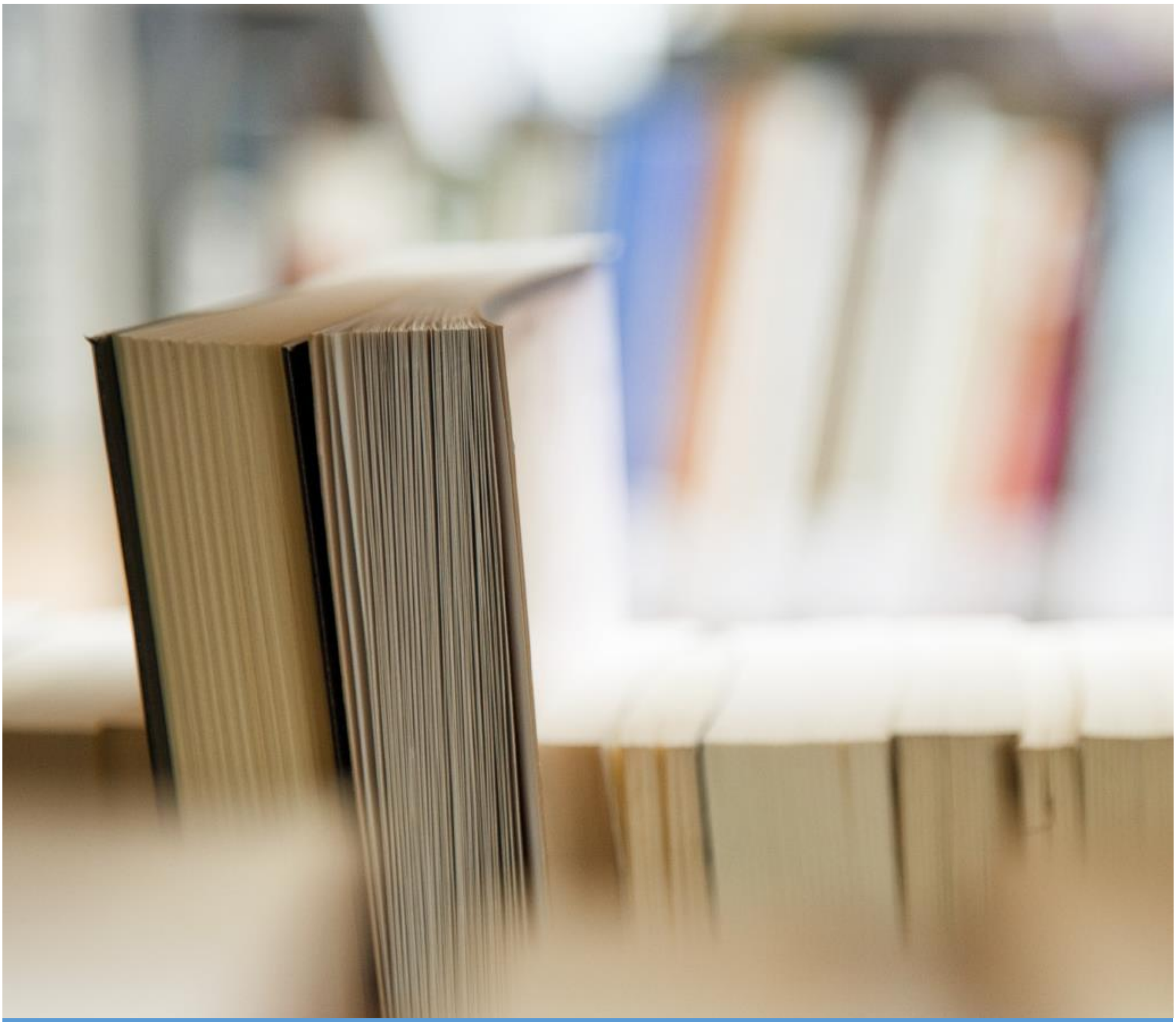

David Akang

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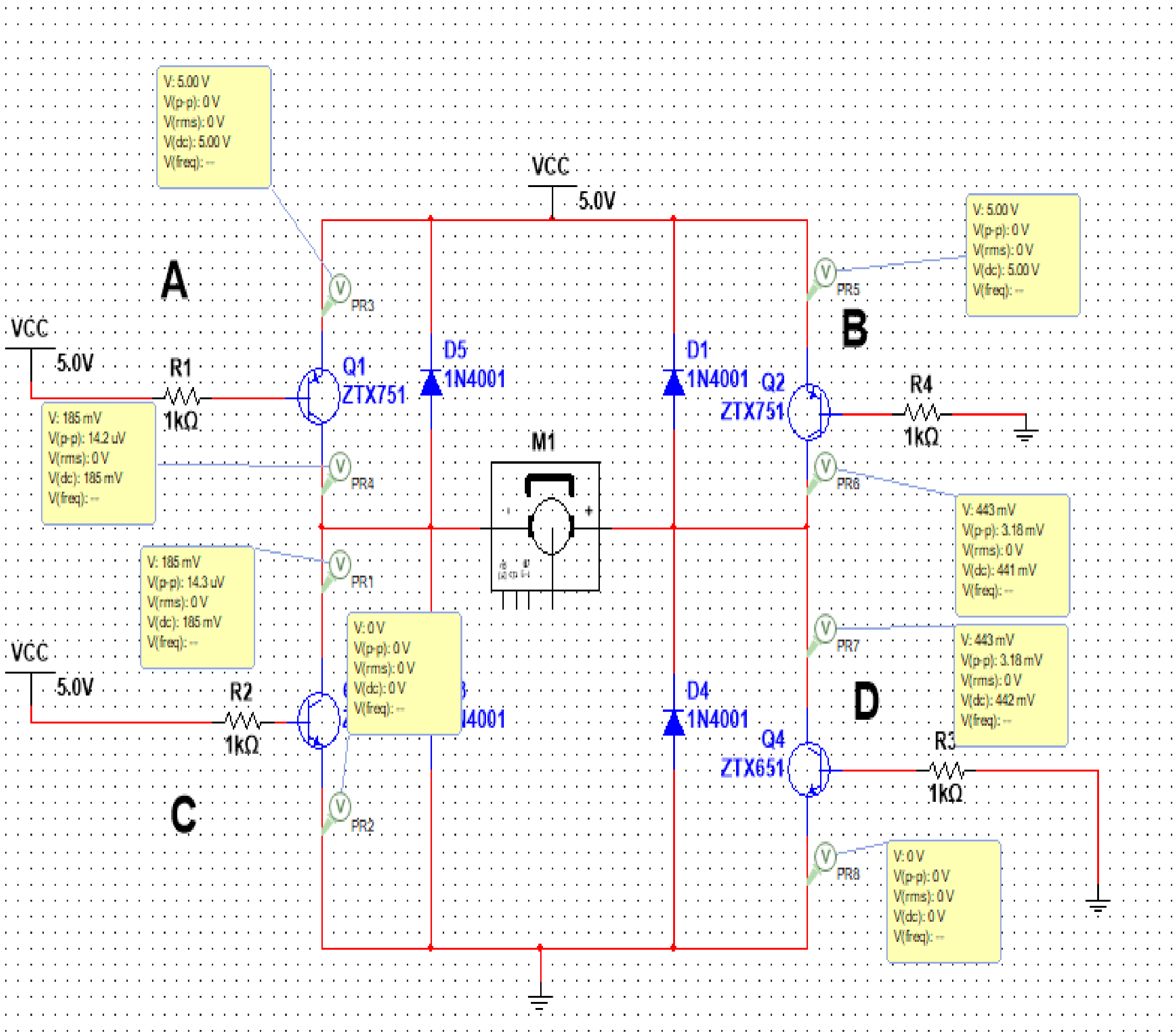
Task 1

Multism Simulation

1. In forward and reverse rotation, note the Base-Emitter (V_{BE}) and Base-Collector (V_{BC}) Voltages for each transistor used.

Forward Rotation

Transistors	Base-Emitter (V_{BE})	Base-Collector (V_{BC})
(A) ZTX 751	5V	180mV
(B) ZTX 751	5V	1.92V
(C) ZTX 651	0V	178mV
(D) ZTX 651	0V	330mV



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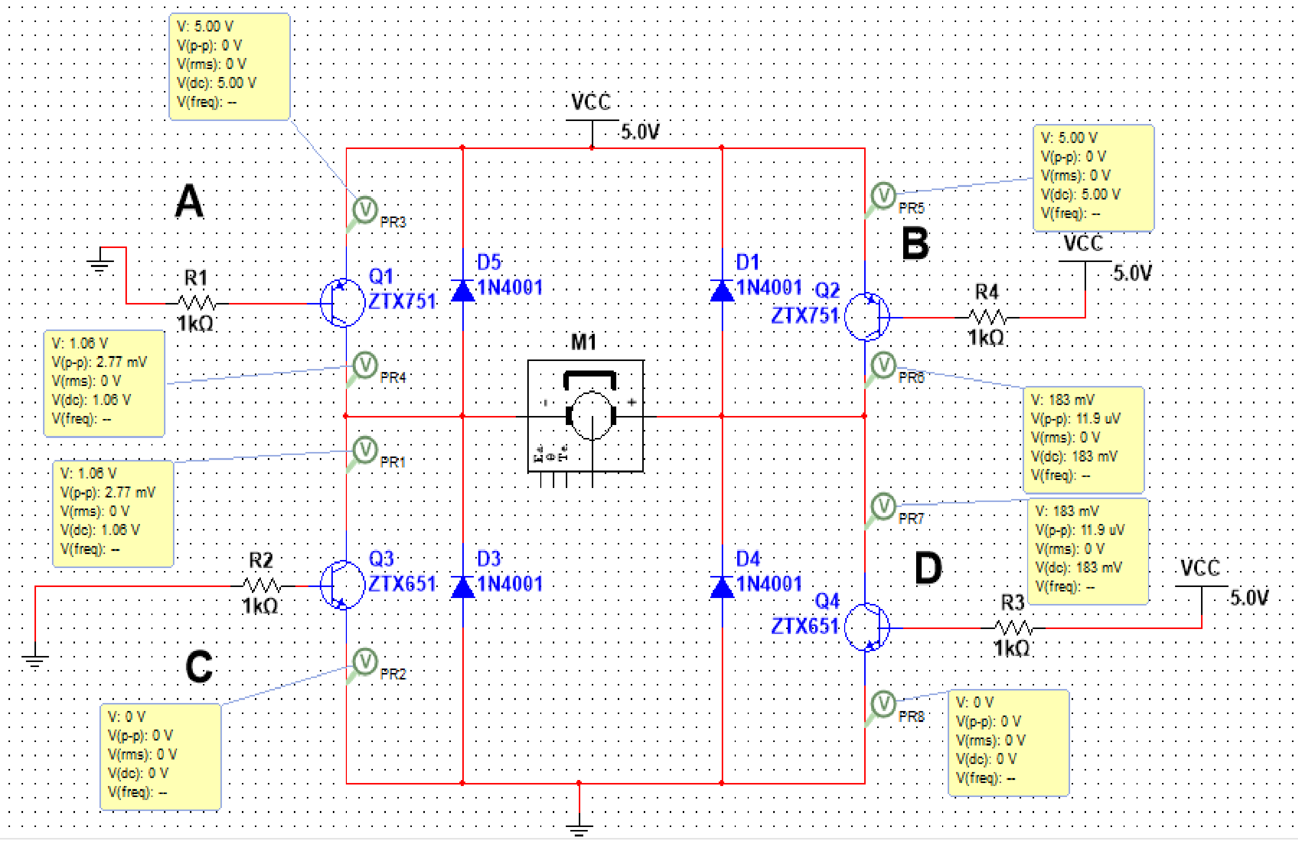
Reverse Rotation

Transistors	Base-Emitter (V_{BE})	Base-Collector (V_{BC})
(A) ZTX 751	5V	1.06V
(B) ZTX 751	5V	183mV
(C) ZTX 651	0V	1.06V
(D) ZTX 651	0V	183mV



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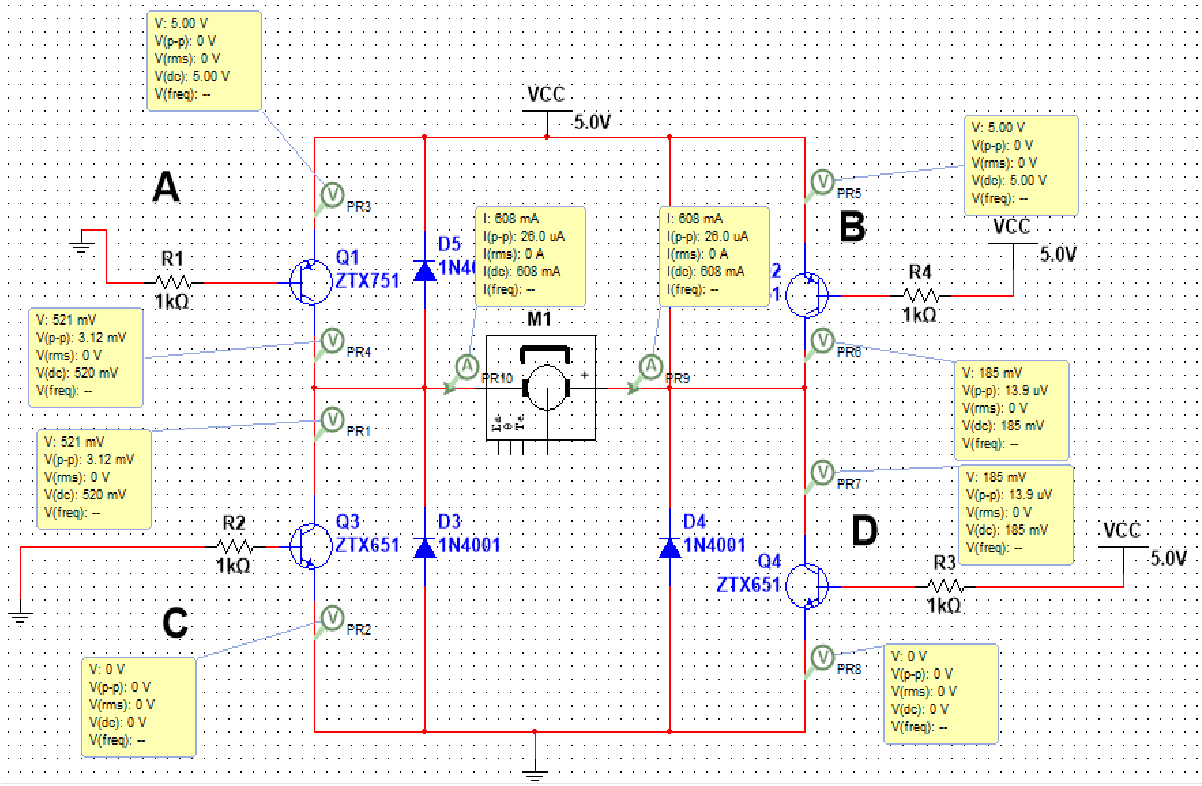
What is the operating current for the DC-Motor in each case?

Reverse Rotation

(-608mA)



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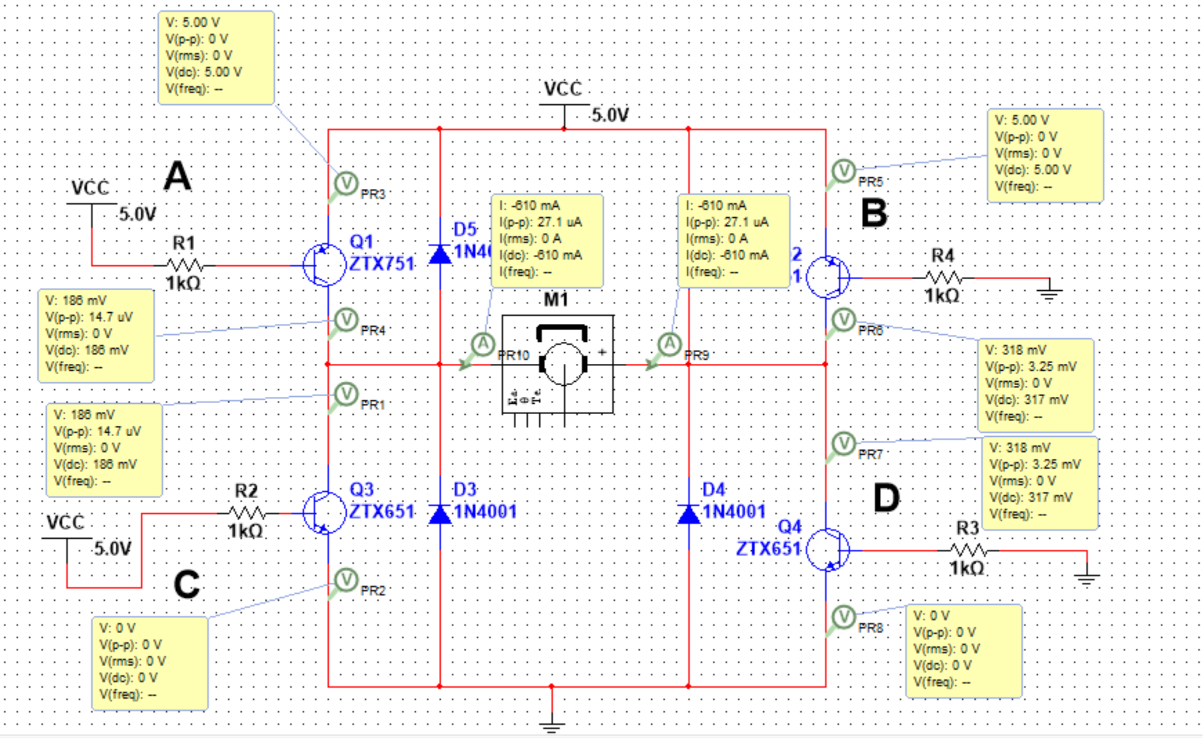
Forward Rotation

(608mA)



2. For all possible combinations of the transistor acting as 'switches' (open – close), note what happens to the DC-Motor, in terms of voltage difference across motor's terminals.
   Table showing transistors and voltage across motors.

(A) ZTX 751	(B) ZTX 751	(C) ZTX 651	(D) ZTX 651	Voltage Across Motor (Volts)
Open	Close	Close	Close	-0.113V
Open	Close	Open	Close	-0.224V
Close	Open	Close	Open	0.133V
Close	Open	Open	Open	0.016uV
Open	Open	Open	Close	-0.057V
Close	Close	Close	Open	6.721nV
Open	Close	Close	Open	0.205nV
Close	Open	Open	Open	6.52nV
Open	Open	Close	Open	0.057V
Close	Close	Open	Open	0.048pV
Open	Open	Open	Open	0.75pV
Open	Open	Close	Close	0.031pV
Close	Close	Close	Close	0V
Close	Close	Open	Close	-6.415nV
Open	Close	Open	Open	-7.922nV
Close	Open	Close	Close	0.046V

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Task 2:

DC-Motor Voltage-Speed Characteristic

Aim: Determine the voltage speed characteristic of a Dc-Motor

The voltage across a dc motor with a fixed load is directly proportional to the speed of the motor, thus an increment in the supply voltage will lead to an increase in the speed of the motor. Likewise a decrement in the supply voltage will lead to a reduction in the speed of the motor.

This activity would involve using a Hall Effect sensor, which is used to measure the magnitude of magnetic fields.

Apparatus:

The following apparatus were used to conduct the experiment:

1. 0- 5 Volts Power supply Unit.
2. Hall Effect Sensor.
3. Tektronix TDS 1002 Oscilloscope.
4. Crocodile clips.
5. Wires.
6. DC Motor.

Experimental Procedure:

The following procedures were used in implementing the experiment:

1. Connect the motor to a DC Power source, then connect the Hall Effect sensor to the motor.
2. Increment the DC motor voltage from 0V to 5V, using the Tektronix TDS 1002 Oscilloscope, depict the Hall Effect output.
3. The oscilloscope was used to depict the time needed for 10 full rotations.
4. Depict in a diagram the voltage speed characteristic

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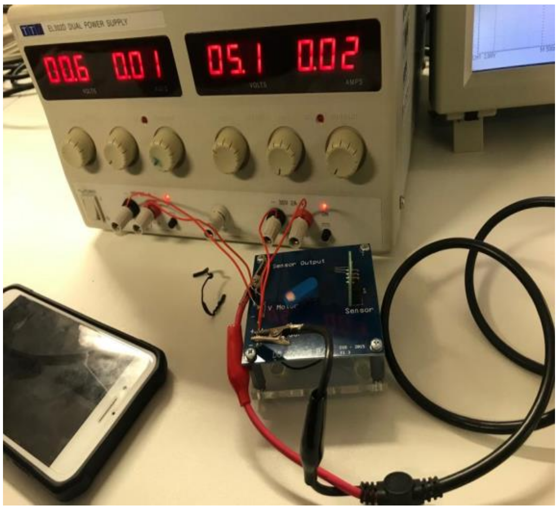
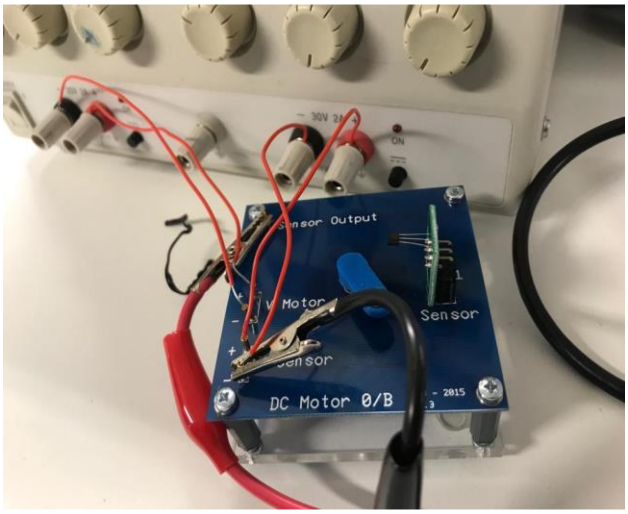
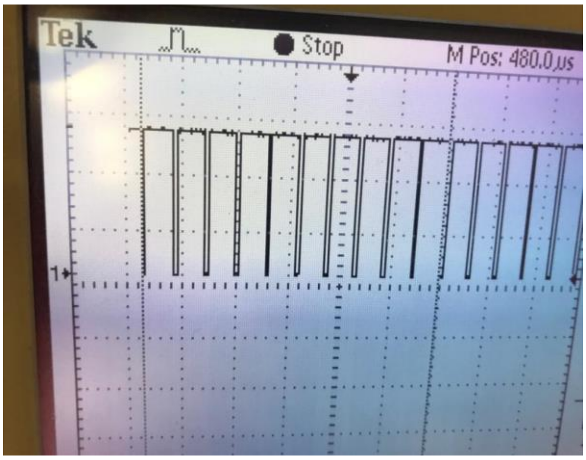
Snapshots:







Results:

Figure 1. Table showing 10 full rotations for each case

V_M (V)	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
T_{10R} (msec)	2840	1400	910	670	510	436	434	326	290	258
ω_r (RPS)	22.124	44.880	69.046	93.779	123.200	144.110	144.774	192.736	216.662	243.534
ω_r (RPM)	1327.440	2692.800	4142.760	5626.740	7392.000	8646.000	8686.440	11564.160	12999.720	14612.040

Where $\omega r = 10.2n/\text{change in } T$…………………….Equation 1

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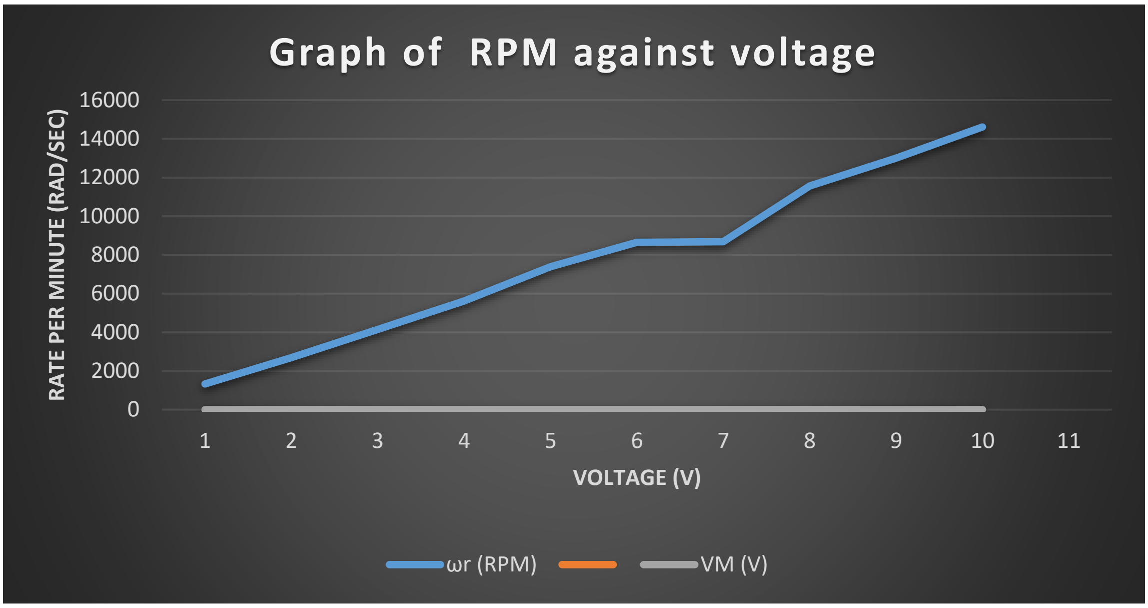
Figure 2. Voltage- Speed Characteristic of Motor



Conclusion:

As seen in the graph in figure 2, the voltage across the motor is directly proportional to the rate at which the motor turns per minute. As the input voltage increments from 0V to 5V, the rpm also increases from 1327.44rps to 14612.04rps. This proves that voltage across a motor with a fixed load is directly proportional to the speed of the motor.

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Task 3:

H-Bridge Implementation

Evidence of correct operation:

https://youtu.be/v7JYvssyILQ

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Task 4:

Introduction:

They are various ways of controlling the speed of DC motors, one of which is by using a variable resistor. They are also referred to as rheostats, they are able to control the current by controlling the current. Practically, they are no more used to control the speed of motors due to its low efficiency which arises from the heat loss derived from the high tension and power flowing through it. This led to pulse width modulation, which is a great method of controlling the amount of power delivered to a load without dissipating wasted power. (Electronics-tutorials, n.d.)

Pulse width modulation (PWM) refers to a modulation technique whereby the amplitude of digital signals are controlled and moderated; in order to control devices or equipment's which require power (techtopedia, n.d). It is also used to moderate the speed of DC Motors. The importance of this technique is that it ensures that excess current is not burned off as heat thereby reducing energy loss.

Moreover, PWM signals work by pulsating digital current, this is done by controlling the amount of time a pulse stays 'on' and 'off'. Pulse width modulators are able to do this, due to the fact that these signals are digital in nature- thus consisting of 1 and 0 as shown in figure 3.

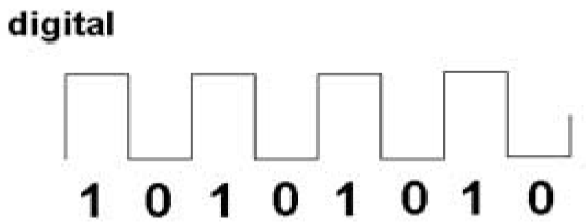

Figure 3 (Digital Signal)

Also, the working principle of these signals is based on the pulse time and duty cycle. The duty cycle specifically describes the time a digital signal is on over an interval or period of time, it is measured in percentage. (Learn.sparkfun.com, n.d.). If the signal is on for half of the time, the duty signal is said to have a duty cycle of 50%. Likewise, if the signal is on for 25% of the time the duty cycle is said to be 25%. Thus, when the duty signal is above 50, the signal is said to spend more time in the high side. On the other hand, if the duty cycle is less than 50%, the signal is said to spend most of the time in the low state. Consequently, a 100% duty cycle would equate to the input voltage from the source and 0% duty would correspond to grounding.

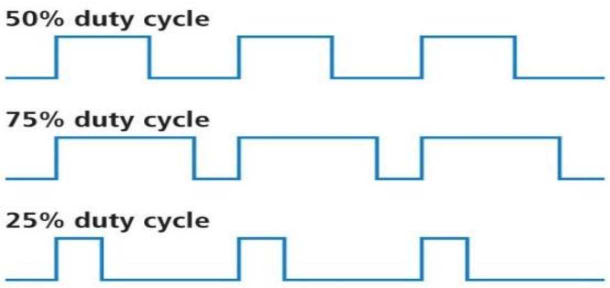

Figure 4: *50%, 75%, and 25% Duty Cycle Examples* (SparkFun Electronics, n.d.)

In addition, while controlling motor speed, PWM signals are used in conjunction with H-bridges; typical H-bridges consist of four diodes, two PNP transistor and two NPN transistor which enable it to control the direction of the applied voltage. The diodes provide a route for the back Emf to be easily dissipated. As seen in figure 5, when point D is pulled to Vcc and A is grounded, current flows in a clockwise direction which makes the motor to rotate forward. Likewise, when B is grounded, and C is pulled to Vcc, current will follow in the opposite direction which would lead to a backward rotation.

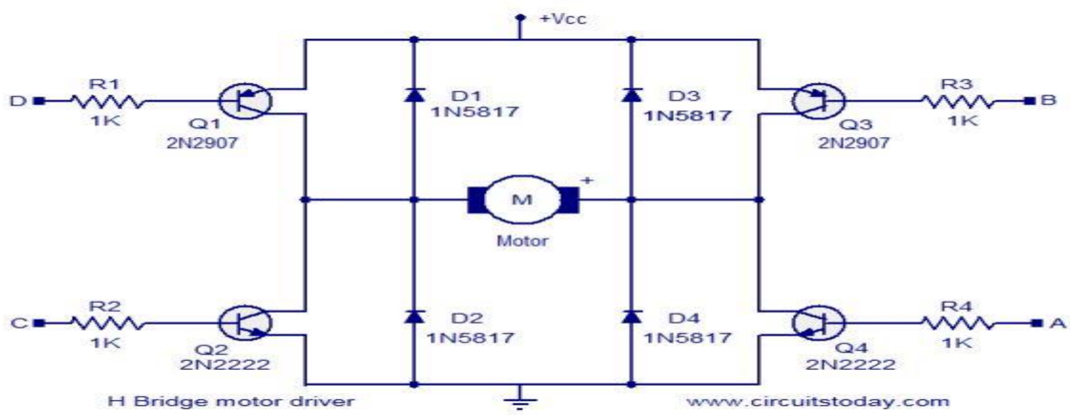

Figure 5: H-Bridge (Circuits Today, n.d.)

Furthermore, PWM signals are often used to drive H bridges, the logic pins would be controlled by using pulse width modulators. Function generators are responsible for producing these pulses. This controls the Input logic of the motor and consequently decide the movement of the motor.

Also, they are other forms of speed control available apart from the H-Bridge. They are flux control methods and armature control methods. Flux control entails the speed being controlled by decreasing and increasing, by implementing the flux the speed decreases and decrementing the flux the speed increases. This is expressed mathematically as shown in Equation 2

$$N \propto K\,Eb/Ø \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{Equation 2}$$

(Where k is a Constant, N is speed in rpm, Eb is Back-emf and Ø is flux)

From the formula, we can see that Speed (N) is indirectly proportional to the flux. Adding resistance in the coil will reduce the flux in the cell and lead to an increase in the speed, vice-versa.

Likewise, for the armature control method, the speed is regulated by using a variable resistor which controls the voltage across the armature. So to decrease the speed of the dc motor, a resistor is connected in series with the armature. This is because as seen in equation 2, the speed of the motor is directly proportional to the back-emf. So consequently, the greater the resistance in series with the armature, the slower the dc motor would be. (Daware, 2017)

In conclusion, the PWM and H-bridge configuration is a viable option industrially because it minimises power losses.

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