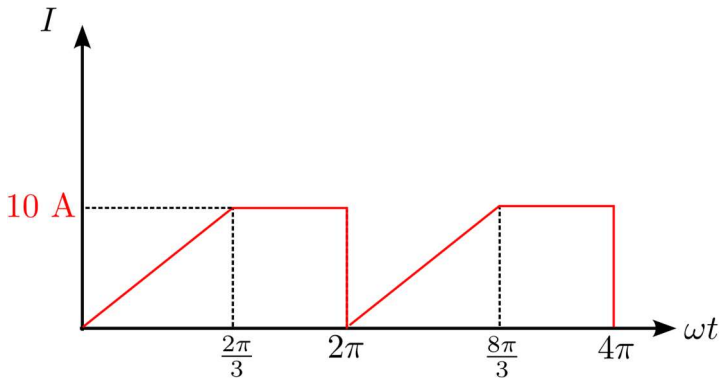
Question 1:

In a power electronic circuit MOSFET is using as a switch. MOSFET has a ON state resistance of $R_{ds}(on) = 0.5\ \Omega$. *What is the conduction loss in the device if the following current waveform is flowing through it during its ON state.*



(a) 35.26 W
(b) 45.27 W
(c) 38.89 W
(d) None

Solution: Correct option is (c)

The mean square value of the current flowing through the MOSFET is given by:

$$I_{rms}^2 = \frac{1}{T}\left[\int_0^{T/3} \frac{30^2}{T^2}\, t^2\, dt + \int_{T/3}^{T} 100.\, dt\right] = 77.78\ A^2$$

The conduction power loss is given by:

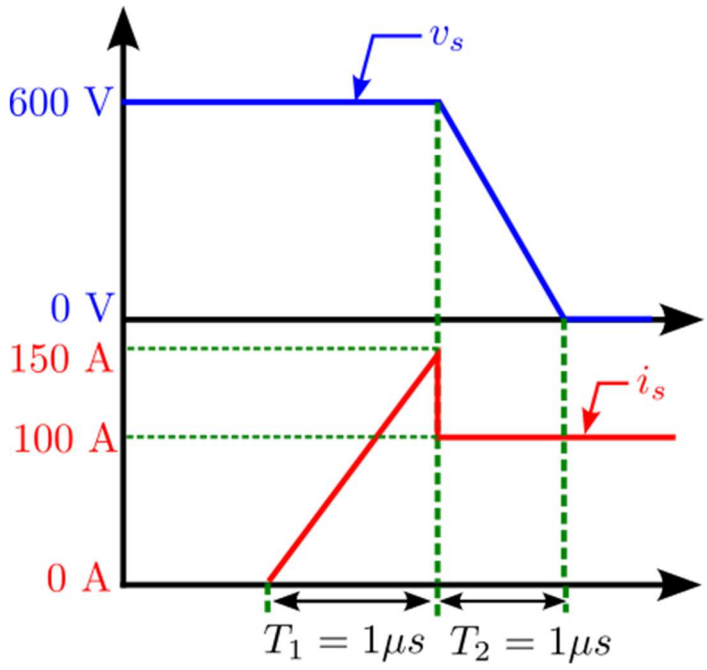
$$P_{cond} = I_{rms}^2 R_{on}$$

Where, R_{on} is the on-state resistance of the MOSFET. Thus, the conduction loss is:

$$P_{cond} = 77.78 \times 0.5 = 38.89\ W$$

Question 2: *(Numerical Type)*

The voltage (v_s) *and current* (i_s) *transition through a semiconductor switch during turn on transition are shown in the figure. The energy dissipated during the transition (in mJ) is* _____.



Solution:

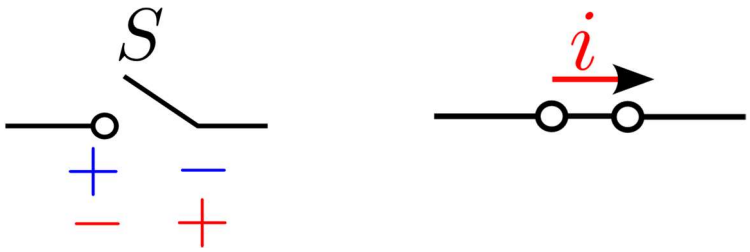
Answer range (74.9-75)

The energy dissipated during the switching transition can be written as

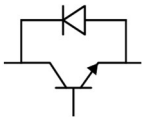
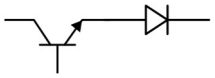
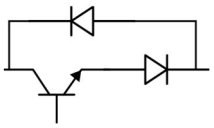
$$E_{sw} = \frac{1}{2} \times 150 \times 600 \times T_1 + \frac{1}{2} \times 100 \times 600 \times T_2 = 0.075\, J = 75\, mJ$$

Question 3:

An electronic switch 'S' is required to block voltage of either polarity during its OFF state as shown in the figure 1(a). This switch is required to conduct in only one direction in its ON state as shown in the figure 1(b).



Which of the following are valid realization of the switch 'S'.

1.  *2.*  *3.*  *4.* 

(a) Only 1
(b) 1 and 2
(c) 1 and 3
(d) 3 and 4

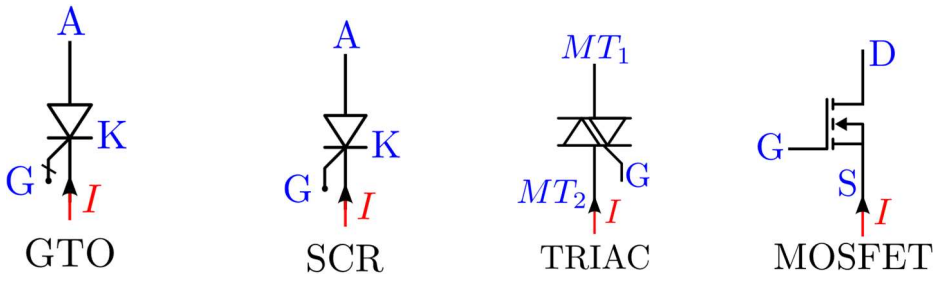
Solution: Correct option is (c)

Thyristor can block voltages of either polarity but can carry current only in forward direction.

Similarly, a diode in series with BJT can block voltages in either direction and can conduct current only in forward direction.

Question 4:

Four power semiconductor devices are shown in the figure along with their relevant terminals. The device(s) that can carry dc current continuously in the direction shown when the gate signal is HIGH is (are)



(a) Triac only
(b) Triac and MOSFET
(c) Triac and GTO
(d) SCR and Triac

Solution: Correct option is (b)

SCR and GTO allow conduction of current from anode to cathode. Hence current cannot flow in the given direction in GTO and SCR.

Triac and MOSFET can conduct current in both directions. Hence, current can flow in the given direction for both MOSFET and Triac.

Question 5: Numerical type

A steady dc current of 100 A is flowing through a power module (S, D) as shown in Fig. (a). The V-I characteristics of the IGBT (S) and the diode (D) are shown in Fig. (b) and (c), respectively. The conduction power loss in the power module (S, D) in watts, is _____.

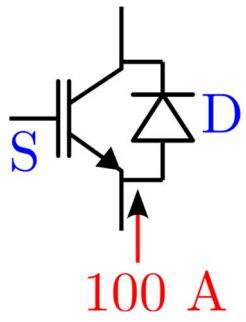


Fig. (a)

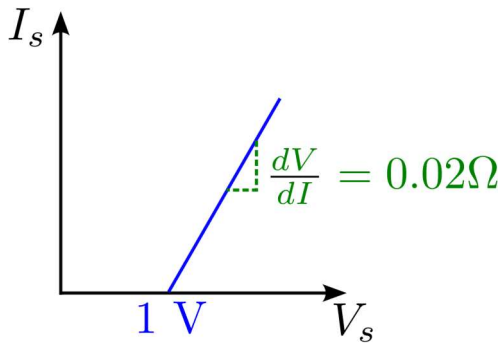


Fig. (b): VI Characteristic of IGBT

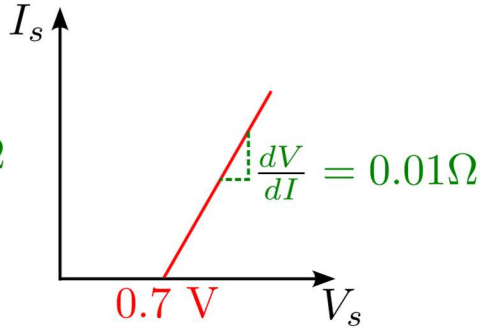


Fig. (c): VI Characteristic of Diode

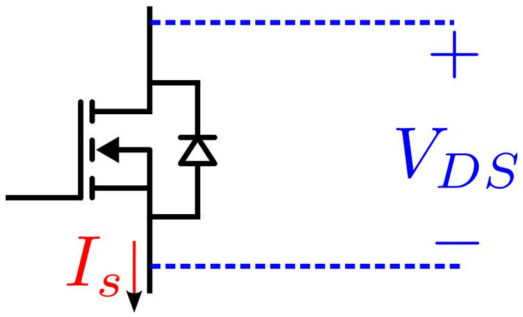
Solution: Answer range (169-171)

IGBT, denoted by 'S', will not allow the flow of the current in the direction as shown in Fig. a. Hence, only the diode will be conducting. As shown in Fig. (c), the forward voltage drop of the diode is 0.7 V and the on-state resistance is 0.01Ω. Thus, the conduction losses in the diode can be calculated as

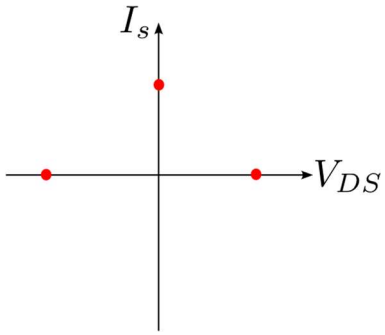
$$P_{loss} = 0.7 \times 100 + 100^2 \times 0.01 = 170\ W$$

Question 6:

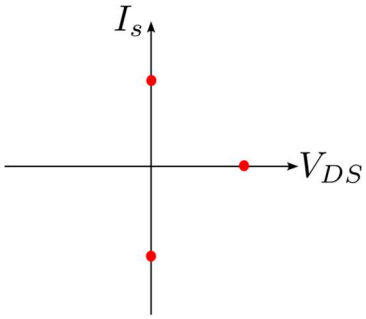
Figure shows a MOSFET with integral body diode. It is employed as a power switching device in the ON and OFF states through appropriate control. The ON-OFF states of the switch are given on the $V_{DS} - I_s$ plane by



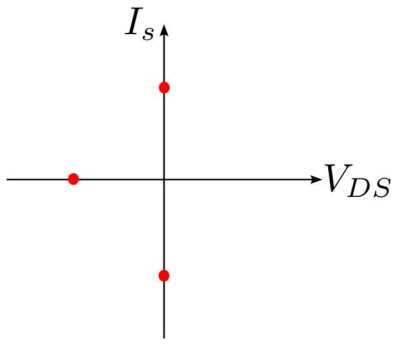
(a)



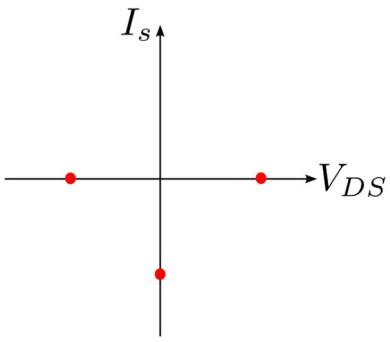
(b)



(c)



(d)



Solution: Correct option is (b)

MOSFET with body diode can carry current in either direction. However, MOSFET with body diode can only block voltages of positive polarity (i.e. $V_{DS} > 0$). If $V_{DS} < 0$, the antiparallel diode will start conducting and hence the switching block cannot block voltage of opposite polarity.

Question 7:

For the power semiconductor devices IGBT, MOSFET, Diode and Thyristor, which of the following statements is true?

(a) All four are majority carrier devices.
(b) All four are minority carrier devices.
(c) IGBT and MOSFET are majority carrier devices, whereas Diode and Thyristor are minority carrier devices.
(d) MOSFET is majority carrier device, whereas IGBT, Thyristor and Diode are minority carrier device.

Solution: Correct option is (d)

Only MOSFET is a majority carrier device whereas all others are minority carrier devices.

Question 8:

The conduction loss versus device current characteristic of a power MOSFET is best approximated by:

(a) Parabola
(b) Straight line
(c) Rectangular hyperbola
(d) Exponentially decaying function

Solution: Correct option is (a)

Conduction power loss of a MOSFET can be calculated as

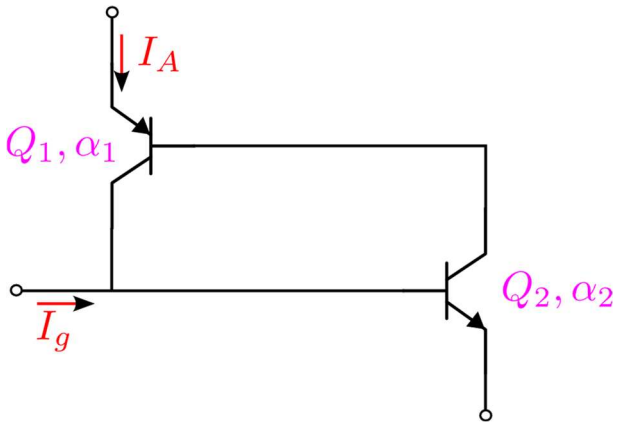
$$P_{loss} = R_{DS(on)}\ I_{rms}^2$$

The above equation can be compared with the equation of the parabola as given below.

$$y = a\,x^2$$

Question 9:

In the figure, Q_1 and Q_2 have common collector current gain values of α_1 and α_2 respectively. (collector - emitter current gain of BJT). Find the expression for I_A.



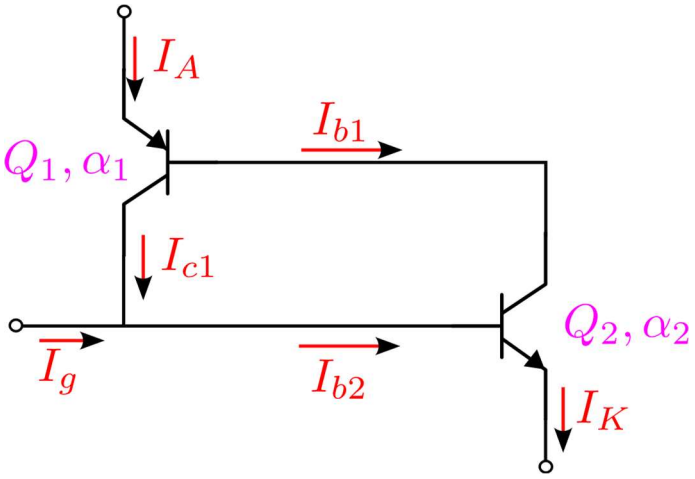
(a) $\frac{\alpha_2 I_g}{1-\alpha_1-\alpha_2}$

(b) $\frac{(\alpha_1+\alpha_2)\, I_g}{\alpha_2}$

(c) $\frac{\alpha_2 I_g}{1+\alpha_1+\alpha_2}$

(d) $\frac{\alpha_1 I_g}{1-\alpha_1-\alpha_2}$

Solution: Correct option is (a)



$$I_{c1} = \alpha_1 I_A$$

$$I_{b1} = \alpha_2 I_K$$

Applying KCL we also have,

$$I_A = I_{c1} + I_{b1} = \alpha_1 I_A + \alpha_2 I_K$$

Again, we also have

$$I_K = I_{b2} + I_{b1} = I_{b2} + \alpha_2 I_K$$

Therefore, we have

$$I_K = \frac{I_{b2}}{1 - \alpha_2}$$

Again, applying KCL we have

$$I_{b2} = I_{c1} + I_g = \alpha_1 I_A + I_g$$

Thus, the expression for I_K can now be written as

$$I_K = \frac{\alpha_1 I_A + I_g}{1 - \alpha_2}$$

Therefore, we have

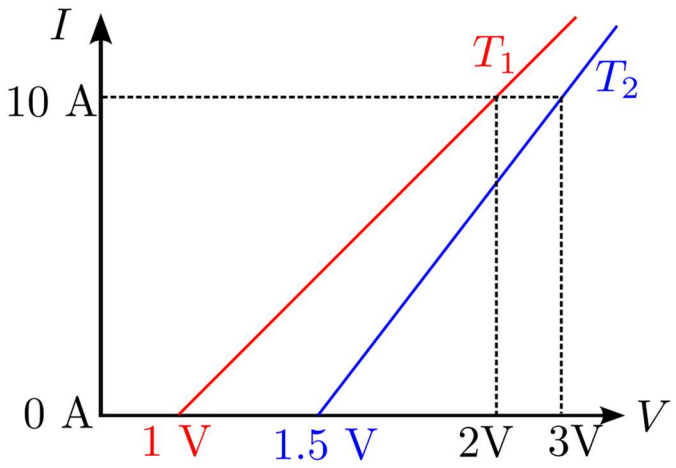
$$I_A = \alpha_1 I_A + \alpha_2 \frac{\alpha_1 I_A + I_g}{1 - \alpha_2}$$

Re-arranging the equation, we get,

$$I_A = \frac{\alpha_2 I_g}{1 - \alpha_1 - \alpha_2}$$

Question 10:

Two thyristors T_1 and T_2 are being operated in parallel. Their V-I characteristic when they are ON are given in figure. The common voltage across the thyristors is 1.8 V. Power loss in T_1 and T_2 respectively are (in watts):



(a) 8, 2
(b) 64, 4
(c) 20, 30
(d) 14.4, 3.6

Solution: Correct option is (d)

The equation for VI characteristic for T_1 can be written as

$$I_1 = 10\,V_1 - 10$$

The equation for VI characteristic for T_2 can be written as

$$I_2 = \frac{20}{3}\,V_2 - 10$$

As the voltage across the thyristors in parallel is 1.8 V we can find the current flowing through each thyristor from the above equations putting $V_1 = V_2 = 1.8\,V$

From the above equations we get

$$I_1 = 8\,A \quad and \quad I_2 = 2\,A$$

Thus,

power loss in $T_1 = 8 \times 1.8 = 14.4\,Watts$

And

power loss in $T_2 = 2 \times 1.8 = 3.6\ Watts$