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Speed Control of DC Shunt Motor Using Microcontroller and Android Application

Ramesh G.B.[1], Nikhil R.Chitragar[2]

[1, 2] *Assistant Professor, Dept. of E & E Engineering, Gogte Institute of Technology, Belagavi-08, India*

***Abstract*-Automation is a trending topic in the 21th century making it play an important role in our daily lives. The main attraction of any automated system is reducing human efforts and time. Our paper presents an idea of microcontroller based voice controlled home automation system using android applications of smartphones. Such a system will enable users to have control over every appliance in his/her home with their voice, all that the user needs is an android Smartphone and a control circuit. The control circuit consists of 8051 microcontroller, which processes the user commands and controls the switching of devices. The connection between the microcontroller and the Smartphone is established via Bluetooth widespread wireless technology used for sharing data.**

***Keywords* – Microcontroller, Android application, Bluetooth, Automation**

I. INTRODUCTION

Wireless technology is not a new concept in today's world of Industrial Automation, it is used to provide convenience for operators to remotely control and monitor the speed of industrial motors as it provides better use of electricity. As by the growth of PC (personal computers), internets, and mobile phones makes it easy for an operator to remotely access and control the industrial appliances. A lot of research has been done and many solutions have been proposed to remotely access the industrial appliances in order to reduce the human effort. Some of them use internet, wireless technology to communicate and control the devices, others used Bluetooth and GSM technology for controlling the industrial devices.

The method reduces the wiring and complexity of the system. It provides portability to the system. It gives opportunity to an operator to control and monitor the speed of industrial motors by simply running the mobile application and giving an input command. The mobile application efficiently converts the input command to digital signal and transfers it to the Bluetooth network. As there is no wired communication between the remote user and appliances control module and the electronic device.

In many industries such as paper mills, rolling mills, printing machine tools, excavators and cranes etc the dc motor is used for waving a product from one place to another on the conveyer belt. So due to these the speed control of the dc motor is very important purpose. Motor speed controller is to take a signal representing the required speed and to drive a motor at that speed For that purpose wireless speed and direction control of dc motor by radio frequency technique is very crucial with pulse width modulation. The microcontroller AT89S52 is used to control the dc motor speed. By adjusting the duty cycle of pulse from Pulse Width Modulation technique simultaneously the terminal voltage of motor is change and hence speed will be varied with terminal voltage.

II. DC MOTOR

A DC motor is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current flow in part of the motor. DC motors were the first type widely used, since they could be powered from existing direct-current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances. Larger DC motors are used in propulsion of electric vehicles, elevator and hoists, or in drives for steel rolling mills

2.1 Methods of Speed Control for DC Shunt Motor

2.1.1Flux Control method

As indicated by the speed equation, the speed is inversely proportional to the flux. The flux is dependent on the current through the shunt field winding. Thus flux can be controlled by adding a rheostat (variable resistance) in series with the shunt field winding as shown in the figure 2.1.

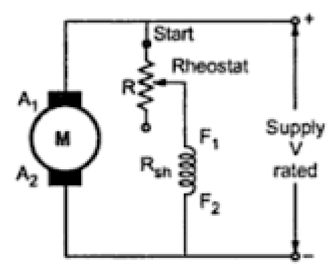


Figure 2.1: Flux control of shunt motor

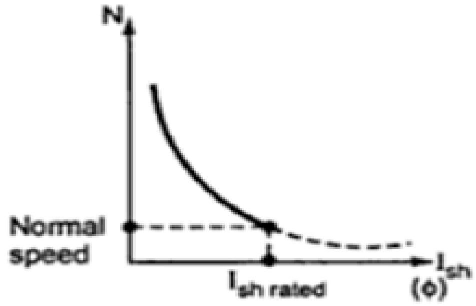


Figure 2.2: N Vs I_{sh} (ϕ) for shunt motor

At the beginning the rheostat R is kept at minimum, indicated as start in the fig. 2.1. The supply voltage is at rated value. So the current through shunt field winding is also at its rated value. Hence the speed also rated speed also called normal speed. Then the resistance R is increased due to which shunt field current Ish decreases, decreasing the flux produced. As N α (1/ϕ), the speed of the motor increases beyond its rated value. The curve in the figure 2.2. Shows the inverse relation between N and ϕ as its nature is rectangular hyperbola.

2.1.2 Armature Voltage Control Method or Rheostatic Control

The speed is directly proportional to the voltage applied across the armature. As the supply voltage is normally constant, the voltage across the armature can be controlled by adding a variable resistance in series with the armature as shown in the figure 2.3.

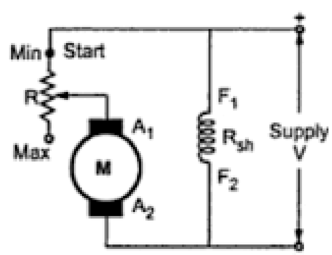


Figure 2.3: Rheostatic control of shunt motor

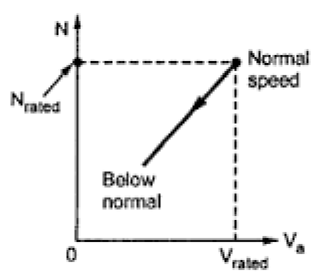


Figure 2.4: Speed Vs voltage across armature

The field winding is excited by the normal voltage hence Ish is rated and constant in this method. Initially the rheostat position is minimum and rated voltage gets applied across the armature. So speed is also rated. For a given load, armature current is fixed. So when extra resistance is added in the armature circuit, Ia remains same and there is voltage drop across the resistance added (IaR). Hence voltage across the armature decreases, decreasing the speed below normal value. By varying this extra resistance, various speeds below rated value can be obtained.

So for a constant load torque, the speed is directly proportional to the voltage across the armature, as shown in the figure 2.4.

2.1.3 Potential Divider Control

The main disadvantage of the above method is, the speed up to zero is not possible as it requires a large rheostat in series with the armature which is practically impossible. If speed control from zero to the rated speed is required, by rheostatic method then voltage across the armature can be varied by connecting rheostat in potential divider arrangement as shown in the figure 2.5.

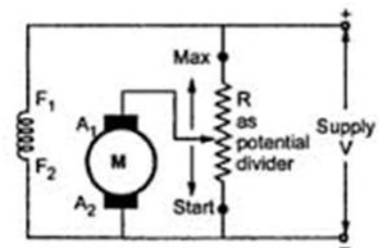


Figure2.5.Potential divider arrangement

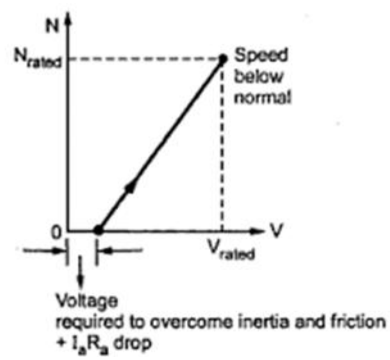


Figure 2.6: Speed Vs Voltage

When the variable rheostat position is at 'start' point shown, voltage across the armature is zero and hence speed is zero. As rheostat is moved towards 'maximum' point shown, the armature voltage increases, increasing the speed. At maximum point the voltage is maximum i.e. rated; hence maximum speed possible is rated speed. The graph is shown in figure2.6.

2.1.4 Applied Voltage Control

3.3.4a Multiple Voltage Control: In this technique the shunt field of the motor is permanently connected to a fixed voltage supply, while the armature is supplied with various voltages by means of suitable switch gear arrangements.

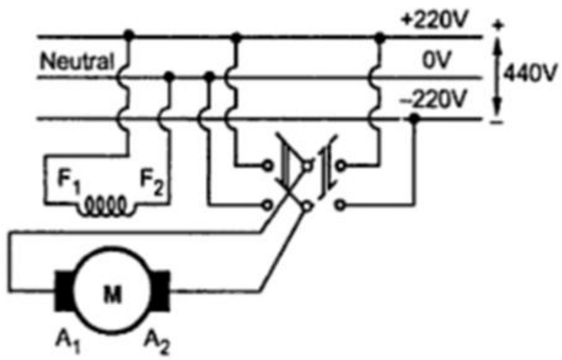


Figure 2.7: Multiple voltage control

The figure 2.7 shows a control of motor by two different voltages which can be applied to it with the help of switch gear.

III. WIRELESS COMMUNICATION

3.1 Infrared

Infrared (IR) radiation is electromagnetic radiation whose wavelength is longer than that of visible light (400 – 700nm), but shorter than that of microwave radiation .Its wavelength spans between 750nm and 100µm and is employed in Short-range communication among devices that conform to the standards published by the Infrared Data Association (IrDA).

Remote controls and IrDA devices use infrared light-emitting diodes(LEDs) to emit infrared radiation which is focused by a plastic lens into a narrow beam. The beam is modulated, i.e. switched on and off, to encode the data. The receiver uses a silicon photodiode to convert the infrared radiation to an electric current. It responds only to the rapidly pulsing signal created by the transmitter, and filters out slowly changing infrared radiation from ambient light. Infrared Communications are useful for indoor use in areas of high population density. IR does not penetrate walls and so does not interfere with other devices in adjoining rooms. Infrared is the most common way for remote controls to command appliances

3.2 Bluetooth

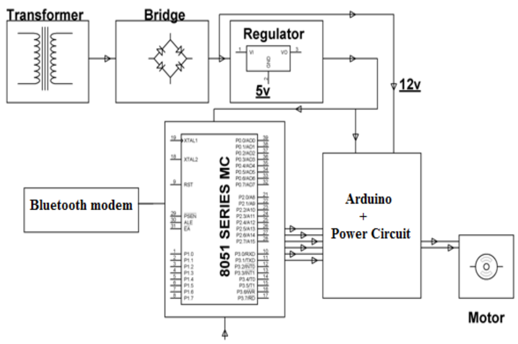
Bluetooth is an open wireless protocol for exchanging data over short distances from fixed and mobile devices, creating personal area networks (PANs). It was originally conceived as a wireless alternative to RS232 data cables. It can connect several devices, overcoming problems of synchronization. It is a standard and a communications protocol primarily designed for low power consumption, with a short range (power-class-dependent: 1 meter, 10 meters, 100 meters) based on low-cost transceiver microchips in each device. Bluetooth makes it possible for devices to communicate with each other when they are in range. Because the devices use a radio (broadcast) communications system, they do not have to be in line of sight of each other. Bluetooth uses a radio technology called frequency-hopping spread spectrum, which chops up the data being sent and transmits chunks of it on up to 79 frequencies. In its basic mode, the modulation is Gaussian frequency-shift keying (GFSK). It can achieve a gross data rate of 1 Mb/s. Bluetooth provides a way to connect and exchange information between devices such as mobile phones, telephones, laptops, personal computers, printers, Global Positioning Systems (GPS) receivers, digital cameras, and video game consoles through a secure, globally unlicensed Industrial, Scientific and Medical (ISM) 2.4 GHz short-range radio frequency band. The Bluetooth specifications are developed and licensed by the Bluetooth Special Interest Group (SIG). The Bluetooth SIG consists of companies in the areas of telecommunication, computing, networking, and consumer electronics (Wikipedia, 2009).

3.3 Ethernet

Ethernet defines a number of wiring and signalling standards for the Physical connection of two or more devices together. Ethernet was originally based on the idea of computers communicating over a shared coaxial cable acting as abroad cast transmission medium. The methods used show some similarities to radio systems, although there are fundamental differences, such as the fact that it is much easier to detect collisions in a cable broadcast system than a radio broadcast. The common cable providing the communication channel was likened to the ether and it was from this reference that the name "Ethernet" was derived (Wikipedia, 2009).From this early and comparatively simple concept, Ethernet evolved into the complex networking technology that today underlies most local area networks. The coaxial cable was replaced with point-to-point links connected by Ethernet hubs and/or switches to reduce installation costs, increase reliability, and enable point-to-point management and troubleshooting. Star LAN was the first step in the evolution of Ethernet from a coaxial cable bus to a hub-managed, twisted-pair network. The advent of twisted-pair wiring dramatically lowered installation costs relative to competing technologies, including the older Ethernet technologies. Through the physical connection, Ethernet stations communicate by sending each other data packets, blocks of data that are individually sent and delivered .Despite the significant changes in Ethernet from a thick coaxial cable bus running at 10 Mbits/s to point-to-point links running at 1 Gbit/s and above, all generations of Ethernet (excluding early experimental versions) share the same frame formats (and hence the same interface for higher layers), and can be readily interconnected. And due to the ubiquity of Ethernet, the ever-decreasing cost of the hardware needed to support it, and the reduced panel space needed by twisted pair Ethernet, most manufacturers now build the functionality of an Ethernet card directly into computer and laptop motherboards, eliminating the need for installation of a separate network card.

IV. METHODOLOGY

4.1 Block Diagram of Speed Control System



. Fig. 4.1 Block diagram of speed control system

Before the actual design of the project work, specific deliberate choices in selection of appropriate implementation platforms and hardware components were made. Priority was given to low cost availability, reliability, flexibility and simplicity in all these selections

4.2 DC Choppers

A chopper is a high speed ON-OFF semiconductor switch. It connects source to load and disconnects load from source at high speed. A power semiconductor device is used as a switch in the overall chopper circuitry. This device can be a MOSFET, a GTO or an IGBT.

4.2.1 Principle of Chopper Operation

Chopper is basically a very high speed on/off switching device. Its basic job is to connect and disconnect the load from source at a great speed. In this way the constant dc voltage is chopped and we obtain a variable dc voltage. There are basically two time periods in chopper operation, one is the "on" time denoted as ton and other is the "off" time denoted as toff. During ton we get the constant source voltage versus across the load and during toff we get zero voltage across the load. The chopper plays the role of providing this pattern of providing alternate zero and Vs. In this way we obtain a chopped dc voltage in the load terminal 5.3 Block Diagram

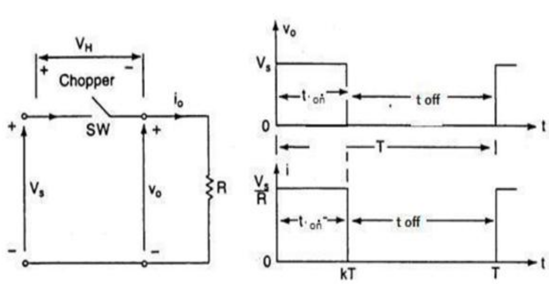


Fig. 4.2: Circuit diagram & Wave form of chopper

Vo = Average output voltage of the circuit

Vs = Source voltage of the circuit

Vo = ton/ (ton + toff) × tonton / (ton + toff) = Duty cycle denoted by α.

Thus we see that we can control the average output voltage by varying the duty cycle.

4.3 PWM-Pulse Width Modulation

One simple and easy way to control the speed of a motor is to regulate the amount of voltage across its terminals and this can be achieved using "Pulse Width Modulation" or PWM.

As its name suggest, pulse width modulation speed control works by driving the motor with a series of "ON-OFF" pulses and varying the duty cycle, the fraction of time that the output voltage is "ON" compared to when it is "OFF", of the pulses while keeping the frequency constant.

The power applied to the motor can be controlled by varying the width of the applied pulses and thereby varying the average DC voltage applied to the motors terminals. By changing or modulating the timing of these pulses the speed of the motor can be controlled, ie. the longer the pulse is "ON", the faster the motor will rotate and likewise, the shorter the pulse is "ON" the slower the motor will rotate.

In other words, the wider the pulse width, the more average voltage applied to the motor terminals, the stronger the magnetic flux inside the armature windings and the faster the motor will rotate.

4.3.1 Pulse Width Modulated Waveform

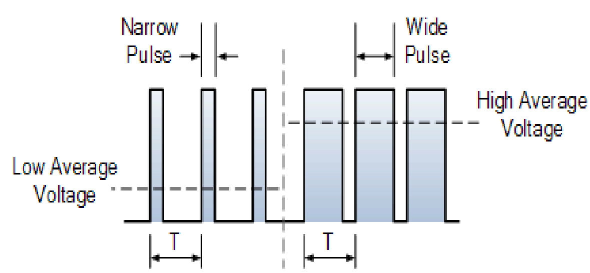


Fig. 4.3: Pulse Width Modulated Waveform

4.4 Power MOSFET

Power MOSFET is a type of MOSFET which is specially meant to handle high levels of power. These exhibit high switching speed and can work much better in comparison with other normal MOSFETs in the case of low voltage levels. However its operating principle is similar to that of any other general MOSFET. Power MOSFETs which are most widely used are n-channel enhancement-mode or p-channel enhancement-mode, n-channel depletion-mode or p-channel depletion-mode in nature.

4.4.1 MOSFET as a Switch

MOSFETs exhibit three regions of operation viz., Cut-off, Linear or Ohmic and Saturation. When the MOSFETs are required to function as switches, they should be biased in such a way that they alter between cut-off and saturation states. This is because, in cut-off region, there is no current flow through the device while in saturation region there will be a constant amount of current flowing through the device, just mimicking the behavior of an open and closed switch, respectively.

A simple circuit uses n-channel enhancement MOSFET as a switch. Here the drain terminal (D) of the MOSFET is connected to the supply voltage VS via the drain resistor RD while its source terminal (S) is grounded. Further, it has an input voltage Vi applied at its gate terminal (G) while the output Vo is drawn from its drain.

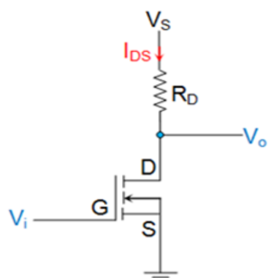


Fig. 4.5: n-channel enhancement-type MOSFET functioning as a switch

4.5 Arduino

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 programmed (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.

4.6 Steps for the project execution.

Step 1: Open the android app, it asks for Bluetooth connection.

Step 2: once the app is opened, scan for the Bluetooth device and connect to HC-05.

Step 3: give the message from app for increasing or decreasing the speed.

Step 4: The message is received by microcontroller and processed message is sent to Arduino.

Step 5: PWM program is dumped in Arduino. It gives the required output and the motor speed changes with respect to the message given by the user from the app.

The flow for execution steps is shown below

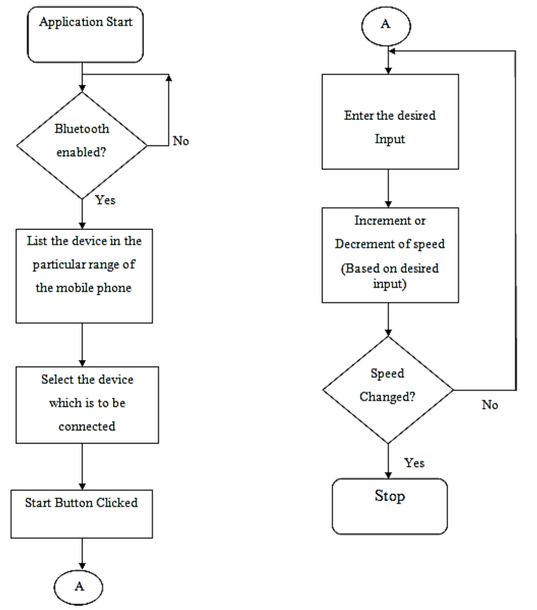


Fig 4.1 Flow chart for the Project execution

V. DESIGN AND IMPLEMENTATION

5.1. Power ratings of the dc motor used are:

- Armature circuit : 180V,3A
- Field Circuit: 220V,0.4A
- Speed :15000rpm

5.2 Circuit Diagramfor proposed project

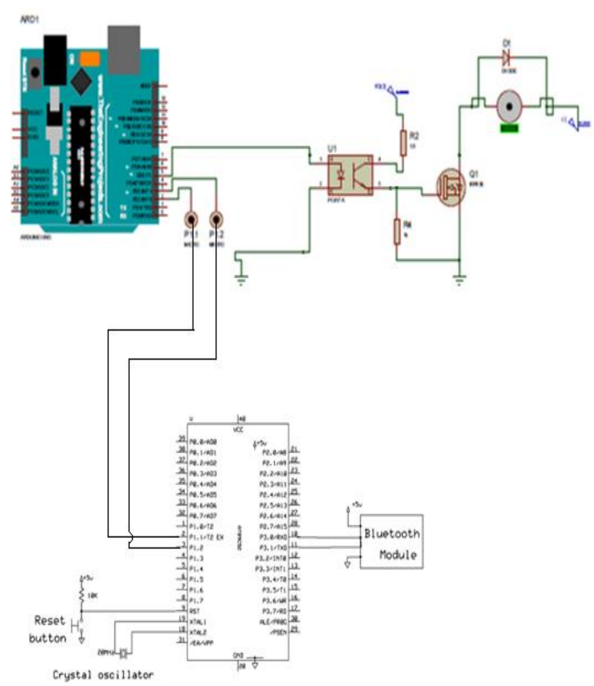


Fig.5.1 Circuit Diagram of Actual implementation

The aim of this project was to remotely control home devices via an Android Smartphone. We the message is given by user from android app. This message is received by Bluetooth module by Bluetooth communication. This signal is received by microcontroller at input pins 1 and 2 of port 1. Pin 1 is configured for "speed up" and pin 2 is configured for "speed down". Once the signal is processed, the processed signal is given to Arduino at input pins of 2 and 3. Pin 2 is for "speed up" and pin 3 is for "speed down". The PWM program is dumped in Arduino. The output is taken from 5th pin of Arduino and is given to the gate of MOSFET, which will switch to vary the voltage across the armature and hence variation in speed is achieved.

VI. RESULTS AND DISCUSSION

Specifications of the DC motor used

Power Rating: 0.5HP

Armature Circuit : 180V,3A

Field Circuit : 220V,0.4A

Speed : 1500rpm

By making the circuit connections as shown in the fig 5.1 the experiment was conducted for separately excited DC motor. The experiment was conducted in two steps. In the first step, field current was fixed at 0.3A and readings of armature voltage as well as corresponding speed were noted down. In the second step armature voltage and corresponding speed were noted down by keeping field current at 0.4A.The readings are tabulated as shown below.

6.1 Observation

Case:1

Supply voltage=110 V

Field current I= 0.3 A

Sl. NO.	Armature Voltage in volts	Speed In RPM
1	20	175
2	30	243
3	40	324
4	50	410
5	61	504
6	70	548
7	80	658
8	90	738
9	100	800
10	110	878

Table 6.1

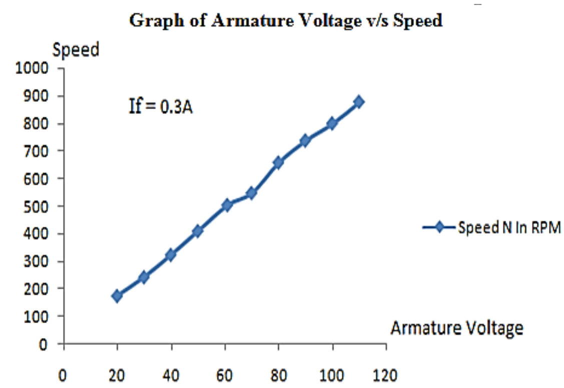


Fig 6.1 Graph of Speed Vs Armature Voltage

Case: II

Supply voltage=110 V, Field current I= 0.4 A

Sl. NO.	Armature Voltage	Speed N In RPM
1	20.1	150
2	30	215
3	40	298
4	51	387
5	62	477
6	70	537
7	81	630
8	91	706
9	100	780
10	110	850

Table 6.2

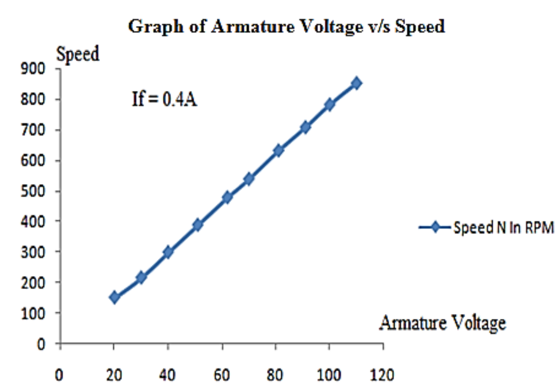


Fig 6.2 Graph of Speed Vs Armature voltage

As it is a known fact that field current is inversely proportional to the speed. For 0.3A of filed current higher speed values were obtained as compared to the speed values when the filed current was 0.4A.

The speed is directly proportional to armature voltage. When the armature voltage was increased in steps the speed was getting increased proportional to the armature voltage.

VII. CONCLUSION

During no-load conditions, the speed control of the separately excited DC motor is achieved with the help of Android mobile application using Bluetooth technology. In this way wireless communication is also achieved. During load conditions, the speed of the motor oscillates around the desired speed for small time and then reaches the desired speed. During over-load conditions, the motor stops rotating and remains stand still. Hence, The Speed Control of separately excited DC motor using microcontroller by using PWM may be a comprehensive system that controls the speed of a motor by giving instructions to the microcontroller to reduce the hardware control circuitry. This method provides better size and cost effectiveness. Android mobile is used as a remote to vary the speed of the separately excited DC motor. This project provides better speed regulation.

7.1 Future Scope

The closed loop control of DC motor using microcontroller can be successfully implemented. Even with a change in load, the speed of the motor can be maintained constant. In future, apart from controlling the speed, even the direction of rotation of DC motors can be altered. The same technique can be implemented in both single phase and three phase AC motors as well. For long range wireless communication WIFI-module can be used. By introducing PID control we can achieve better response. It is also possible to design fuzzy PID control of DC motor by using fuzzy rules in this concept. Touch screen technology can also be implemented.

REFERENCES

[1] G. A. P. RakaAgung, S. Huda, "Speed Control for DC Motor with Pulse Width Modulation (PWM) Method Using Infrared Remote Control Based on ATmega16 Microcontroller" IEEE transactions on , ISBN :978-1-4799-6127-6
[2] K.S Ravi Kumar, Jaideep, "Microprocessor Based Closed Loop Speed Control of DC Motor Using PWM", International Conference on Control, lnstrumentation, Communication and Computational Technologies (2015)
[3] K.A.Wadile, S.R.Chillarge, D.D.Jadhav,"Speed Control and Direction Control of Dc Motor Using Arm7", IJECS Volume 4 Issue 2 February, 2015.
[4] B.Gokul, K.Karthi, "Android Based Closed Loop Speed Control of DC Motor Using Voice Recognition via Bluetooth", IJAREEIE, Vol. 5, Issue 3, March 2016.
[5] K.S. Varsha, P. SudharshanPalaniappan, "Speed and Direction Control of DC Motor using Android Mobile Application", International Journal of Engineering Science and Computing, March 2017

AUTHORS

Ramesh G B
Assistant Professor,
Dept. of E&E,
Gogte Institute of Technology (GIT),
Belagavi,
Karnataka, India--590008.

Nikhil R Chitragar
Assistant Professor
Dept. of E&E, Gogte Institute of Technology (GIT),
Belagavi,
Karnataka, India--590008