Department of Electrical Engineering

Term Project

Power Electronics

BS 8TH (Fall 2019)

Instructor: Engr. Shayan Tariq Jan

Attributes Coverage																
PLOs												EA1	EA2	EA3	EA4	EA5
1	2	3	4	5	6	7	8	9	10	11	12					

The Term Project is of 20 marks and will count as 20% weightage of your whole grade.

Proposal is of 5 marks (5% of total weightage)

Final Report is of 15 marks (15% of total weightage)

Task: To write a report on the complete analysis of a Power Electronics Application.

Due Date: End of semester.

Final Report

Problem Description

1. Select any one switching device from the following list and state its characteristics
   a. Power diode
   b. Thyristors (SCR)
   c. Bipolar -Junction Transistor (BJT)
   d. Metal-Oxide-Semiconductor Field-Effect Transistor (MOSFET)
   e. Insulated-Gate Bipolar Transistor (IGBT)

2. What are the merits and demerits of your selected switching device as compared to the others?

3. Select one power electronics circuit (rectifier, invertor, DC converter) in which your selected switch is used.

4. Explain the working of the circuit, what is the purpose of the switch in this circuit and what are the jobs of the other components used in the circuit.

5. Select one application of your selected circuit. Explain the application in detail and the purpose/working of your selected circuit in the application.

6. Design the complete circuit of your selected application.

7. What are the parameters of your circuit (input and output power, current and voltage).

8. State the equations used for deriving the values of the components. Mathematically derive each value of your component.

9. Using Multisim or Matlab simulate your circuit. Show and explain the results of your simulation.

10. Write your conclusion about the project.

Templet

1. All text should be in Times New Roman font.
2. Headings should be **bold** and in **14** size.
3. Sub-heading should be **bold** in **12** size.
4. Rest of the text should be normal in 12 size.
5. Labelling of figures and tables should be *Italic* in *11* size.
6. Use proper referencing.

Do not write the complete questions. Only give its designated number and main heading

Do not copy paste the figures, tables and graphs. Redraw the figures. Remake the table and graphs from the data available in the papers.

Plagiarism should not be more than **20%. You have to submit plagiarism report with the task**.

Engr. Shayan Tariq Jan
Course Instructor

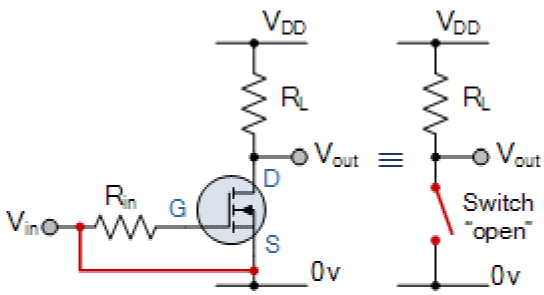
NAME:	**Fawad Ahmad**
ID:	**13204**
Assignment:	**Sectional**
Department:	**B.Electrical Engineering**
Semester:	**8^{th}**
Subject:	**Power Electronic**
Submitted to:	**Engr. Shayan Tariq Jan sir**

Question 1:

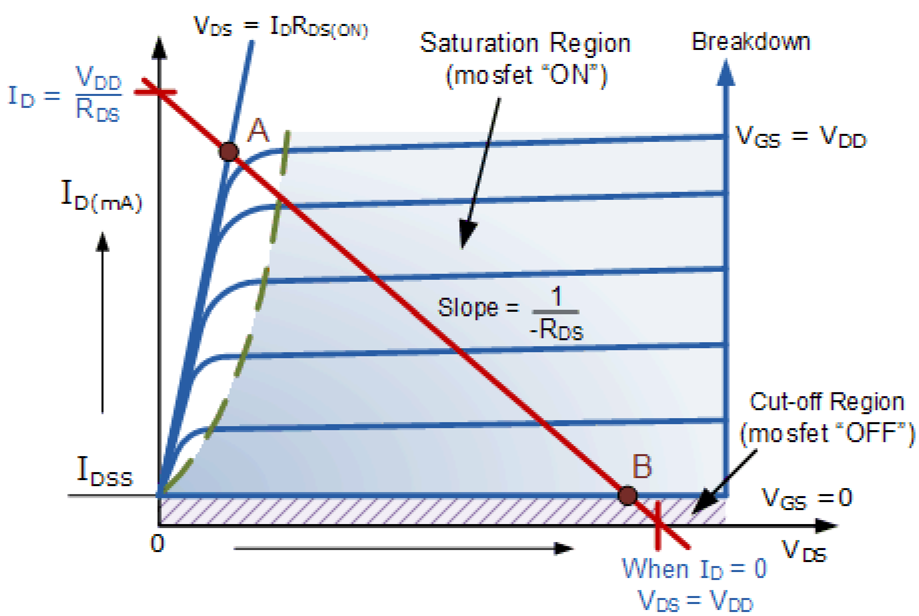
Answer:

MOSFET as a Switch:

MOSFET's make very good electronic switches for controlling loads and in CMOS digital circuits as they operate between their cut-off and saturation regions.



MOSFET Characteristics Curves:



The minimum ON-state gate voltage required to ensure that the MOSFET remains "ON" when carrying the selected drain current can be determined from the V-I transfer curves above. When V_{IN} is HIGH or equal to V_{DD}, the MOSFET Q-point moves to point A along the load line.

The drain current I_D increases to its maximum value due to a reduction in the channel resistance. I_D becomes a constant value independent of V_{DD}, and is dependent only on V_{GS}.

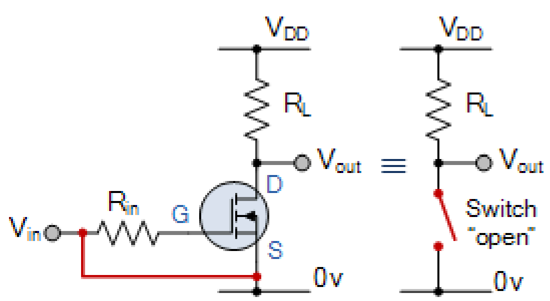
Therefore, the transistor behaves like a closed switch but the channel ON-resistance does not reduce fully to zero due to its $R_{DS(on)}$ value, but gets very small.

Likewise, when V_{IN} is LOW or reduced to zero, the MOSFET Q-point moves from point A to point B along the load line. The channel resistance is very high so the transistor acts like an open circuit and no current flows through the channel. So if the gate voltage of the MOSFET toggles between two values, HIGH and LOW the MOSFET will behave as a “single-pole single-throw” (SPST) solid state switch and this action is defined as:

1. Cut-off Region

Here the operating conditions of the transistor are zero input gate voltage (V_{IN}), zero drain current I_D and output voltage $V_{DS} = V_{DD}$. Therefore for an enhancement type MOSFET the conductive channel is closed and the device is switched “OFF”.

Cut-off Characteristics:



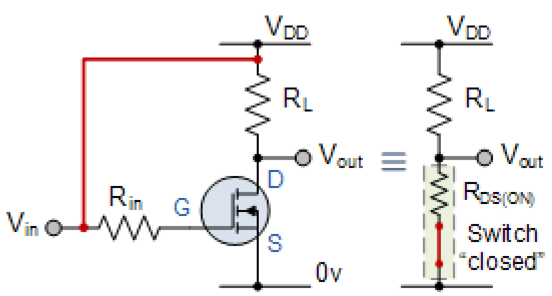
- The input and Gate are grounded (0V)
- Gate-source voltage less than threshold voltage $V_{GS} < V_{TH}$
- MOSFET is “OFF” (Cut-off region)
- No Drain current flows ($I_D = 0$ Amps)
- $V_{OUT} = V_{DS} = V_{DD} =$ ”1″
- MOSFET operates as an “open switch”

Then we can define the cut-off region or “OFF mode” when using an e-MOSFET as a switch as being, gate voltage, $V_{GS} < V_{TH}$ thus $I_D = 0$. For a P-channel enhancement MOSFET, the Gate potential must be more positive with respect to the Source.

2. Saturation Region:

In the saturation or linear region, the transistor will be biased so that the maximum amount of gate voltage is applied to the device which results in the channel resistance $R_{DS(on}$ being as small as possible with maximum drain current flowing through the MOSFET switch. Therefore for the enhancement type MOSFET the conductive channel is open and the device is switched “ON”.

Saturation Characteristics:



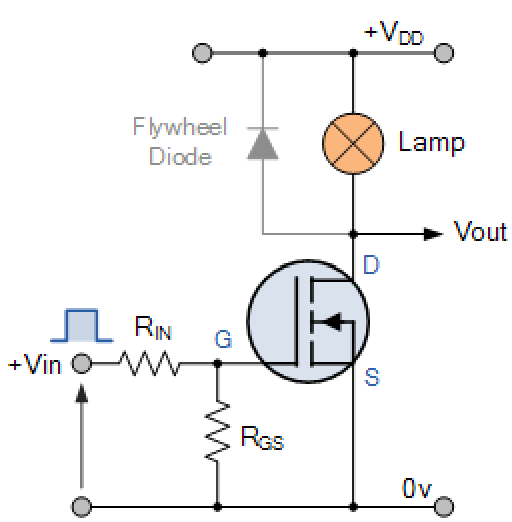
- The input and Gate are connected to V_{DD}
- Gate-source voltage is much greater than threshold voltage $V_{GS} > V_{TH}$
- MOSFET is "ON" (saturation region)
- Max Drain current flows ($I_D = V_{DD} / R_L$)
- $V_{DS} = 0V$ (ideal saturation)
- Min channel resistance $R_{DS(on)} < 0.1\Omega$
- $V_{OUT} = V_{DS} \cong 0.2V$ due to $R_{DS(on)}$
- MOSFET operates as a low resistance "closed switch"

Then we can define the saturation region or "ON mode" when using an e-MOSFET as a switch as gate-source voltage, $V_{GS} > V_{TH}$ thus I_D = Maximum. For a P-channel enhancement MOSFET, the Gate potential must be more negative with respect to the Source.

By applying a suitable drive voltage to the gate of an FET, the resistance of the drain-source channel, $R_{DS(on)}$ can be varied from an "OFF-resistance" of many hundreds of kΩ, effectively an open circuit, to an "ON-resistance" of less than 1Ω, effectively acting as a short circuit.

When using the MOSFET as a switch we can drive the MOSFET to turn "ON" faster or slower, or pass high or low currents. This ability to turn the power MOSFET "ON" and "OFF" allows the device to be used as a very efficient switch with switching speeds much faster than standard bipolar junction transistors.

<u>An example of using the MOSFET as a switch:</u>



In this circuit arrangement an Enhancement-mode N-channel MOSFET is being used to switch a simple lamp "ON" and "OFF" (could also be an LED).

The gate input voltage V_{GS} is taken to an appropriate positive voltage level to turn the device and therefore the lamp load either "ON", (V_{GS} = +ve) or at a zero voltage level that turns the device "OFF", (V_{GS} = 0V).

If the resistive load of the lamp was to be replaced by an inductive load such as a coil, solenoid or relay a "flywheel diode" would be required in parallel with the load to protect the MOSFET from any self generated back-emf.

Then we can summarise the switching characteristics of both the N-channel and P-channel type MOSFET within the following table.

MOSFET Type	$V_{GS} \ll 0$	$V_{GS} = 0$	$V_{GS} \gg 0$
N-channel Enhancement	OFF	OFF	ON
N-channel Depletion	OFF	ON	ON
P-channel Enhancement	ON	OFF	OFF
P-channel Depletion	ON	ON	OFF

https://www.electronics-tutorials.ws/transistor/tran_7.html

Question 2:

Answer:

Advantages of MOSFET :

- Ability to scale down in size.
- It has low power consumption to allow more components per chip surface area.
- MOSFET has no gate diode. This makes it is possible to operate with a positive or negative gate voltage.
- It read directly with very thin active area.
- They have high drain resistance due to lower resistance of a channel.
- Physical size is less than 4 mm^2 when it is a package form.
- It is widely used than JFET.
- The enhancement type MOSFET find wide application in digital circuitry.
- They support high speed operation compare to JFETs.
- They have high input impedance compare to JFET.
- It is easier to fabricate MOSFET than JFET.
- They can easy to manufacture.

Disadvantages of MOSFET :

- Has a short life.
- Required repeated calibration for accurate dose measurement.
- They have very susceptible to overload voltage, hence due to installation special handling is to be.

https://www.ecstuff4u.com/2018/05/advantages-and-disadvantages-of-mosfet.html

Question 3:

Answer:

I have selected the power electronic circuit/project which is (Speed Control of DC Motor Using Pulse Width Modulation) in which the MOSFET is used as switch.

Question 4:

Answer:

Working:

In this circuit, the DC motor is operated by a 555 integrated circuit. The IC 555 in this circuit is being operated in astable mode, which produces a continuous HIGH and LOW pulses.

In this mode, the 555 IC can be used as a pulse width modulator with a few small adjustments to the circuit. The frequency of operation of the circuit is provided by the passive parameters of resistances and capacitors attached to it.

Used as switch:

It is used for switching or amplifying signals. The ability to change conductivity with the amount of applied voltage can be used for amplifying or switching electronic signals. MOSFETs are now even more common than BJTs (bipolar junction transistors) in digital and analog circuits.

Components used:

There are multiple components which is used in the circuit some of these are

Capacitor: A start **capacitors** is **used** to briefly increase **motor** starting torque and allow a **motor** to turn on and off rapidly

Resistor: The **starting resistors** are **used** in a **DC motor** by placing them in the **starting circuit** of the **motor** controller that is **used** to **start** the **DC motor**. ... As the speed of the **motor** increases, counter EMF will begin to increase, decreasing armature current

Transistor: Add a **Motor** and **Transistor**. The **transistor** allows you to control a **circuit** that's carrying higher current and voltage from the a lower voltage and current. It acts as an electronic switch

Diode: Diodes only allow electricity to flow in one direction (the direction of their arrow). When you turn the power off to a **motor**, you get a negative spike of voltage, that can damage your Arduino or the **transistor**. The **diode** protects against this, by shorting out any such reverse current from the **motor.**

https://www.electronicshub.org/speed-control-of-dc-motor-using-pulse-width-modulation/

Question 5:

Answer:

Application:

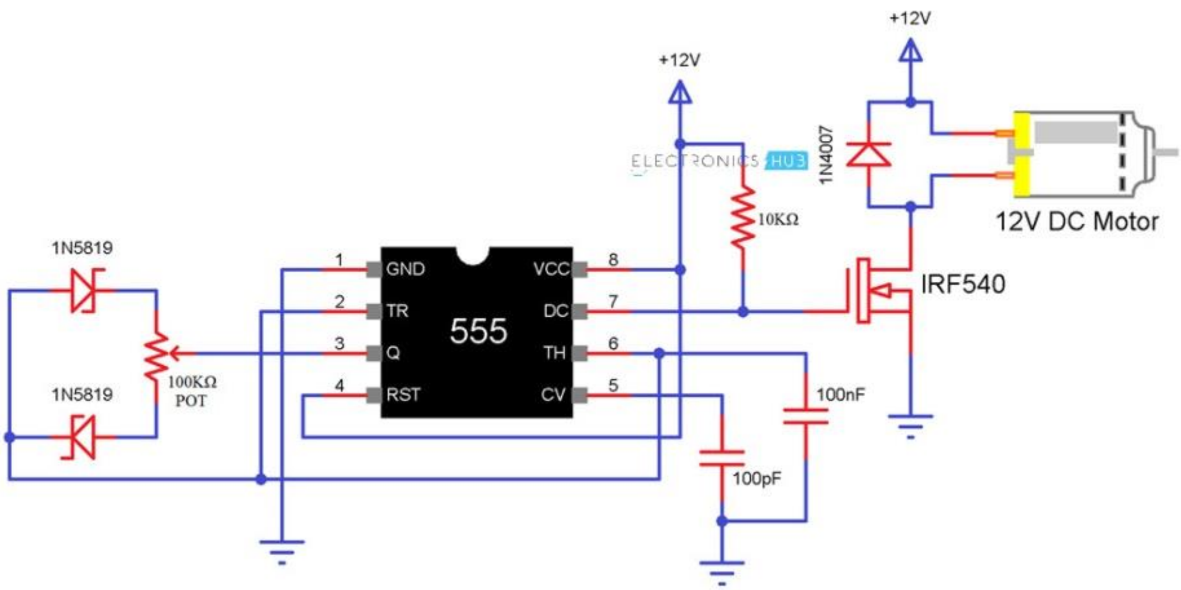
DC motors are suitable for many applications – including conveyors, turntables and others for which adjustable speed and constant or low-speed torque are required. They also work well in dynamic braking and reversing applications, which are common in many industrial machines.

Their quick acceleration, stopping and reversing – along with their linear-speed torque curve – make the DC motor a popular choice in many new designs, particularly for fractional hp applications.

Question 6:

Answer:

Circuit design:



https://www.electronicshub.org/speed-control-of-dc-motor-using-pulse-width-modulation/

Question 7:

Answer:

Parameters pf motor:

- Lisa model file**: DC MOTOR**
- Nominal Voltage: **12v**
- Coil resistance: **12**
- Coil inductance: **100mH**
- Zero load RPM: **1000**
- Load/Maximum Torque %: **50**
- Effective mass: **0.01**
- Vcc: **12v**

Reference: Proteus software

Question 8:

Answer:

Mathematically derivation:

Since,

$$V = E_b + I_a R_a \quad \ldots\ldots..(1)$$

Multiplying the equation (1) by I_a we get

$$VI_a = E_b I_a + I_a^2 R_a \quad \ldots\ldots..(2)$$

Where,

VI_a is the electrical power input to the armature.

$I^2_a R_a$ is the copper loss in the armature

We know that,

Total electrical power supplied to the armature = Mechanical power developed by the armature + losses due to armature resistance

Now, the mechanical power developed by the armature is Pm.

$$P_m = F_b I_a \dots \dots .(3)$$

Also, the mechanical power rotating armature can be given regarding torque T and speed n.

$$P_m = \omega T = 2\pi\, nT \quad \dots \dots .(4)$$

Where n is in revolution per seconds (rps) and T is in Newton-Meter.

Hence,

$$2\pi\, nT = E_b I_a \quad \text{or}$$

$$T = \frac{E_b I_a}{2\pi n}$$

But,

$$E_b = \frac{\varphi ZNP}{60\ A}$$

Where N is the speed in revolution per minute (rpm) and

$$n = \frac{N}{60}$$

Where, n is the speed in (rps).

Therefore,

$$E_b = \frac{\varphi ZnP}{A}$$

So, the torque equation is given as

$$T = \frac{\varphi ZP}{2\pi A} . I_a$$

For a particular DC Motor, the number of poles (P) and the number of conductors per parallel path (Z/A) are constant.

$$T = K\varphi I_a$$

Where,

$$K = \frac{ZP}{2\pi A} \quad \text{or}$$

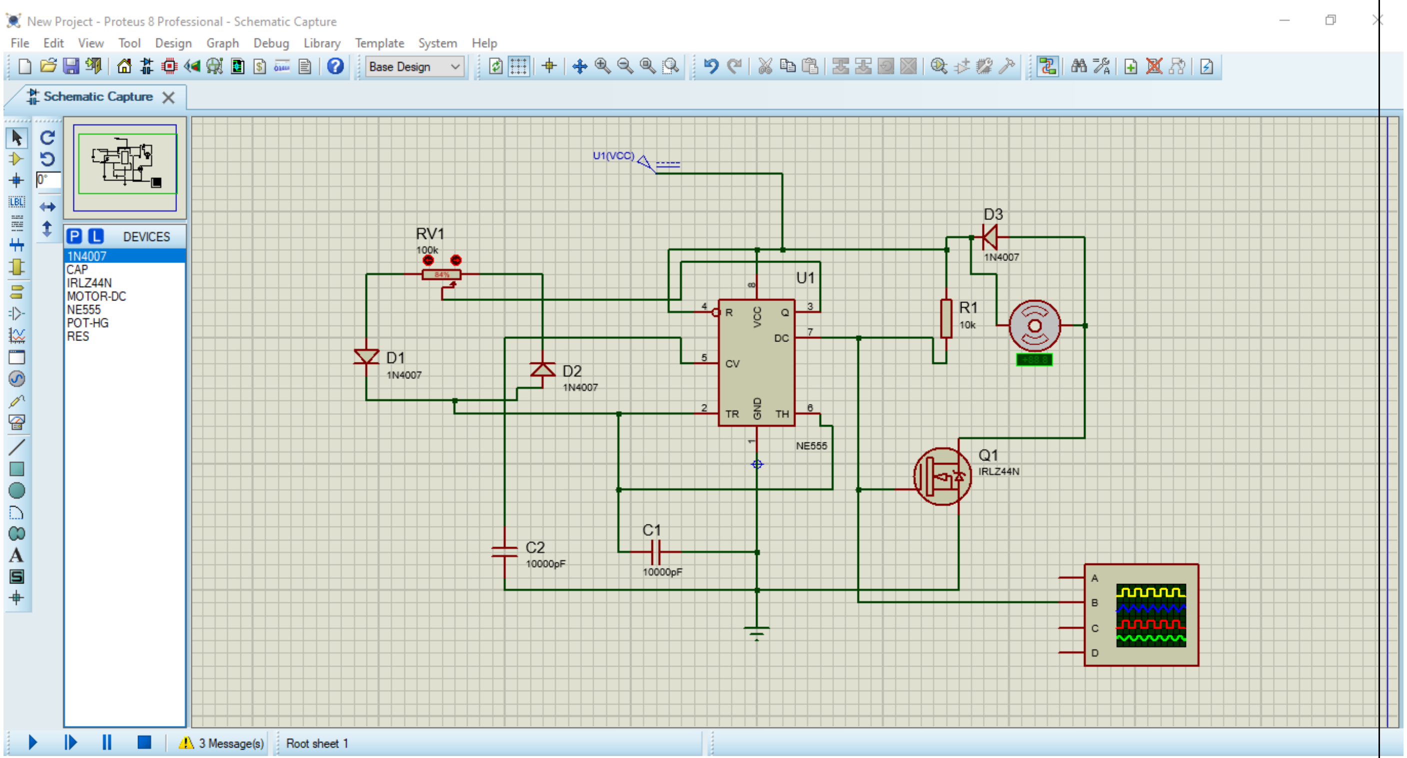
$$T \propto \varphi I_a \dots \dots (5)$$

https://circuitglobe.com/torque-equation-of-dc-motor.html

Question 9:

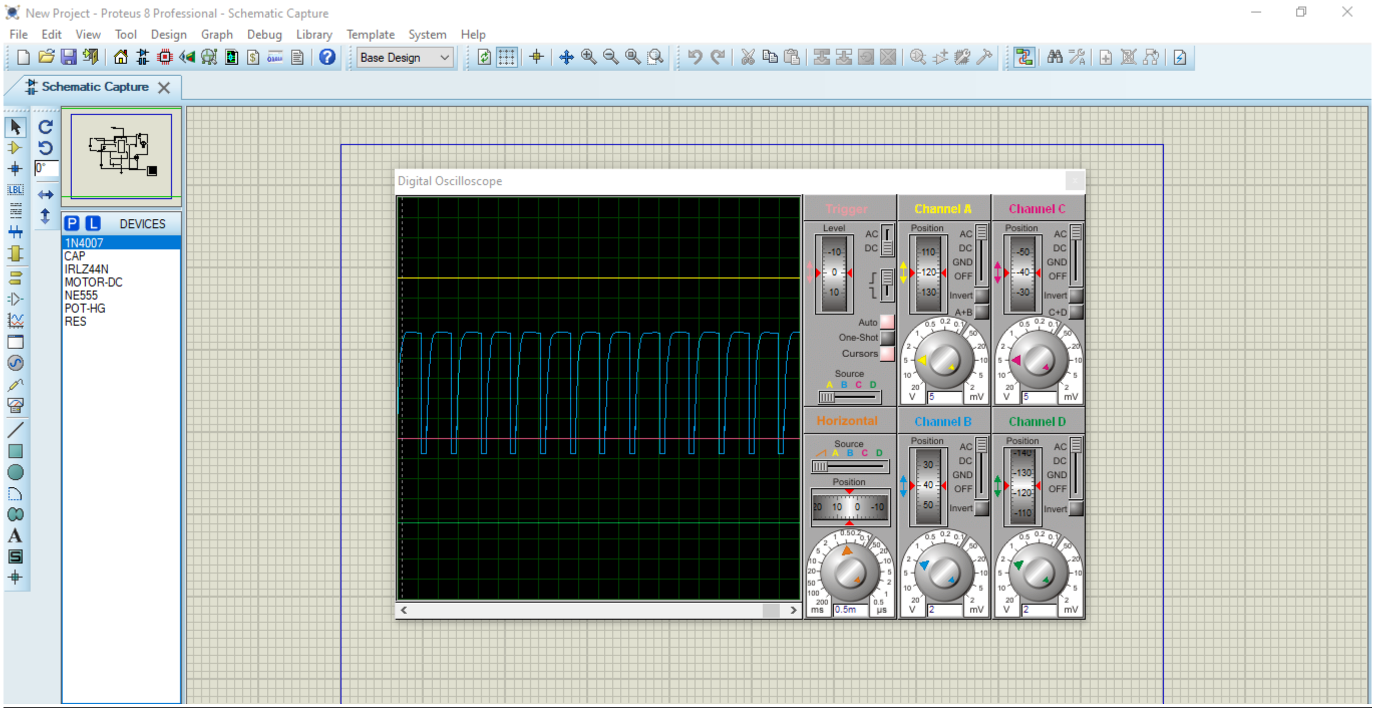
Answer:

Simulation of DC motor using PROTEUS software:



Reference: Proteus software

Output of simulation:



Reference: Proteus software

Question 10:

Answer:

Conclusion:

We have designed fixed speed control system for DC motor, which has reliability, precision and adaptability for different system ratting with response. It means the motor will run at fixed speed at any load condition. When amount of load is applied the speed does not vary and software is made according to the requirement of speed control. This designed system and implemented automatic speed control system of DC motor, it control the speed of DC motor by using PWM method.