IQRA NATIONAL UNIVERSITY PESHAWAR

DEPTT. B.E. (ELECTRICAL)

8TH SEMESTER

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MID TERM EXAMINATION

POWER ELECTRONICS

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QUESTION NO.1 (A):

An appliance circuit has a R-L connected in series with a diode. After some time, modification is done to the circuit and a free-wheeling diode in added in parallel to the R-L. Will it have any impact on the performance and output of the circuit. Back your answer with before & after data, facts and figures.

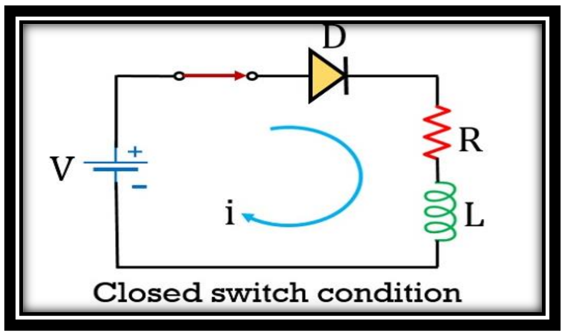
Does adding a free-wheeling diode in parallel to a R-C circuit have the same effect, different effect or no effect.

ANSWER:

Flyback Voltage:

Flyback is basically defined as an abrupt increase in voltage across the inductive load when the current through the circuit shows a reduction.

Consider the circuit shown below:



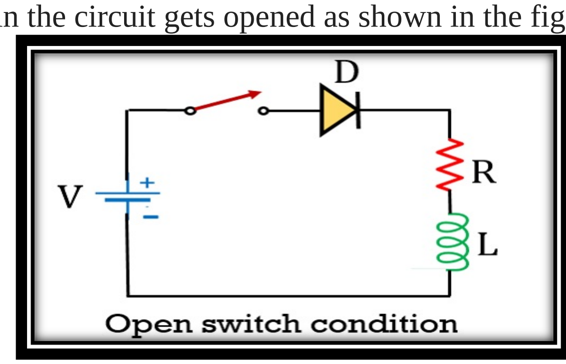
As we can see that the circuit shown above is composed of a diode, a switch and RL load. Also a supply voltage V is provided to it.

Once the switch gets closed so due to applied external potential, the diode in the circuit gets forward biased and current starts flowing through the load RL.

We know that an inductor is basically a conductive loop of wire that produces a magnetic field when current flows through it. The inductor holds the energy in the form of an electromagnetic field.

So, in closed switch condition, the flow of current through the inductor leads to the generation of the magnetic field, causing it to get fully charged.

But as the switch in the circuit gets opened as shown in the figure below:



Flyback voltage across the inductor has significantly greater value than actually applied potential by the external source.

This leads to a flow of high current through the circuit. Resultantly causing a high reverse voltage to set up across the switch as well as the diode, that may lead to damaging of the devices in the circuit.

The voltage spike across the inductor is given as:

$$V = L\, di/dt$$

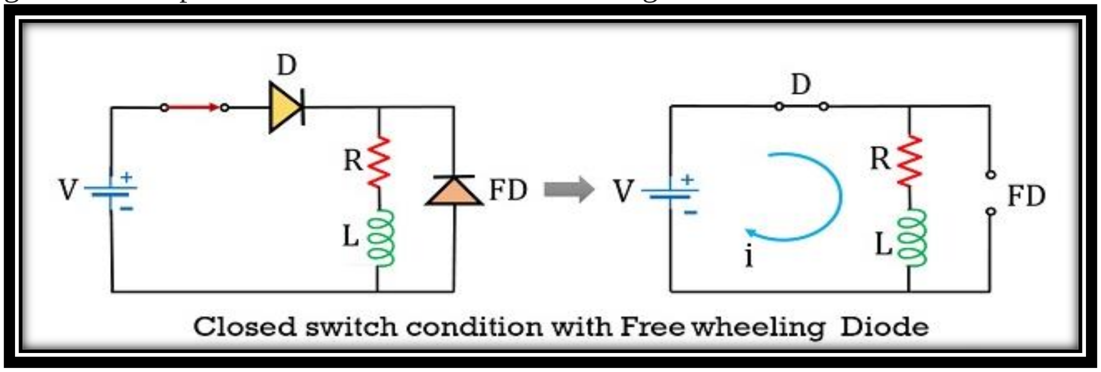
Where, **di/dt** is the rate of change of current across the inductor and
L denotes the inductance of the coil.

Thus it can be said that voltage across the inductor and current flowing through the circuit holds the relation of direct proportionality.

So, due to this reason, a free-wheeling diode is connected across the inductor to avoid the damage in the circuit.

Working of Freewheeling (Flyback) Diode

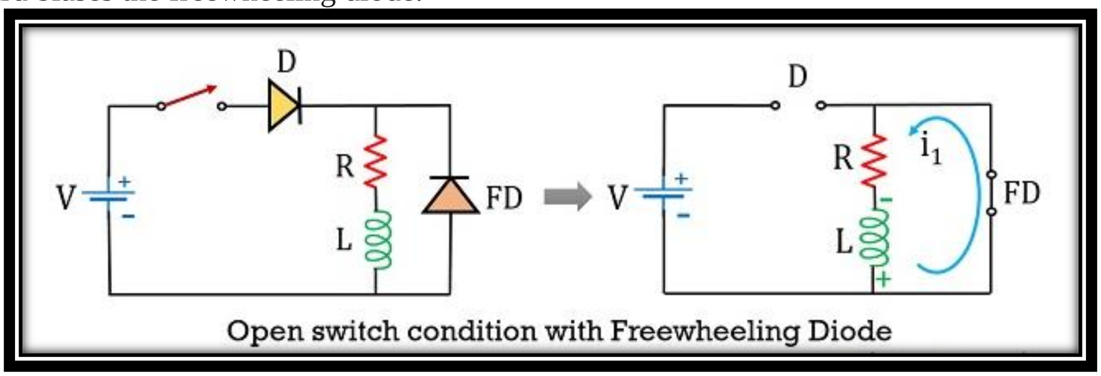
The figure below represents a circuit with a freewheeling diode:



It is clear from the figure that the freewheeling diode is connected directly across the inductor. The presence of Flyback diode gives an alternate path to the current, produced due to Flyback voltage at the inductor.

Under normal operating conditions when the switch is closed, the external potential reverse biases the freewheeling diode present in the circuit. And so the freewheeling diode plays no such crucial role under normal or steady-state condition.

But in the presence of FD when the switch is opened, the voltage across the inductor forward biases the freewheeling diode.



Due to small resistivity offered by FD, current in open switch condition now flows through the part of a circuit comprising of the freewheeling diode, R and L. This resultantly leads to the protection of switching device present in the circuit.

QUESTION NO.1 (B):

A Power Mosfet is connected in a circuit.

The Drain to Source voltage, V_{DS} = (Last 2 digits of your student ID) V and Threshold Voltage, V_T = (Last 1 digits of your student ID) V.

What is the minimum Gate to Drain Voltage, V_{GS} required for the P.Mosfet to be in saturation mood.

DATA:

$V_{DS} = 09V$

$V_T = 9V$

TO FIND:

$V_{GS} = ?$

SOLUTION:

As we know that

$$V_{DS} \geq V_{GS} - V_T$$

let,

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

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

Now putting values

$$V_{GS} = 09 + 9$$

$$\boxed{V_{GS} = 18V}$$

QUESTION NO.2 (A):

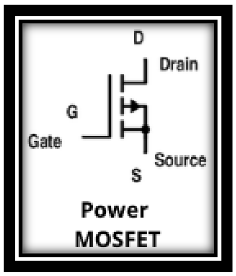
A Power Electronics appliance of 500W, 220V, 500KHz rating is using a Power Mosfet for switching purpose. If the P.Mosfet is replaced with a Power Bipolar Junction Transistor what effect will it have on the performance, losses and efficiency of the appliance. Will any other changes to the circuit be required? Back your reasons with valid data, facts and figures.

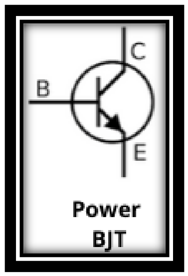
ANSWER:

The main benefit of the power MOSFET compared to the BJT is that the MOSFET is a depletion channel device and so voltage, not current, is necessary to create a conduction path from drain to source. At low frequencies this greatly reduces gate current because it is only required to charge gate capacitance during switching, though as frequencies increase this advantage is reduced. Most losses in MOSFETs are due to on-resistance, can increase as more current flows through the device and are also greater in devices that must provide a high blocking voltage. BVdss

Due to replacement of Power BJT with Power Mosfet the constant voltage (gate voltage) will disturb and the constant current (Base current) will take the place of it, because BJT's output is controlled by controlling base current while the output of MOSFET is controlled by controlling gate voltage. Losses of the circuit will be decrease, because Power Mosfet has higher losses than BJTs. The circuit will able to use in high power application. The switching frequency will decrease because the switching frequency of BJT is lower than Power MOSFET. It effect the temperature too. Because BJT has negative temperature coefficient while the MOSFET has positive temperature coefficient.

SYMBOLS:





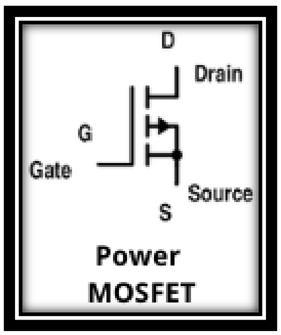
QUESTION NO.2 (B):

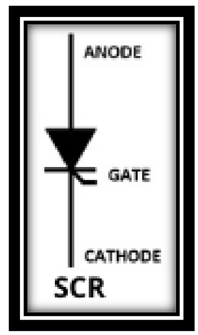
In the above appliance (Q2.a) if the P.Mosfet is replaced with a Silicon Controlled Rectifier what effect will it have on the performance, losses and efficiency of the appliance. Will any other changes to the circuit be required? Back your reasons with valid data, facts and figures.

ANSWER:

Silicon Controlled Rectifier is a minority carrier type of device while the Power Mosfet is a majority carier device, and it is a current control device where Power Mosfet is voltage control device. Its commutation is necessary but power mosfet hasn't necessary. The blocking capacity is symmetrical while the blocking capacity of power mosfet is asymetrical. Losses of the circuit will be decrease, because Power Mosfet has higher losses than SCRs. The operating frequency is between 400 to 500Hz. This means that the frequency decreases because the operating frequency of power mosfet is 100kHz. A small gate pulse triggers the device ON. It stays latched until the current through the device drops below its holding current where the power mosfet is voltage controlled so it needs continuous gate drive.

SYMBOLS:

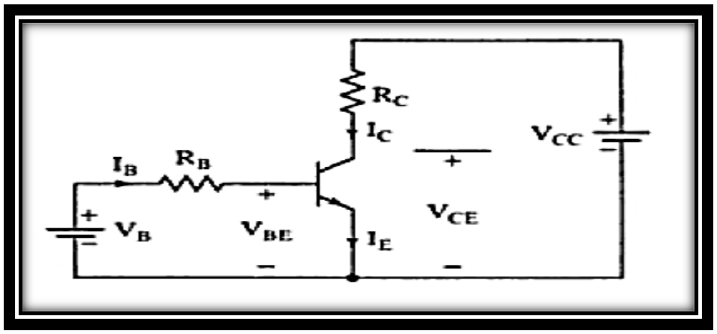




QUESTION NO.3:

The bipolar transistor in the Figure below is specified to have β_F in the range of 8 to 40. The load resistance, R_C = (Last 2 digits of your student ID) Ω.
The dc supply voltage, V_{CC} = (Last 3 digits of your student ID) V and the input voltage to the base circuit, V_B = 10 V.
If V_{CE} = (First digits of your student ID) V and V_{BE} = 1.5 V, find

(a) The mode of operation of the transistor
(b) the value of R_B that results in saturation with an ODF of 5,
(c) the β_{forced},
(d) the power loss, P_T in the transistor.



DATA:

β_F = 8 to 40
R_c = 09 Ω
V_{CC} = 009V
V_B = 10V
V_{CE} = 1V
V_{BE} = 1.5V

TO FIND:

a) The mode of operation of the transistor
b) the value of R_B that results in saturation with an ODF of 5,
c) the β_{forced},
d) the power loss, P_T in the transistor.

SOLUTION:

(a) The Mode Of Operation Of The Transistor:

The mode of operation of the transistor is saturation mode. Due to saturation mode the transistor acts as a close switch.

(b) The Value Of R_B That Result Saturation With An ODF Of 5

We know that

$$Ics = \frac{V_{CC} - V_{CE(Sat)}}{R_C}$$

Putting the values

$$Ics = \frac{009 - 1}{09\Omega}$$

$$\boxed{Ics = 0.89A}$$

We know that

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

Now putting values

$$I_{BS} = \frac{0.89}{8}$$

$$\boxed{I_{BS} = 0.11\ A}$$

We know that

$$I_B = overdrive\ factor \times I_{BS}$$

Now putting values $I_B = 5 \times 0.11$

$$\boxed{I_B = 0.55A}$$

We know that

$$I_B \frac{V_B - V_{BE(sat)}}{R_B}$$

So, $$R_B = \frac{V_B - V_{BE(sat)}}{I_B}$$

Now putting values

$$R_B = \frac{10-1.5}{0.55}$$

$$\boxed{R_B = 15.45\Omega}$$

(c) The β_{forced}

We know that

$$\beta_T = \frac{I_{CS}}{I_B}$$

Putting the values

$$\beta_T = \frac{0.89}{0.55}$$

$$\boxed{\beta_T = 1.618}$$

(d) The Power Loss, P_T In The Transistor:

$$P_T = V_{BE} \times I_B + V_{CE} \times I_C$$

$$P_T = 1.5 \times 0.55 + 1 \times 0.89$$

$$P_T = 0.825 + 0.89$$

$$\boxed{P_T = 1.715W}$$