Power Electronics and Drives Test 2

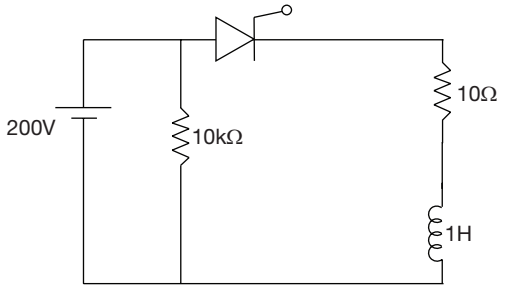
Number of Questions: 25 **Section Marks: 25**

Directions for questions 1 to 25: Select the correct alternative from the given choices.

1. Which of the following statement gives the protection of the GTO from the abnormal conditions.
(A) Turn-off snubbers to minimize over currents through the device during turn-off.
(B) Turn-on snubbers to minimize over voltages through the device at turn-ON.
(C) Stress reduction snubbers that shape the device switching wave forms.
(D) None of the above

2. Which of the following gives justification for using idealized device characteristics.
(A) The temperature coefficient of the device on-state resistance determines the ease of connecting them in parallel to handle large currents.
(B) The power required by the control circuit determines the conduction losses in the device.
(C) On-state voltage or on-state resistance determines the ease of controlling the device.
(D) Energy loss per transition in the device is independent on the switching times of the device.

3. The turn-ON time of the SCR is 10 μs for the pure resistive load, latching current is 60 mA and holding current is 45 mA is triggered by a short duration pulse and its is used in the circuit shown in figure, the minimum pulse width required to turn on the SCR is?

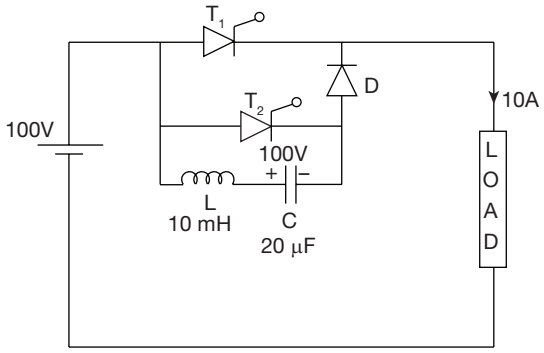


(A) 300 μs (B) 250 μs
(C) 750 μs (D) 500 μs

4. A thyristor controlled inductor will work as a variable inductor or fixed inductor, respectively for firing angles.
(A) less than 90°, greater than 90°
(B) greater than 90°, less than or equal to 90°
(C) less than 90°, greater than or equal to 90°
(D) less than or equal to 90°, greater than 90°

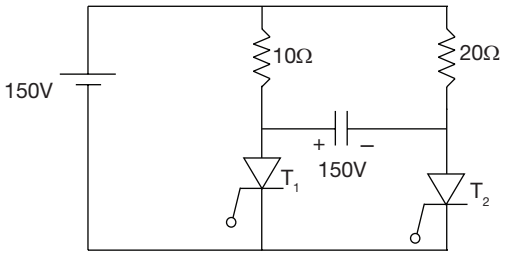
5. The device turn-off time of an SCR used in single phase half wave rectifier is 550 μs. For what value of the supply frequency the natural commutation takes place for the thyristor?
(A) 50Hz (B) 100Hz
(C) 150Hz (D) 200Hz

6. The commutation circuit shown below, initially T_1 is in ON state and load is carrying constant current of 10A. The capacitor is stored with 100V. The minimum conduction time of the thyristor T_1 after T_2 triggered is ?



(A) 0.702 ms (B) 1.40 ms
(C) 2.80 ms (D) 3.51 ms

7. In the circuit shown below the two thyristors are complementary commutated to each other. What will be the maximum current flowing through T_1 when initial voltage across capacitor is 150V polarities as shown below.



(A) 7.5 A (B) 15 A
(C) 30 A (D) 45 A

8. A three phase half wave rectifier operates with supply voltage 441V, 50 Hz and feeding a pure resistive load. The average output voltage expression when firing angle $\alpha < 30°$ is $V_o = \frac{3\sqrt{3}\,V}{2\pi}\cos\alpha$. The maximum instantaneous output voltage will be?
(A) 180V (B) 360V
(C) 623.66V (D) 311.83V

9. Which of the following is a characteristic of asymmetrical silicon controlled rectifier.
(A) Increased turn-ON time but reduced turn-OFF time.
(B) Faster switching frequency compared to conventional SCR.

(C) Increased reverse voltage blocking capability.
(D) Increased turn-OFF time but reduced turn-ON time.

10. Unequal sharing of voltages occurs when the thyristors are connected in series due to
(A) difference in forward conduction characteristics
(B) difference in reverse recovery characteristics
(C) difference in reverse blocking characteristics
(D) thermal difference.

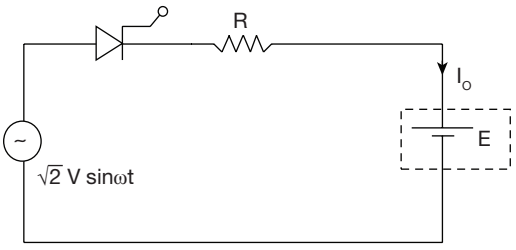
11. The circuit for protection against noise signal used gate circuit of SCR is having
(A) a resistor in series with capacitor connected across gate and cathode terminals.
(B) a resistor in parallel with capacitor connected across the gate and cathode terminals.
(C) a resistor in series with capacitor connected in series to the gate terminal.
(D) a resistor in parallel with capacitor connected in series to the gate supply.

12. In a 3 – ϕ semi converter, for firing angle equal to 125° and extinction angle equal to 105°, each SCR and free-wheeling diode conduct respectively for
(A) 55°, 50° (B) 65°, 75°
(C) 55°, 25° (D) 65°, 105°

13. A single phase semi converter feed RLE load such that load current is constant for a firing angle of 90°. The input power factor will be
(A) 0.866 lag (B) 0.866 lead
(C) 0.636 lag (D) 0.636 lead

14. A purely inductive load is controlled by a single phase AC voltage regulator using back to back connected SCRs. If the triggering angle of the SCR is 70°, the current through the two SCRs will flow for
(A) 280° and 0° (B) 220° and 0°
(C) 110° and 0° (D) 180° and 180°

15. A DC battery is charged through a resistor R as shown in the figure.



The SCR is fired continuously. If V = 220V(rms), E = 100 and R = 5 Ω, the power supplied to the battery will be?
(A) 2000W (B) 1084W
(C) 542W (D) 1000W

16. If the turn-on time of a SCR is 7.2 μs, an ideal gate trigger pulse should have
(A) short rise-time and pulse width of 8 μs
(B) short rise-time and pulse width of 4 μs
(C) high rise-time and pulse width of 4 μs
(D) high rise-time and pulse width of 8 μs

17. Two thyristors A and B have rated gate current of 150 mA and 3A respectively
(A) A is GTO and B is conventional SCR
(B) B is GTO and A is conventional SCR
(C) Thyristor B may operate as transistor
(D) None of the above

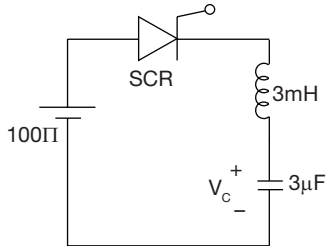
18. A single phase semi converter is operated from a 50 Hz, 111V ac source. If a resistive load of 50 Ω is connected at the dc terminals of converter and the average output voltage is 25% of the maximum possible average output voltage, the average load current will be?
(A) 0.5A (B) 0.6A
(C) 0.78A (D) 0.39A

19. For a thyristor, maximum junction temperature is 100°C. The thermal resistance for thyristor-sink combination are θ_{jc} = 0.12 and θ_{cs} = 0.08° C/W. In case the heat sink temperature is brought to 60°C from 80°C by forced cooling, the percentage increase in the device rating will be
(A) 50 (B) 100
(C) 41.4 (D) 82.8

20. A 230V, 50Hz one pulse SCR controlled converter is triggered at firing angle of 60° and the load current extinguishes at 120°. The circuit turn-off time and average output voltage will be respectively
(A) 33.33 ms, 155.31V (B) 33.33 ms, 77.64V
(C) 13.33 ms, 51.77V (D) 13.33 ms, 103.53V

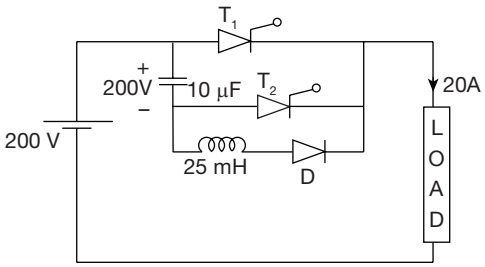
21. A three phase full converter is supplying a purely resistive load at 400V d.c. for 30° firing angle. The output voltage for 90° firing angle would be
(A) 0V (B) 61.9V
(C) 83.4V (D) 112.5V

22. The initial voltage across the capacitor is zero, if the SCR is triggered at t = 0s, the voltage across capacitor V_C at the instant t = 74.5 μs is



(A) 74V (B) 80V
(C) 92V (D) 104V

23. A chopper circuit shown in figure is initially capacitor stored to supply voltage as shown in figure and SCR T_1 is in conduction by drawing constant load current of 20A. The switching frequency is 500Hz. What will be the minimum value of the output voltage?



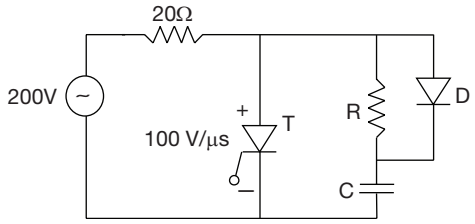
(A) 20 π (B) 30 π
(C) 50 π (D) 100 π

24. A single phase full converter is connected to an AC supply of 330 sin 314*t* volts. It operates at firing angle $\alpha = \frac{\pi}{4}$. The load current is maintained constant at 5A and load voltage is 140V. The angle of overlap due to effect of source will be

(A) 1.54° (B) 4.53°
(C) 6.62° (D) 9.18°

25. A thyristor protection circuit shown in figure is operated with source voltage of 200V and load resistance is 20 Ω. The SCR can withstand a $\frac{dV}{dt}$ value of 100 V/μs.

If the snubber discharge current must be limited to 4A, what will be the value of snubber capacitor



(A) 44.5 nF (B) 63.5 nF
(C) 89 nF (D) 127 nF

Answer Keys

1. C	**2.** A	**3.** A	**4.** B	**5.** A	**6.** B	**7.** C	**8.** B	**9.** B	**10.** B
11. B	**12.** A	**13.** C	**14.** D	**15.** B	**16.** A	**17.** B	**18.** A	**19.** C	**20.** D
21. B	**22.** C	**23.** C	**24.** C	**25.** C					

Hints and Explanations

1. Stress reduction snubbers that shape the device switching waveforms such that the voltage and current associated with a device are not high simultaneously.

Choice (C)

2. Choice (A)

3. Current flowing through SCR is $i(t) = \frac{V}{R}[1 - e^{-t/\tau}] = I_L$

and $\tau = \frac{L}{R} = \frac{1}{10}$

$i(t) = \frac{200}{10}[1 - e^{-10t}] = 60$ mA

$P.W = t_{min} = 300$ μs Choice (A)

4. Choice (B)

5. For single phase HWR, circuit turn-off angle $\omega t_c = \pi$

$t_c = \frac{\pi}{2\pi f} = \frac{1}{2f}$

From the options only at $f = 50$ Hz

$t_c = \frac{1}{\omega_o} = 1000\,\mu s$

hence $t_c > t_q$, natural commutation occurs.

Choice (A)

6. The minimum condution time of T_1 is $= \pi\sqrt{LC}$

$= \pi\sqrt{(10\times10^{-3})(20\times10^{-6})} = 1.40$ ms

Choice (B)

7. The peak current flowing through T_1 is

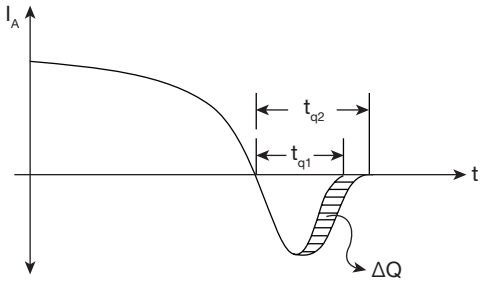
$(I_{T_1})_{peak} = \frac{V_S}{R_1} + \frac{2V_S}{R_2}$

$= \frac{150}{10} + \frac{2\times150}{20} = 30$A Choice (C)

8. $V_{mph} = V = 441\sqrt{\frac{2}{3}} = 360$V Choice (B)

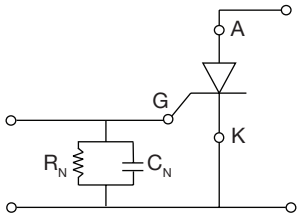
9. ASCR is made with reduced reverse voltage blocking capability which has an improved turn-ON and turn-OFF times. Hence it has faster switching frequency compared to conventional thyristor. Choice (B)

10. During the reverse recovery process the SCR having low turn-OFF time should share the complete string voltage for a very short duration.



Choice (B)

11.



For the noise signal capacitor acts as short circuit hence all noise is diverted through the capacitor and will be wasted in the form of heat through resistance R_N.

Choice (B)

12. For 3 – ϕ semi converter, for α = 125°, thyristor and diode conducts for 55° only. Freewheeling diode conducts for 105° – 55° = 50°. Choice (A)

13. Input power factor $= \dfrac{V_o I_o}{V_{sr} \times I_{sr}}$

$V_o = \dfrac{V_s}{\pi}\left[1+\cos\alpha\right]$,

$I_{sr} = I_o\sqrt{\dfrac{\pi-\alpha}{\pi}}$

For α = 90°

Input power factor $= \dfrac{\frac{V_m}{\pi}\left[1+\cos\alpha\right]\times I_o}{\left(\frac{V_m}{\sqrt{2}}\right)\times\sqrt{\frac{\pi/2}{\pi}}\times I_o} = \dfrac{2}{\pi}$

= 0.6363 lag Choice (C)

Note: Always source current lags the source voltage.

14. For pure inductive loads impedance angle ϕ = 90°
But α < ϕ
hence Continuous conduction exists and so both SCRs conducts for 180°. Choice (D)

15. Power supplied to the battery = $E \times I_{avg}$

$I_{avg} = \dfrac{1}{2\pi}\int_{\theta_1}^{\theta_2}\dfrac{V_m \sin\omega t - E}{R}d\omega t$

$= \dfrac{1}{2\pi R}\left[2V_m\cos\theta_1 - E\left(\pi-2\theta_1\right)\right]$

$\theta_1 = \sin^{-1}\left[\dfrac{100}{\sqrt{2}\times 220}\right] = 18.75° = 0.327\text{ rad}$

$I_{avg} = \dfrac{1}{2\pi\times 5}\left[\begin{matrix}2\times\sqrt{2}\times 220\times\cos(18.75) - \\ 100\left(\pi-2(0.327)\right)\end{matrix}\right]$ $I_{avg} = 10.84\text{A}$

The power supplied = $E\,I_{avg}$ = 100 × 10.84 = 1084 W.

Choice (B)

16. An ideal gate trigger should have short rise time and pulse width should be greater than turn-ON time of a SCR.

Choice (A)

17. GTO triggering gate current is higher than that required for a conventional SCR due to multi cathode structure of GTO. Choice (B)

18. The average output voltage of a semiconverter

$V_o = \dfrac{V_m}{\pi}\left[1+\cos\alpha\right]$

Maximum output voltage = $\dfrac{2V_m}{\pi}$

$\dfrac{V_m}{\pi}\left[1+\cos\alpha\right] = \dfrac{2V_m}{\pi}(0.25)$

1 + cos α = 0.5
α = 120°

Average load current, $I_{avg} = \dfrac{V_o}{R} = \dfrac{V_m}{\pi R}\left[1+\cos\alpha\right]$

$= \dfrac{111\sqrt{2}}{\pi\times 50}\left[1+\cos 120^o\right]$ = 0.5 A Choice (A)

19. Initially the heat sink temperature at 80°C.

average power loss = $P_{avg_1} = \dfrac{T_j - T_s}{\theta_{js}} = \dfrac{100-80}{0.12+0.08}$

$= \dfrac{20}{0.20} = 100\text{W}$

When sink temperature brought down to 60°C

$P_{avg_2} = \dfrac{100-60}{0.12+0.08} = \dfrac{40}{0.2} = 200\text{W}$

% increase in device rating = $\dfrac{\sqrt{P_{avg_2}} - \sqrt{P_{avg_1}}}{\sqrt{P_{avg_1}}}\times 100$

$= \dfrac{\sqrt{200}-\sqrt{100}}{\sqrt{100}}\times 100 = \left(\sqrt{2}-1\right)\times 100 = 41.4\%$

Choice (C)

20. Circuit turn-off time = $t_c = \dfrac{2\pi-\beta}{\omega}$

$t_c = \dfrac{2\pi - \frac{2\pi}{3}}{2\pi\times 50}$; $t_c = \dfrac{2}{3\times 50} = \dfrac{1}{75}$; t_c = 13.33 ms

Average output voltage = $V_o = \dfrac{V_m}{2\pi}\left[\cos\alpha - \cos\beta\right]$

$= \dfrac{230\sqrt{2}}{2\pi}\left[\cos 60° - \cos 120°\right]$ = 103.53V Choice (D)

21. Average output voltage of 3 – Φ full converter,

$\left[\because 0<\alpha<\dfrac{\pi}{3}\right]\ (V_o)_{avg} = \dfrac{3V_{m\ell}}{\pi}\cos\alpha$

$400 = \dfrac{3V_{m\ell}}{\pi}\times\cos 30^o$

$$\frac{3V_{m\ell}}{\pi}=461.88$$

$$\text{For } \frac{\pi}{3}<\alpha<\frac{2\pi}{3};\ V_o=\frac{3V_{m\ell}}{\pi}\left[1+\cos\left(\alpha+\frac{\pi}{3}\right)\right]$$

$$V_o=461.88\left[1+\cos\left(\frac{\pi}{2}+\frac{\pi}{3}\right)\right]=61.9\text{V}$$ Choice (B)

22. When SCR is turned on, $V_S=L\frac{di}{dt}+\frac{1}{C}\int i\,dt$

$$\frac{V_s}{S}=LS\,I(S)+\frac{1}{CS}I(S)$$

$$I(S)=\frac{V_S}{L}\left\{\frac{1}{S^2+\frac{1}{LC}}\right\}$$

$$I(t)=V_S\sqrt{\frac{C}{L}}\sin\left(t/\sqrt{LC}\right)$$

Voltage across inductor, $V_L=V_S\cos\omega_o t$

$V_C=V_S-V_L=V_S[1-\cos\omega_o t]$

V_C at $t=74.5\ \mu s$

$$\omega_o=\frac{1}{\sqrt{LC}}=\frac{1}{\sqrt{(3\times10^{-3})(3\times10^{-6})}}$$

$\omega_o=10540.92$ rad/s

$\omega_o t=10540.92\times74.5\times10^{-6}$

$$\omega_o t=0.785=\frac{\pi}{4}\text{ rad}$$

$$V_C=100\,\pi\left[1-\cos\left(\frac{\pi}{4}\right)\right]=92\text{V}$$ Choice (C)

23. The minimum turn-ON time of the SCR is $=\pi\sqrt{LC}$

$T_{ON}=\pi\sqrt{LC}$

For step down chopper, $V_o=\delta\,V_S$

$$V_o=\frac{T_{ON}}{T}V_S$$

$V_o=T_{ON}.V_S.f$

$$(V_o)_{\min}=\left(\frac{\pi}{\sqrt{LC}}\right)V_s\,f$$

$$(V_o)_{\min}=\pi\left(\sqrt{25\times10^{-3}\times10\times10^{-6}}\right)\times200\times500$$

$(V_o)_{\min}=50\,\pi$ V Choice (C)

24. Average output voltage $V_o=\frac{2V_m}{\pi}\cos\alpha-\frac{\omega L_s}{\pi}I_o$

$$140=\frac{2\times330}{\pi}\cos\left(\frac{\pi}{4}\right)-\frac{(314)L_s\times5}{\pi}$$

$L_S=17.11$ mH

Average load current $I_o=\frac{V_m}{\omega L_S}\left[\cos\alpha-\cos(\alpha+\mu)\right]$

$$5=\frac{330}{314\times0.017113}\left[\cos\frac{\pi}{4}-\cos\left(\frac{\pi}{4}+\mu\right)\right]$$

$\mu=6.627^o$ Choice (C)

25. Discharge current $I_d=\frac{V_{\max}}{R}=4\text{A}$

$$\frac{\sqrt{2}\times200}{R}=4$$

$R=50\sqrt{2}\Omega$

The maximum $\frac{dV}{dt}$ changes across the thyristor

$$\left(\frac{dV}{dt}\right)_{\max}=\frac{0.632V_m}{R_LC}=\frac{0.632\sqrt{2}\times200}{20\times100}=89\text{ nF}$$

Choice (C)