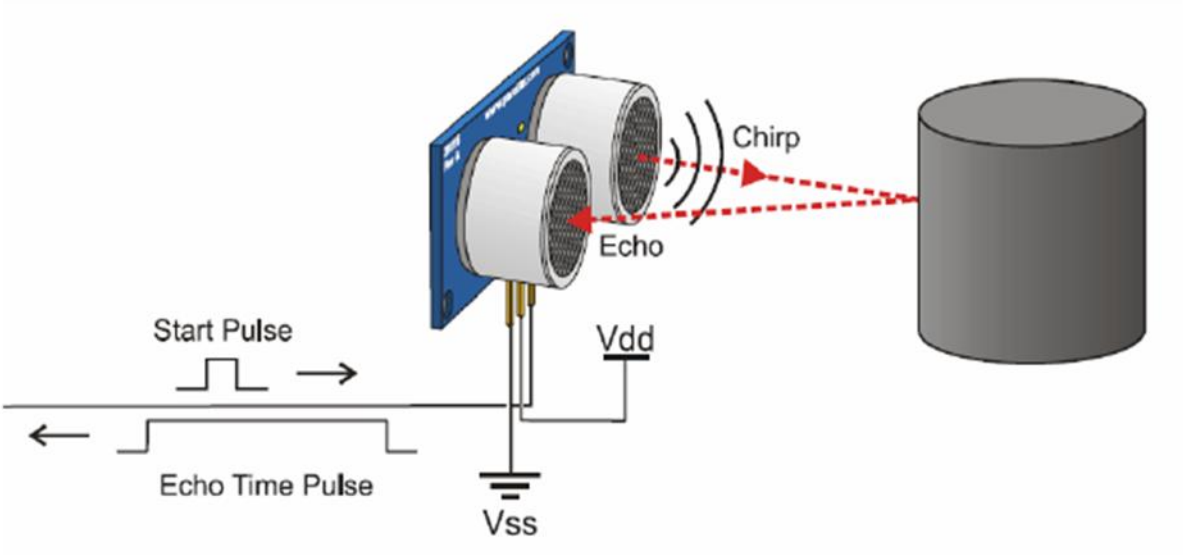


Figure 4.3: Working Diagram of Ultra-Sonic Sensor

Now, to calculate the distance using the above formulae, we should know the Speed and time. Since we are using the Ultrasonic wave we know the universal speed of US wave at room conditions which is 330m/s. The circuitry inbuilt on the module will calculate the time taken for the US wave to come back and turns on the echo pin high for that same particular amount of time, this way we can also know the time taken [15]. Now simply calculate the distance using a microcontroller or microprocessor.

4.6Advantages of Ultrasonic Sensors

- Not affected by color or transparency of objects.
- Can be used in dark environments.
- Low-cost option.
- Not highly affected by dust, dirt, or high-moisture environments.

4.7Limitations of Ultrasonic Sensors

- Cannot work in a vacuum area.
- Not applicable in underwater.
- Sensing accuracy affected by soft materials and temperature.
- Have a limited detection range.

CHAPTER 5

Motor Driver IC

5.1 L298D

L2938D is a typical Motor driver or Motor Driver IC which allows DC motor to drive on either direction [16]. L298D is a 15-pin IC which can control a set of two DC motors simultaneously in any direction. L298D is known as a dual bidirectional motor driver which is based on dual H-Bridge Motor driver IC. This circuit allows you to control two DC motorsindependently in either direction.

5.2Features

1)High operating voltage, which can be up to 40 volts.

2)Large output current, the instantaneous peak current can be up to 3A.

3) 25W rated power;

4) Two built in H-bridge, high voltage, large current, full bridge driver, which can be used to drive DC motors, stepper motors, relay coils and other inductive loads.

5)Using standard logic level signal to control.

6)Able to drive a two-phase stepper motor or four-phase stepper motor, and two-phase DC motors.

7) Adopt a high-capacity filter capacitor and a freewheeling diode that protects devices in the circuit from being damaged by the reverse current of an inductive load, enhancing reliability.

8) The module can utilize the built-in stabilivolt tube 78M05 to obtain 5V from the power supply. But to protect the chip of the 78M05 from damage, when the drive voltage is greater than 12v, an external 5v logic supply should be used.

9) Drive voltage: 5-35V; logic voltage.

10) TTL control inputs.

5.3Application

- Stepper Motor Drivers.
- DC Motor Drivers from 0°C to 70°C.
- Latching Relay Drivers.

5.4 DC Motor with Gear

Gear motor is an electric motor that utilize a type of gear system on the output of the motor. This gearing arrangement is called a gear reducer or gear box. Gear motor are small brushed and available wide range of gear ratio. Gear are assembly helps to increasing torque and reducing the speed. The DC motors don't have enough torque to drive a robot directly by connecting wheels in it. Gears are used to increase the torque of dc motor on the expense of its speed. Mathematical interpretation: Rotational power (Pr) is given by: Pr = Torque (T)* Rotational Speed (ω) Thus $T = \frac{Pr}{w}$

Pr is constant for DC motor for a constant input electrical power. Thus torque (T) is inversely proportional speed (ω). $T = \frac{1}{w}$

Thus to increase the value of torque we have to loose speed.



Figure 5.1: Gear Motor

5.5 Differential Drive

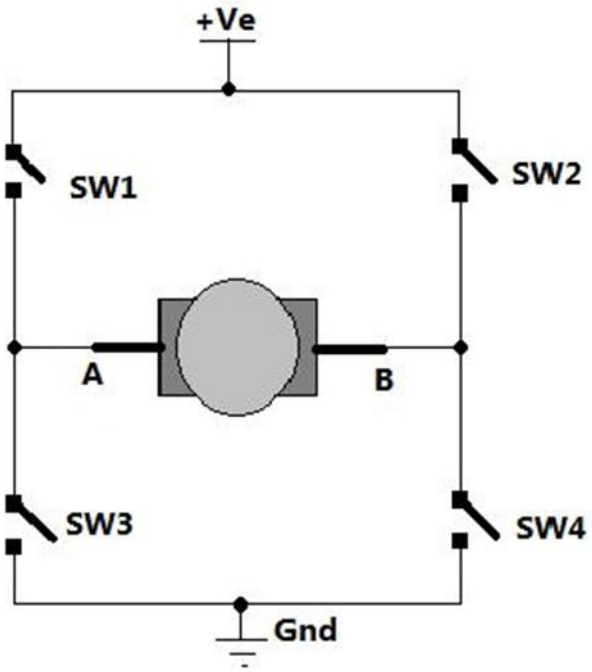
By using two motors we can move our robot in any direction. This steering mechanism of robot is called as differential drive. Let's check how it works

Table 5.1: Differential Drive of L298 [17]

Enable-1	Input-1	Input-2	Result
1	0	1	Clock wise direction
1	1	0	Anti-Clock wise direction

Left Motor	Right Motor	Robot Movement
Clockwise	Clockwise	Forward
Stop	Clockwise	Left
Clockwise	Stop	Right
Anticlockwise	Anticlockwise	Backward

5.6 H-Bridge:



- It is an electronic circuit which enables a voltage to be applied across a load in either direction.
- It allows a circuit full control over a standard electric DC motor. That is, with an H-bridge, a microcontroller, logic chip, or remote control can electronically command the motor to go forward, reverse, brake, and coast.
- H-bridges are available as integrated circuits, or can be built from discrete components.
- A "double pole double throw" relay can generally achieve the same electrical functionality as an H-bridge, but an H-bridge would be preferable where a smaller physical size is needed, high speed switching, low driving voltage, or where the wearing out of mechanical parts is undesirable.
- The term "H-bridge" is derived from the typical graphical representation of such a circuit, which is built with four switches, either solid-state or mechanical (e.g. relays).
- To power the motor, you turn on two switches that are diagonally opposed.

5.7 Motor Driver IC L298D:

- The current provided by the MCU is of the order of 5mA and that required by a motor is ~500mA. Hence, motor can't be controlled directly by MCU and we need an interface between the MCU and the motor.
- A Motor Driver IC like L293D or L298 is used for this purpose which has two H-Bridge drivers. Hence, each IC can drive two motors.
- Note that a motor driver does not amplify the current; it only acts as a switch (An H bridge is nothing but 4 switches).
- Drivers are enabled in pairs, with drivers 1 and 2 being enabled by the Enable pin. When an enable input is high (logic 1or +5V), the associated drivers are enabled and their outputs are active and in phase with their inputs
- When the enable pin is low, the output is neither high nor low (disconnected), irrespective of the input.
- Direction of the motor is controlled by asserting one of the inputs to motor to be high (logic 1) and the other to be low (logic 0).
- To move the motor in opposite direction just interchange the logic applied to the two inputs of the motors.
- Asserting both inputs to logic high or logic low will stop the motor.

5.8 Pin Configuration

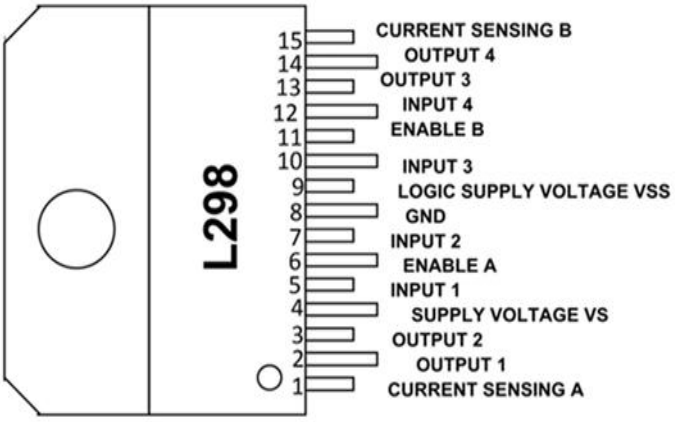


Figure 5.2: Pin Configuration of L298D [18]

5.9 Description of Pin Configuration:

L298 is a 15-pin IC as shown in L298 pin diagram and function of each pin is described below

Table 5.2: Pin Function of L298

Pin Name	Pin Function
CURRENT SENSING A	Between this pin and ground is connected the sense resistor to control the current of the load.
OUTPUT 3 OUTPUT 4	Outputs of the H- Bridge A. The current that flows through the load connected between these two pins is monitored at pin 1
SUPPLY VOLTAGEV S	Connected to +5V
ENABLE A	TTL compatible enable inputs the low state for disable.
INPUT 1 INPUT 2	TTL Compatible Control Inputs of the Bridge A
GND	Connected to GROUND
LOGIC SUPPLY VOLTAGE VSS	Supply Voltage for the Logic Blocks
INPUT 3 INPUT 4	TTL Compatible Control Inputs of the Bridge B
ENABLE B	TTL Compatible Enable Input. The LOW state for disable
OUTPUT 3 OUTPUT 4	Outputs of the H- Bridge B. The current that flows through the load connected between these two pins is monitored at pin 15

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5.10Circuit Diagram of L298:

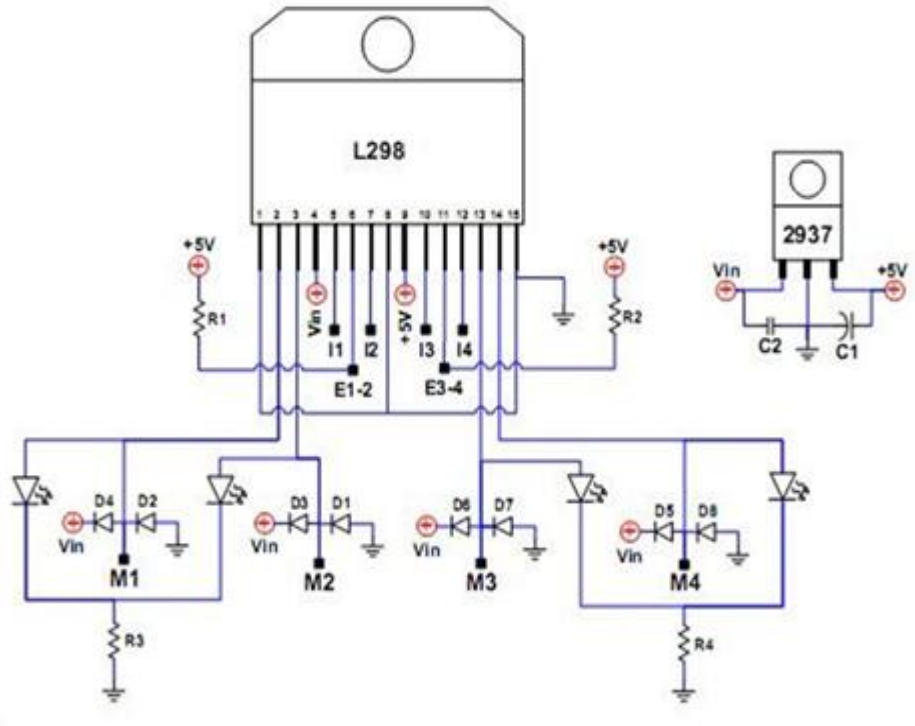
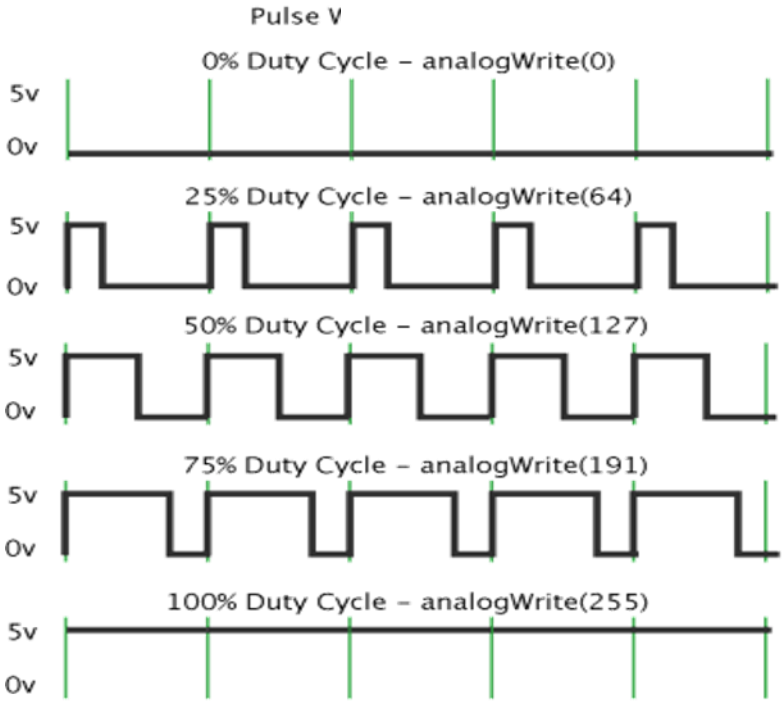


Fig 5.3: Circuit Diagram of L298 [19]

5.11 Speed Control:

For controlling the motors speed, pulse width modulation (PWM) is used. Pulse width modulation is a simple method of controlling analogue devices via a digital signal through changing or modulating the pulse width [20]. An analogue device is become digital by powering it with a pulse signal switches between on and off (5V and 0V). This digital control is used to create a square wave. The duty cycle is defined as the percentage of digital 'High' to digital 'Low' plus digital 'High' pulse-width during a PWM period. The average DC voltage value for 0% duty cycle is zero; with 25% duty cycle the average value is 1.25V (25% of 5V). With 50% duty cycle the average value is 2.5V, and if the duty cycle is 75%, the average voltage is 3.75V and so on. So, by varying the average voltage, the motor speed can be controlledresult,the power loss in PWM switching devices is very low. In many cases it is near to 0. So, this is the main advantage of PWM. While being used, resistors will tend to loss more power because of its heat dissipation. So, PWM is efficient in controlling motors.



5.12 Algorithm:

The most common algorithm for maze solving robot is Wall following algorithm. The robot will take its direction by following either left or right wall. This algorithm also called, left hand-right hand rules. Whenever the robot reaches a junction, it will sense for the opening walls and select it direction giving the priority to the selected wall [21]. By taking the walls as guide, this strategy is capable to make the robot reaches the finish point of the maze

Table 5.3: Left-Right Wall Following Routine

Right wall following routine	**Left wall following routine**
if there is no wall at right	if there is no wall at left
turn right	turn left
Else	else
if there is no wall at straight	if there is no wall at straight
keep straight	keep straight
Else	else
if there is no wall at left	if there is no wall at right
turn left	turn right
Else	else
turn around	turn around

5.13 Voltage Regulator:

The voltage regulator is used to supply constant 5V to the ultrasonic sensors. A very common voltage regulator IC is 7805 which has been used in this project.

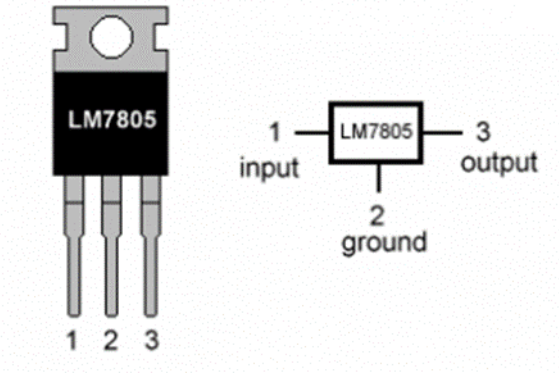


Fig 5.2: Pin Out of LM7805 [22]

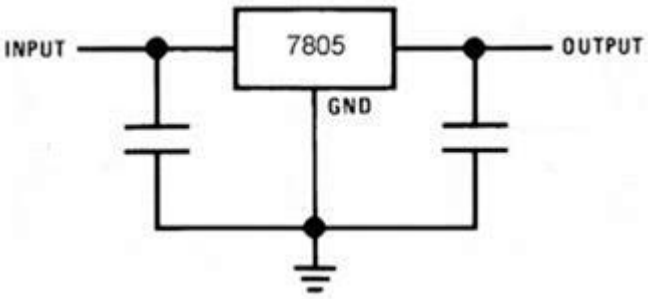


Fig 5.5: Circuit Diagram of 7805 Voltage Regulator

CHAPTER 6

Design of Maze Solving Robot

6.1 Design Layout:

The robot has a length of 16 cm, a width of 15 cm and height of 13 cm. As illustrated in Figure the robot is equipped with three ultra-sonic sensors facing front, and left and right. the robot body is three layered. Arduino and motor driver circuit has been placed on the top robot chassis. Three ultrasonic sonar sensors have also been placed on the top chassis. The power section has been placed at the middle part of the chassis. A 1500mAh battery and voltage regulator circuit has been placed on it. At bottom part, two gear motors with wheel and ball caster wheels have been attached.

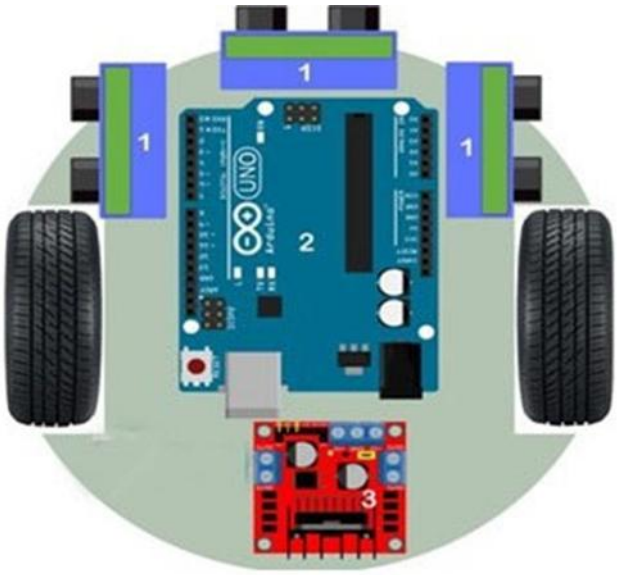


Figure: 6.1: Physical Configuration (Top view)

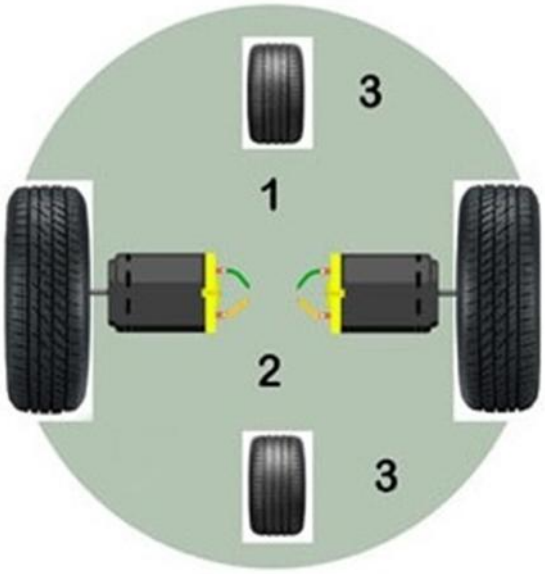


Figure: 6.2: Physical Configuration (Bottom view)

Top part	Bottom part
1. Ultrasonic sonar sensors. 2. Arduino. 3. L298 motor controller	1. DC motor with wheel. 2. DC motor with wheel. 3. Caster wheel

6.2 Flow chart:

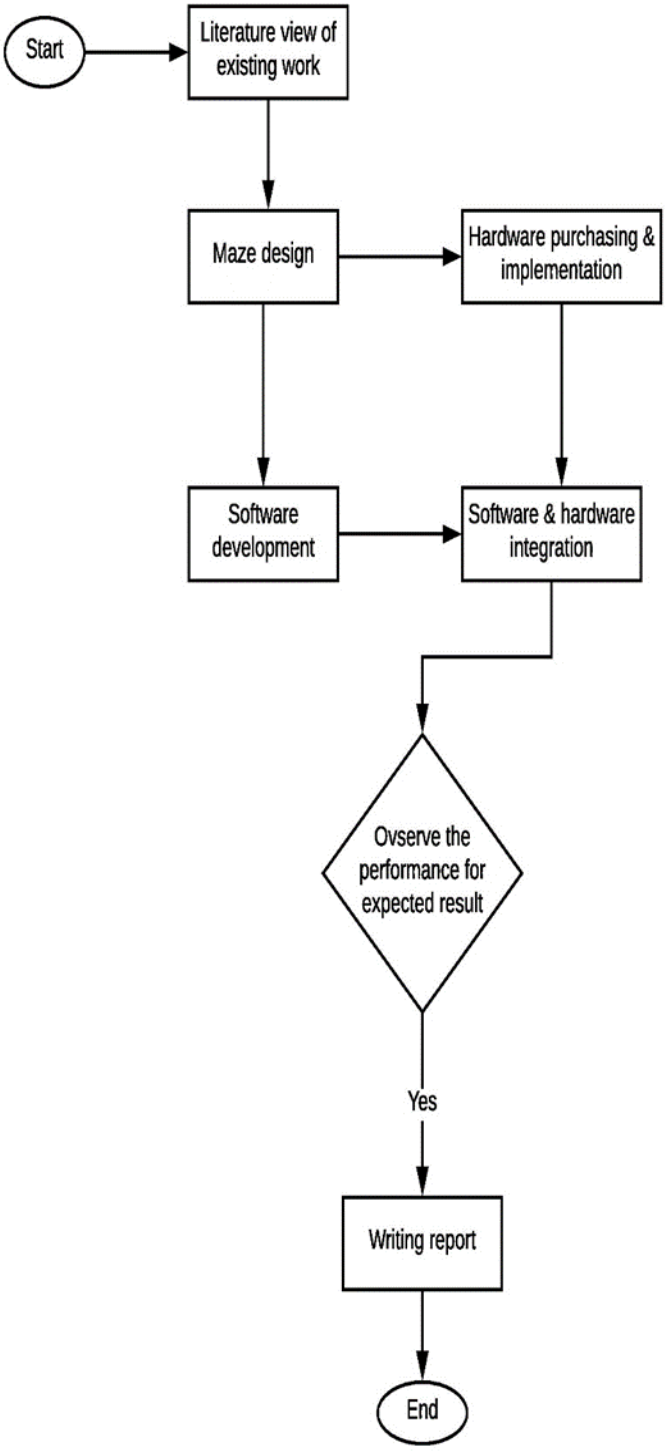
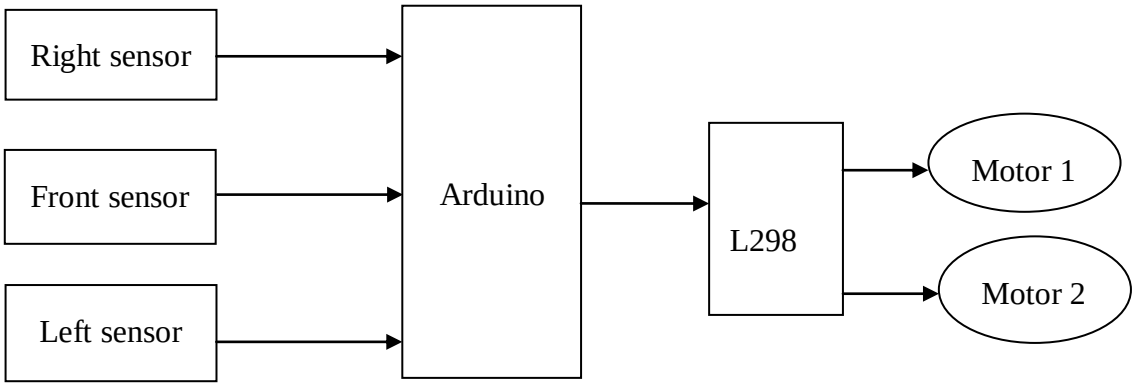


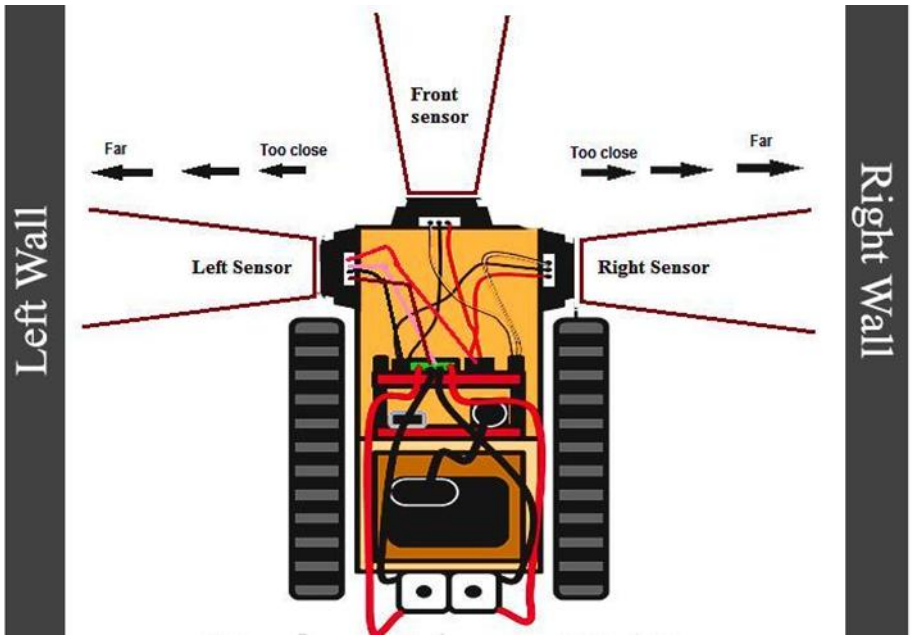
Figure: 6.3: Flow Chart Design

6.3 Block Diagram:



6.4 Robot Program:

This robot is designed to solve the maze. So, the hardware and software part is designed to solve this type of maze. Left and right sensors flow the left and right wall. The front sensor is used to map the front wall. At first, it solves the maze using wall following algorithm. At the same time, it makes a map of the maze using all sensors. It stores the map value cell by cell in its memory. Figure bellow shows the working function of this robot



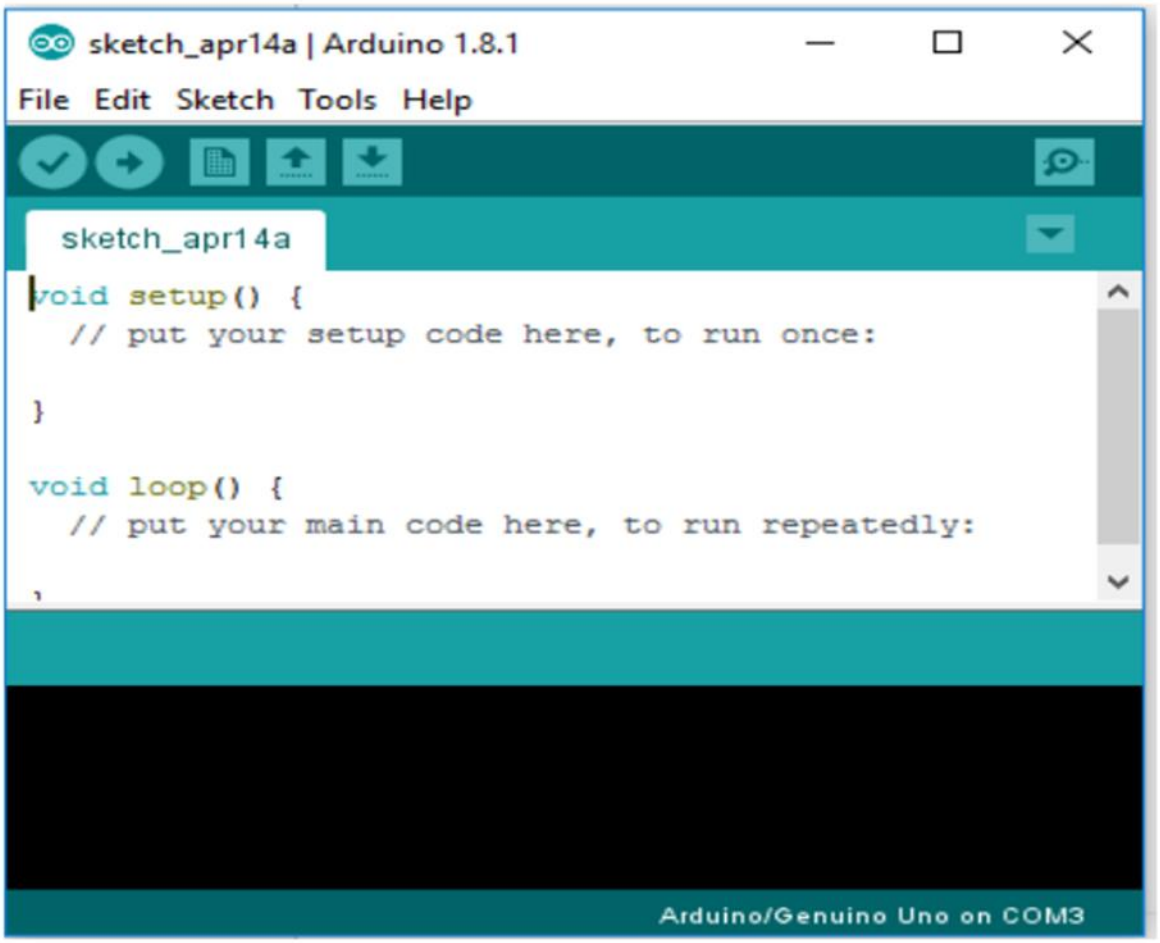


Figure: 6.4:Arduino Software

6.5 Experimental Result

Motor supply voltage: 12 Volt

Motor speed: 255 rpm

We tested the motor speed by changing the motor supply voltage

Supply voltage 10.5 volt, get motor speed 223 rpm.

Supply voltage 9 volt, get motor speed 191 rpm.

Supply voltage 8 volt, get motor speed 170 rpm.

Table6.1:Time,Volt,Distance Data of Maze Solving Robot

Volt	R.P.M	Distance(cm)	Time (µS)	Remarks
8	170	7	11	Interrupt
8	170	7	12	Interrupt
9	191	8	13	Interrupt
9	191	8	14	Interrupt
10.5	223	9	15	Finished
10.5	223	10	16	Finished
11	223	11	17	Interrupt

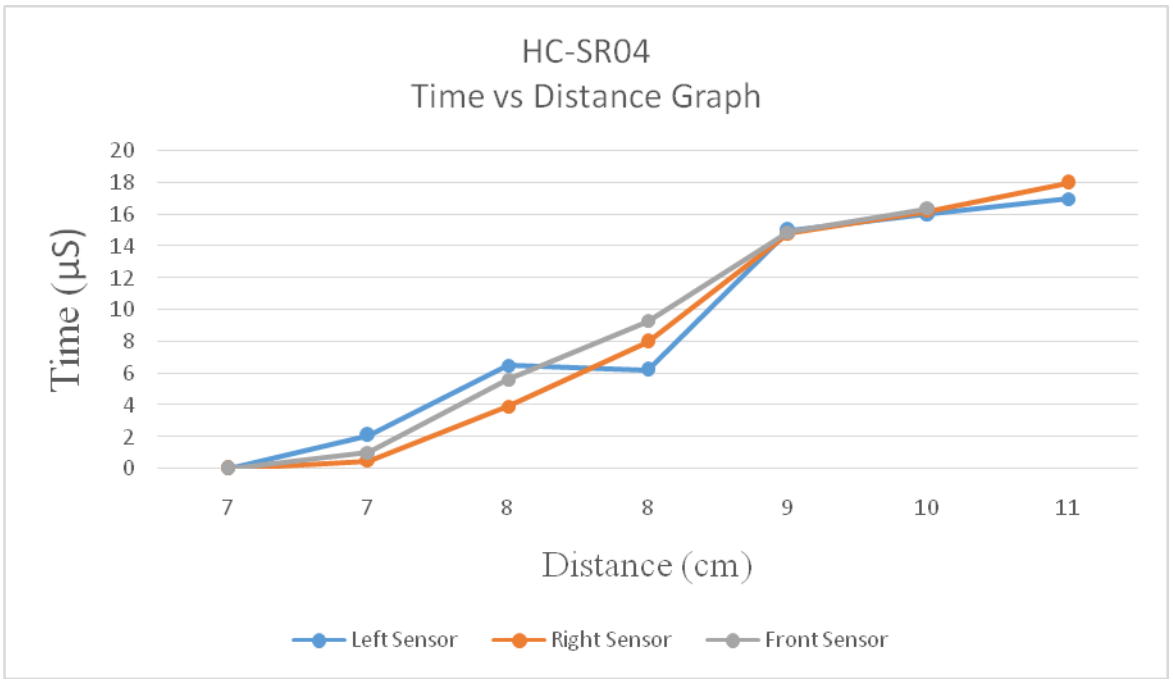


Figure: 6.5: Time vs. Distance Graph of HC-SRO4 (Ultrasonic sonar sensors)

Figure 6.5 shows the Time vs. Distance Graph of Left, right and Front ultrasonic sonar sensor. Ultrasonic sonar is used to measure the distance of wall. The values are measured by using serial monitor of Arduino IDE.

The robot solves the maze by following the wall. In real maze, this robot was tested. In figure 6.6, right wall is closed, left and front wall was opened so, it moves left. In figure 6.6, both left and right wall and front wall is closed. So, as defined as code, it makes 180° turn. After that, both left and right wall are closed but front wall is open. So, it moves forward.In figure 6.7, both left and right wall is closed.So, it moves forward.In the maze, it works in this manner and solves the maze.

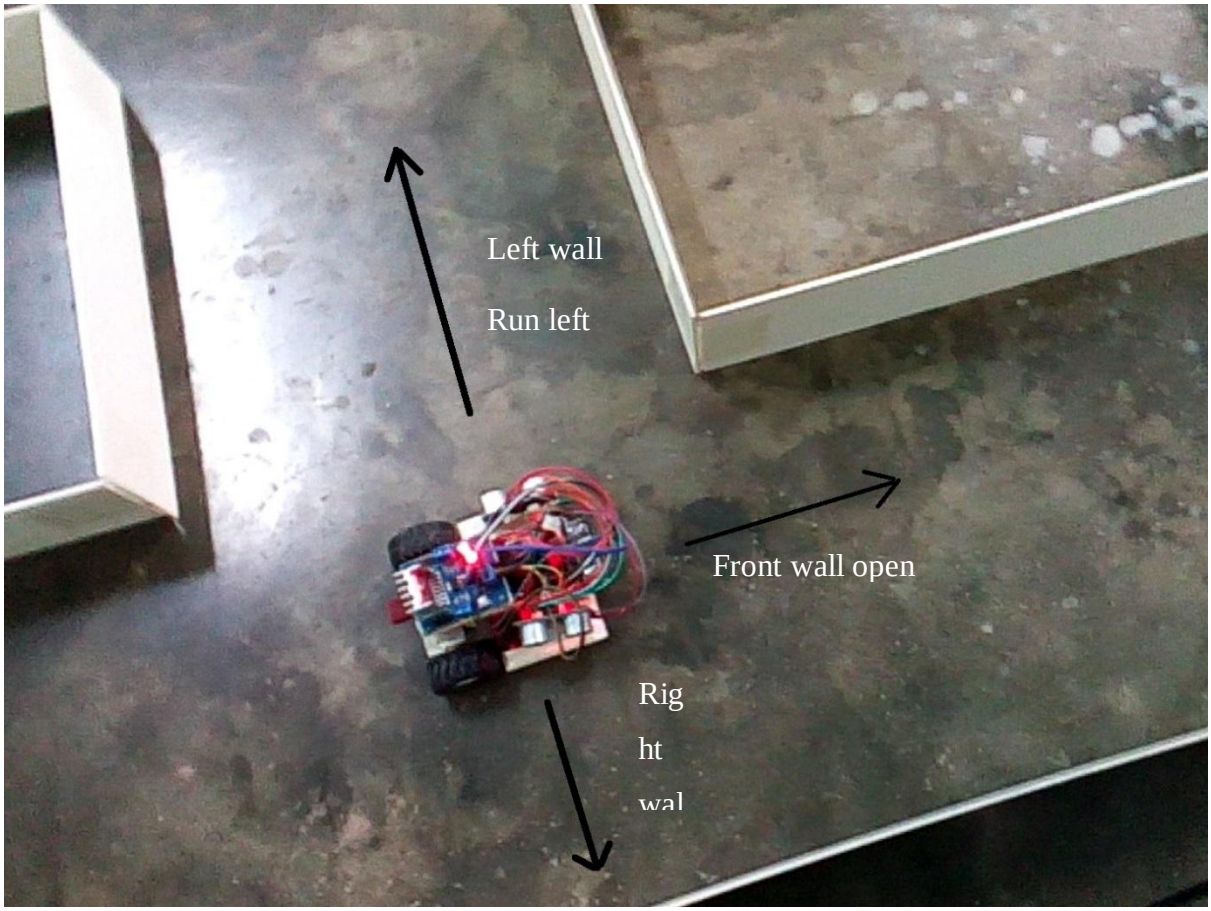


Figure: 6.6:Run in Maze. (R wall is closed; F & L wall is opened)

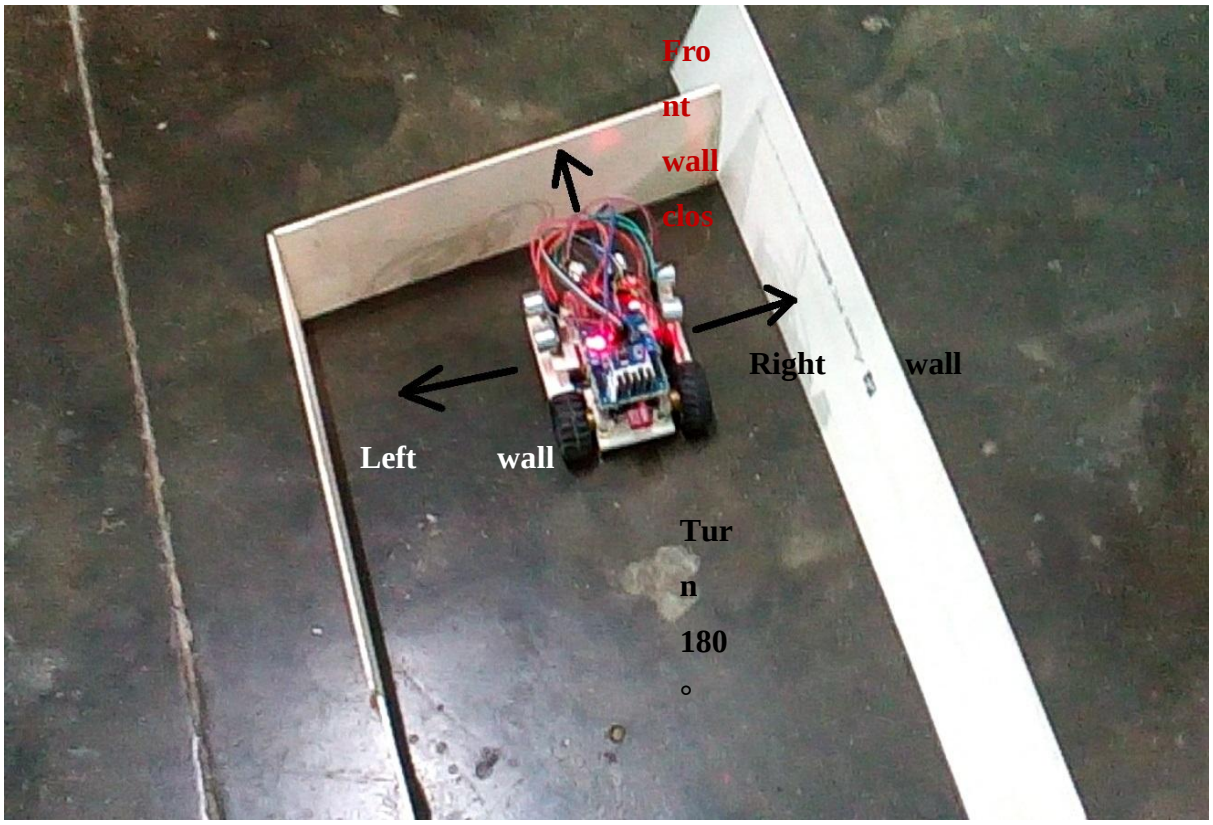


Figure: 6.7:Run in Maze. (Both R &L wall and F wall is closed 180° Turn)

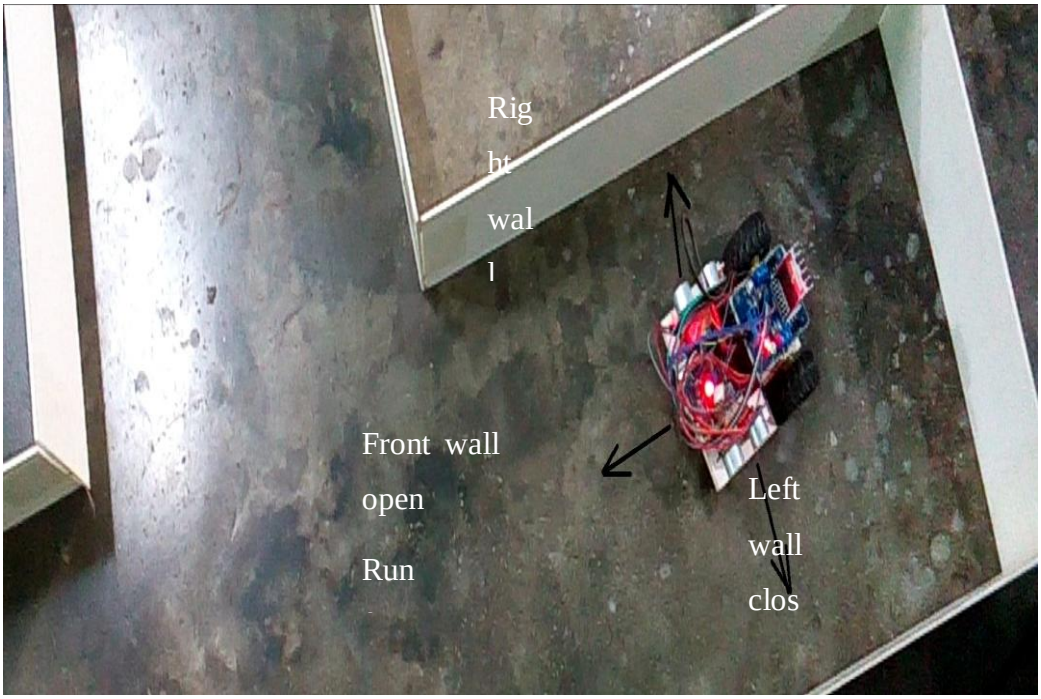


Figure: 6.8:Run in Maze. (R & L wall is closed and F wall is open)

6.6 Battery:

A lithium polymer battery, or more correctly lithium-ion polymer battery (abbreviated variously as LiPo, LIP, Li-poly and others), is a rechargeable battery of lithium-ion technology in a pouch format [23]. Unlike cylindrical and prismatic cells, LiPo come in a soft package or pouch, which makes them lighter but also less rigid. It may be interpreted in two ways. Originally, "lithium polymer" stood for a developing technology using a polymer electrolyte instead of the more common liquid electrolyte. The result is a "plastic" cell, which theoretically could be thin, flexible, and manufactured in different shapes, without risk of electrolyte leakage. These batteries are available although the technology has not been fully developed and commercialized and research is ongoing.

6.7 Mechanical Characteristics:

Type number: LP573450

Designation IEC system: Lithium polymer battery pack

Length: 50 ± 0.4mm

Width: 34 ± 0.4mm

Thickness: 5.7 ± 0.2mm

Cable: 150 ± 3.0mm (26AWG UL 10 07)

Weight: approx. 100g

Connector: JST 2, 54

6.8 Electrical Specification:

Rated capacity: 1500mAh.

Nominal voltage: 7.4V

Max. Operating voltage range: 5.0V to 7.0V

Charge voltage: 7.8 ± 50mV

Initial charge current: Standard charge: 490mA, Rapid Charge: 980mA

Charging cut-off (A or B)

A) By time: Standard charge: 3 hours, Rapid charge: 3 hours

B) By min. current: 19.6mA

Max continuous discharge current: 980mA

Exp. cycle life: >500 cycles >70% of initial cap. (0.5C/0.5C)

Internal impedance (1 kHz): approx. 25mOhm

Cell protection

Overcharge detection: 7.325 ± 25mV (0.5 to 2.0 sec. delay, resume 7.075 ± 50mV)

Over discharge detection: 4.00V ± 25mV (6.25 to 250msec. delay, resume 3.9V ± 100mV)



Figure: 6.9: Lithium Battery

6.9 Jumper Wire:

A jump wire, is a short electrical wire with a solid tip at each end (or sometimes without them, simply "tinned"), which is normally used to interconnect the components in a breadboard. They are used to transfer electrical signals from anyway



Figure: 6.10:Jumper Wire

Jump wires are fitted by inserting their "end connectors" into the slots provided in the breadboard that beneath its surface has a few sets of parallel plates that connect the slots in groups of rows or columns depending on the area. The "end connectors" are inserted into the breadboard, without soldering, in the particular slots that need to be connected in the specific prototype.

6.10 Wheel:

We use wheel to movement of the robot. We set the wheels into the gear motor. We also use Ball caster to movement any direction.

This following figure 2.3.10 is shows Wheel.



Figure: 6.11: Wheel [24]

6.11 Discussion:

Generally Robot can do something which is instructed by human. When a human made programs controls a machine automatically then it's called robot or when an electrical device can make decision of any kind of multiple situation respect to the human instruction it's also called Robot. An autonomous robot system which exists in physical world, can sense its environment and act on the inputs to achieve some goals without any human intervention. A maze solving robot is an autonomous robot that is able to explore and find the way throughout a maze by itself without human innervation Maze solving robot is one of the most discoveries of the era. Therefore, people got the option to complete any hard work with minimal effort. Such as robot frame, wheels, battery, microcontroller, motor driver, voltage booster, and many types of other components. The operation of this robot is basically based on a microcontroller. Power supply is provided to a microcontroller, motor driver and two DC motor. Two wheels rotate with two gear motors. This type of robot can perform difficult and repetitive works for humans. Maze solving robot can be used in searching people who are in building destroyed by the earthquake by using camera is installed in robots. There are many caves that are like mazes where humans could get lost in. This robot can find its way out again. It can also be used in too small or dangerous cave where human can't enter.Design, construction and performance test of a maze solving robot is conducted in this study. The results showed that the robot is successfully able to run maze.

CHAPTER 7

Conclusion and Future Work

7.1 Conclusion:

As a conclusion, the mazes solving algorithm have successfully been implemented in the robot and the objectives of the project have been achieved. The algorithm was wall following algorithm. The basic method shows a good result for solving the maze way. This project helps to improve various important information about robotics, knowledge about many decision making algorithms. It's also helped to learn about many electronics components such as motor driver, sensors, etc. This gained knowledge will have a significant impact on our life.

7.2 Future Work:

The response of the robot is little bit slow, so new method should be developed. The size of the robot can be made smaller. In this project, the ultrasonic sensor is used for mapping the maze. Other efficient navigating sensors can be used. At last, it needs development in its wheels and body to make it comfortable in rough surface.

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