

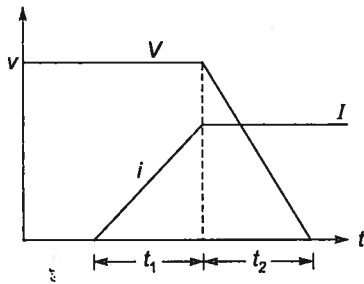
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Power Semiconductor Devices



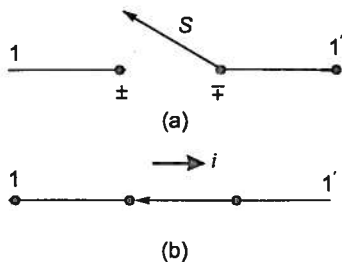
Multiple Choice Questions

- Q.1** The figure shows the voltage across a power semiconductor device and the current through the device during a switching transitions. The transition shown in the graph is a turn on transition or turn off transition and what is the energy lost during the transition?

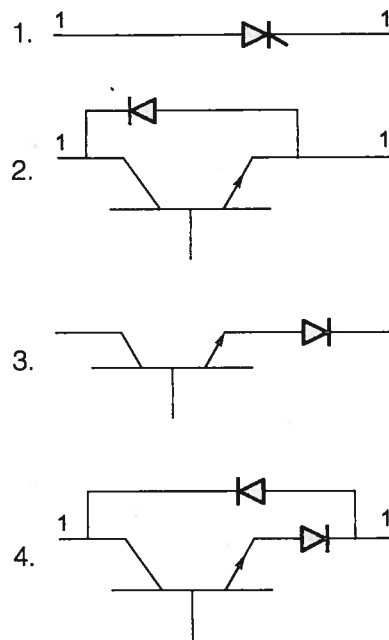


- (a) Turn ON, $\frac{VI}{2} (t_1 + t_2)$
 (b) Turn OFF, $VI(t_1 + t_2)$
 (c) Turn ON, $VI(t_1 + t_2)$
 (d) Turn OFF, $\frac{VI}{2} (t_1 + t_2)$ [GATE-2005]

- Q.2** An electronics switch S is required to block voltage of either polarity during its OFF state as shown in the figure (a). This switch is required to conduct in only one direction its ON state as shown in the figure (b).



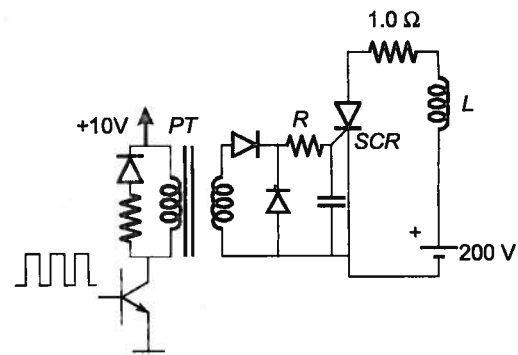
Which of the following are valid realizations of the switch S ?



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

[GATE-2005]

- Q.3** A 1:1 Pulse transformer (PT) is used to trigger the SCR in the figure. The SCR is rated at 1.5 kV, 250 A with $I_L = 250$ mA, $I_H = 150$ mA, and $I_{Gmax} = 150$ mA with $I_L = 250$ mA, $I_{Gmin} = 100$ mA. The SCR is connected to an inductive load, where $L = 150$ mH in series with a small resistance and the supply voltage is 200 V dc. The forward drops of all transistors/diodes and gate-cathode junction during ON state are 1.0 V. The resistance R should be



- (a) 4.7 k Ω (b) 470 k Ω
(c) 47 Ω (d) 4.7 Ω

Q.4 In the above question, the minimum approximate volt-second rating of the pulse transformer suitable for triggering the SCR should be: (Volt-second rating is the maximum of product of the voltage and the width of the pulse that may be applied)

- (a) 2000 μ V-s (b) 200 μ V-s
(c) 20 μ V-s (d) 2 μ V-s

[GATE-2007]

Q.5 Consider the following statements

When gate triggering is employed, a thyristor can withstand higher values of di/dt (rate of change of forward current), if

1. the gate current is increased.
2. the rate of rise of gate current is increased.
3. the gate current is decreased.
4. the rate of rise of gate current is decreased.

Of these statements:

- (a) 3 and 4 are correct
(b) 1 and 4 are correct
(c) 2 and 3 are correct
(d) 1 and 2 are correct

[IAS-1994]

Q.6 Which one of the following is necessary for a triggering system for thyristors in a line commutator converter?

- (a) It must use separate power supply
(b) It should provide a train of pulses
(c) It should be synchronized with the mains supply providing a single pulse of suitable value
(d) It should be synchronized with mains providing a train of pulses

[IAS-1998]

Q.7 Which of the following statements are correct when a positive voltage is applied to the gate of a reverse biased SCR?

- (a) This injects more electrons into junction J_1
(b) This increases reverse leakage current into anode
(c) Heating of junction is unaffected
(d) Failure of junction occurs due to thermal runaway

- (a) (a) and (c) (b) (a) and (b)
(c) (b) and (c) (d) (b) and (d)

Q.8 If a diode is connected in antiparallel with a thyristor, then

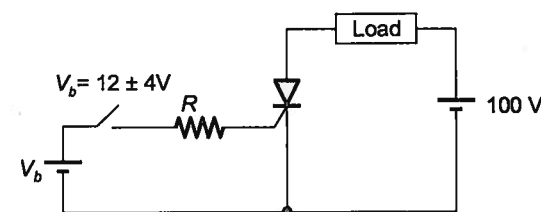
- (a) both turnoff power loss and turnoff time decrease
(b) turnoff power loss decreases, but turnoff time increases
(c) turnoff power loss increases, but turnoff time decreases
(d) none of the above

[GATE-1997]



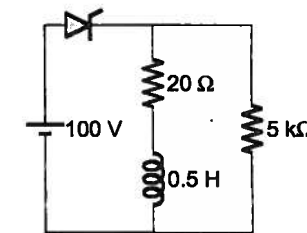
Numerical Data Type Questions

Q.9 The triggering circuit of a thyristor is shown in figure. The thyristor requires a gate current of 10 mA, for guaranteed turn-on. The value of R required for the thyristor to turn on reliably under all conditions of V_b variation is _____ Ω .



[GATE-2004]

Q.10 An SCR having a turn ON time of 5 μ sec, latching current of 50 mA and holding current of 40 mA is triggered by a short duration pulse and is used in the circuit shown in figure. The minimum pulse width required to turn the SCR ON will be _____ μ sec.

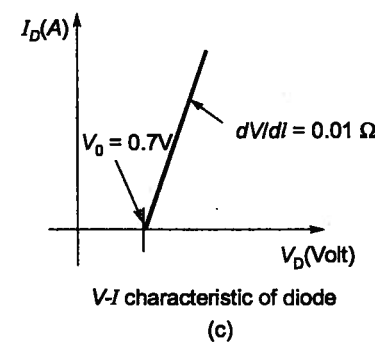
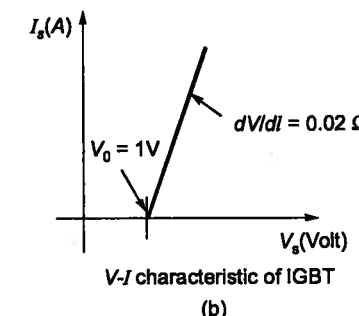
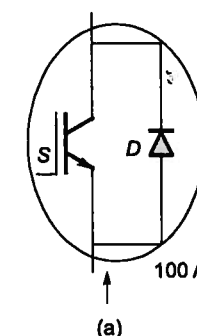


[GATE-2006]

Q.11 An SCR has half cycle surge current rating of 3000A for 50 Hz supply. One cycle surge current rating will be _____ A.

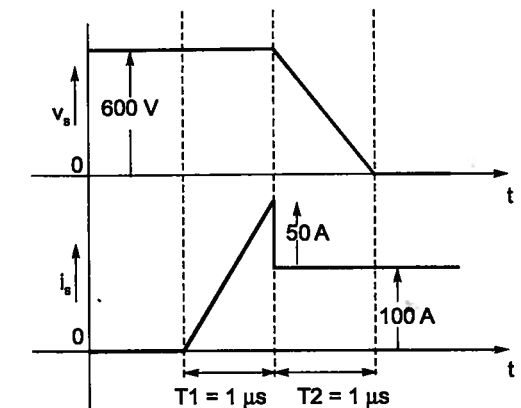
Q.12 An SCR gives maximum rms on-state current as 35A. If this SCR is used in resistance circuit, complete average on-state current rating for half-sinewave current for conduction angles of 30° is _____ A.

Q.13 A steady dc current of 100 A is flowing through a power module (S, D) as shown in Figure (a). The V-I characteristics of the IGBT (S) and the diode (D) are shown in Figures (b) and (c), respectively. The conduction power loss in the power module (S, D), in watts, is _____.



[GATE-2016]

Q.14 The voltage (v_s) across and the current (i_s) through a semiconductor switch during a turn-ON transition are shown in figure. The energy dissipated during the turn-ON transition, in mJ, is



[GATE-2016]

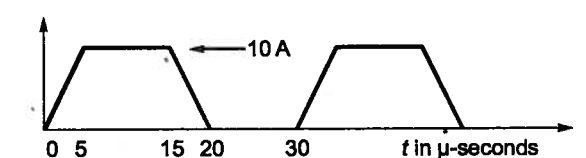


Conventional Questions

Q.15 For a thyristor maximum junction temperature is 125°C. The thermal resistance for thyristor-sink combination are $\theta_{jc} = 0.16$ and $\theta_{cs} = 0.08^\circ\text{C/W}$. For a heat sink temperature of 70°C, compute the total average power loss in the thyristor sink combination. In case the heat sink is brought down to 60°C by forced cooling, find the percentage increase in the device rating.

[ESE-2006]

Q.16 The periodic current through a power-switching device in a switching converter application is shown in Fig.



- Q.17** (a) Discuss the power loss in a diode during the reverse recovery transients.
(b) The forward characteristic of a power diode can be represented by $v_f = 0.88 + 0.015 i_f$.

Determine the average power loss and rms current for a constant current of 50 A for $2/3$ of a cycle.

[Hint. (b) With T as the time of a cycle, average power loss

$$= \frac{1}{T} \int_0^{2T/3} v_f I_f dt = \frac{2}{3} \cdot v_f I_f \text{ etc.}$$

Q.18 A thyristor operating from a peak supply voltage of 400 V has the following specifications:
Repetitive peak current,

$$I_p = 200 \text{ A}, \left(\frac{di}{dt} \right)_{\max} = 50 \text{ A/s}, \left(\frac{dv}{dt} \right)_{\max} = 200 \text{ V/s.}$$

Choosing a factor of safety of 2 for I_p , $\left(\frac{di}{dt} \right)_{\max}$

and $\left(\frac{dv}{dt} \right)_{\max}$, design a suitable snubber circuit.

The minimum value of load resistance is 10Ω .

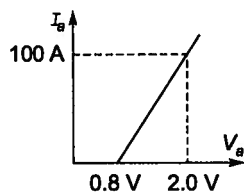


Try Yourself

T1. Latching current for an SCR, inserted in between a dc voltage source of 200 V and the load, is 100 mA. The minimum width of gate pulse current required to turn on this SCR in case the load consists of $R = 20 \Omega$ in series with $L = 0.2 \text{ H}$ is ____ μs .

[Ans: 100.50]

T2. During forward conduction, a thyristor has static I - V characteristic as shown below.

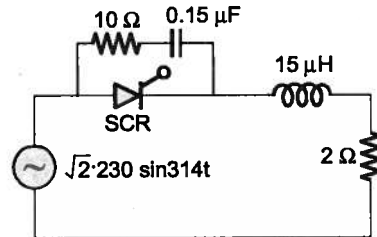


The average powerloss in the thyristor and its rms current rating if the load condition is a constant current of 80 A for one half cycle is

- (a) 70.4 W and 42.18 A
- (b) 64.75 W and 56.57 A
- (c) 70.4 W and 56.57 A
- (d) 64.75 W and 42.18 A

[Ans: (c)]

T3. In the circuit shown below

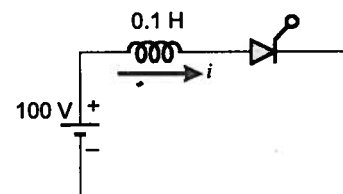


the maximum value of $\frac{dv}{dt}$ for the SCR is

- (a) 164 V/ μsec
- (b) 202 V/ μsec
- (c) 185 V/ μsec
- (d) 216.85 V/ μsec

[Ans: (d)]

T4. In the circuit shown below, if the Latching current of the thyristor is 4 mA then the minimum width of the gate pulse required to properly turn on the SCR is



- (a) 1 μs
- (b) 2 μs
- (c) 3 μs
- (d) 4 μs

[Ans: (d)]

