Direct Current (DC) Motor Speed and Direction Controller

Nurshahirah Shaharudin¹, Mohd Zamri Hasan¹ and Syatirah Mohd Noor¹

¹Faculty of Electrical Engineering Technology, Universiti Malaysia Perlis, Perlis, Malaysia.

Email: zamrihasan@unimap.edu.my

Abstract. The direct current motor is an important drive configuration for many applications across a wide range of power and speeds. It has variable characteristics and is used extensively in variable-speed drives. The goals of this project are to control the direction and speed of a Direct Current (DC) motor. Due to the advancement of wireless technology, there are several communication devices introduced such as GSM, Wi-Fi, ZIGBEE and Bluetooth. Each of the connections has its own unique specification and application. Among these wireless connections, Bluetooth technology is often implemented and can be sent from the mobile phone at a distance of 10 meters. The speed control was implemented using Bluetooth technology to provide communication access from a smartphone. Instead, the ARDUINO UNO platform can be used to quickly promote electronic systems. And an electronics technique is called Pulse Width Modulation (PWM) is used to achieve speed control, and this technique generates high and low pulses, then these pulses vary the speed in the motor. In order to control this PWM pulse, variable resistors are used and depend on it the speed of the DC motor will increase or decrease. The variable resistor is adjusting to varying the speed of the motor, and the higher the resistance the lower the speed of the motor rotates. The direction of the motor is controlled by the relay by giving and giving a command on the virtual terminal. The speed of the motor is directly proportional to the resistance as the speed increased after the resistance also increased and vice versa. The significance of this study is practical and highly feasible from the economic point of view and has the advantage of running the motor at a higher rating in term of a reliable, durable, accurate and efficient way of controlling speed and direction control.

1. Introduction

The direct current (DC) motor means electrical energy converts to mechanical energy and is always used in industries. The application of speed controllers used on a large scale, easy and used in many ways. In most applications, speed and direction are very important. The purpose of a motor speed controller is to take a signal representing the demanded speed and to drive a motor at that speed. There are a lot of applications where control of speed is needed, as in drilling machines, conveyer, lift and elevators. These applications may demand high-speed control accuracy and good dynamic responses. In-home appliances, washers, dryers and mixers are good examples of the usage of the motor.

There are numerous applications in our life that require DC motor speed control. DC motors have the ability to change speed, torque and direction at any time to meet the new condition. At low speed, DC motors are able to provide a high starting torque, and it is possible to obtain speed control over a wide range. DC motors are suitable in many applications, for example, conveyors, turntables and others for which adjustable direction and constant or low-speed torque are required. The DC motor can also work in dynamic braking and reversing applications, which are usually used in many industrial machines. So, the study of controlling the DC motor is more practical and important [1]. Nowadays the
majority of the industries use DC motors in their machines. So, speed and direction controlling of DC motors play a very important role [2]. The past years have brought standards for the use and conservation of power, leading engineers all around the world to build low-power consumption. Nowadays, our day-to-day life becomes very vast, so it is not possible for industries to go to the workplace and control motor working. All home appliances are preferred to control wired and wireless mechanism. For example, the previous technology only used a remote control to control the speed of the motor such as a ceiling fan or a switch to operate the machines. By using wireless control, eliminates the need for the operator to be in direct contact with running machines. This brings to the importance of the control of DC motors. 

The motor needs to vary the speed because some machines need to operate more than one speed. Thus, the following challenges are encountered: speed control of DC motor needs to vary the value of the resistor to get a different value of speed. Next, the rotation of the motor is important because it makes it more functional. The previous technology like conventional exhaust a fan is able to rotate in one direction only [3]. So, the project needs to drive a DC motor for the required application in clockwise and anti-clockwise directions. In this project, the aim is to simulate the speed and direction of the DC motor using Proteus software. Next, it is to measure the speed of the DC motor after it is varied by using a variable resistor and to control the rotation of the motor using a mobile phone.

2. Methodology

Figure 1 shows a block diagram of DC motor speed and direction controller. In general, terminal mode chooses to write the instruction from the Bluetooth application "Arduino Bluetooth" and the signal will be sent to Arduino via Bluetooth Module HC-06. Then Arduino will send the signal to the motor driver, and the motor will rotate according to the command sent through the Bluetooth as shown in Figure 1.

![Figure 1. The block diagram of the DC motor speed and direction controller.](image)

2.1 Software Development Process

Proteus was designed to be easy to use, readable and consistent. Proteus has everything needed such as to develop, test and virtually prototype designs. This design allows engineers to develop their projects more quickly and empowering them with the flexibility to make hardware and reduce time to design. For this project, Proteus software needs to be used by connecting the entire circuit. The circuit comprises the triggering circuit, supply and virtual load connections [4-5]. Figure 2 shows the circuit diagram drawn by using Proteus 8 Professional. The Variable resistor is connected with the Arduino and depends on the value of that resistor given; the DC motor speed will either increase or decrease. The relay is simulated in a simple circuit in which when you run the simulation, the relay will automatically activate and control the relay using logic. For example, when you provide 5 V to it and
then the relay will go activated, and when you give GND, then it will de-energize and vice versa. But this simulation is connected to PWM and GND. The relay acts as a switching as the command is given to the virtual terminal.

**Figure 2.** Circuit diagram by using Proteus software.

2.2 Hardware Development Process

Hardware development is developed after the simulation is working successfully. The circuit was tested on a breadboard first before fully transfer to the printed circuit board (PCB) because to check the circuit whether it is working well or not. After a few tests and troubleshoot, the circuit is transferred to PCB for the last progress. Figure 3(a) shows the components used in hardware development. The circuit first, as in Figure 3 (b) tests and troubleshoot the circuit if there is any fault or error during the circuit is connected.

**Figure 3.** (a) Component Hardware Development, (b) Hardware circuit diagram on the breadboard

After being satisfied with the circuit and it is functioning well, then the circuit transferred to PCB. On PCB, the interconnection between the components is made through copper tracks instead of using a number of current-carrying wires. It makes the interconnections less bulky and better presentation.
A typical PCB offers a simple platform to arrange the electronic components in a compressed and efficient way. This compactness allows the creation of big and complicated electronic circuits in small form factors. This, in turn, takes less space in devices. For the communication device between a mobile phone and Bluetooth, and apps, Arduino Bluetooth Controller is installed at the play store. As the Bluetooth used HC-06, so it will connect to a device. After a successful connection, there are a few modes popping up on the screen, and Terminal mode is chosen as the command [6-8]. Figure 4 shows the final product of hardware development with different views. The circuit, power supply and motor are put in a Perspex box. The blade of the motor is used to show the motor rotating in which direction. The variable resistor is put at the side of the box, so it is easier to control the motor without opening the box.

Figure 4. Final product (a) Side view, (b) Top view

3. Results and Discussion

Theoretically, the motor is measured using the tachometer to get the speed of the motor in rpm. As the resistance is increased, the speed of the motor decreased. This is because PWM is produced by the transistor driving the motor with ‘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 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. Two types of variable resistor were used to compare the speed of the motor by using a different value of resistance. Table 1 is the information of the motor and variable resistor 10 K\(\Omega\) and 1 M\(\Omega\). Figures 5 and 6 show the result of the speed of the motor by using a variable resistor 10 K\(\Omega\) and 1 M\(\Omega\) respectively.

| Supply Voltage | Current Motor | Motor Type | Variable Resistor |
|---------------|--------------|------------|------------------|
| 9 V           | 0.03 A       | 6 to 24 V  | 10 K\(\Omega\)   |
| 9 V           | 0.03 A       | 6 to 24 V  | 1 M\(\Omega\)    |

Figure 5 shows the variety of behaviour of the graph after obtaining the data from the hardware. The higher the resistance, the lower the speed of the motor. The resistor limits torque and protects the motor from being damaged by a high current. If the armature resistance is an increase, the drop across armature increases, which causes the speed to decrease. Increasing the total voltage will increase the speed of the motor. The current and voltages also drop as the resistance increases as shown in Figure 5.
Figure 5. Graph current, mA and voltage, V of motor versus speed of motor, rpm for 10KΩ

Figure 6. Graph current, mA and voltage, V of motor versus speed of motor, rpm for 1MΩ

Figure 6 shows the various behaviour of the graph after obtaining the data from the hardware. The graph shows the higher the resistance, the lower the speed of the motor. But this resistance is higher, so the speed drops slower. The resistor limits torque and protects the motor from being damaged by a high current. If the armature resistance is an increase, the drop across armature increases, which causes the speed to decrease. Increasing the total voltage will increase the speed of the motor. The current and voltages also drop as the resistance increased. The current is smaller than the previous current, and it is almost 0 A.

Table 2 shows the result of the direction control using a mobile phone. The commands are typed on the terminal mode either C, A or S to change the direction. The LEDs also light up according to the rotation of the motor. Both LEDs will light up if the motor is signaling the LED to stop. The speed of the motor depends on the variable resistor when the shaft of the variable resistor is turned during the command sent. The motor takes time to change the direction from clockwise to anti-clockwise or vice versa because the motor needs to slow down until 0 rpm, then the direction will change.
Table 2. Result direction of the motor.

| Command | Direction          | Speed, rpm | LED          |
|---------|--------------------|------------|--------------|
| C       | Clockwise          | 8422       | Yellow       |
| A       | Anti-Clockwise     | 8422       | Green and    |
|         |                    |            | Yellow       |
| S       | Stop               | 8422       | Yellow and   |
|         |                    |            | Green        |

4. Conclusion
The control of the DC motor has been developed by using Bluetooth technology as one of the wireless connection technologies, which is widely available in mobile phones and computers. The proposed project is to simulate the speed and direction of a DC motor using Proteus software. The simulation is successfully done after all the LEDs and motor functioned as expected. The speed of the motor is also successfully done after varying the speed by using a variable resistor but by using a 9 V power supply and 6 to 24 Vdc motor. Two variable resistors were used to see the difference between speed, voltage and current produced. The direction of the motor by using Bluetooth and a mobile phone is barely achieved because it is not working as expected as in the simulation. The Bluetooth was connected with the phone, but the transmission is not received well between Bluetooth and mobile phone.

References
[1] Varsha K S, Sudharshanpalaniappan P, Susmithaa S and Raj 2017 *M P Int J.*
[2] Manikandasanthosh C, Rajesh K, Rajeswaran G and Sathish R 2016 *International Journal of Advanced Research in Science, Engineering and Technology*. 1647–1651.
[3] Shubham B, Sandipta M, Bhaskar S and Arnab J M 2018 *Int. J. Adv. Sci. Eng. Technol*. 5 6592–6596.
[4] Ramesh G B and Chitragar N R 2017 *Int. J. Latest Technol. Eng. Manag. Appl. Sci*. 6 192–198.
[5] Ankesh A M D, Nichat N, Ali S K, Yogesh D S and Amit M D 2015 *Int. J. Eng. Trends Technol*. 20 48–51.
[6] Chandra P, Anand P and Chantola P C 2014 *Int. J. Mech. Ind. Eng*. 1 86–90.
[7] Yadav S, Khan P, Chauhan S and Chauhan Y 2015 *Int. J. Res*. 1 1719–1724.
[8] Tyagi A, Shukla A, Yadav A, Ah K, Gupta M and Shukla M 2017 *Int. J. Eng. Sci. Comput*. 7 4768–4771.