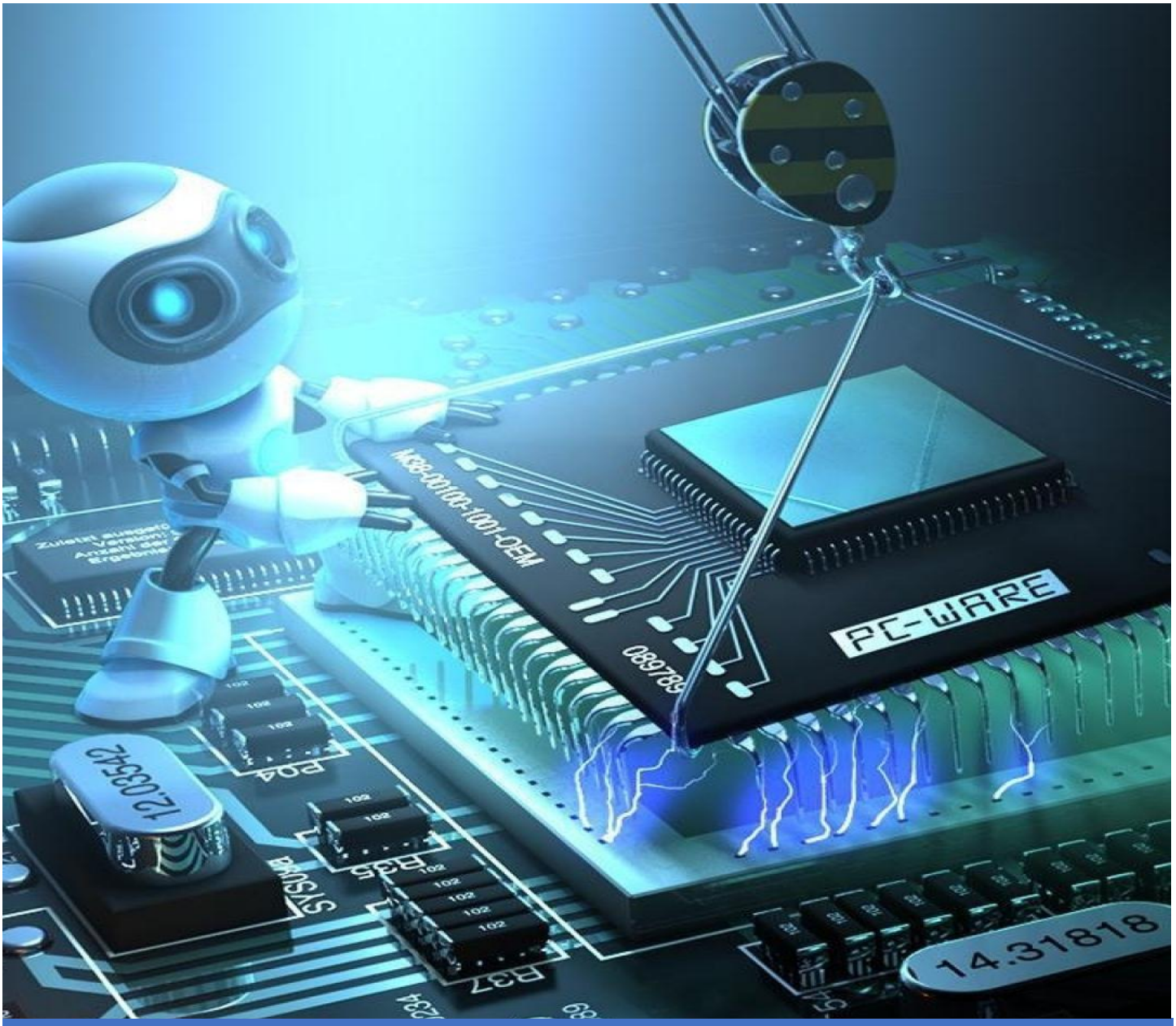

MULTI-PURPOSE AUTOMATION

MINOR PROJECT REPORT

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SESSION(2018-19)

BLE-593

ALIGARH MUSLIM UNIVERSITY

PROJECT REPORT

SESSION (2018-19)

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Certificate

This is to certify that the work embodied in the project report entitled "Multi-Purpose Automation" which is being submitted by UBAID UR REHMAN, NAUSHAD ALAM, RITIK SHARMA, CHIRAG AGARWAL AND MOHD SARIM as a minor project work in "DIPLOMA IN ELECTRONICS ENGINEERING" of UNIVERSITY POLYTECHNIC (BOYS), ALIGARH MUSLIM UNIVERSITY, ALIGARH. This is a record of their cumulative effort carried out under my supervision and guidance. They completed this work with unflagging zeal, interest and enthusiasm.

Ms. Sarah Anjum.

ACKNOWLEDGEMENT

With immense pleasure and great sense of satisfaction we acknowledge those without whom, the completion of this project couldn't have been achieved. It is with great privilege that I take this opportunity to express my heartfelt regard and gratitude to my teacher "Ms. Sarah Anjum", University Polytechnic (BOYS), Aligarh Muslim University, Aligarh for his inspiring guidance, constant encouragement and assistance which was always forthcoming.

This affectionate attitude and constructive criticism made this work easy and interesting.

ABSTRACT

In The Project "Multi-Purpose Automation" controls a car with the help of commands given through voice . When the command is given through a Bluetooth device it is processed by the arduino ,which is the microcontroller, and it gives signals to the L298N module which controls the motion of the motors and the according to the command given by the user car moves accordingly. When the car moves left the motor on the right side moves in the clock-wise direction and the car turns left. Similarly when the car moves right the motor on the left side moves in clockwise direction and the motor turns right.

CONTENTS

1. INTRODUCTION

This Work is based on Arduino, motor driver and Bluetooth module. Arduino is an open source prototyping platform Based on easy-to-use hardware and software. Arduino uses an ATmega328 microcontroller. Since robotics has become a major part in our daily life and also in the engineering field and it plays a vital role in the development of new technology. This is a very simple and easy type form of remote control car, where the ordinary micro-controller has been replaced by Arduino and IR sensors has been replaced by a Bluetooth module. The remote can be any android or IOS cell phones. This project can be made in a bigger scale for real time vehicles.

As can be seen by taking a look at the introduction, the main hardware requirement of the project is Arduino UNO and L298N motor driver module. The project of ours also uses software coding with C++ programming language.

The hardware requirement of the project is –

1. Arduino UNO (ATMEGA32)
2. L298N Motor driver module
3. HC-05 bluetooth module
4. DC motors (12V, 100rpm)
5. A wooden board
6. Some jumper wires.

1.1. ARDUINO UNO

Arduino is a prototype platform (open-source) based on an easy-to-use hardware and software. It consists of a circuit board, which can be programed (referred to as a microcontroller) and a ready-made software called Arduino IDE (Integrated Development Environment), which is used to write and upload the computer code to the physical board.

The key features are −

- ✓ Arduino boards are able to read analog or digital input signals from different sensors and turn it into an output such as activating a motor, turning LED on/off, connect to the cloud and many other actions.
- ✓ You can control your board functions by sending a set of instructions to the microcontroller on the board via Arduino IDE (referred to as uploading software) [see fig.(1.1)].

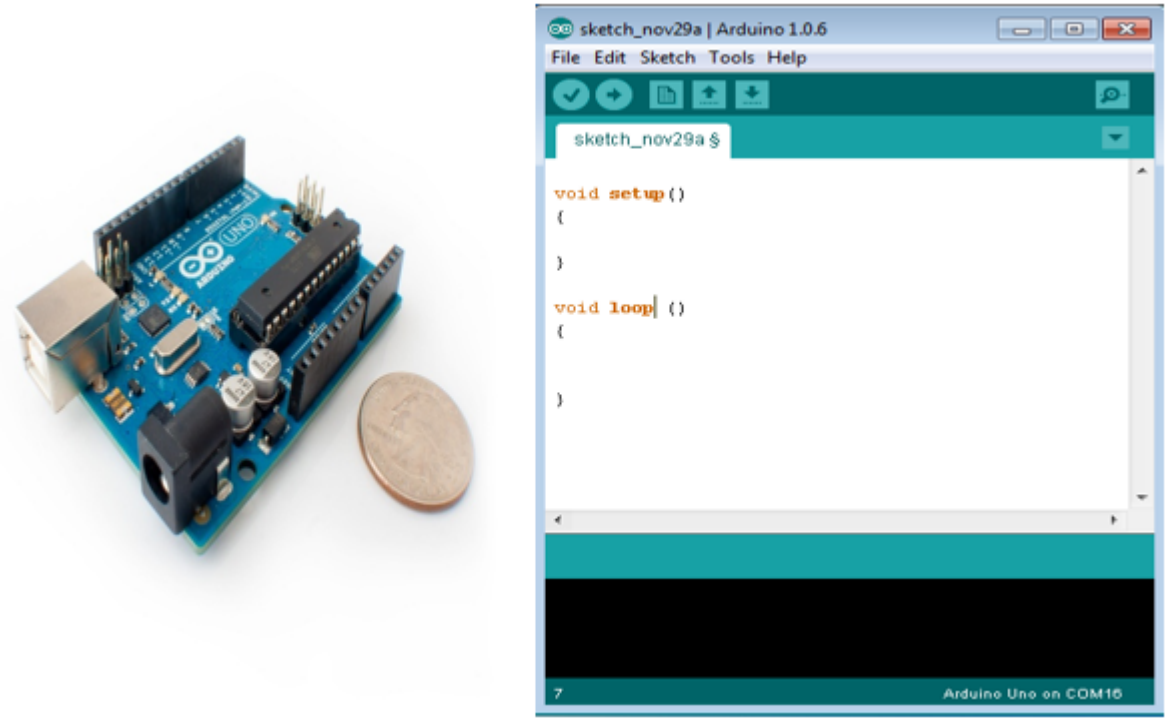


Fig.(1.1)

- ✓ Unlike most previous programmable circuit boards, Arduino does not need an extra piece of hardware (called a programmer) in order to load a new code onto the board. You can simply use a USB cable.
- ✓ Additionally, the Arduino IDE uses a simplified version of C++, making it easier to learn to program.
- ✓ Finally, Arduino provides a standard form factor that breaks the functions of the micro-controller into a more accessible package.

1.1.1 Board Types

- ✓ Various kinds of Arduino boards are available depending on different microcontrollers used. However, all Arduino boards have one thing in common: they are programed through the Arduino IDE.
- ✓ The differences are based on the number of inputs and outputs (the number of sensors, LEDs, and buttons you can use on a single board), speed, operating voltage, form factor etc. Some boards are designed to be embedded and have no programming interface (hardware), which you would need to buy separately. Some can run directly from a 3.7V battery, others need at least 5V.
- ✓ The Board that we have used in our project is ARDUINO UNO R3 which employs USB via ATMega16U2 programming interface and requires 5V supply and with a clock speed of 16MHz.

1.1.2 Pin Description of ARDUINO UNO[see fig.(1.20]

Power USB

1. Arduino board can be powered by using the USB cable from your computer. All you need to do is connect the USB cable to the USB connection (1).

Power (Barrel Jack)

2. Arduino boards can be powered directly from the AC mains power supply by connecting it to the Barrel Jack (2).

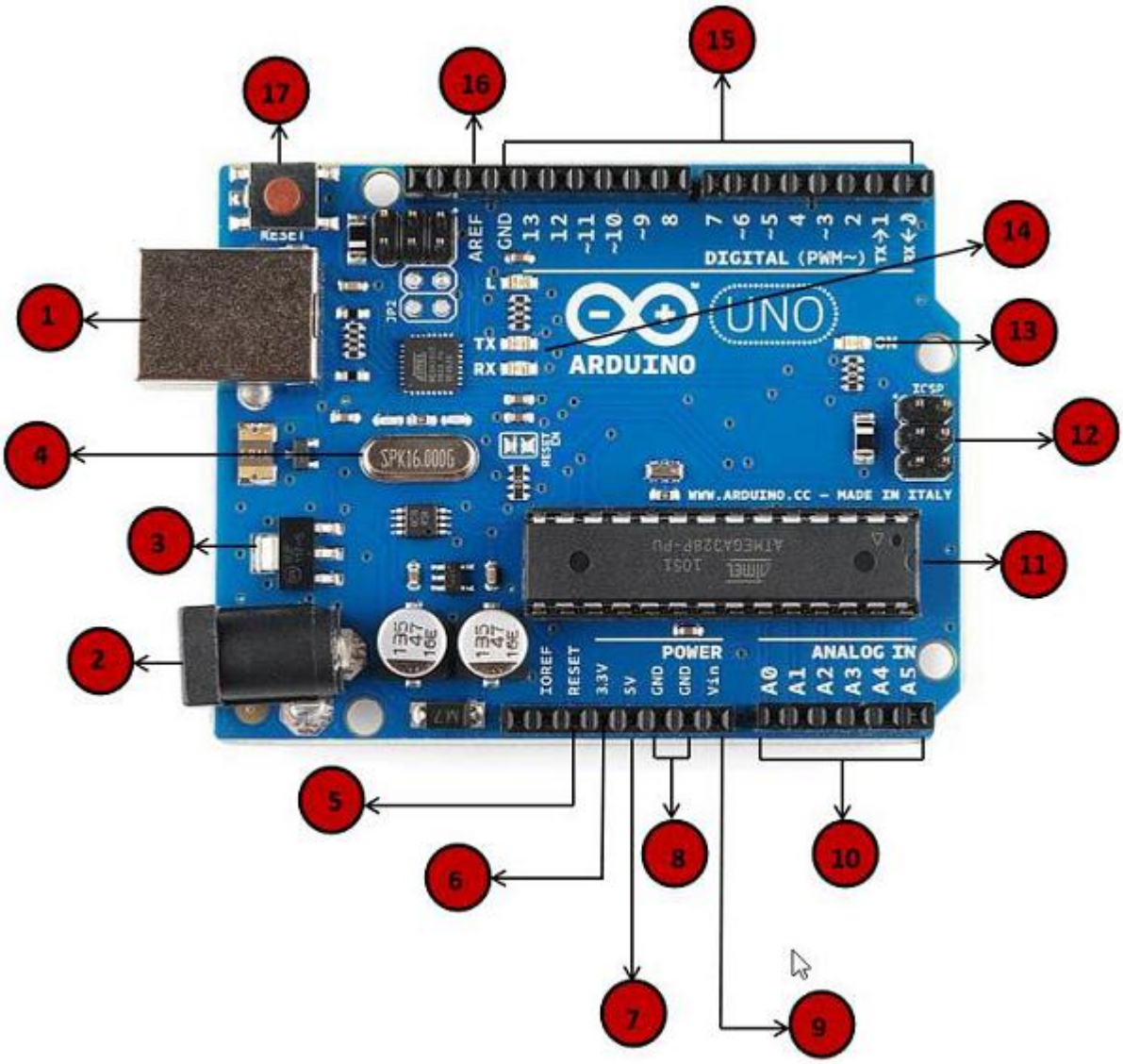


Fig.(1.2)

Voltage Regulator

3 The function of the voltage regulator is to control the voltage given to the Arduino board and stabilize the DC voltages used by the processor and other elements.

Crystal Oscillator

4

The crystal oscillator helps Arduino in dealing with time issues. How does Arduino calculate time? The answer is, by using the crystal oscillator. The number printed on top of the Arduino crystal is 16.000H9H. It tells us that the frequency is 16,000,000 Hertz or 16 MHz.

Arduino Reset

5,17

You can reset your Arduino board, i.e., start your program from the beginning. You can reset the UNO board in two ways. First, by using the reset button (17) on the board. Second, you can connect an external reset button to the Arduino pin labelled RESET (5).

Pins (3.3, 5, GND, Vin)

6,7 8,9

- 3.3V (6) − Supply 3.3 output volt
- 5V (7) − Supply 5 output volt
- Most of the components used with Arduino board works fine with 3.3 volt and 5 volt.
- GND (8)(Ground) − There are several GND pins on the Arduino, any of which can be used to ground your circuit.
- Vin (9) − This pin also can be used to power the Arduino board from an external power source, like AC mains power supply.

Analog pins

10

The Arduino UNO board has five analog input pins A0 through A5. These pins can read the signal from an analog sensor like the humidity sensor or temperature sensor and convert it into a digital value that can be read by the microprocessor.

Main microcontroller

11 Each Arduino board has its own microcontroller (11). You can assume it as the brain of your board. The main IC (integrated circuit) on the Arduino is slightly different from board to board. The microcontrollers are usually of the ATMEL Company. You must know what IC your board has before loading up a new program from the Arduino IDE. This information is available on the top of the IC. For more details about the IC construction and functions, you can refer to the data sheet.

ICSP pin

12 Mostly, ICSP (12) is an AVR, a tiny programming header for the Arduino consisting of MOSI, MISO, SCK, RESET, VCC, and GND. It is often referred to as an SPI (Serial Peripheral Interface), which could be considered as an "expansion" of the output. Actually, you are slaving the output device to the master of the SPI bus.

Power LED indicator

13 This LED should light up when you plug your Arduino into a power source to indicate that your board is powered up correctly. If this light does not turn on, then there is something wrong with the connection.

TX and RX LEDs

14 On your board, you will find two labels: TX (transmit) and RX (receive). They appear in two places on the Arduino UNO board. First, at the digital pins 0 and 1, to indicate the pins responsible for serial communication. Second, the TX and RX led (13). The TX led flashes with different speed while sending the serial data. The

speed of flashing depends on the baud rate used by the board. RX flashes during the receiving process.

Digital I/O

15 The Arduino UNO board has 14 digital I/O pins (15) (of which 6 provide PWM (Pulse Width Modulation) output. These pins can be configured to work as input digital pins to read logic values (0 or 1) or as digital output pins to drive different modules like LEDs, relays, etc. The pins labeled "~" can be used to generate PWM.

AREF

16 AREF stands for Analog Reference. It is sometimes, used to set an external reference voltage (between 0 and 5 Volts) as the upper limit for the analog input pins.

1.2. L298N MODULE

The L298N is a dual H-Bridge motor driver[see Fig.(2.1)] which allows speed and direction control of two DC motors at the same time. The module can drive DC motors that have voltages between 5 and 35V, with a peak current up to 2A.

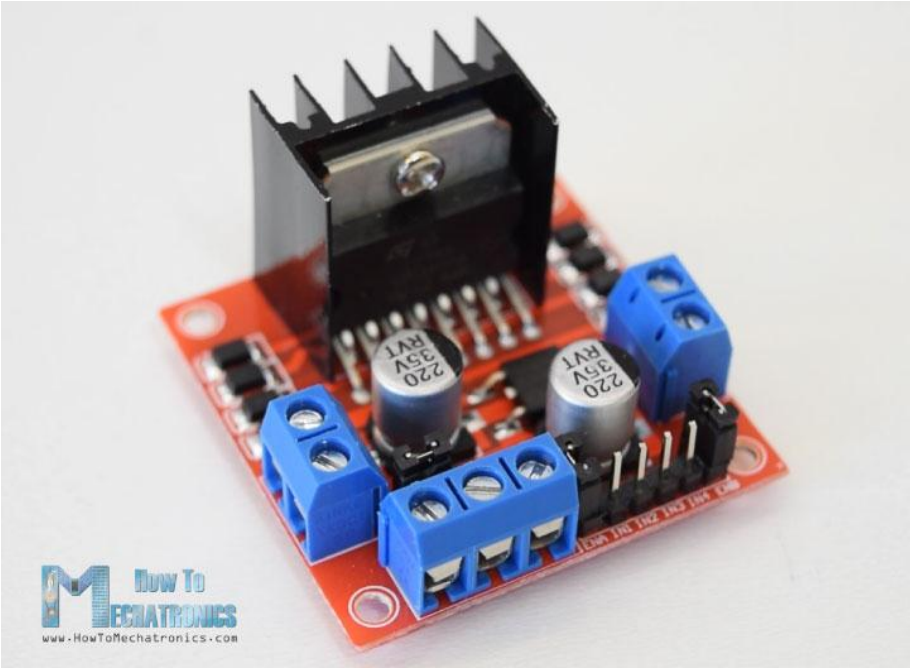


Fig (2.1)

- ✓ The module has two screw terminal blocks for the motor A and B, and another screw terminal block for the Ground pin, the VCC for motor and a 5V pin which can either be an input or output.
- ✓ This depends on the voltage used at the motors VCC. The module have an onboard 5V regulator which is either enabled or disabled using a jumper. If the motor supply voltage is up to 12V we can enable the 5V regulator and the 5V pin can be used as output, for example for powering our Arduino board [see fig.(2.2)].

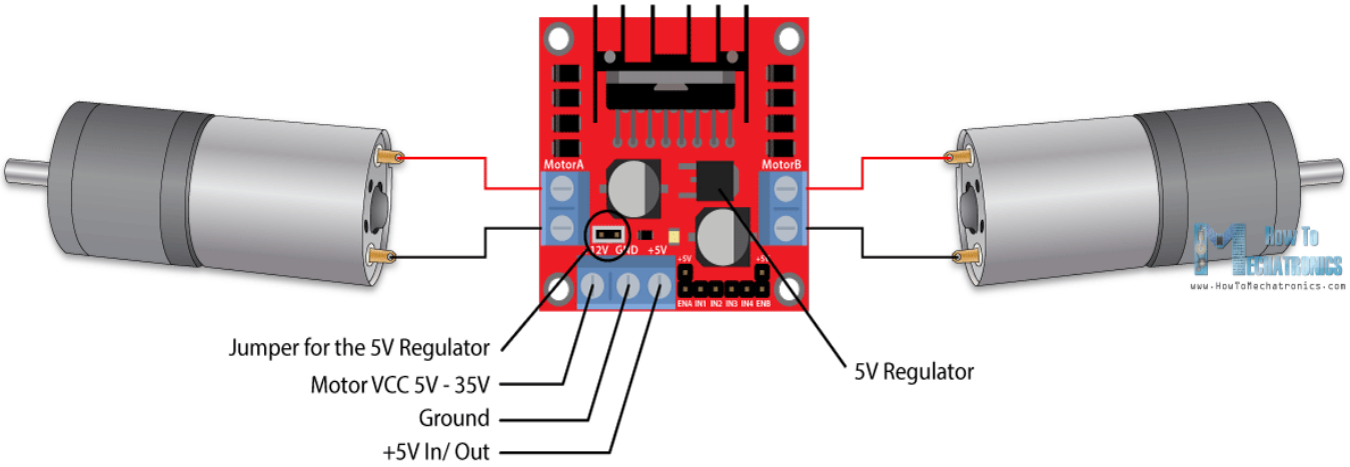


Fig.(2.2)

- ✓ But if the motor voltage is greater than 12V we must disconnect the jumper because those voltages will cause damage to the onboard 5V regulator. In this case the 5V pin will be used as input as we need connect it to a 5V power supply in order the IC to work properly.

  We can note here that this IC makes a voltage drop of about 2V. So for example, if we use a 12V power supply, the voltage at motors terminals will be about 10V, which means that we won't be able to get the maximum speed out of our 12V DC motor.

Next are the logic control inputs. The Enable A and Enable B pins are used for enabling and controlling the speed of the motor. If a jumper is present on this pin, the motor will be enabled and work at maximum speed, and if we remove the jumper we can connect a PWM input to this pin and in that way control the speed of the motor. If we connect this pin to a Ground the motor will be disabled.[see fig.(2.3)]

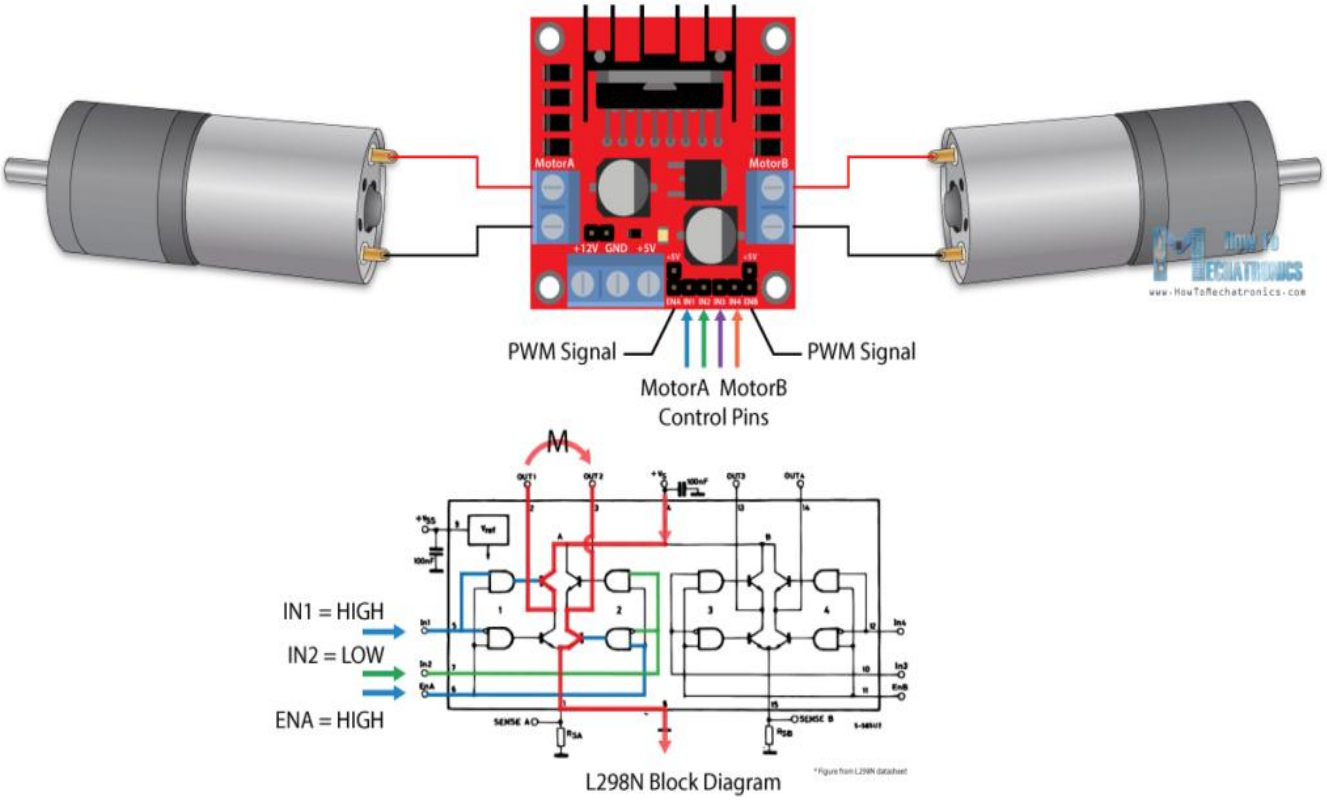

MotorA
MotorB
+12V GND +5V
PWM Signal
PWM Signal
MotorA MotorB
Control Pins
M
IN1 = HIGH
IN2 = LOW
ENA = HIGH
L298N Block Diagram

Fig.(2.3)

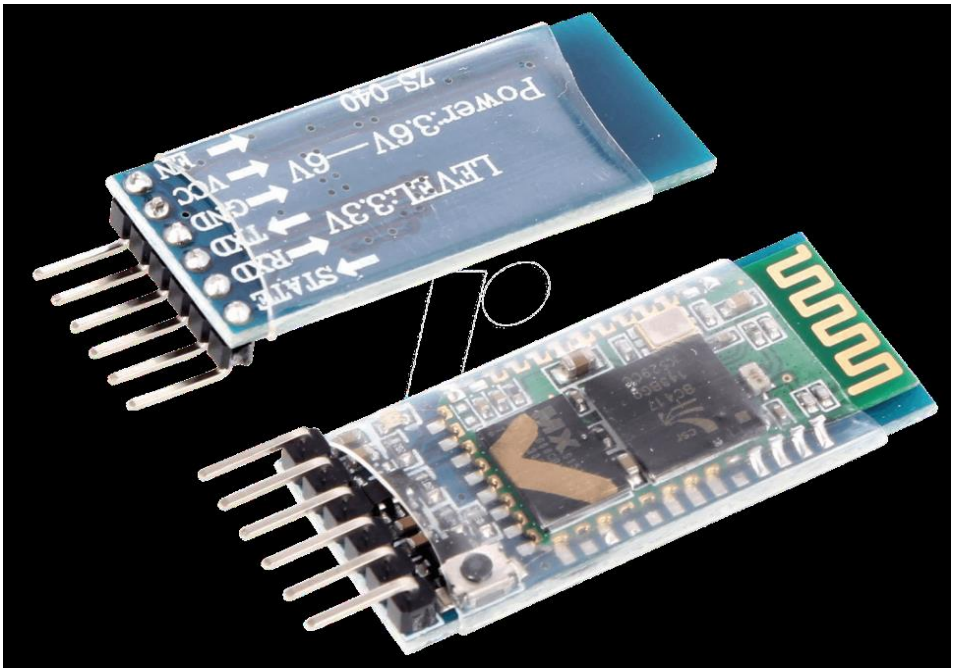
1.3 BLUETOOTH MODULE

1.3.1. INTRODUCTION

Bluetooth modules are designed for wireless data transmission between small distances it Considered as wireless personal area network technology (WPAN) it works at ultra-high frequencies (UHF). Regarding to industrial, scientific and medical (ISM) radio bands witch governing industrial, scientific and medical frequencies, the Bluetooth range from 2.402 GHZ to 2.480.

It considers as the cheapest method for data transmission, easiest and more flexible compared to other methods. It even can transmit files reach to 25 Mb/s.

This technique depends on frequency hopping spread spectrum technique (FHSS) it use this technique to avoid interference with other devices and it a full duplex transmission which mean it can transmit and receive at same time.



Fig(3.1)

1.3.2 Pin Description

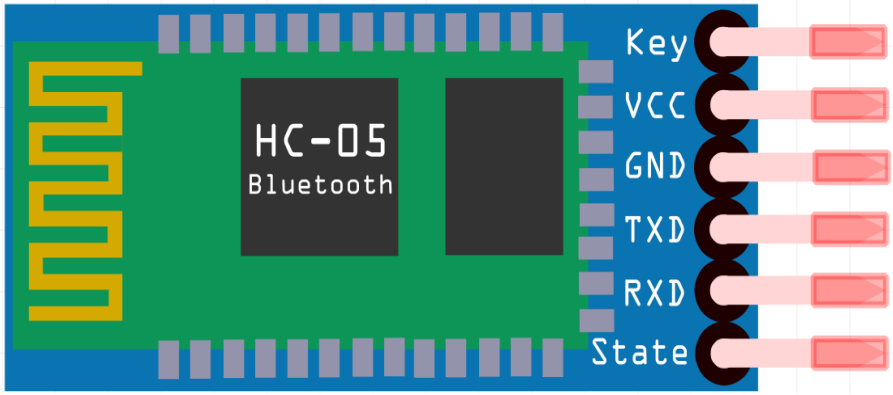


Fig.(3.2)

It has 6 pins,[see fig.(3.2)]
1.Key/EN: It is used to bring Bluetooth module in AT commands mode. By default this pin operates in data mode. Key/EN pin should be high to operate Bluetooth in command mode. The default baud rate of HC-05 in command mode is 38400bps and 9600 in data mode.HC-05 module has two modes,

- **Data mode:** Exchange of data between devices. Baud rate is 9600bps in data mode.
- **Command mode:** It uses AT commands which are used to change setting of HC-05. Baud rate is 38400bps in command mode.

2. VCC: Connect 5 V or 3.3 V to this Pin.

3. GND: Ground Pin of module.

4. TXD: Connect with Microcontroller RXD pin of Microcontroller. Transmit Serial data (wirelessly received data by Bluetooth module transmitted out serially on TXD pin)

5. RXD: Connect with Microcontroller TXD pin of Microcontroller. Received data will be transmitted wirelessly by Bluetooth module.

6. State: It tells whether module is connected or not. It acts as a status indicator.

1.3.3 Bluetooth module HC05 Features

- ✓ Operating voltage: 5 v
- ✓ Master/ Slave: master/slave is a model for a communication protocol in which one device or process known as the master controls one or more other devices or processes known as slaves. H05 module works in three modes master mode, slave mode and slave loop mode. It can sit as master or slave using AT command.
- ✓ Enable bin: it can be connected to 5V or left without connecting this allow the module to work but in case of connecting it to ground it doesn't work.
- ✓ Key pin: some modules doesn't contain this pin so a wire could be welded to it.

This pin has two modes AT mode which allow the user to enter commands to it and connection mode which allow the connection between device

1.3.4. How Bluetooth connection occurs?

1- The master device sends request to all surrounding Bluetooth modules, all slave modules reply with the 48-bit number which is unique for each Bluetooth device similar to MAC address

2- When the master determines the slave wants to pair with it starts synchronization process as the master send message with the internal date, time, type of the device, services provided by him and operating frequency these process occurred in base band layer.

3- After that the link manager layer in which Link Management Protocol (LMP) responsible for authentication and authorization process, data Encryption and frequency hopping management.

4- Then in the next layer Logical Link Control and Adaptation Protocol (L2CAP) which responsible for data transmission management and data divide into packets.

5- Using Service Discovery Protocol (SDP) the master Bluetooth module determines the service provided by the slave (profile) depending on this profile the master determines the type of data to send to this device.

6- Finally the paring action occurs when the master device gives the pin number to allow the master to exchange data at any time.

1.4. BLUETOOTH COMMUNICATION

Bluetooth is a standard used in links of radio of short scope, destined to replacewired connections between electronic devices like cellular telephones, Personal Digital Assistants (PDA), computers, and many other devices. Bluetooth technology can beused at home, in the office, in the car, etc.
Between the principal characteristics, must be named the hardiness, low complexity, low consume and low cost. The Bluetooth is a small microchip that operates in a band of available frequency throughout the world. Communications can realize point to point and point multipoint.

1.4.1. How it works?

Every device will have to be equipped with a microchip (transceiver) that transmits and receives in the frequency of 2.4 GHz that is available in the whole world (with some variations of bandwidth in different countries). Besides the information, there are three channels of voice available. Every single Bluetooth device has a unique 48-bit address, commonly abbreviated BD_ADDR. This will usually be presented in the form of a 12-digit hexadecimal value. The most-significant half (24 bits) of the address is an organization unique identifier (OUI), which identifies the manufacturer. The lower 24-bits are the more unique part of the address. The information can be exchanged to speeds of up to 1 megabit for second (2 megabits for second in the Second Generation of this Technology). A scheme of "frequency hop" (jumps of frequency) allows to the devices to communicate inclusive in areas where a great electromagnetic interference exists. Besides that is provided with schemes of encryptation and check. The standard Bluetooth operates in the band of 2,4 GHz. Though worldwide,this band is available, the width of the band can differ in

different countries. This is the frequency of band of the scientific and medical industries 2.45 GHz (ISM*). The ranges of the bandwidth in The United States and Europe are between 2.400 to 2.483,5 MHz
and it covers part of France and Spain. The ranges of the bandwidth in Japan are between 2.471 to 2.497 MHz.

1.4.2. Masters, Slaves, and Piconets

Bluetooth networks (commonly referred to as piconets) use a master/slave model to control when and where devices can send data. In this model, a single master device can be connected to up to seven different slave devices. Any slave device in the piconet can only be connected to a single master.
The master coordinates communication throughout the piconet. It can send data to any of its slaves and request data from them as well. Slaves are only allowed to transmit to and receive from their master. They can't talk to other slaves in the piconet.[see fig. (4.1)]

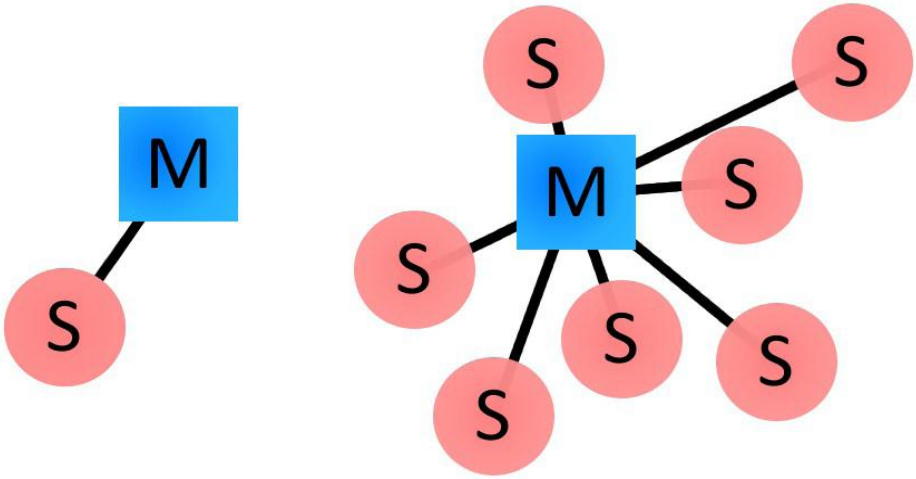


Fig. (4.1)

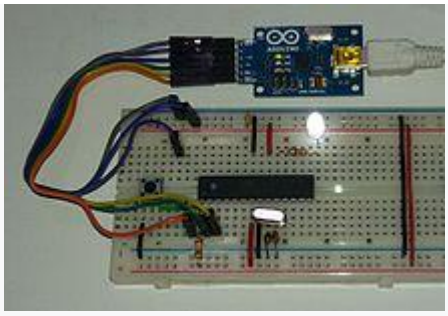
1.5. JUMPER WIRE

A **jump wire** (also known as jumper, jumper wire, jumper cable, DuPontwire, or DuPont cable – named for one manufacturer of them) is an electrical wire or group of them in a cable with a connector or pin at each end (or sometimes without them – simply "tinned"), which is normally used to interconnect the components of a breadboard or other prototype or test circuit, internally or with other equipment or components, without soldering.[1]

Individual jump wires are fitted by inserting their "end connectors" into the slots provided in a breadboard, the header connector of a circuit board, or a piece of test equipment.

1.5.1. Types

Jumper wires with crocodile clips.



Jump wires at the end of a multi-colored ribbon cable are used to connect the pin header at the left side of a blue USB2Serial board to a white breadboard below. Another jumper cable ending in a USB micro male connector mates it**.**

2. OUR WORK

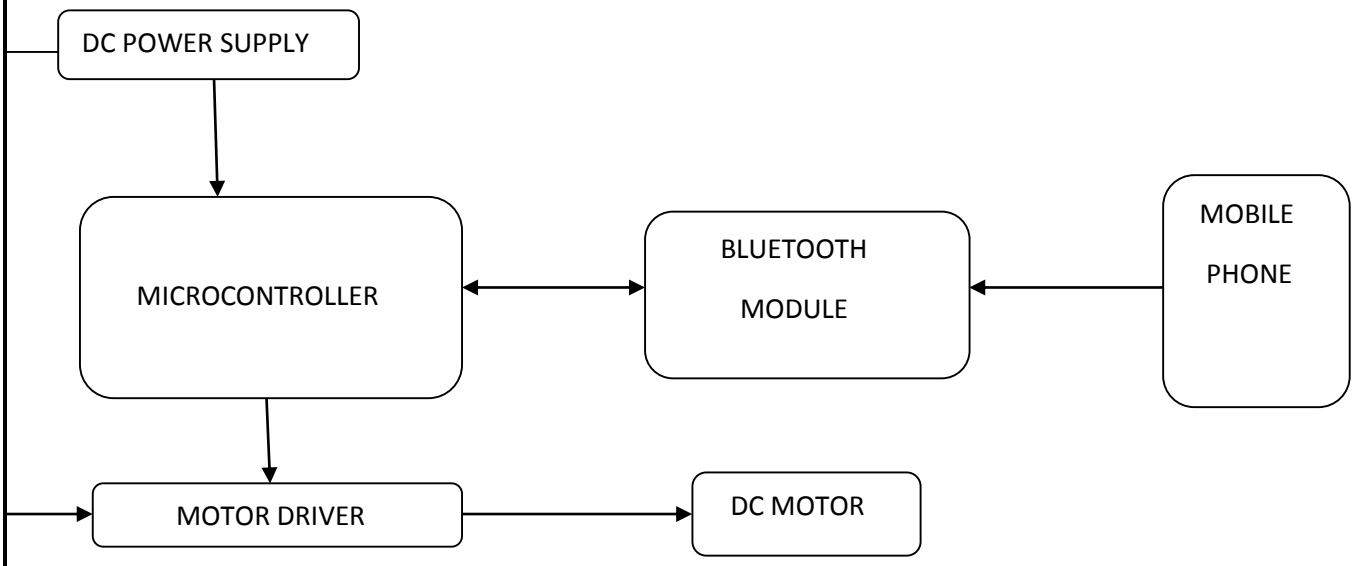
This project of ours is controlling car not by using sensors or transmitter but using Bluetooth which is a very simple communication medium in the present day. The remote in this project is an android device which has an inbuilt Bluetooth module. The
Bluetooth is a serial communication medium through which we can connect two devices.

Here we have inserted a Bluetooth module which gets connected to the phone‘s Bluetooth, that allows us to communicate and allows to take command over it. The Bluetooth module does not work on its own in controlling the car. The main part in controlling the car is played by the Arduino UNO which houses the micro-controller ATMEGA32. Arduino has played a major role in the robotic section and has made it easier to convert digital and analog signal to physical movements.

The project is Bluetooth based because it gives us wider range of control and more efficiency. It also gives us the advantage of changing the remote anytime, meaning that we can use any android
devices including phones, tablets, computers. Physical barriers like walls, doors, etc. do not effect in controlling the car.

2.1. Block diagram showing the basic working

The working principle is kept as simple as possible. The working principle of the circuit has been elaborated with the help of a block diagram, of the system interconnection as shown in Figure below.



A DC power supply is required to run the system. The DC power supple feeds the Microcontroller and the Bluetooth module. The Bluetooth module receives the signal sent from an android smart-phone, where the application software coded in C language is installed. The microcontroller, thereby, sends instructions, which when executed, helps in functioning of the motor driver. The movement and functioning of the motor can be controlled by using the android based application software.

2.2. Circuit Diagram

Hardware of this project consists of Arduino UNO, Bluetooth module and a motor driver IC. The Bluetooth module is connected with the Arduino UNO board for the connection with the user. Through the Bluetooth module for monitoring and controlling the particular motor reaches the board and process accordingly and the output of the Arduino goes to the motor driver IC and it controls the particular motor. Our proposed project consists of the following three sections:

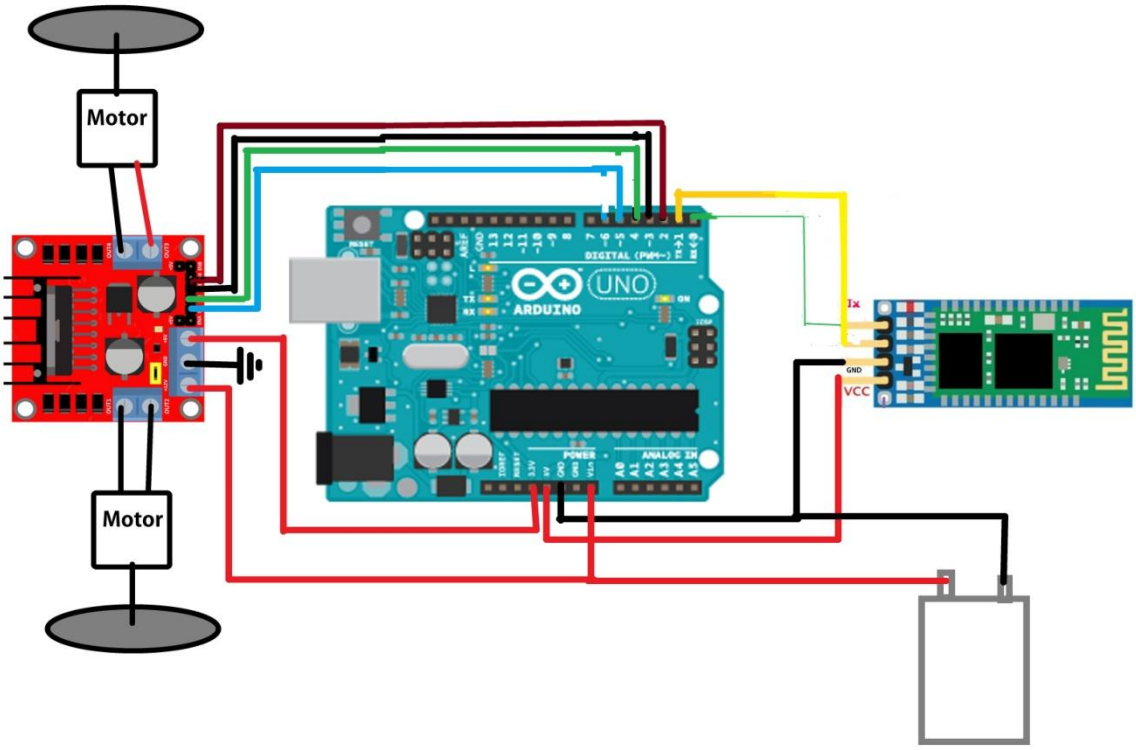


fig.(3.1)

a) Input section
b) Microcontroller section
c) Output section

In our android application base Bluetooth controlled robotic car, the user interacts with the system with a smart phone. In this method user must be present within in range (< 15 meters) to control the system. In future we would try to extend the range using Internet of Things (IoT) .When user sends any data to the Arduino board then the corresponding pin of Arduino goes to high state and switches the motor driver ic in the on mode. The corresponding motor moves as per the input data. Here in this project the user (android application) is the input section. This device is connected with the Arduino board (microcontroller section) by the means wirelessly i.e. Bluetooth module. The system can now be connected with the motors (output section) to be controlled via wireless connectivity.
The circuit diagram of this project is shown in fig.(3.1).
The circuit is shown to be simple by not showing the connections of ENA and ENB to 10 and 11 digital pin of Arduino UNO respectively.

Here at first we construct the circuit as shown in Figure 3.1. Then through the data cable we insert the commands in the microcontroller ATMEGA 16U2. These commands help the microcontroller to interface with the Bluetooth module HC- 05 and also with the motor driver MODULE L298N. Here the Bluetooth module act as a receiver which receives the instruction from the smart phone (remote or transmitter). Then the microcontroller decides the operation for the instruction which is coming from the smart phone. The functions of the given instructions are operated by the microcontroller. The instructions are sent by the smart phone. We can easily control the movements of the dc motor. The Bluetooth module can operate below the 10 m range, which we would try to extend in future. Here we are using four 12 V, 100 R.P.M DC motors and a 12 V DC battery as main power supply of this system. Until we send any instruction to the microcontroller the motors remain stop. When any input is given then the motors moves as per the preloaded functions in the microcontroller.

2.3. PWM DC motor control

We can control the speed of the DC motor by simply controlling the input voltage to the motor and the most common method of doing that is by using PWM signal.

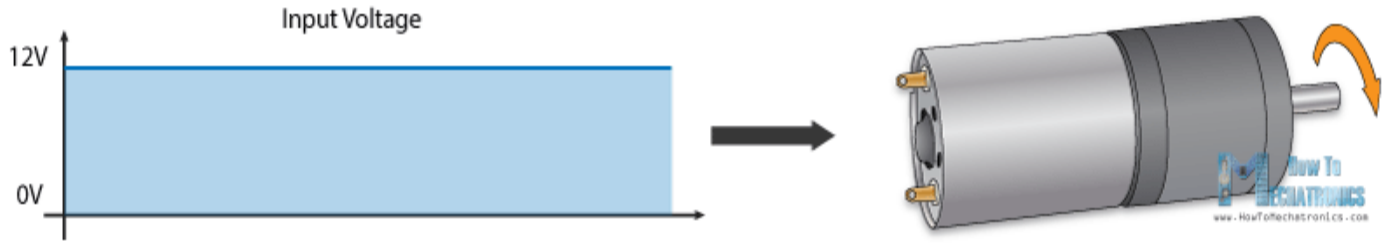


Fig. (4.1)

PWM, or pulse width modulation is a technique which allows us to adjust the average value of the voltage that's going to the electronic device by turning on and off the power at a fast rate. The average voltage depends on the duty cycle, or the amount of time the signal is ON versus the amount of time the signal is OFF in a single period of time.

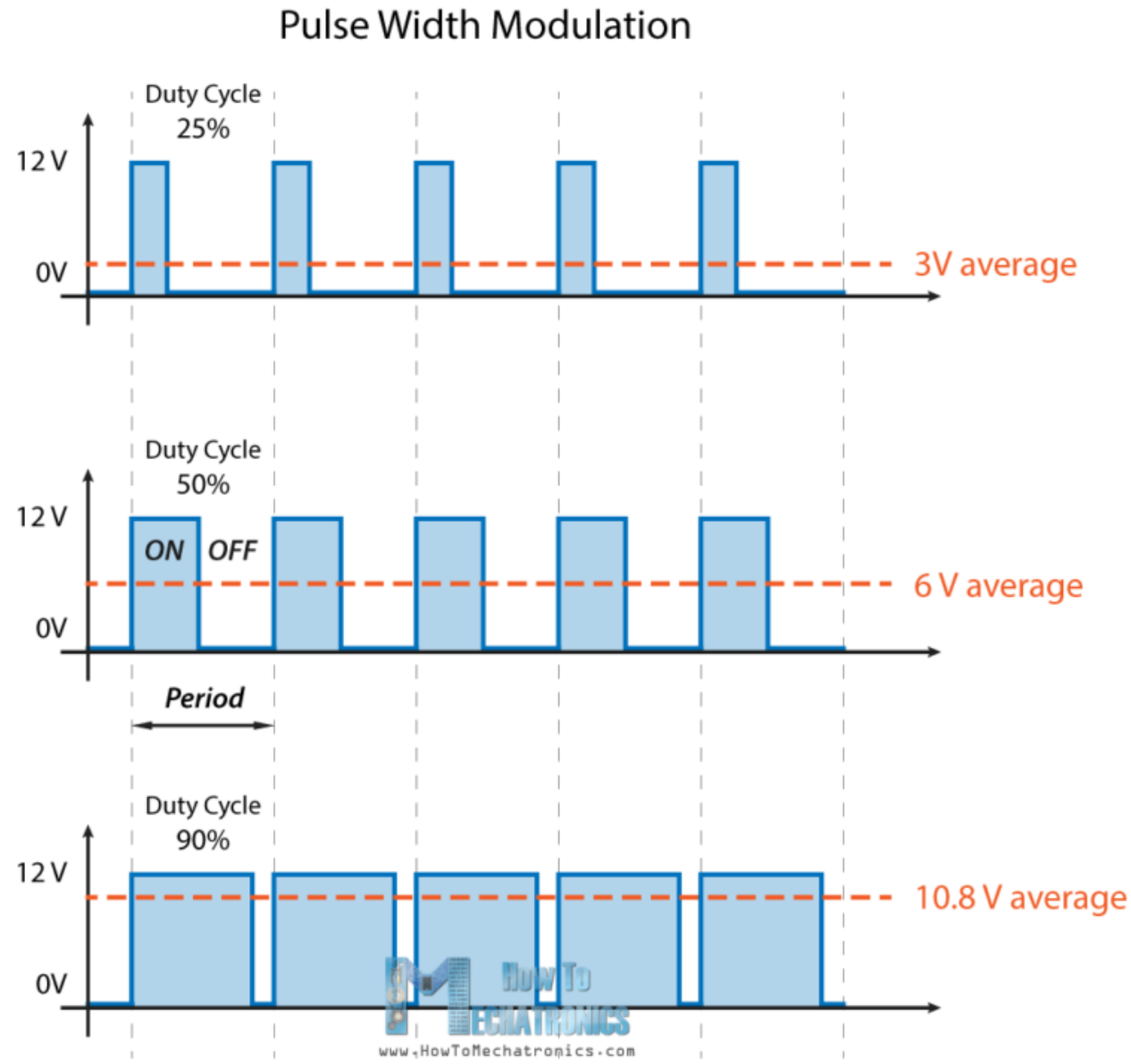


Fig. (4.2)

So depending on the size of the motor, we can simply connect an Arduino PWM output to the base of transistor or the gate of a MOSFET and control

the speed of the motor by controlling the PWM output. The low power Arduino PWM signal switches on and off the gate at the MOSFET through which the high power motor is driven.

2.4. H-Bridge DC Motor Control

On the other hand, for controlling the rotation direction, we just need to inverse the direction of the current flow through the motor, and the most common method of doing that is by using an H-Bridge. An H-Bridge circuit contains four switching elements, transistors or MOSFETs, with the motor at the center forming an H-like configuration. By activating two particular switches at the same time we can change the direction of the current flow, thus change the rotation direction of the motor.

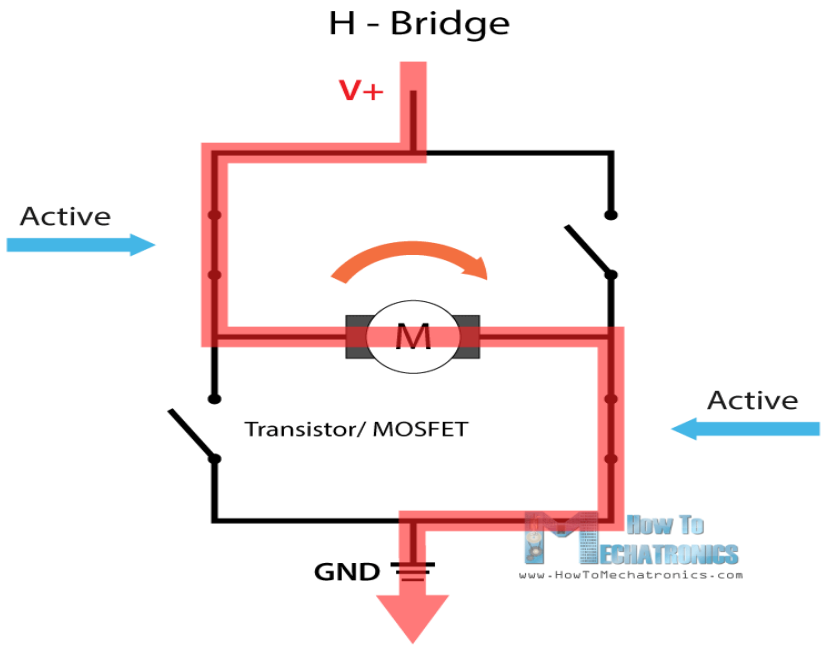


Fig.(4.3)

So if we combine these two methods, the PWM and the H-Bridge, we can have a complete control over the DC motor. There are many DC motor drivers that have these features and the L298N is one of them.

3. PROGRAMMING

```
#include <SoftwareSerial.h>

SoftwareSerialBT(10, 11); //TX, RX respetively
String readdata;
int motorLpin1=2;
int motorLpin2=3;
int motorRpin1=4;
int motorRpin2=5;
intmotorLpwm=10;
intmotorRpwm=11;

intmotorSpeed=125;
int turn=50;

void setup() {
Serial.begin(9600);
Serial.flush();
pinMode(motorLpin1,OUTPUT);
pinMode(motorLpin2,OUTPUT);
```

```
pinMode(motorRpin1,OUTPUT);
pinMode(motorRpin2,OUTPUT);
pinMode(motorLpwm,OUTPUT);
pinMode(motorRpwm,OUTPUT);
}

void loop() {
  String input="";
while(Serial.available()){
    input+=(char)Serial.read();
delay(5);
  }

  if(input=="forward"){
fwd();
  }
  else if(input=="stop"){
stp();
  }
  else if(input=="backward"){
rev();
  }
```

```
  else if(input.indexOf("left")>-1){
lft();
  }
  else if(input.indexOf("right")>-1){
rght();
  }
  else if(input!=""){
motorSpeed=input.toInt();
  }
}

void fwd(){
analogWrite(motorLpwm,motorSpeed);
analogWrite(motorRpwm,motorSpeed);
digitalWrite(motorLpin1,1);
digitalWrite(motorLpin2,0);
digitalWrite(motorRpin1,1);
digitalWrite(motorRpin2,0);
}

void rev(){
analogWrite(motorLpwm,motorSpeed);
```

```
analogWrite(motorRpwm,motorSpeed);
digitalWrite(motorLpin1,0);
digitalWrite(motorLpin2,1);
digitalWrite(motorRpin1,0);
digitalWrite(motorRpin2,1);
}

void lft(){
analogWrite(motorLpwm,motorSpeed-turn);
analogWrite(motorRpwm,motorSpeed+turn);
digitalWrite(motorLpin1,0);
digitalWrite(motorLpin2,1);
digitalWrite(motorRpin1,1);
digitalWrite(motorRpin2,0);
}

void rght(){
analogWrite(motorLpwm,motorSpeed+turn);
analogWrite(motorRpwm,motorSpeed-turn);
digitalWrite(motorLpin1,1);
digitalWrite(motorLpin2,0);
digitalWrite(motorRpin1,0);
```

```
digitalWrite(motorRpin2,1);
}

void stp(){
analogWrite(motorLpwm,0);
analogWrite(motorRpwm,0);
digitalWrite(motorLpin1,1);
digitalWrite(motorLpin2,1);
digitalWrite(motorRpin1,1);
digitalWrite(motorRpin2,1);
}
```

4.CONCLUSION

4.1. Advantages

- ✓ It is easy to implement and of low cost.
- ✓ It can be manually as well as voice controlled.
- ✓ As it requires Bluetooth connection for communication between master and slave that's why it can be easily used by anyone.
- ✓ The structure is robust, hence, it can be applicable in many areas.

4.2. Disadvantages

The one and only considerable disadvantage is the range of Bluetooth communication. But further research can be done for large range communication.

4.3. Applications

It is applicable in many areas like in offices, home and medical. In all the 3 above mentioned industries it can be used for automation control.

This is indeed a cost-effective and efficient project. The novelty lies in the fact that it is a cost-effective project with a simple and easy to use interface compared to existing ones. Also the Bluetooth RC Controller application is more user friendly. The robot is small in size so it can be used in spying purpose. With few additions and modifications, this robot can

be used in army for detecting and disposing hidden land mines. The robot can be used for surveillance. In future we can interface sensors to this robot so that it can monitor some parameters and we can improve the efficiency using Internet of Things (IoT) technology. We can also add wireless camera, in order to incorporate other security features.
The Arduino is an open source device that has been the brain for numerous projects. The Arduino has everything that is required by the user which includes its inbuilt converter, i/o pins etc. With the combination of Arduino, and the Bluetooth Shield we can control over many other things, like home Lightings, air conditioner and many more through our cell phones. The Arduino can also contribute at large for the SmartHome system. By doing this Project we found out a lot about the Arduino, and how it has made us easier to convert digital signals into physical movements. One more advantage of Arduino is that once a program is burned we don‘t need to worry about the program getting erased as long as it is not RESET. Arduino is also over all other microcontroller because of its efficiency and user friendly property.

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