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Open Practice Test Series
(Also useful for ESE & Other Exams)

EE : ELECTRICAL ENGINEERING

TEST No. 08 | POWER ELECTRONICS & DRIVES

Read the following instructions carefully

1. This question paper contains 33 MCQ's & NAQ's. Bifurcation of the questions are given below:

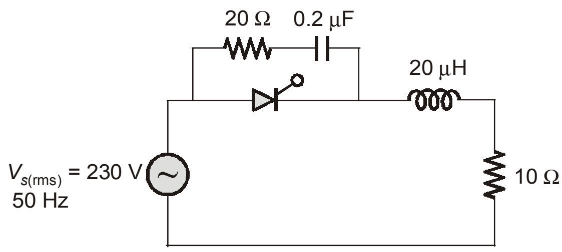
Subjectwise Test Pattern

Questions	Question Type	No. of Questions	Marks	Total Marks	Negative Marking
1 to 9	Multiple Choice Ques.	9	1	9	0.33
10 to 16	Numerical Answer Type Ques.	7	1	7	None
17 to 25	Multiple Choice Ques.	9	2	18	0.66
26 to 33	Numerical Answer Type Ques.	8	2	16	None
Total Questions : 33		**Total Marks : 50**		**Total Duration : 90 min**	

2. Choose the closest numerical answer among the choices given.

Multiple Choice Questions : Q.1 to Q.9 carry 1 mark each

Q.1 In the circuit shown below the maximum values of $\frac{di}{dt}$ for the SCR is



(a) 11.5 A/μs
(b) 16.26 A/μs
(c) 23 A/μs
(d) 32.5 A/μs

1. (b)

$$\left(\frac{di}{dt}\right)_{max} = \frac{V_m}{L} = \frac{230\sqrt{2}}{20\,\mu\text{H}} = 16.26 \text{ A}/\mu \text{ sec}$$

Q.2 When the conduction angle of thyristor increases then, its average rating of on state current

(a) Do not change
(b) Increases
(c) Decreases
(d) Cannot say

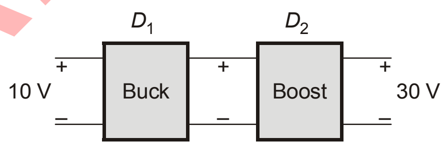
2. (b)

When conduction angle of thyristor increases, form factor decreases.

$$I_{T(avg)} = \frac{I_{rms}\,(\text{rating})}{F.F}$$

If form factor decreases then $I_{T(avg)}$ increases.

Q.3 In the figure shown below, the duty ratio of buck converter is D_1 and the duty ratio of boost converter is D_2. The input voltage of buck converter is 10 V and the output voltage of boost converter is 30 V. Which of the following equation satisfy the correct relation between D_1 and D_2.



(a) $D_2 + 3D_1 = 3$
(b) $D_1 = 3D_2$
(c) $D_2 = 3D_1$
(d) $D_1 + 3D_2 = 3$

3. (d)

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

$$V_1 = 10\,D_1$$

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

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

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

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

Q.4 From the following converters which cannot be used for armature voltage speed control of DC motor

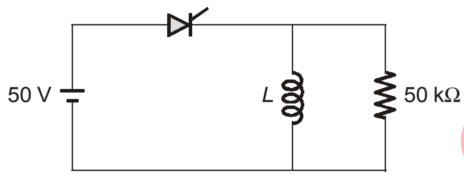
(a) Buck - Boost converter (b) Buck - converter

(c) Single phase semi converter (d) Boost converter

4. (d)

In armature voltage control speed control method in DC machine we reduce the voltage, we cannot increase the voltage due to insulation of windings. So for this purpose we can't use boost converter.

Q.5 A thyristor switching circuit is shown below. The thyristor is rated for a latching current of 5 mA and is turned on within 5 μs. The value of inductance L is



(a) 0.601 H (b) 0.104 H

(c) 0.062 H (d) 6 H

5. (c)

For proper turn on

$$I_A \geq I_L$$

$$I_A = \frac{1}{L}\int V\,dt + \frac{V}{R}$$

$$I_A = \frac{V}{L}t + \frac{V}{R}$$

or $$\frac{V}{L}t + \frac{V}{R} \geq 5 \times 10^{-3}$$

or $$\frac{50}{L} \times 5 \times 10^{-6} + \frac{50}{50 \times 10^{3}} \geq 5 \times 10^{-3}$$

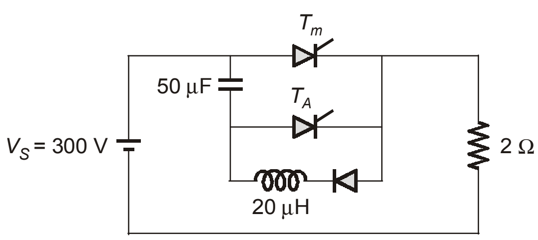
or $$\frac{250 \times 10^{-6}}{L} \geq 4 \times 10^{-3}$$

or $$L \leq \frac{250 \times 10^{-6}}{4 \times 10^{-3}}$$

or $$L \leq 0.0625 \text{ H}$$

$$L = 0.0625 \text{ H}$$

Q.6 In the circuit shown below, the circuit turn off-time of main thyristor T_m is



(a) 2 μs (b) 61.2 μs

(c) 69.3 μs (d) 0.01 ms

6. **(c)**

Circuit turn off time of main thyristor is,

$$t_{cm} = RC\ln 2$$
$$= 2 \times 50 \times 10^{-6} \times \ln 2$$
$$t_{cm} = 69.3\ \mu\text{s}$$

Q.7 A single-phase VSI fed from dc source voltage V_s. For the load $R = 2\ \Omega$, $X_L = 4\ \Omega$, $X_C = 2\ \Omega$, the shape of output voltage is

(a) Sinusoidal wave (b) Trapezoidal wave
(c) Triangular wave (d) Square wave

7. **(d)**

In voltage source inverter the shape of output voltage is independent from load parameter. The output voltage shape will be square wave (or) rectangular depended upon switching.

Q.8 A single phase semiconverter feeds a highly inductive load with ripple free load current. The input supply voltage V_S to the converter. Triggering angle of the bridge converter is $\alpha = 30°$. The input power factor of the bridge is

(a) 0.78 (b) 0.92
(c) 0.65 (d) 0.82

8. **(b)**

$$\alpha = 30°$$

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

Q.9 For class A commutation (Load commutation) the commutation circuit parameter is $L = 20\ \mu$H, $C = 50\ \mu$F. For proper commutation what will be the value of load resistance

(a) $2\ \Omega$ (b) $1\ \Omega$
(c) $4\ \Omega$ (d) $1.5\ \Omega$

9. **(b)**

For proper commutation the circuit should be under damped.

$$\frac{1}{LC} - \left(\frac{R}{2L}\right)^2 > 0$$

or
$$R < \sqrt{\frac{4L}{C}}$$

$$R < \sqrt{\frac{4 \times 20 \times 10^{-6}}{50 \times 10^{-6}}}$$

$$R < 1.26\ \Omega$$

Option (b) is the only value which is less than $1.26\ \Omega$

$$\therefore \quad R_L = 1\ \Omega$$

Numerical Answer Type Questions : Q. 10 to Q. 16 carry 1 mark each

Q.10 A step down chopper feeding a inductive load and current is ripple free in the output circuit. If duty cycle is 0.75, then the ratio of rms current through freewheeling diode to rms current through switch is _______

10. 0.57 (0.40 to 0.70)

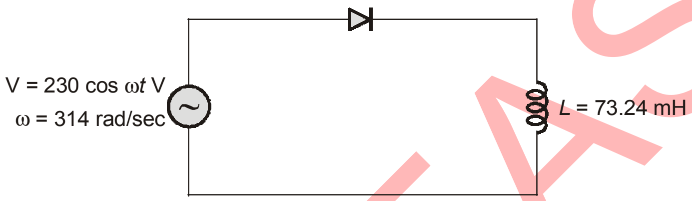
Let, I_0 = ripple free load current

Rms current through free wheeling diode = $I_0\sqrt{1-D}$

$$\text{Rms current through switch} = I_0\sqrt{D}$$

$$\text{Required Ratio} = \frac{I_0\sqrt{1-D}}{I_0\sqrt{D}} = \frac{\sqrt{1-0.75}}{\sqrt{0.75}} = 0.57$$

Q.11 In the circuit shown below, the maximum value of current passing through inductor is ________ A.



11. 10 (9.00 to 11.00)

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, $t = 0,\quad i(t) = 0$

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

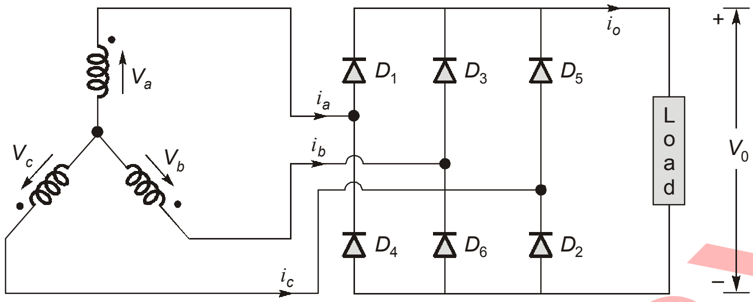
$$k = 0$$

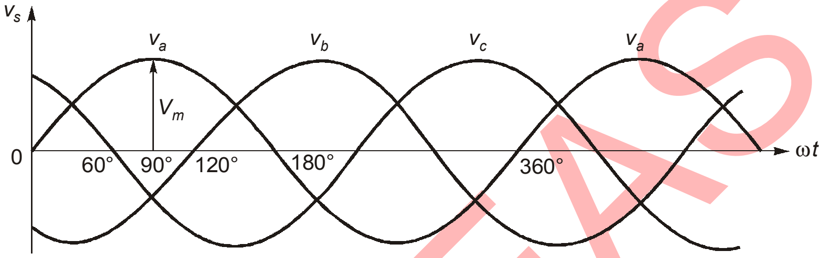
$$i(t) = \frac{230}{\omega L}\sin\omega t$$

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

Q.12 In a 3-phase diode bridge rectifier fed from the star-connected secondary of a transformer, let the voltage to the neutral of the A-phase (phase sequence A, B, C) be $V_m \sin\omega t$. At the instant when the voltage of A-phase is maximum, the output voltage at the rectifier terminals will be ________ V_m.

12. 1.5 (1.20 to 1.70)





$$V_A = V_m \sin\omega t$$

Phase A will get maximum voltage at $\omega t = 90°$. At this instant

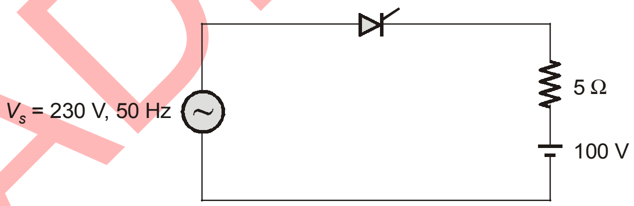
$$V_0 = V_A - V_B$$

$$V_0 = V_m \sin\omega t - V_m \sin(\omega t - 120°)$$

$$= V_m - V_m \sin(-30°)[\because \ \omega t = 90°]$$

$$V_0 = 1.5\ V_m$$

Q.13 In the circuit shown below, the circuit turn off time of thyristor is ________ ms.



13. 11.99 (11.50 to 12.25)

$$\text{Circuit turn off time of thyristor} = \frac{\pi + 2\theta_1}{\omega}$$

For value of θ_1

$$V_m \sin\theta_1 = E$$

or $$230\sqrt{2}\sin\theta_1 = 100$$

or $$\theta_1 = \sin^{-1}\left(\frac{100}{230\sqrt{2}}\right) = 17.90°$$

$$t_c = \frac{\pi + \left(\dfrac{2 \times 17.90° \times \pi}{180°}\right)}{2\pi \times 50}$$

$$= 11.99 \text{ ms}$$

Q.14 For type A chopper circuit, source voltage V_S = 200 V chopping period T = 1500 μs, Load circuit parameters R = 1 Ω, L = 5 mH and E = 30 V. The value of duty ratio for the load current is just continuous is ________

14. 0.17 (0.12 to 0.25)

$$T_a = \frac{L}{R} = \frac{5\times 10^{-3}}{1} = 5 \text{ ms}$$

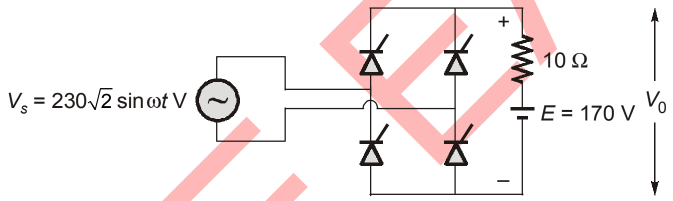
$$\frac{T_a}{T} = \frac{5\times 10^{-3}}{1500\times 10^{-6}} = 3.33$$

$$m = \frac{E_b}{V_s} = \frac{30}{200} = 0.15$$

$$D = \frac{T_a}{T} ln\left[1+m\left(e^{T/T_a}-1\right)\right]$$

$$D = 3.33 ln\left[1+0.15\left(e^{\frac{1}{3.33}}-1\right)\right] = 0.17$$

Q.15 A DC battery is charged through a resistor R as shown below. The output voltage of the load at firing angle 15° is ________ V.



15. 170 (168.00 to 172.00)

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

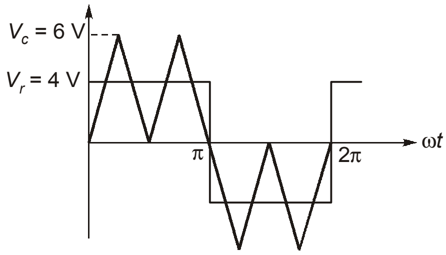
at, α = 15°

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.

Q.16 Output voltage of an inverter is controlled by multiple pulse modulation technique. If the peak value of reference voltage is 4 V and peak value of carrier voltage is 6 V. Then the total pulse width in each half cycle is ________ degrees.



16. **60 (58.00 to 62.00)**

$$V_r = 4\text{ V}$$
$$V_c = 6\text{ V}$$
$$\text{Total pulse width} = 2d$$
$$\frac{2d}{N} = \left(1-\frac{V_r}{V_c}\right)\frac{\pi}{N} \qquad \text{(Where } N \text{ is number of pulses per half cycle)}$$
$$2d = \left(1-\frac{V_r}{V_C}\right)\pi$$
$$2d = \left(1-\frac{4}{6}\right)180^\circ = 60^\circ$$

Multiple Choice Questions : Q.17 to Q.25 carry 2 marks each

Q.17 In sinusoidal PWM, there are 'm' cycles of the triangular carrier wave in the half cycle of reference sinusoidal signal. If zero of the reference sinusoid coincides with zero of the triangular carrier wave, then number of pulses generated in each half cycle are

(a) $(m-1)$
(b) $(m+1)$
(c) m
(d) $(m+2)$

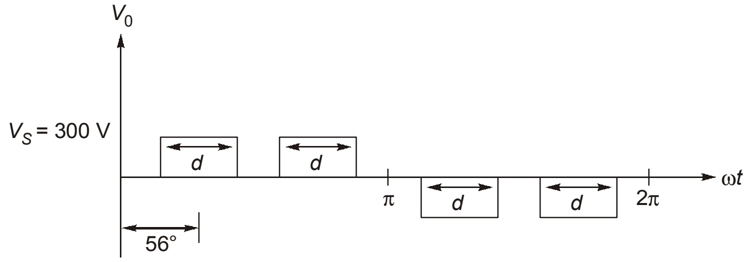
17. **(a)**

When zero of the triangular wave coincides with zero of the reference sinusoid, there are $(m-1)$ pulses per half cycle.

i.e., $\left(\frac{f_c}{2f}-1\right)$

$\therefore$ $(m-1)$

Q.18 Output voltage of an inverter is controlled by multiple pulse modulation technique. The peak value of fundamental voltage components is



(a) 155.37 V
(b) 109.85 V
(c) 93.10 V
(d) 131.67 V

18. (d)

The amplitude of n[th] harmonic of the two pulse waveform is

$$V_m = \frac{8V_s}{n\pi}\sin n\gamma.\sin\frac{nd}{2}$$

Peak value of fundamental voltage component

$$V_1 = \frac{8V_S}{\pi}\cdot\sin\frac{d}{2}\cdot\sin\gamma$$

$$V_S = 300\text{ V},\ N = 2\ ,\ \gamma = 56°$$

$$\gamma = \frac{\pi-2d}{N+1}+\frac{d}{N} \qquad \text{(we known)}$$

$$\left(\frac{\pi}{180}\right)56° = \frac{\pi-2d}{3}+\frac{d}{2}$$

or $\quad d = 24°$

Hence

$$V_1 = \frac{8\times 300}{\pi}\cdot\sin\frac{24°}{2}\cdot\sin 56° = 131.67\text{ V}$$

Q.19 A single-phase full bridge inverter has RLC load of $R = 4\ \Omega$, $L = 35$ mH and $C = 155\ \mu$F. The dc input voltage is 230 V and output frequency is 50 Hz. The 3rd harmonic component in load current is

(a) 1.6 A (b) 2.24 A
(c) 1.98 A (d) 2.61 A

19. (d)

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

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

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

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

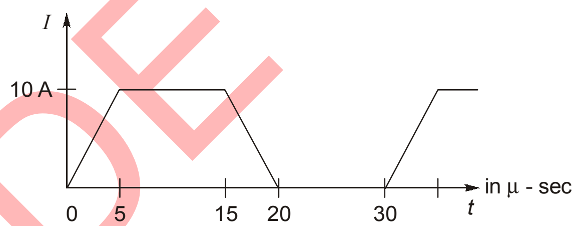
$$= 4 + j(32.986 - 6.8453)$$

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

$$Z_3 = 26.44\ \Omega$$

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

Q.20 The periodic current through a power switching device in a converter application is shown below.



The average value of current is

(a) 3 A (b) 4 A
(c) 5 A (d) 6 A

20. (c)

To obtain the average value of the periodic waveform,

$$I_{\text{average}} = \frac{\text{Area under the curve}}{\text{Total time period}}$$

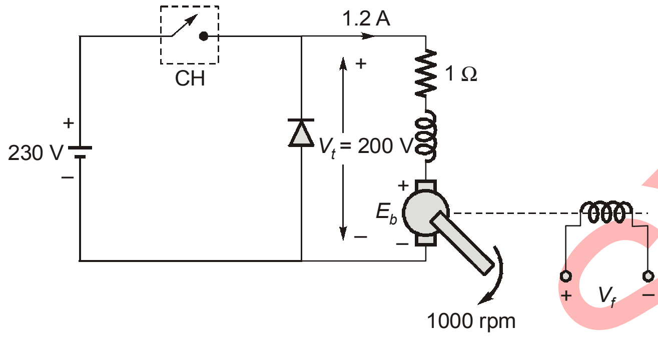
$$= \frac{\left(\frac{1}{2}\times 5\times 10\right) + (10\times 10) + \left(\frac{1}{2}\times 5\times 10\right)}{30}$$

$$I_{\text{avg}} = 5\text{ A}$$

Q.21 A 200 V, 1000 rpm, 12 A separately excited DC motor is controlled in constant torque mode by using stepdown chopper. Armature resistance is 1 Ω. If the motor is to be run at 750 rpm, then the duty cycle required if input to the converter is 230 V is

(a) 0.2
(b) 0.4
(c) 0.6
(d) 0.8

21. (c)



$$E_{b1} = V_t - I_a R_a$$
$$= 200 - (12 \times 1)$$
$$E_{b1} = 188 \text{ V}$$

E_{b2} is the back emf at 750 rpm, hence the motor is running at constant torque mode armature current should be same in both the cases,

$$E \; \alpha \; N\phi$$

$$\frac{E_{b1}}{E_{b2}} = \frac{N_1}{N_2}$$

$$\frac{188}{E_{b2}} = \frac{1000}{750}$$

$$E_{b2} = 141 \text{ V}$$

I_a is held constant

by KVL:

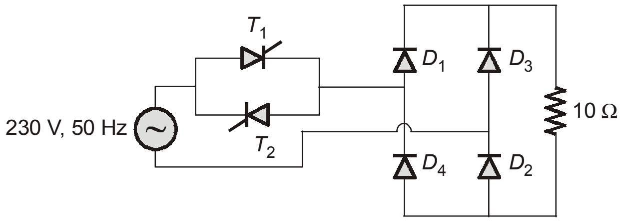
$$-V_t + I_a R_a + E = 0$$
$$I_a R_a + E_{b2} = V_t$$
$$V_t = 141 + 12 = 153 \text{ V}$$
$$V_0 = V_t = 153 \text{ V}$$

and $V_s = 230$ V

∴ $V_0 = \alpha V_s$

$$\alpha = \frac{V_0}{V_s} = \frac{153}{230} = 0.66$$

Q.22 In the following circuit, the rms value of load current in amperes, if firing angle $\alpha = 90°$ is



(a) 14 A (b) 23 A
(c) 16 A (d) 0 A

22. (c)

$$V_{or} = \frac{V_m}{\sqrt{2}}\left[\frac{1}{\pi}\left\{(\pi-\alpha)+\frac{\sin 2\alpha}{2}\right\}\right]^{1/2}$$

$$= \frac{230\sqrt{2}}{\sqrt{2}}\left[\frac{1}{\pi}\left\{\left(\pi-\frac{\pi}{2}\right)+\frac{\sin 180°}{2}\right\}\right]^{1/2}$$

$$V_{or} = 162.63 \text{ V}$$

This is rms input to the diode bridge rectifier.
The output rms of diode bridge rectifier,

$$V_{0\,rms} = \frac{V_m}{\sqrt{2}} = \frac{162.63\sqrt{2}}{\sqrt{2}}$$

$$V_{0,\,rms} = 162.63 \text{ V}$$

$$I_{0,\,rms} = \frac{162.63}{10} = 16.26 \text{ A}$$

Q.23 A single-phase full bridge inverter is fed from a dc source $V_S = 230$ V, if the load $R = 2\ \Omega$ and $X_c = 8\ \Omega$ then the conduction angles of each switch and feedback diodes respectively are

(a) 135°, 45° (b) 45°, 135°
(c) 76°, 104° (d) 104°, 76°

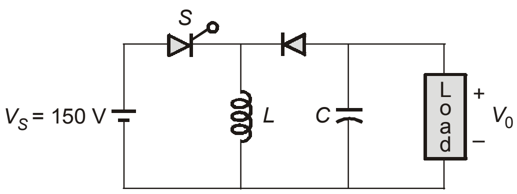
23. (d)

$$R = 2\ \Omega,\ X_C = 8\ \Omega$$

$$\theta = \tan^{-1}\frac{X_C}{R} = \tan^{-1} 4 = 76°$$

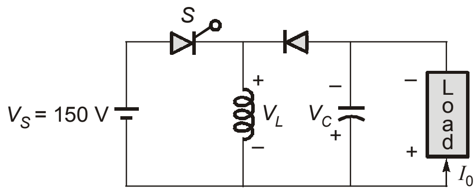
Conduction angle of diode = 76°
Conduction angle of switch = 180 – 76 = 104°

Q.24 Figure shows a chopper operating from a 150 V dc input the duty ratio of switch S is 0.4. The average output voltage of the chopper will be



(a) 100 V (b) – 100 V
(c) 60 V (d) – 60 V

24. (b)



The given chopper is Buck-Boost

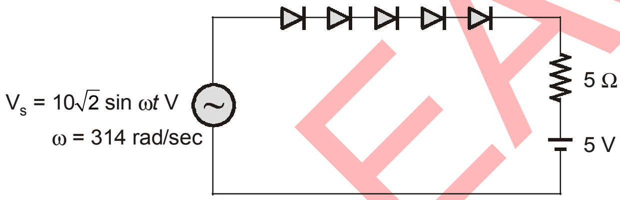
$$V_0 = \frac{V_S \times D}{1-D}$$

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

bef in question they asked opposite to the actual polarity

so, $V_0 = -100$ V

Q.25 In the given circuit the diodes cut in voltage is 0.7 V. The average charging current through the battery in amperes is



(a) 0.21
(b) 0.15
(c) 0.25
(d) 0.4

25. (a)

$$\text{Average charging current} = I_{avg} = \frac{\int_{\theta_1}^{\pi-\theta_1} [V_m \sin\omega t - (E + 0.7 \times 5)]\, d\omega t}{2\pi R}$$

For θ_1

$$10\sqrt{2}\sin\theta_1 = E + (5 \times 0.7)$$

or $$10\sqrt{2}\sin\theta_1 = 5 + 3.5$$

$$\sin\theta_1 = \frac{8.5}{10\sqrt{2}}$$

$$\theta_1 = 36.94°$$

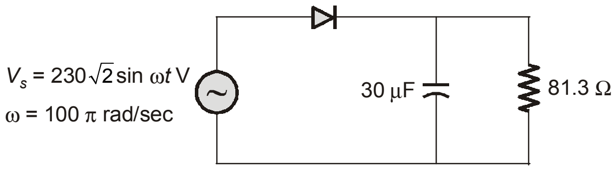
$$I_{avg} = \frac{\int_{36.94°}^{143.06°} (10\sqrt{2}\sin\omega t)\, d\omega t - \int_{36.94°}^{143.06°} (8.5)\, d\omega t}{2\pi \times 5}$$

$$= \frac{-10\sqrt{2}[\cos 143.06° - \cos 36.94°] - \left[\frac{8.5(143.06° - 36.94°) \times \pi}{180°}\right]}{10\pi}$$

$$I_{avg} = \frac{22.6 - 15.74}{10\pi} = 0.21\ A$$

Numerical Answer Type Questions : Q. 26 to Q. 33 carry 2 marks each

Q.26 In the circuit shown below, the peak current passing through the diode is ________ A.



26. 5.03 (4.60 to 5.30)

$$I_D = I_C + I_R$$

$$= \frac{C\,dV_C}{dt} + \frac{V}{R} = \frac{Cd}{dt}\left[230\sqrt{2}\sin\omega t\right] + \frac{230\sqrt{2}\sin\omega t}{81.3}$$

$$= 30\times 10^{-6}\times 230\times\sqrt{2}\times 100\pi\times\cos\omega t + 4\sin\omega t$$

$$= 3.06\cos\omega t + 4\sin\omega t$$

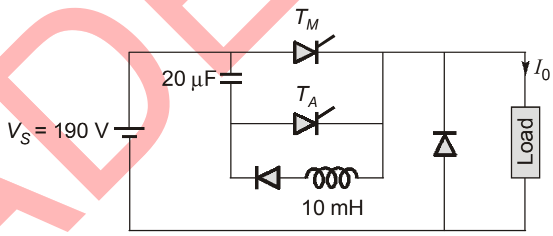
$$I_D = 4\sin\omega t + 3.06\cos\omega t$$

$$I_D = \sqrt{4^2 + 3.06^2}\sin\left(\omega t + \tan^{-1}\frac{3.06}{4}\right)$$

$$I_D = 5.03\sin(\omega t + 37.41°)$$

So, Peak Current = 5.03 A

Q.27 A voltage commutated chopper is given below. The chopper duty ratio is 50%. The load current remains constant 10 A assuming the input voltage to be 190 V and devices to be ideal. Maximum value of current through capacitor is ________ A.



27. 10 (9.50 to 10.50)

From capacitor two current will pass through it at different instants one is sinusoidal whose peak value is $V_S\sqrt{\frac{C}{L}}$ and another is load current.

Peak value of current in sinusoidal component through capacitor

$$= 190\times\sqrt{\frac{20\times 10^{-6}}{10\times 10^{-3}}} = 8.5\text{ A}$$

Load current passing through capacitor

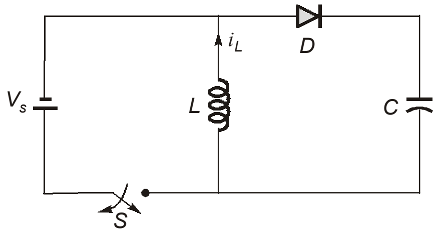
$$= 10\text{ A}$$

From both load current is maximum

So, peak current through capacitor

$$= 10\text{ A}$$

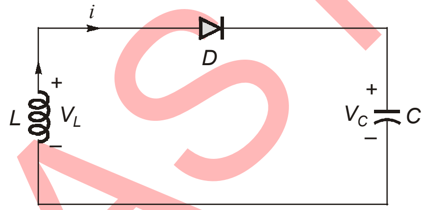
Q.28 In the circuit shown below, the switch is opend at the instant when the inductor current is 100 A. If the circuit parameters are L = 15 μH, C = 40 μF, then the conduction time of diode is ________ μs.



28. 38.47 (38.20 to 38.60)

$$V_L + V_C = 0$$

$$L\frac{di(t)}{dt} + \frac{1}{C}\int i(t)df = 0$$



Applying Laplace transform

$$LsI(s) - LI(0^+) + \frac{1}{Cs}I(s) = 0$$

$$I(s)\left[Ls + \frac{1}{Cs}\right] = LI(0^+)$$

$$I(s) = \frac{LCs\,I(0^+)}{LCs^2 + 1}$$

$$I(s) = \frac{LCI(0^+)\cdot s}{LC\left(s^2 + \frac{1}{LC}\right)}$$

$$I(s) = I(0^+)\cdot\frac{s}{s^2 + \left(\frac{1}{\sqrt{LC}}\right)^2}$$

Applying inverse laplace transform

$$i(t) = I(0^+)\cos\frac{1}{\sqrt{LC}}t = I(0^+)\cos\omega t$$

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

After $t = \frac{\pi}{2}$ currents gets reverse i.e. negative current diode will not allow, so conduction angle = $\frac{\pi}{2}$

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

$$t = \frac{\pi}{2\omega} = \frac{\pi}{2\times\frac{1}{\sqrt{LC}}} = \frac{\pi\sqrt{LC}}{2} = 38.47\ \mu s$$

Q.29 A separately-excited dc motor, operating from a single-phase half-controlled bridge at a speed of 1400 rpm, has an input voltage of V_s = 330 sin 314t V and a back emf 80 V. The SCRs are fired symmetrically at $\alpha = 30°$ in every half cycle and the armature has a resistance of 4 Ω. The motor torque will be ________ Nm.

29. 15.82 (15.60 to 15.95)

For a single-phase semiconverter feeding a separately excited motor.

$$V_0 = V_t = \frac{V_m}{\pi}(1+\cos\alpha) = E_a + I_a r_a$$

$$\frac{330}{\pi}(1+\cos 30°) = 80 + I_a \cdot 4$$

$$196.01 = 80 + I_a \cdot 4$$

$\therefore$ Average armature current,

$$I_a = \frac{196.01-80}{4} = 29 \text{ A}$$

Motor torque,
$$T = \frac{E\, I_a}{2\pi \times \frac{N}{60}} = \frac{80 \times 29}{2\pi \times \frac{1400}{60}} = 15.82 \text{ Nm}$$

Q.30 In single-pulse modulation used in PWM inverter, V_S is the input dc voltage. For eliminating third harmonic, the magnitude of rms value of fundamental component of output voltage is (k_1 V_S) volts and pulse width is (60 k_2) degree, then the value of $k_1 + k_2$ ________.

30. 2.78 (2.60 to 2.90)

$$V_{on} = \sum_{n=1,3,5}^{\infty} \frac{4V_S}{n\pi} \cdot \sin\frac{n\pi}{2} \sin nd \cdot \sin n\omega t$$

for eliminating of 3rd harmonic, pulse width 2d must be equal to $\frac{2\pi}{3} = 120°$

$$\therefore \quad (60\,K_2)° = 120°$$

$$K_2 = 2$$

$$V_{0,\,\text{rms}} = \frac{4V_s}{\sqrt{2}\pi}\sin\frac{\pi}{2}\sin d$$

$$= \frac{4V_S}{\sqrt{2}\pi} \times \sin 60° \times 1$$

$$V_{0,\,\text{rms}} = 0.78\, V_S$$

$$V_{o1} = k_1 V_S = 0.78\, V_S$$

$$k_1 = 0.78$$

$$k_1 + k_2 = 2 + 0.78 = 2.78$$

Q.31 A single phase dual converter is fed from 230 V, 50 Hz source. The load is $R = 10\ \Omega$ and the current limiting reactor has $L = 0.06$ H. For $\alpha_1 = 120°$ the peak value of circulating current is _______ A.

31. 17.25 (17.15 to 17.35)

Since we know that

$$\alpha_1 + \alpha_2 = 180$$

$$120 + \alpha_2 = 180$$

or $$\alpha_2 = 60°$$

Peak value of circulatory current

$$I = \frac{2V_m}{\omega L}(1 - \cos\alpha_2)$$

we take $$\alpha < 90 \text{ (always)}$$

$$I = \frac{2 \times 230\sqrt{2}}{2 \times \pi \times 50 \times 0.06}[1 - \cos 60°]$$

$$= 17.25 \text{ A}$$

Q.32 A single phase semi-converter connected to 230 V, 50 Hz source is feeding a highly inductive load $R = 10\ \Omega$, $L = 3$ mH. The load current is ripple free. For the firing angle 30° the reactive power input in KVAR is ________.

32. 1 (0.95 to 1.05)

Average output voltage, $$V_0 = \frac{V_m}{\pi}(1 + \cos\alpha)$$

$$= \frac{230\sqrt{2}}{\pi}[1 + \cos 30°] = 193.20 \text{ V}$$

$$I_0 = \frac{V_0}{R} = \frac{193.20}{10} = 19.32 \text{ A}$$

Reactive power $$= V_0 I_0 \tan\left(\frac{\alpha}{2}\right) = 1 \text{ KVAR}$$

Q.33 A delta connected load of RΩ per phase is fed from source voltage V_S through a 3-phase bridge VSI in 120° mode. Let P_1 be the total load power in this mode. Another star connected load of RΩ per phase is fed from source voltage V_S through 3-phase bridge VSI in 180° mode. Let P_2 be the power output across the load, then the ratio of $\frac{P_1}{P_2}$ = ________.

33. **2.25 (2.20 to 2.30)**

120° mode

Converting delta load into star equivalent so,

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

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

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

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

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