

Design and Implementation of an Improved Automatic DC Motor Speed Control Systems Using Microcontroller

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ABSTRACT

Energy wastage is one of the major challenges that is facing the world now as there is insufficient supply of energy and the little ones supplied was not appropriately used. This energy wastage has made many researchers to engage more on the research to stop this energy waste as a result of inappropriate allocation of energy to some devices even when they don't need it. This research work was able to design and implement an improved automated DC Motor speed controller system using microcontroller successfully. The software used for this research work were Fritzing software and Arduino Nano. This project was able to improve on the working system of the DC Motors and energy was automatically and successfully saved. The system runs entirely on Bluetooth technology which consumes less power than other devices. The Android application is user-friendly with enhanced Wireless communication. This design was successfully developed and implemented with 80% accuracy. The design was able to work effectively by increasing the cutting speed when the softness of the material decreases and as the cutting tool material becomes stronger, the cutting speed increases. This showed that the design is effectively and efficiently developed with less energy/power consumption which is the earnest desire of an Engineer as it reduces cost.

Keywords: Microcontroller, Improved Automatic DC Motor, Energy, Arduino, PWM

INTRODUCTION

Most of the industrial process requires to be run on the certain parameters since almost all the industries require motors in their operation to either increases or decrease the speed of the machine. Speed control of dc motor could be achieved using various mechanical or electrical techniques but this research project will basically focus on Pulse with Modulation (PWM) technique. Pulse with modulation is a modulation technique that generates variable pulses width to represent the amplitude of an analog input signal. By using pulse with modulation (PWM) technique, it is easy to control the average power delivered to a load and hence made it easy to control the speed of the DC motor. Pulse width modulation control works by switching the power supplied to the motor on and off very rapidly and the DC voltage is converted to a square wave signal, alternating between full (nearly

12v) and zero, giving the motor a series of power "kicks". Pulse width modulation techniques is a technique for speed control which can overcome the problem of poor starting performance of a motor [1][2][3][4][5].

The electric drive systems used in many industrial applications require higher performance, reliability and variable speed. The speed control of DC motor is important in applications where precision and protection are of importance. DC Motors are used in many systems in our day to day life which include running cranes, lifts, hair drier, electric footing, vacuum cleaner and in speed regulation applications such as wiper. DC motor is an electric motor that runs on direct current power. It works on the fact that a current-carrying conductor placed in a magnetic field experiences a force that causes it to rotate with respect to its original

position. Practical DC Motor consists of field windings to provide the magnetic flux and armature which acts as the conductor. The input of a brushless DC motor is current/voltage and its output is torque [6][7][8][9][10][4].

Furthermore, the challenge of controlling speed of motors used by different machines to a desired speed level required by the machine is always paramount to avoid wastage of energy. This problem of machines not been rated according to the required energy consumption which made the DC motor to be running at high speed while it needs to be operating at low speed has led to high energy or power consumption [2][1] [13] [14].

From the extensive review, it was observed that many others have never considered the problem of wastage of energy as many DC motors in machine were designed to be consuming energy more than required as there is no auto-regulator embedded on it.

METHODOLOGY

This system was designed based on the following sequential methods:

- i. The system was designed using the Fritzing software which is a circuit design simulation software
- ii. A circuit board was used to connect the different electronic components following the circuit design that was done using Fritzing software.
- iii. Microcontroller was programmed using Arduino Uno/C++ software language with a computer.
- iv. A Control Panel interface was made using Bluetooth software and an android phone was used to connect to the Bluetooth

This research work will solve the problem of inappropriate allocation of DC motors in a machine without auto-control system. This research work will showcase the best way to control the speed of DC Motor using Pulse Width Modulation (PWM) technique coupled with android mobile phone Bluetooth applications. Smart phones have in-built Bluetooth technology which an external Bluetooth module and Arduino Uno microcontroller will be interfaced them for easy communication [15] [16] [17] [18] [19] [20]. The Bluetooth module receives command from the android mobile phone through the help of Arduino whereas MOSFET can be used to vary the voltage as well as the speed of the DC motor using PWM technique. The main objective of this research paper is to Design and Implement an Improved Automatic DC Motor Speed Control Systems Using Microcontroller that will be conservative in saving power/energy.

Module first and then the control panel will be used to run the entire system. This means that the Control Panel is able to switch the system ON or OFF and also control the speed.

System design

The system design of the proposed system uses two architecture designs which involve the power supply, input stage, control stage and output stage. This setup consists of two basic primary elements communicating Bluetooth devices such as (i) Bluetooth of smartphone which is connected to the Arduino microcontroller, and DC Motor interfaced with a switch and (ii) a Bluetooth module HC-05. Figure 1 is the systematic block diagram of energy flow in the designed system.

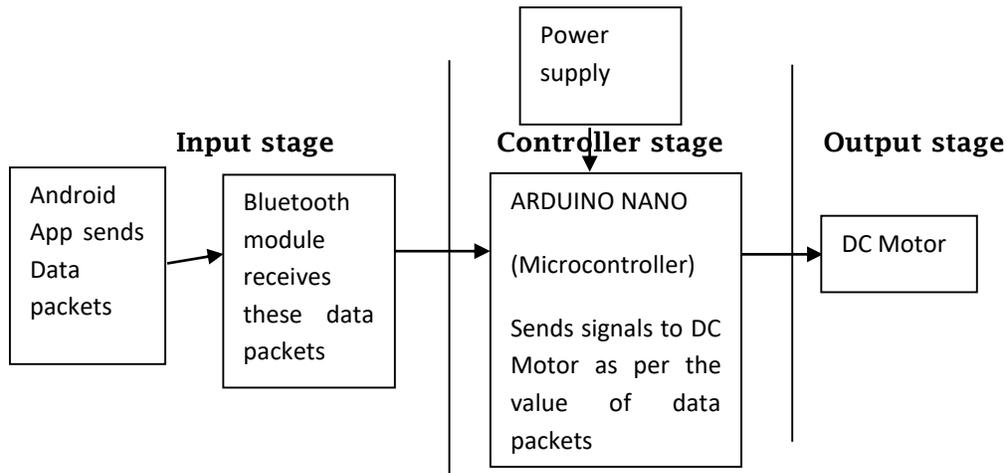


Figure 1: Block Diagram of Energy flow in the circuit

Bluetooth Module

Bluetooth serial communication module is one of the input device in this project design and it has two work modes: order-response work mode and automatic connection work mode. And there are three work roles at the automatic connection work mode. When the module is at the automatic connection work mode, it will follow the default way set lastly to

transmit the data automatically. When the module is at the order response work mode, user can send the AT command to the module to set the control parameters and sent control order. The work mode of this Module can be switched by controlling the module PIN (PIO11) input level. In this project Bluetooth module is used to send signals from the Arduino Uno.

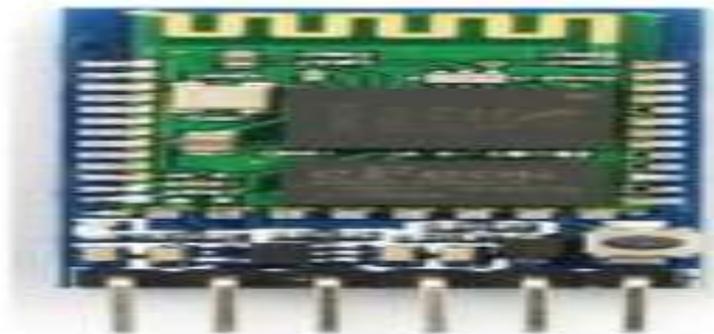


Figure 2: Bluetooth module

Arduino Nano is one of the controller in this research design on 8-bit ATmega328P microcontroller. It also consists of other components such as crystal oscillator, serial communication, voltage regulator, etc. to support the microcontroller. Arduino Nano has 14 digital input/output

pins (out of which 6 can be used as PWM outputs), 8 analog input pins, a USB connection, A Power barrel jack, an ICSP header and a reset button. The ATmega328P microcontroller provides UART TTL (5V) serial communication

which can be done using digital pin 0 (Rx) and digital pin 1 (Tx).



Figure 3: Arduino Nano

Android Phone: Android phone was used as an input which contains the Control

Panel that will be used to control the system.

Table 1: Component used for the Design and its Specifications

Items	Quantity	Items	Quantity
NE555P TIMER IC	1	100 nF Capacitor	2
1KΩ Resistor	2	1N4007 Diode	3
100KΩ Potentiometer	1	Transistor (Darlington TIP122)	1
12V Power Supply	1	12V DC Motor	1
Connecting Wire	½ roll	Transformer (12-0-12)	1
1N4007 Diode	4	Capacitor (470 μF, 25V)	1
Capacitor (0.1 μF)	2	Regulator (IC2 7812)	1
4.7 KΩ Resistor	1	LED bulb	1

Designing steps 1: The components of the system have been connected as shown in the circuit diagram of figure 4.

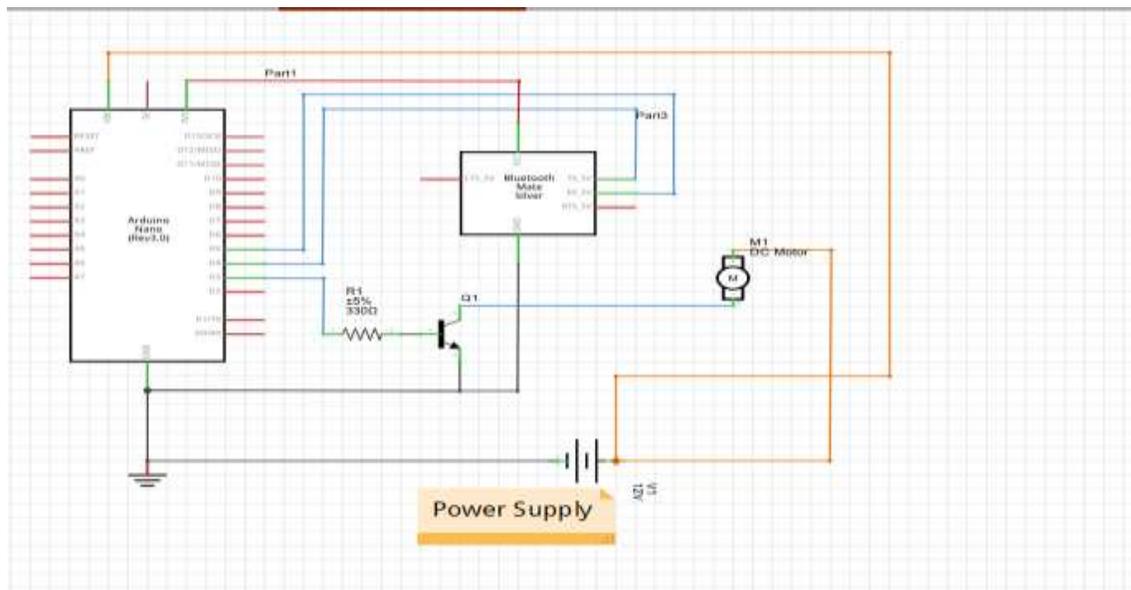


Figure 4: Schematic Circuit Diagram of a Dc Motor Using Pulse Width Modulation

The system has been designed by Fritzing software since it is among the best latest of circuit design software and incorporate all of the devices used to come up with the prototype. Figure 4 is a simple illustration of how the system was implemented and the various components that's made up the system.

Step 1b: The connection of the Arduino and Bluetooth module: This circuit is built

using only three components: Arduino NANO, the Bluetooth module HC05, and a Darlington transistor TIP122. The HC05 has four interfacing pins: Vcc, GND, Tx, and Rx. Here, the Vcc pin is given a 5-V supply from the Arduino board and the GND pin is connected with the board's ground. The Tx and Rx pins are connected with Arduino's pins D4 and D5, respectively.

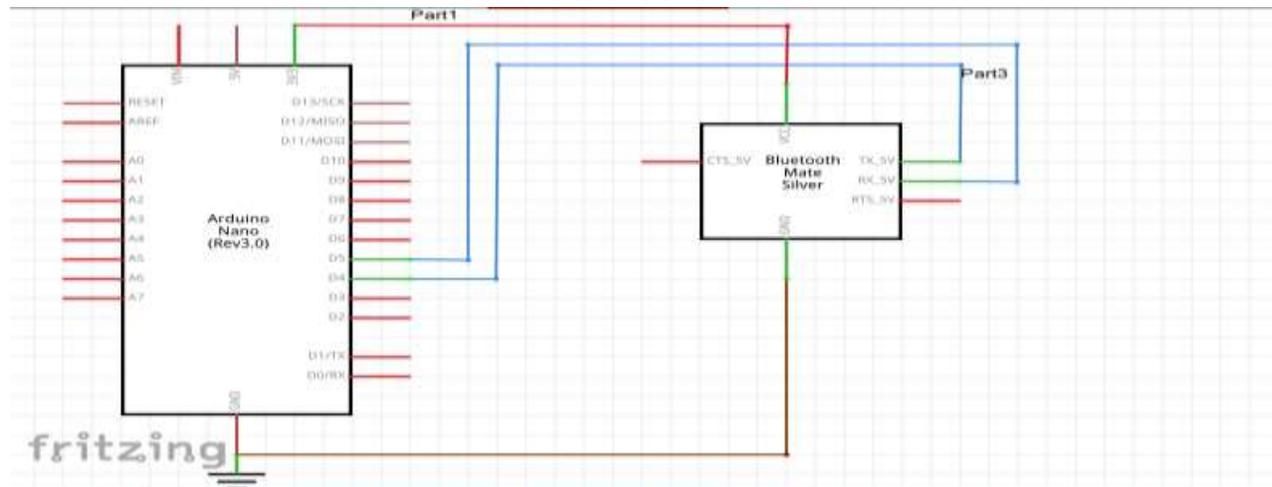


Figure 5: Schematic Circuit Diagram of Arduino NANO and Bluetooth module HC05

The circuit connections were followed below to build the System. The PWM output pin D3 drives the 12-V DC motor using the TIP122. It's connected to TIP122's base terminal through the current limiting 330-ohm resistor. The TIP122 is used to

amplify the current, providing the required current to the motor. The DC motor is connected between the collector output and the 12-V supply. The TIP122's emitter terminal is connected to the ground.

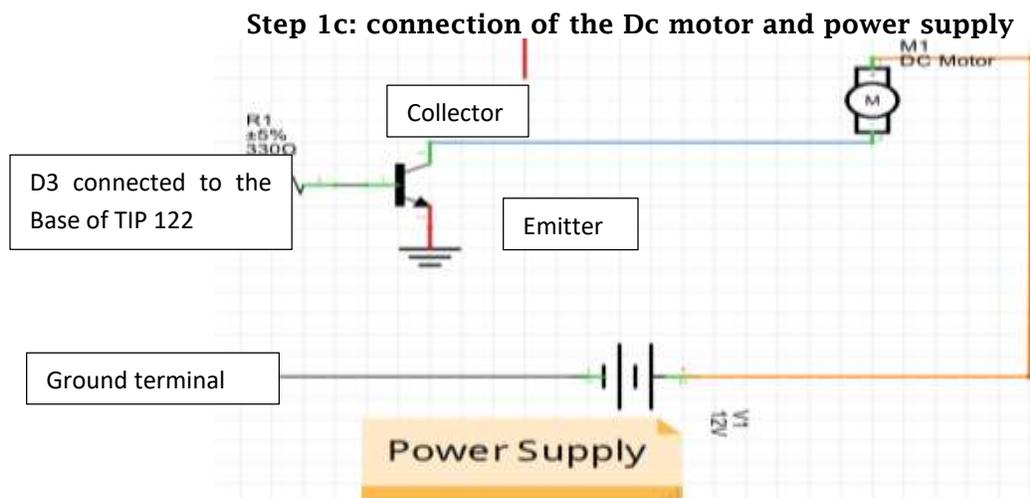


Figure 6: Schematic Circuit Diagram of a Dc Motor and TIP 122 Transistor

Circuit operation: The circuit controls the speed of the 12-V DC motor using the Android app on a smartphone. The app sends the commands to start or stop the motor and to change the speed of the motor via the smartphone's Bluetooth. These commands are received by the HC05 module, which passes them on to the Arduino NANO via the Tx and Rx pins. As per the commands sent over, Arduino will run or stop the DC motor, or vary its speed from minimum to maximum. Arduino generates a PWM signal on its D3 pin to run or stop the motor or to vary the motor speed. To stop the motor, the pulse width

on the pin D3 is 0 (0%). And to run the motor at full speed, it's 255 (100%). So, as Arduino changes the pulse width on its D3 pin, the motor speed changes from min to max — or vice versa. Arduino can also send a change in motor speed (0 to 100 %) from the HC05 module to the smartphone's app. The Android app will then display this motor speed value on an analog dial (or speed dial).

Step 2: Launch the “blink program” to test the board status: Open your Arduino software from your computer and follow the steps as shown in the figure 7

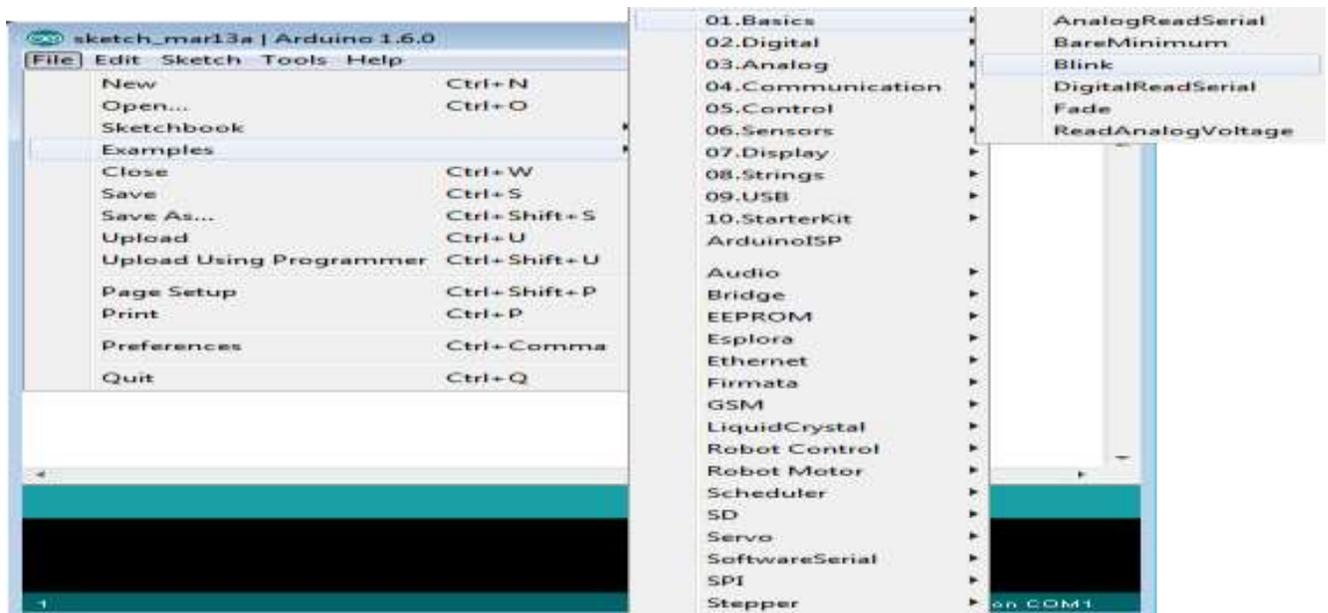


Figure 7: How launch the “blink program” to test the board status

Step 3: Select the Arduino Nano Board type

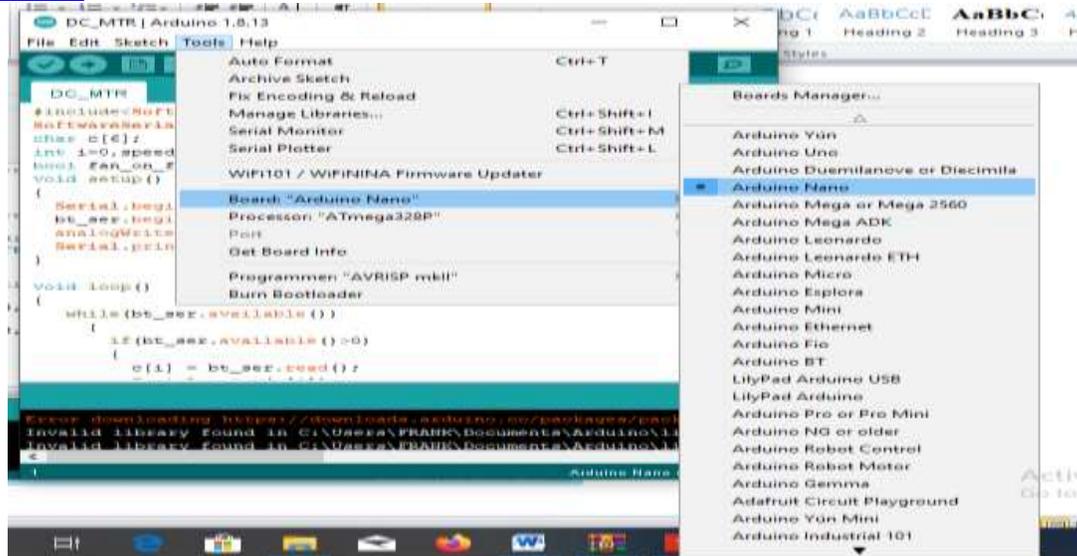


Figure 8: Selection of Arduino Nano Board type

Step 4: The program code in the Arduino software: Copy and paste this gate code in your Arduino software as shown below:

```
#include<SoftwareSerial.h>
SoftwareSerial bt_ser(4,5);
char c[6];
int i=0, speed_value=150,send_value;
bool fan_on_flag = false;
void setup()
{
  Serial.begin(9600);
  bt_ser.begin(9600);
  analogWrite(3,0);
  Serial.println("DC Motor speed control using android app");
}

void loop()
{
  while(bt_ser.available())
  {
    if(bt_ser.available()>0)
    {
      c[i] = bt_ser.read();
      Serial.print(c[i]);
      i++;
    }
    if(c[i-1]=='N')
    {
      analogWrite(3,speed_value);
      fan_on_flag = true;
      i=0;
    }
    if(c[i-1]=='F')
    {
      analogWrite(3,0);
      fan_on_flag = false;
      i=0;
    }
  }
}
```

```
}  
if(c[i-1]!='#')  
{  
    speed_value = (c[1]-48)*100+(c[2]-48)*10+(c[3]-48)*1;  
    send_value = map(speed_value,100,255,0,100);  
    if(fan_on_flag) analogWrite(3,speed_value);  
    Serial.print(speed_value);  
    Serial.print('\t');  
    Serial.println(send_value);  
    bt_ser.print("*D");  
    bt_ser.print(send_value);  
    bt_ser.print("*");  
    i=0;  
}  
}  
}
```

Step 5: Select serial COM port: Connect the Arduino NANO to the computer's USB port using a using a USB cable and then

select the Serial COM port to be used. For example, in the illustration figure 10 serial COM port 15 was selected.

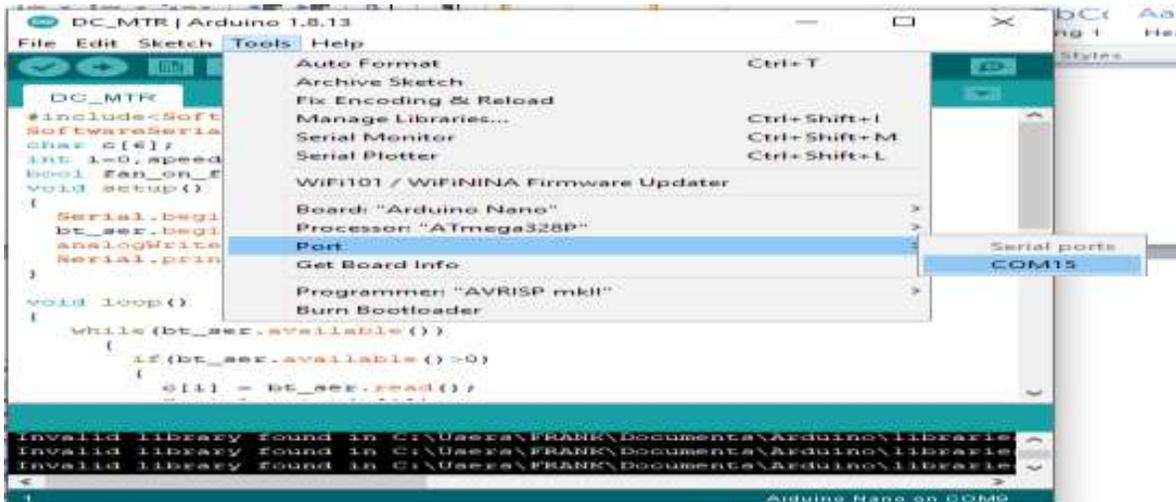


Figure 9: Select Board type

Step 6: Verify and upload the Arduino software program

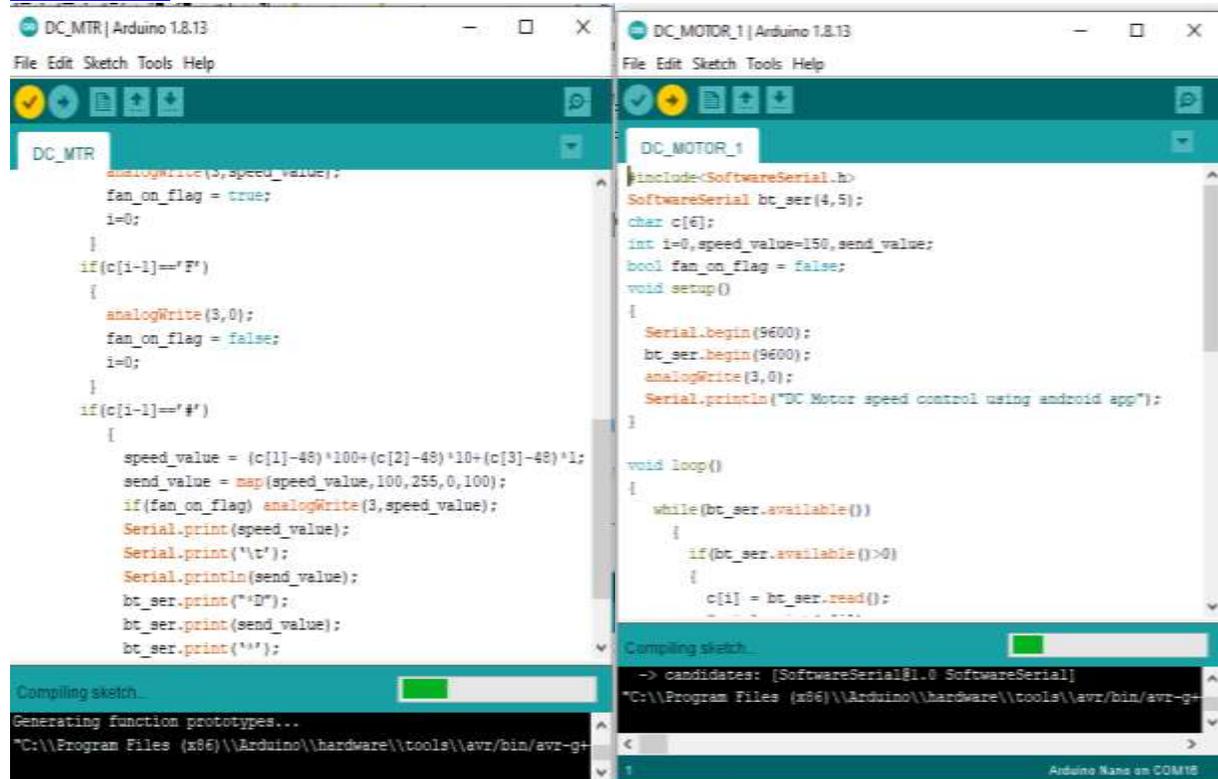


Figure 11: Verified Arduino software and Uploaded Arduino software program

Step 6: Build the Android app or Panel:

The Android application is built using the “Bluetooth Electronics” application, which is available for free on Google Play. First, download and install the “Bluetooth Electronics” app on your Android phone and open it. It will ask if you want to turn “ON” the device’s Bluetooth. Allow it to do so. Once the app starts, you’ll see a few readymade control panels that control Arduino-based projects. Perhaps the most interesting feature of this app. It also allows the users to build a customized panel to control Arduino projects.

The Arduino panel that controls the app is built as show below: The panel consists of a green and red button to turn the mother “ON” or “OFF.” It also has one slider to vary the motor speed and one dial to view the motor speed.

1. Select one green button. Then, go to the right corner of the screen and edit the button properties as follows:

Press Text: N

Release Text:

2. Choose the text size with either a small or medium font, and write “Motor ON.”

3. Select one red button and edit its properties as follows:

Press Text: F

Release Text:

4. Choose the text size with either a small or medium font, and write “Motor OFF.”

5. Select the biggest slider from the slider options and edit its properties as follows:

Min Value: 100

Max value: 255

Select “Send on slider change”

String starts with: *

String Ends with: #

6. Go to the indicator options and choose the analog dial. Edit its properties like this:

Receive character: D

Min Text: 0

Max Text: 100

min value: 0

max value: 100

leave default all others

7. Write all of the other text, such as “min”, “max”, “motor speed”, “speed indicator” etc., as you choose.

And that’s it! Your android app is ready to control the DC motor speed.

Running the project

1. Connect the circuit as per the given schematic on the bread board or on the general purpose PCB.
2. Give the 12-V power supply to the circuit.
3. Initially, the motor is not moving and is in the stop position. The HC05 module will start blinking to indicate it's searching for the device.
4. Start the "Bluetooth electronics" application in your smartphone, ensuring the Bluetooth is "ON."
5. Press the connect button so it searches for the HC05 module. When the device is

- found, select "HC05" and press connect. When doing so for this first time, you'll have to enter passkey "1234."
6. Once the HC05 is connected, press done.
7. Now, you can run your panel.
8. From the panel, press the green button to start the motor or the red button to stop it.
9. While the motor is running, change the slider to vary the motor speed.
10. As the slider moves, the speed dial will indicate the motor speed (from 0 to 100%).

Table 2: Description of Methodology

Objective	Method	Description / purpose
Types motor uses	-Interview -Statistical analysis	Factories and industries will be visited randomly for an interview schedule aimed at getting the following data; to know the different motors in their factories and industries. The purpose of this exercise is to know the advantages and disadvantages of different types of motors in those factories and industries and also to know problems associated with different motors in different factories and industries.
Methods speed control of motors.	-Interview -Internet -search	Engineers from different factories and industries will be interviewed about the different methods they employ in controlling the speed of motors in these different factories and industries. The purpose of this is to know the challenges these factories and industries face during speed control of motors.
PWM technique	-Library and internet search	The university academic library and the internet sites will be visited to obtain the following; relevant engineering text books to discover the right information required upon the pulse width modulation. The purpose of this research will help in material selection to be used.

RESULTS AND DISCUSIONS

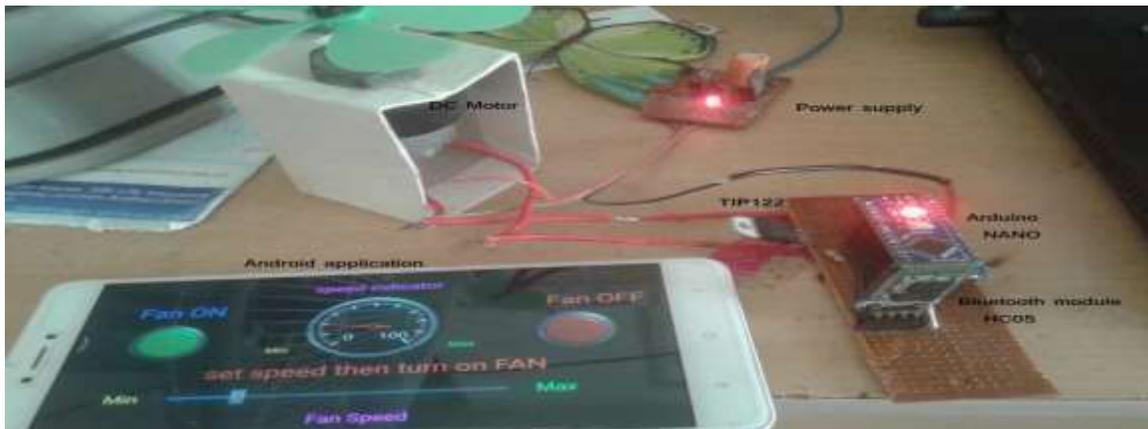


Figure 12: Hardware Assembly of the Components

The hardware assembly of the components as diagram of the circuit was as shown in

figure 12, this showed the sequential flow of the programs in the system.

RESULTS

This designed system has to undergo testing which will require running the system using the Control Panel of the phone which should be able to switch the

system ON or OFF and vary the speed of the DC Motor from Minimum to Maximum speeds.

Table 3: Cutting Rotational Speed for Material

No	Tests (Material)	Results (RPM)
1.	Mild steel	100
2.	Carbon steel	80
3.	Aluminum	230-235
4.	Soft brass	175
5.	Cast Iron	100
6.	Annealed stainless	80-100

Table 4 showed the cutting speed (usually in feet per minute) of a tool when it is cutting the work. It is observed from table 4 that as the softness of the material decreases, the cutting speed increases and

as the cutting tool material becomes stronger, the cutting speed increases. This showed that the design is effective and efficient and as well conserves energy and power usage.

Table 4: Cutting Rotational speed of Electrical Machines

No	Tests (Material)	Results (RPM)
1.	Axial Machines	30,000-48,000
2.	Hysteresis motors	30,000-60,000
3.	Turbo molecular pumps	200-1,000,000
4.	Turbine Generators	700,000-840,000
5.	Robot/mechatronics	400,000
6.	Electric motor and small power spindles	200,000
7.	Drilling machine	85,000-370,000

Table 4 showed the cutting rotation speed of an electrical machine in radian per minute. It was observed from table 4 that

all ultra-high-speed materials were operated on jointly with power electronics and control systems. This obviously safes

energy and power the rotation speed is relative to the material it is operating on whereas same material observes the same speed.

Summary of the findings

The testing is done in stages, this helped to identify the current and voltage flow in

Energy consumption is increasingly becoming high over time, which is becoming costly because of no speed control measures. This project was able to improve on the working system of the Motors which shall be used to run the machines using an automated control system which saves energy and power from being wasted. The system runs entirely on Bluetooth technology which consumes less power than other devices. The Android application is user-friendly

the circuit. It was done in different intervals to confirm the current and voltage in the circuits. The results from the tests done, confirmed that the design and implementation of the system is doing exactly what it was designed for and therefore the design was successful.

CONCLUSION

with enhanced Wireless communication. This design was successfully developed and implemented with 80% accuracy. The design was able to work effectively by increasing the cutting speed when the softness of the material decreases and as the cutting tool material becomes stronger, the cutting speed increases. This showed that the design is effective and efficient and as well conserves energy and power usage which is the earnest desire of an Engineer as it reduces cost.

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