NAME: Muhammad Faaiq Shah

ID: 12930

Subject: Power Electronics

Submitted to: Sir Shayan Tariq

Dated: 19th April, 2020

Spring 2020

IQRA NATIONAL UNIVERSITY

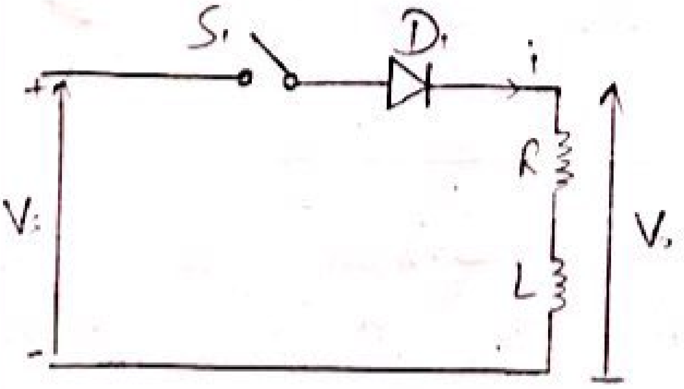
PESHAWAR.

ID : 12930

Question no # 01

a) **Answer:**

Diode with an RL circuit

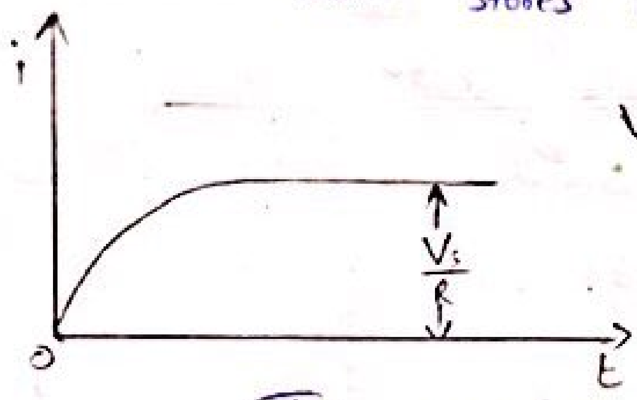


This is a simple circuit in which a diode is connected in series with RL load. When the switch is in the OFF state, there is zero current across the inductive load and hence a high voltage drop across the diode D_1.

When we turn ON the switch, a steady current flows through the diode, the diode becomes forward biased and conducting, and

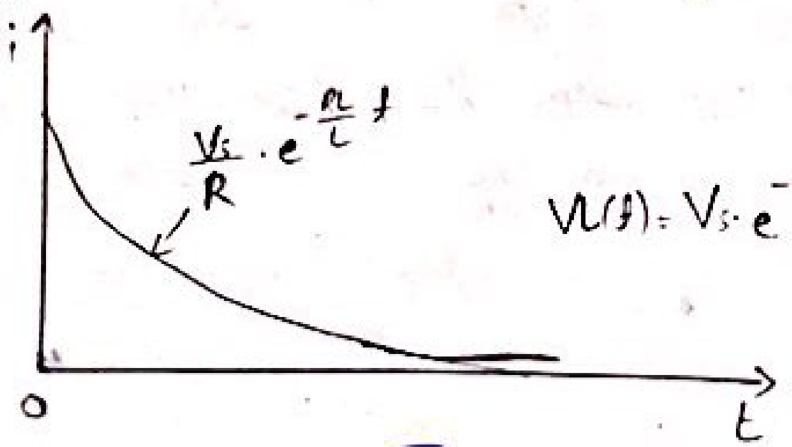
ID: 12930

then the current flows through the resistor R and inductor L and the inductor will stores energy.



$V_s = Ri + L\frac{di}{dt}$

This waveform shows the voltage across the resistor R, when the switch is in ON-State and is equal to $\frac{V_s}{R}$. V_s is the input voltage.



$V_L(t) = V_s \cdot e^{-R/L\,t}$

This waveform shows the voltage across the inductor, when the current is flowing through the inductor, the voltage across it start decreasing and becomes equal to zero.

ID: 12930

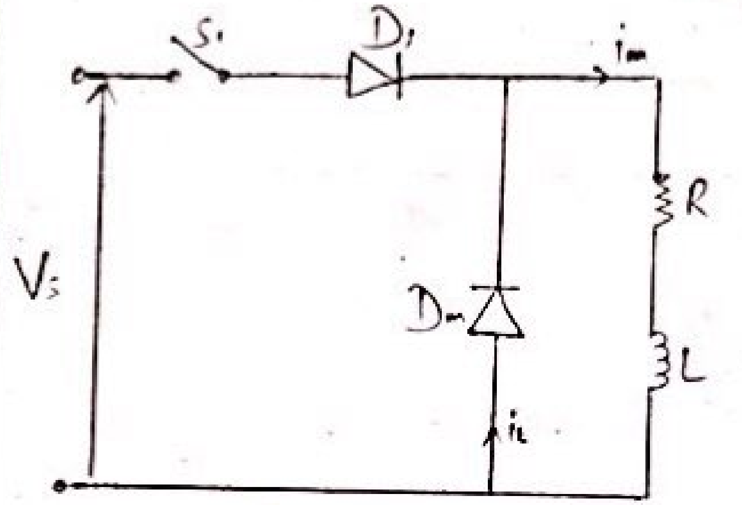
and at this time the inductor stores energy.

And when we turn off the switch, the steady current will suddenly becomes zero which results in high value of $\frac{di}{dt}$ (rate of change of current w.r.t time)

this will result in the appearance of high voltage across the inductor equal to $L\frac{di}{dt}$. This high voltage may damage the diode and the switch connected in the circuit.

ID : 12930

Freewheeling Diode is connected to the circuit:-



A freewheeling diode is a simple diode which is connected accross the terminals of inductive load, so as to prevent the development of high voltage across the inductor L. Under the normal condition when the switch is closed, the freewheeling diode is reverse biased and acts like an open switch.

When we suddenly

ID: 12930

open the switch i-e off state, the current will start to decay and develop a high voltage across the terminals of inductor L as per Lenz's law. Due to this voltage the freewheeling diode will become forward biased and will act like a short circuit and will provide a path to that ~~voltage~~ decay current which is equal to

$$i = \left(\frac{V}{R}\right)e^{-t/\tau}$$

By using a freewheeling diode we are just providing a path to the decay current when the switch is opened. By adding a freewheeling diode to the circuit the performance and output of the circuit will become more reliable and long termed

ID: 12930

By adding a freewheeling diode to R-C circuit have the same effect as the R-L circuit.

$\Longleftrightarrow$

b)- A Power MOSFET is connected in the circuit.

$V_{DS} = 30\ V$

Threshold voltage $V_T = 3\ V$

V_{GS} required for the mosfet to be in saturation mood.

$V_{GS} = ?$

So,

$V_{DS} = V_{GS} - V_T$

$V_{GS} = V_{DS} + V_T$

By putting the values

$V_{GS} = 30 + 3$

$\boxed{V_{GS} = 33\ V}$

ID: 12930

Question no # 02

a) When we replace a ~~high~~ Power mosfet with a Power BJT there will be a high effect on its output and performance of the appliance.

BJT is a current controll device, for such high voltage rating I recone the power mosfet.

But the losses occurs in the appliance becomes slightly lower because BJT has lesser losses as compared to Mosfet. But BJT has switching limits i-e second Breakdown (SB). It is a destructive phenomenon results from the current flow to a small portion of the base, producing localized hot spots

If the energy in these hot spots is sufficiant, the

ID: 12930

excessive localized heating may damage the transistor.

But to avoid this problem the manufacteres usually provide the forward biased safe operating area (FBSOA) and reverse biased safe operating area (RBSOA) which works in turn-ON and turn-OFF conditions.

It indicates the $i_c - V_{ce}$ limits of the transistor. For reliable operation the transistor must not be subjected to greater power dissipation than that shown by the FBSOA and RBSOA.

The BJT have high switching frequencies since their turn ON and turn OFF times are low. The Mosfet driver circuit is simple and easy to design, but the BJT driver circuit is complex

ID : 12930

You can add a thyristor to the circuit because both provides a good controll range of current with small controlling current. Also for the operating frequency because the operating frequency of BJT is quite low as compare to Mosfet.

<==================>

b)- The silicon controlled rectifier is a current controlled needs single pulse to turn ON as BJT. The ON-state voltage drop is lower i-e less than 2 volts as compare to Power Mosfet.

The rating given in the question falls in the category of SCR and BJT as its maximum V-I rating of SCR is 100kV/5000Am

ID: 12930

and of BJT is 2kV/1000 Amp.

But the operating frequency of SCR is quite lower than power Mosfet, so it will damage the efficiancy and performance of the appliance

ID: 12930

Question no # 03

Solution:-

Load resistance, $R_C = 30\Omega$

DC supply voltage, $V_{CC} = 930V$

$V_B = 10V$

$V_{CE} = 1V$

$V_{BE} = 1.5V$

Find:

a) The mode of operation of the transistor:

The mode of operation will be saturation mode.

b) The value of R_B that results in saturation with an ODF of 5:

For this we have to find:

$$I_{CS} = \frac{V_{CC} - V_{CE(sat)}}{R_C}$$

ID: 12930

$$I_{CS} = \frac{930 - 1}{30}$$

$$\boxed{I_{CS} = 30.96\,A}$$

$$I_{BS} = \frac{I_{CS}}{\beta_{min}}$$

$$I_{BS} = \frac{30.96}{8}$$

$$\boxed{I_{BS} = 3.87\,A}$$

Now,

$$ODF = \frac{I_B}{I_{BS}}$$

$$I_B = ODF \times I_{BS}$$

$$I_B = 5 \times 3.87$$

$$\boxed{I_B = 19.35\,A}$$

Now we will find R_B:

$$R_B = \frac{V_B - V_{BE}}{I_B}$$

$$R_B = \frac{10 - 1.5}{19.35}$$

$$\boxed{R_B = 0.4392\,\Omega}$$

ID: 12930

c) the β_{forced} ?

$$\beta_{forced} = \frac{I_{CS}}{I_B}$$

$$\beta_{forced} = \frac{30.96}{19.35}$$

$$\boxed{\beta_{forced} = 1.6}$$

d) the power loss, P_T in the transistor:

First we will find.

$$I_C = \frac{V_{CC} - V_{CE}}{R_C}$$

$$I_C = \frac{930 - 1}{30}$$

$$\boxed{I_C = 30.96\ A}$$

Now, $P_T = V_{BE} I_B + V_{CE} I_C$

By putting the values.

$$P_T = 1.5 \times 19.35 + 1 \times 30.96$$

$$P_T = 29.025 + 30.96$$

$$\boxed{P_T = 59.985\ \omega}$$