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Power Electronics

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CLASS TEST 2019-2020

ELECTRICAL ENGINEERING

Date of Test : 05/09/2019

ANSWER KEY ➤ Power Electronics

1.	(d)	7.	(a)	13.	(c)	19.	(a)	25.	(c)
2.	(b)	8.	(c)	14.	(a)	20.	(c)	26.	(a)
3.	(b)	9.	(d)	15.	(d)	21.	(c)	27.	(c)
4.	(a)	10.	(b)	16.	(c)	22.	(d)	28.	(c)
5.	(b)	11.	(c)	17.	(c)	23.	(d)	29.	(c)
6.	(b)	12.	(b)	18.	(b)	24.	(d)	30.	(b)

Detailed Explanations

1. (d)

Let, V_1 = Output of buck converter = Input of boost converter

$$V_1 = 10\,D_1$$

$$\text{Output of boost converter} = 30\text{ V} = \frac{V_1}{1-D_2}$$

$$30 = \frac{10\,D_1}{1-D_2}$$

or $$3 - 3\,D_2 = D_1$$

or $$D_1 + 3\,D_2 = 3$$

2. (b)

$$\alpha = 30^\circ$$

$$\text{Input power factor} = \frac{\sqrt{2}(1+\cos\alpha)}{\sqrt{\pi(\pi-\alpha)}} = \frac{\sqrt{2}(1+\cos 30)}{\sqrt{\pi\left(\pi-\frac{\pi}{6}\right)}} = 0.92$$

3. (b)

Triac and RCT possess bi-directional current capability. IGBT and GTO are unidirectional current devices.

4. (a)

Applying *kVL*

$$230\cos\omega t = L\frac{di(t)}{dt}$$

$$\frac{di(t)}{dt} = \frac{230}{L}\cos\omega t$$

or $$di(t) = \frac{230}{L}\cos\omega t\,dt$$

$$\int di(t) = \int\frac{230}{L}\cos\omega t\,dt$$

$$i(t) = \frac{230}{\omega L}\sin\omega t + k$$

at, $$t = 0, \qquad i(t) = 0$$

$$0 = \frac{230}{\omega L}\sin 0 + k$$

$$k = 0$$

$$i(t) = \frac{230}{\omega L}\sin\omega t$$

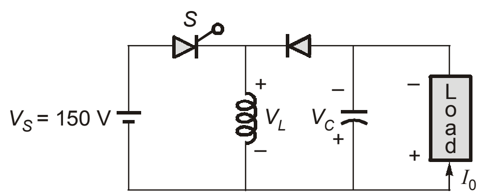
$$I_{max} = \frac{230}{\omega L} = \frac{230}{314\times 73.24\times 10^{-3}} = 10.00\text{ A}$$

5. (b)

For single phase full bridge controlled converter,

$$\text{Fundamental displacement factor} = \cos\alpha = \cos 45° = 0.707$$

6. (b)



The given chopper is Buck-Boost

$$V_0 = \frac{V_S \times D}{1-D}$$

$$V_0 = \frac{150\times 0.4}{1-0.4} = \frac{150\times 4}{60} = 100 \text{ V}$$

bef in question they asked opposite to the actual polarity

so, $V_0 = -100$ V

7. (a)

8. (c)

For turning on of SCR when it is fired it should be in forward bias.

at, $\alpha = 15°$

The magnitude of source voltage

$$V_s = 230\sqrt{2}\sin 15° = 84.18 \text{ V}$$

Since in this instant the battery emf is greater than the source voltage. So battery makes thyristor into reverse bias. The output voltage of the load at firing angle 15° is 170 V.

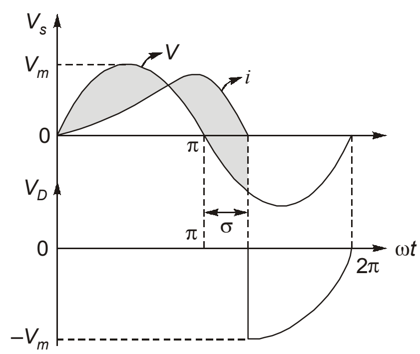
9. (d)

All the statements given are correct, hence the correct option is (d).

10. (b)

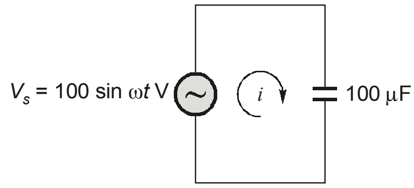
Due to inductive load, the conduction period of diode *D* will extend beyond 180° until the current becomes zero at $\omega t = \pi + \sigma$.

The waveform of voltage and current are will be as shown below.

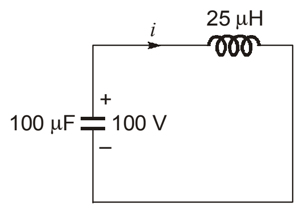


11. (c)

When S_1 is closed,



Since circuit has only capacitor, so it will charge up to maximum value V_m instantly. When S_1 opens and S_2 is closed, the circuit will be as shown below.



The peak current flowing in the circuit is

$$I_{peak} = V_{(0)}\sqrt{\frac{C}{L}}$$

$$= 100\sqrt{\frac{100}{25}}$$

$$I_{peak} = 200 \text{ A}$$

12. (b)

When compared with SCR, magnitude of latching and holding currents are more in a GTO.

13. (c)

120° mode

Converting delta load into star equivalent so,

$$(R_Y)_{P_2} \text{ phase} = \frac{R\Delta}{3} = \frac{R}{3}$$

$$\text{Output phase voltage (Rms)} = \sqrt{\frac{2}{3}} \cdot \frac{V_S}{2}$$

$$\text{Total power } P_1 = 3 \times \frac{\left(\sqrt{\frac{2}{3}} \cdot \frac{V_S}{2}\right)^2}{\frac{R}{3}} = \frac{3V_S^2}{2R} \quad \text{...(i)}$$

180° mode

$$\text{Output line voltage} = \sqrt{\frac{2}{3}} \cdot V_S$$

$$\text{Phase voltage} = \frac{V_L}{\sqrt{3}} = \sqrt{\frac{2}{3}} \cdot \frac{V_S}{\sqrt{3}} = \frac{\sqrt{2}\,V_S}{3}$$

$$\text{Total load power } P_2 = 3 \cdot \frac{(V_P)^2}{R} = \frac{3 \cdot \left(\frac{\sqrt{2}\,V_S}{3}\right)^2}{R} = \frac{2V_S^2}{3R}$$

So,

$$\frac{P_1}{P_2} = \frac{\frac{3}{2R}V_S^2}{\frac{2}{3R}V_S^2} = \frac{9}{4} = 2.25$$

14. (a)

The peak value of current through T_2 is,

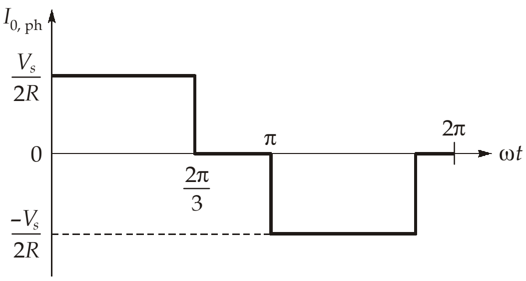
$$I_{T_2\,\max} = V_s\left[\frac{2}{R_1} + \frac{1}{R_2}\right]$$

$$= 200\left[\frac{2}{10} + \frac{1}{100}\right]$$

$$I_{T_2\,\max} = 42 \text{ A}$$

15. (d)

Wave form of load phase current in 120° conduction mode



Rms value of per phase load current $I_{0,\,\text{rms}}$ is

$$I_{\text{ph rms}} = \frac{V_s}{2R}\sqrt{\frac{\left(\frac{2\pi}{3}\right)}{\pi}} = \frac{450}{2 \times 10}\sqrt{\frac{2}{3}} = 18.37 \text{ A}$$

16. (c)

The given circuit is a Boost regulator,

$$V_0 = \frac{V_s}{1-\alpha}$$

$$15 = \frac{5}{1-\alpha}$$

$$\alpha = 0.6667$$

or,
$$\Delta I = \frac{V_s\,\alpha}{f\,L}$$

$$\Delta I = \frac{5 \times 0.6667}{25 \times 10^3 \times 150 \times 10^{-6}}$$

$$= 0.89\text{ A}$$

17. (c)

$$\text{Derating factor} = 1 - \text{string efficiency}$$

$$\text{String efficiency} = \frac{\text{Actual voltage rating of whole string}}{(\text{Individual voltage rating of one SCR}) \times (\text{No. of SCR})}$$

$$\eta = \frac{(10 \times 10^3)}{(500) \times (n_s)}$$

$$\text{DRF} = 0.15 = 1 - \frac{10 \times 10^3}{(500) \times (n_s)}$$

Number of SCR's required in series,

$$n_s = \frac{10 \times 10^3}{(500) \times (0.85)} \cong 23.53 = 24$$

18. (b)

Let the magnitude of the wave is taken as

$$A = 150\text{ V}$$

rms value of the periodic wave form is

$$V_{rms} = \left[\frac{2}{T}\int_0^{\frac{\alpha T}{2}} \left[\frac{A}{\left(\frac{\alpha T}{2}\right)} t\right]^2 dt\right]^{1/2}$$

$$= \sqrt{\frac{2}{T}\left(\frac{2A}{\alpha T}\right)^2 \left(\frac{t^3}{3}\Bigg|_0^{\frac{\alpha T}{2}}\right)} = \sqrt{\frac{2}{T}\left(\frac{4A^2}{\alpha^2 T^2}\right)\left(\frac{\alpha^3 T^3}{8 \times 3}\right)}$$

$$= \sqrt{A^2\left(\frac{\alpha}{3}\right)}$$

or, $$V_{0,rms} = A\sqrt{\frac{\alpha}{3}} = 150\sqrt{\frac{\alpha}{3}} \quad ...(i)$$

$$\text{Power consumed} = 50\text{ W} = \frac{V_{rms}^2}{R}$$

or, $$V_{rms} = \sqrt{5000}\text{ volts} \quad ...(ii)$$

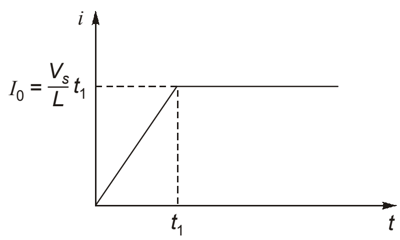
Equating both the equations:

$$150\sqrt{\frac{\alpha}{3}} = \sqrt{5000}$$

$$\alpha = \frac{2}{3} = 0.67$$

19. (a)

When the switch is closed at $t = 0$, the load current rises linearly and is expressed as



$$i(t) = \frac{V_s}{L}t$$

At $$t = t_1,$$

$$I_0 = \frac{V_s t_1}{L}$$

$$= \frac{220 \times 100 \times 10^{-6}}{220 \times 10^{-6}} = 100\text{ A}$$

When switch is opened at $t = t_1$, the load current starts to flow through diode FD. Because there is no dissipative (resistive) element in the circuit, the load current remain constant at $I_o = 100$ A, and the energy stored in the inductor is

$$0.5\,LI_0^2 = 0.5 \times 220 \times 10^{-6} \times (100)^2 = 1.1\text{ J}$$

20. (c)

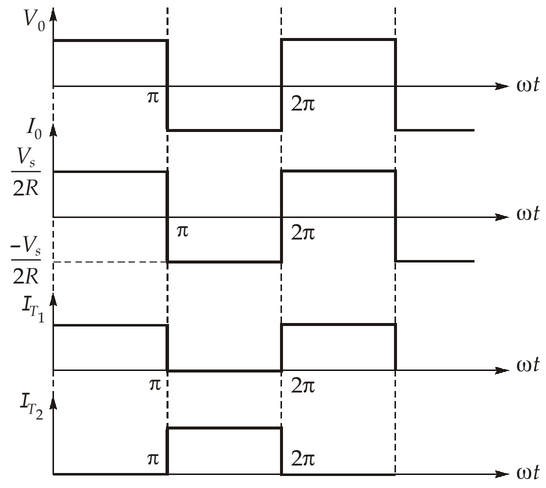
Peak Inverse Voltage across FD $= 2\,V_s$

$= 2 \times 230 = 460$ V

Peak Inverse Voltage across main thyristor

$= V_s = 230$ V

21. (c)



Average value of current through each thyristor is,

$$I_{T(avg)} = \frac{1}{2\pi}\int_0^{\pi} \frac{V_s}{2R}\, d\omega t$$

$$I_{T(avg)} = \frac{V_s}{4R} = 11.5\,\text{A}$$

Peak value of current through each thyristor is

$$\frac{V_S}{2R} = \frac{230}{2\times 5} = 23\ \text{A}$$

22. (d)

$$V_{03} = \frac{4\,V_s}{3\pi}\sin 3(\omega t) = \frac{4\times 230}{3\times\pi}\sin 3(\omega t)$$

$$= 97.6150 \sin(942.47t)$$

$$Z_3 = R + j\left(3\,\omega L - \frac{1}{3\omega C}\right)$$

$$= 4 + j\left(3\times 2\pi\times 50\times 35\times 10^{-3} - \frac{1}{3\times 2\pi\times 50\times 155\times 10^{-6}}\right)$$

$$= 4 + j(32.986 - 6.8453)$$

$$= \sqrt{4^2 + (26.1407)^2}$$

$$Z_3 = 26.44\ \Omega$$

$$I_0 = \frac{97.6150}{\sqrt{2}}\times\frac{1}{26.44} = 2.61\,\text{A}$$

23. (d)

Average value of load voltage,

$$V_0 = \frac{2V_m}{\pi}\cos\alpha = E + I_0 R$$

$$\frac{2\sqrt{2}\times 230}{\pi}\cos 60° = 50 + (I_0 \times 10)$$

Average value of load current,

$$I_0 = 5.35 \text{ A}$$

24. (d)

Since the given chopper is a step down chopper,

$$\text{Output voltage, } V_0 = \delta\ V_s$$

$$\text{Ripple current, } \Delta I = \frac{V_0 T_{\text{off}}}{L}$$

At boundary condition,

$$\Delta I = 2\ I_0 = 2I_L$$

So,

$$2\ I_0 = \frac{\delta V_s(1-\delta)}{Lf}$$

$$L = \frac{\delta\ V_s(1-\delta)}{2 I_0 f}$$

Multiplying and dividing by R, we get

$$L = \frac{\delta\ V_s R(1-\delta)}{2 I_0 R f} \qquad (V_0 = I_0 R)$$

$$L = \frac{R(1-\delta)}{2f}$$

$$\frac{2fL}{R} = 1-\delta$$

$$\delta = 1-\frac{2L}{RT}$$

25. (c)

The conduction time of SCR 'T' is,

$$\omega t = \pi$$

$$t = \frac{\pi}{\omega_0} = \pi\sqrt{LC}$$

$$= \pi\sqrt{\left(\frac{200}{\pi}\right)\left(\frac{200}{\pi}\right)}$$

$$t = 200\ \mu\text{sec}$$

26. (a)

$$\text{Pulse width} = \frac{2d}{N} = \left(1 - \frac{V_r}{V_c}\right)\frac{\pi}{N}$$

$$= \left(1 - \frac{1}{2}\right)\frac{\pi}{5} = \frac{\pi}{10} = 18°$$

27. (c)

From α_1 to 59.99° only thyristor T_1 conduct so maximum current in this duration through T_1 is

$$= \frac{230\sqrt{2}\sin(59.99°)}{10} = 28.16\,\text{A}$$

at, $\alpha_2 = 60°$ both T_1 and T_2 conduct and at $\omega t = \frac{\pi}{2}$ the maximum current through the load

$$= \frac{230\sqrt{2}}{10} = 32.52\ \text{A}$$

current through both T_1 and T_2

$$= \frac{32.52}{2} = 16.26\ \text{A}$$

at $\alpha_3 = 120°$ all thyristors conduct so maximum current at this instant $= \frac{230\sqrt{2}\sin 120°}{10} = 28.16\,\text{A}$

current passing through each thyristor

$$= \frac{28.16}{3} = 9.38\,\text{A}$$

So, peak current through, T_1 = 28.16 A
peak current through, T_2 = 16.26 A
peak current though, T_3 = 9.38 A

28. (c)

The circuit is a oscillatory circuit,

$$I = V_s\sqrt{\frac{L}{C}}\sin\omega t$$

$$I(t) = 250\sqrt{\frac{100}{25}}\sin\omega t$$

$$\omega = \frac{1}{\sqrt{LC}}$$

$$I(t) = 500\sin\omega t\ \text{A}$$

For maximum value of current

$$\sin\omega t = 1$$

$$\omega t = \frac{\pi}{2}$$

$$t = \frac{\pi}{2\omega} = \frac{\pi}{2\times\frac{1}{\sqrt{LC}}} = \frac{\pi\sqrt{LC}}{2}$$

$$= \frac{\pi\sqrt{25\times10^{-6}\times100\times10^{-6}}}{2}$$

$$t = 78.5\ \mu s$$

$$V_c = \frac{1}{C}\int_0^{157\mu\sec} 500\sin\omega t\ dt - 250$$

$$= \frac{500}{\omega C}\left(-\cos\omega t\Big|_0^{157\mu s}\right) - 250 = -250\ (1-1) - 250$$

$$V_C = -250\ \text{V}$$

29. (c)

For practical boost converter

$$\frac{V_0}{V_{in}} = \frac{1-D}{\frac{r}{R_L}+(1-D)^2}$$

or
$$\frac{V_0}{100} = \frac{1-0.5}{\frac{2}{10}+(1-0.5)^2}$$

$$\frac{V_0}{100} = 1.1111$$

$$V_0 = 111.11\ \text{V}$$

30. (b)

rms value of load voltage

if, $\alpha \le 30°$

$$V_{or} = V_{mL}\left[\frac{1}{6}+\frac{1}{8\pi}\sqrt{3}\cos2\alpha\right]^{1/2}$$

$$V_{or} = \sqrt{2}\times230\left[\frac{1}{6}+\frac{\sqrt{3}}{8\pi}\cos60\right]^{1/2}$$

$$= 145.87\ \text{V}$$

$$P = \frac{V_{or}^2}{R} = \frac{145.87^2}{5\times1000}\text{kW}$$

$$= 4.25\ \text{kW}$$

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