CLASS TEST

S.No.: 01JP_EE_06082024

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ELECTRICAL ENGINEERING

POWER ELECTRONICS

Duration : 1:00 hr. **Maximum Marks : 50**

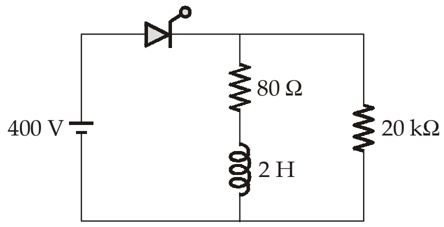
Read the following instructions carefully

1. This question paper contains **30** objective questions. **Q.1-10** carry one mark each and **Q.11-30** carry two marks each.
2. Answer all the questions.
3. Questions must be answered on Objective Response Sheet (**ORS**) by darkening the appropriate bubble (marked **A**, **B**, **C**, **D**) using HB pencil against the question number. Each question has only one correct answer. In case you wish to change an answer, erase the old answer completely using a good soft eraser.
4. There will be **NEGATIVE** marking. For each wrong answer **1/3rd** of the full marks of the question will be deducted. More than one answer marked against a question will be deemed as an incorrect response and will be negatively marked.
5. Write your name & Roll No. at the specified locations on the right half of the **ORS**.
6. No charts or tables will be provided in the examination hall.
7. Choose the **Closest** numerical answer among the choices given.
8. If a candidate gives more than one answer, it will be treated as a **wrong answer** even if one of the given answers happens to be correct and there will be same penalty as above to that questions.
9. If a question is left blank, i.e., no answer is given by the candidate, there will be **no penalty** for that question.

DO NOT OPEN THIS TEST BOOKLET UNTIL YOU ARE ASKED TO DO SO

Q.No. 1 to Q.No. 10 carry 1 mark each

Q.1 An SCR having a, latching current of 60 mA and holding current of 40 mA, is triggered by short duration pulse and is used in the circuit shown in figure. The minimum pulse width required to turn the SCR ON will be



(a) 100 μsec
(b) 200 μsec
(c) 300 μsec
(d) 250 μsec

Q.2 A single-phase full converter is delivering a constant a load current. When converter has firing angle of 35° and the overlap angle of 4°, then value of inductive voltage regulation will be

(a) 0.0520 (b) 0.0260
(c) 0.0209 (d) 0.0418

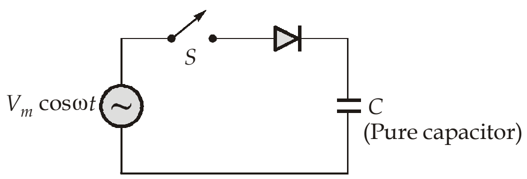
Q.3 Which of the following device are bidirectional and bipolar?

(a) TRIAC
(b) Unidirectional
(c) SCR
(d) both (a) and (b)

Q.4 The reverse recover time of Schottky diode is in range of

(a) millisecond
(b) microsecond
(c) nanosecond
(d) picosecond

Q.5 In the circuit shown below,



If switch in figure is closed $t = 0$, then at steady state the diode 'D' conducts for

(a) 0° (b) 15°
(c) 30° (d) 45°

Q.6 A type A chopper has input dc voltage of 200 V and a load of $R = 10\ \Omega$ in series with $L = 80$ mH. If the load current varies linearly between 12 A and 16 A, the time ratio $\frac{T_{on}}{T_{off}}$ for this chopper is

(a) 1.50 (b) 1.66
(c) 2.50 (d) 2.33

Q.7 A six pulse thyristor rectifier bridge is connected to a balanced 60 Hz three-phase AC source. Assuming that the DC output current of the rectifier is constant. The lowest frequency component of the AC source line current is

(a) 60 Hz (b) 120 Hz
(c) 300 Hz (d) 180 Hz

Q.8 In a single pulse modulation of PWM inverters the pulse width is 60°. For an input voltage of 600 V, the rms value of output voltage will be

(a) 346.4 V
(b) 282.40 V
(c) 115.4 V
(d) 462.80 V

Q.9 A single phase full bridge inverter is connected to an RL load of 20 Ω and 0.1 H. For a dc source voltage of 240 V and frequency of 50 Hz, the maximum value of load current at the end of first half cycle is (Assume the circuit is initially relaxed)

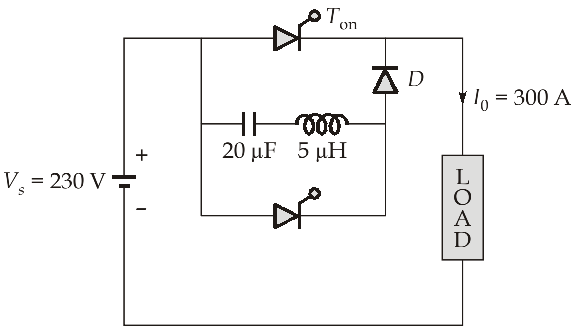
(a) 10.37 A (b) 8.27 A
(c) 7.34 A (d) 5.20 A

Q.10 In a 3-ϕ, 180° mode of operation of a bridge inverter, the lowest order harmonics in output phase voltage will be (fundamental frequency of output is 50 Hz)

(a) 50 Hz
(b) 300 Hz
(c) 150 Hz
(d) 250 Hz

Q. No. 11 to Q. No. 30 carry 2 marks each

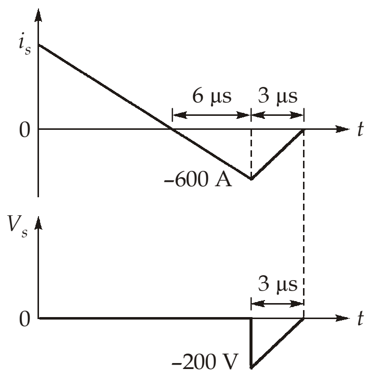
Q.11 In the circuit shown below:



the voltage across main thyristor (T_m) when it gets turned off is

(a) 174.37 V (b) 247.17 V
(c) 95.23 V (d) 147.73 V

Q.12 During turn off a thyristor, idealized voltage and current waveforms are shown below. For a triggering frequency of 50 Hz, the mean power loss due to turn off is



(a) 3 W (b) 6 W
(c) 8 W (d) 12 W

Q.13 A single phase half bridge inverter has a resistive load of 5 Ω and the center tap dc input voltage is 96 V. The fundamental power consumed by the load is

(a) 1.49 kW (b) 2.49 kW
(c) 1.75 kW (d) 3.50 kW

Q.14 A single phase half bridge inverter has a resistive load of R = 10 Ω and the dc input voltage of 48 volts. The harmonic factor of the lowest order harmonic would be equal to

(a) 33.33% (b) 33.98%
(c) 34.89% (d) 35.99%

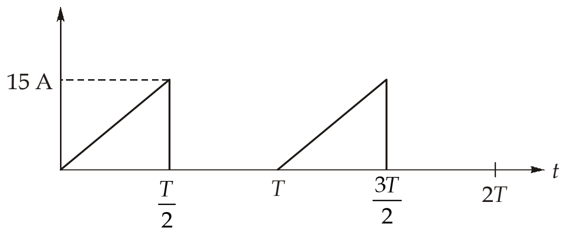
Q.15 A single phase CSI (with ideal switches) has the following data:
I = 30 A, f = 500 Hz and load of pure capacitance = 20 μF.
The peak value of reverse voltage that appears across thyristors is

(a) 450 V (b) 750 V
(c) 900 V (d) 1200 V

Q.16 A single phase inverter is operating with PWM technique to eliminate 5th harmonic content in the output. The rms value of 7th harmonic content in the output is _______ V_S (Volts).

(a) 0.12 (b) 0.14
(c) 0.08 (d) 0.04

Q.17 A MOSFET rated for 15 A, carries a periodic current as shown in figure. The ON state resistance of MOSFET is 0.25 Ω. The average ON state loss in the MOSFET is

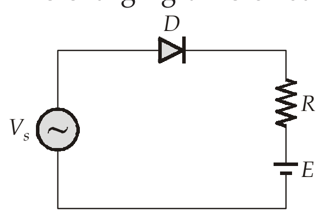


(a) 18.75 W (b) 9.375 W
(c) 28.125 W (d) 15.37 W

Q.18 For an SCR, the gate-cathode characteristic has straight line slope of 120. For trigger source voltage of 20 V, and allowable gate power dissipation of 0.4 watt, the value of gate source resistance is

(a) 226.54 Ω (b) 218.20 Ω
(c) 200.10 Ω (d) 185.20 Ω

Q.19 A dc battery of constant emf E is being charged through a resistor as shown. The source voltage V_s = 230 V, f = 50 Hz, R = 10 Ω, E = 120 V and battery capacity is 8.85 kWh. The charging time of battery is



(a) 9.30 hrs (b) 12.20 hrs
(c) 14.54 hrs (d) 18.20 hrs

Q.20 A single-phase semiconverter is operated from 230 V, 50 Hz ac supply. The load current with an average value I_{dc} is continuous and ripple free, firing angle $\alpha = \frac{\pi}{4}$. The harmonic factor of input current is

(a) 48.28% (b) 30.65%
(c) 31.08% (d) 28.98%

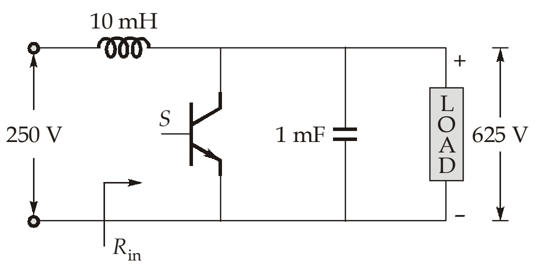
Q.21 For a thyristor, maximum junction temperature is 110° C. The thermal resistance for the thyristor sink combination are θ_{jc} = 0.16 and θ_{cs} = 0.05 C/W for a heat-sink temperature of 80° C. In case the heat sink temperature is brought down to 50° C by forced cooling, the percentage increase in the device rating is

(a) 20.20 (b) 30.40
(c) 41.42 (d) 50.20

Q.22 The Buck-converter has an input voltage of 40 V and the required average output voltage is 16 V. If the peak to peak ripple current of inductor is limited to 0.8 A and switching frequency is 20 kHz then the value of filter inductance '*L*' is

(a) 1000 μH (b) 600 μH
(c) 800 μH (d) 400 μH

Q.23 A DC-DC boost converter, as shown in the figure below, is used to boost 250 V to 625 V, at a power of 3.125 kW. Switch operating at 25 kHz all devices are ideal. Under steady-state condition, the average resistance R_{in} as seen by the source is

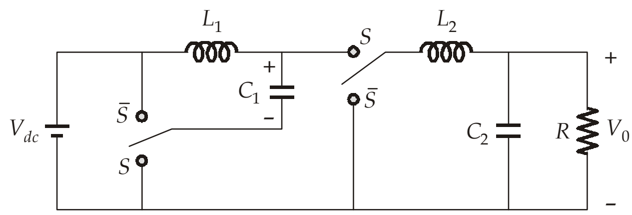


(a) 18 Ω (b) 20 Ω
(c) 28 Ω (d) 40 Ω

Q.24 In a DC-DC buck boost converter, the duty ratio is controlled to regulate the output at 36 V. The input DC voltage is 24 V. The output power is 144 W. The switching frequency is 20 kHz. Assume ideal components and a very large output filter capacitor. The converter operates at the boundary between continuous and discontinuous conduction modes. The value of the Buck-boost inductor (in μH) is

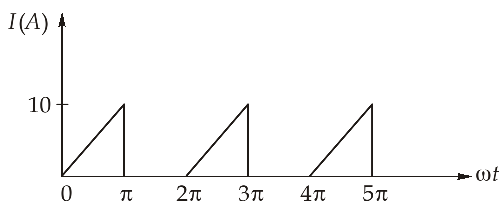
(a) 90 (b) 60
(c) 45 (d) 36

Q.25 A DC-DC converter is shown below. Consider switching time is *T* and duty ratio of switches is *D*. Both switches are at '*S*' position for *DT* and $\bar{S}$ position for (1 – *D*)*T*. If V_{dc} = 80 V, *D* = 0.75 and *R* = 40 Ω then output voltage is



(a) 20 V (b) 25 V
(c) 30 V (d) 45 V

Q.26 A MOSFET rated for 15 A carries a periodic current as shown in the below figure. The ON state resistance of the MOSFET is 0.15 Ω. The average ON state loss in the MOSFET is



(a) 3.75 W (b) 2.5 W
(c) 5.0 W (d) 10.0 W

Q.27 A single-phase full-bridge inverter is operated from a 60 V battery and is supplying power to a pure resistive load of 12 Ω. The fundamental output power is

(a) 243.41 W (b) 343.20 W
(c) 423.10 W (d) 454.05 W

Q.28 A 3-phase voltage source inverter is operated in 120° conduction mode. Which one of the following statements is true?

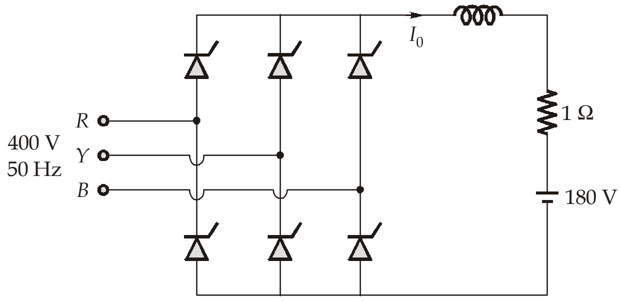
(a) Both pole-voltage and line-voltage will have 3rd harmonic components.

(b) Pole-voltage will have 3rd harmonic component but line-voltage will be free from 3rd harmonic.

(c) Line-voltage will have 3rd harmonic component but pole-voltage will be free from 3rd harmonic.

(d) Both pole-voltage and line-voltage will be free from 2nd harmonic components.

Q.29 A three phase fully controlled converter bridge is used to control the armature voltage of a separately excited dc motor. The dc motor load is represented by an equivalent circuit as shown. Assume load inductance is sufficient to ensure continuous and ripple free load current. If load current I_0 = 20 A then firing angle of the bridge is ________ .



(a) 60° (b) 68.28°

(c) 65.15° (d) 72.25°

Q.30 The input voltage given to a converter is $V_i = 200\sqrt{2}\sin(120\pi t)\text{V}$. The current drawn by the converter is

$$i_1 = \left(20\sqrt{2}\sin\left(120\pi t - \frac{\pi}{3}\right) + 10\sqrt{2}\sin\left(360\pi + \frac{\pi}{4}\right)\right) + 4\sqrt{2}\sin\left(840\pi t - \frac{\pi}{6}\right)\text{A}.$$

The input power factor of the converter is

(a) 0.11 (b) 0.22

(c) 0.33 (d) 0.44

■■■■

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POWER ELECTRONICS

ELECTRICAL ENGINEERING

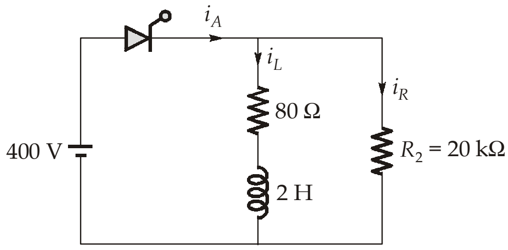
Date of Test : 06/08/2024

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (b)



Current through 20 kΩ resistor,

$$i_R = \frac{400}{20\times10^3} = 0.02 \text{ A}$$

Current through inductor,

$$i_L = \frac{V}{R_1}\left(1-e^{-R_1/Lt}\right) = \frac{200}{40}\left(1-e^{-40t}\right)$$

$$= 5(1 - e^{-40t})$$

$$i_A = i_R + i_L$$

$$= 0.02 + 5(1 - e^{-40t})$$

To turn on $i_A \geq$ latching current,

$$0.02 + 5(1 - e^{-40t}) = 60 \text{ mA}$$

$$T = 200 \text{ µsec}$$

2. (c)

Using relation,

$$\cos\alpha - \cos(\alpha + \mu) = \text{constant} \quad ...(1)$$

$$\alpha = 35°, \quad \mu = 4°$$

$$K = \cos35° - \cos(35 + 4°) = 0.042$$

At $\alpha = 0°$

Let, $\mu = \mu_0$

$$K = \cos0° - \cos(0 + \mu_0)$$

$$0.042 = 1 - \cos\mu_0$$

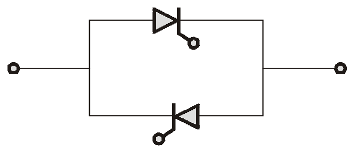
$$\cos\mu_0 = 0.958$$

$$\mu_0 = 16.66°$$

$$\text{Inductive voltage regulation} = \frac{1-\cos\mu_0}{2} = 0.0209$$

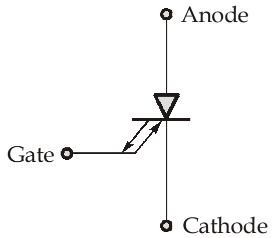
3. (a)

TRIAC



Bidirectional and Bipolar

GTO



It is also unidirectional and bipolar

4. (c)

Due to absence of minority carrier reverse recover time of schottky diode is in nanosecond. It is used in SMPS.

5. (a)

The source is a 'cosine' function. So capacitor charges to its maximum value instantaneously as switch is closed at t = 0. So diode conducts for 0°.

6. (d)

$$\text{Average load current} = \frac{12+16}{2} = 14 \text{ A}$$

$$\text{Average load voltage} = V_0 = I_0 R = 14 \times 10 = 140 \text{ V}$$

$$V_0 = \alpha\, V_s$$

Since the chopper is step down or type-A,

$$140 = \alpha\, 200$$

$$\alpha = \frac{140}{200} = 0.7$$

$$\frac{T_{on}}{T_{on}+T_{off}} = 0.7$$

$$0.3\, T_{on} = 0.7\, T_{off}$$

$$\frac{T_{on}}{T_{off}} = 2.33$$

7. (a)

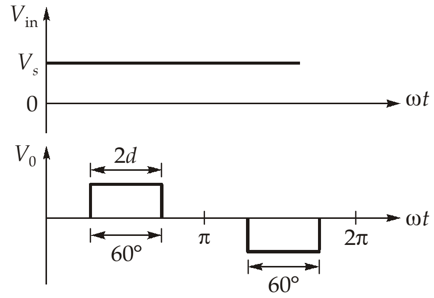
In 6 pulse thyristor, frequency components available on supply side current are

f_s , $(6K \pm 1)\, f_s$ where K = 1, 2, 3, 4, ...

60, 300, 420, 660

Lowest frequency component is 60.

8. (a)

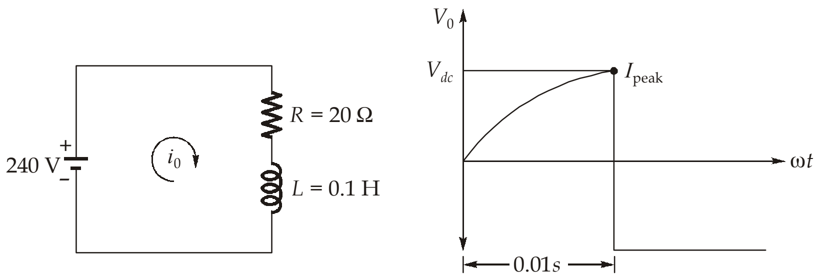


$$V_{or} = V_s\sqrt{\frac{2d}{\pi}}$$

$$V_{0\text{ rms}} = 600\sqrt{\frac{60°}{180°}} = 346.4\text{ V}$$

9. (a)

During the positive half cycle the circuit is,



$$i(t) = \frac{V_s}{R}\left(1 - e^{-t/\tau}\right) = \frac{240}{20}\left(1 - e^{\frac{-0.01\times 20}{0.1}}\right)$$

$$i_{(0.01)} = 10.37\text{ A}$$

10. (d)

In the output phase voltage the even, third and multiples of 3rd harmonics are absent. So, lowest order harmonics are 5th harmonics,

$$\text{Fourier series, } V_R = \sum_{n=6k\pm1}\frac{2V_s}{n\pi}\sin n\omega t$$

So, frequency of 5th harmonis = 5 × fundamental frequency = 5 × 50 = 250 Hz

11. (a)

The main thyristor is turned off when i_c is,

$$i_c = I_p \sin \omega t = I_0$$

$$\omega t = \sin^{-1}\left(\frac{I_0}{I_p}\right)$$

Peak value of current through capacitor,

$$I_p = V_s\sqrt{\frac{C}{L}} = 230\times\sqrt{\frac{20\times10^{-6}}{5\times10^{-6}}} = 460 \text{ A}$$

$$\omega t = \sin^{-1}\left(\frac{300}{460}\right) = 40.70°$$

Voltage across main thyristor $= V_s \cos \omega t$

$= 230 \times \cos 40.70°$

$= 174.37$ V

12. (b)

The power loss, $$P = \frac{1}{T}\int_0^3 V_s(t)\, i_s(t)\, dt$$

$$= \frac{1}{T}\int_0^3 \left(\frac{200}{3}t\right)\left(\frac{600}{3}t\right)dt = \frac{40000}{3T}\int_0^3 t^2\, dt$$

$$P = \frac{40000}{3T}\left[\frac{t^3}{3}\right]_0^3$$

Where T is in μsec

$\Rightarrow$ $$T = \frac{1}{50}\times10^6 = 20000$$

So, $$P = \frac{40000}{3\times20000}\left[\frac{3^3}{3}\right]$$

$P = 6$ Watt average power loss

13. (a)

Given, $$\frac{V_{dc}}{2} = 96$$

$$V_{dc} = 192 \text{ V}$$

Rms value of the fundamental voltage in the output,

$$V_{01} = \frac{2V_s}{\sqrt{2}\pi} = \frac{2\times192}{\sqrt{2}\pi} = 86.43 \text{ V}$$

Fundamental power in the output,

$$= \frac{(V_{01})^2}{R} = \frac{(86.43)^2}{5} = 1494 \text{ W}$$

14. (a)

Fourier expression of output voltage is,

$$V_{0,\,n} = \sum_{n=1,3,5}^{\infty} \frac{2V_{dc}}{n\pi}\sin n\omega t \text{ V}$$

Harmonic factor for 3rd harmonic

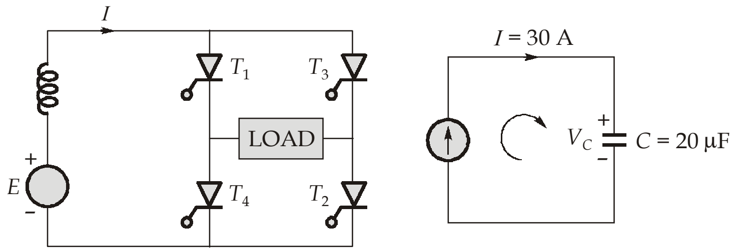
$$\text{H.F.} = \frac{V_{3,\,\text{rms}}}{V_{1,\,\text{rms}}}$$

$$\text{H.F.} = \frac{V_{3,\,\text{rms}}}{V_{1,\,\text{rms}}} = \frac{\dfrac{2\times 48}{\sqrt{2}\times 3\pi}}{\dfrac{2\times 48}{\sqrt{2}\,\pi}} \times 100$$

$$= \frac{1}{3}\times 100 = 33.33\%$$

15. (b)

During the on period of T_1 and T_2 the circuit behaves as

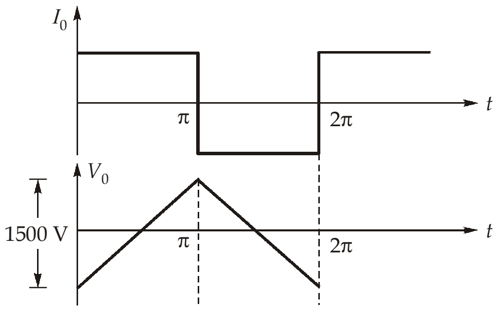


$$V_C = \frac{1}{C}\int_0^{t_{on}} i\,dt$$

$$V_C = \frac{30}{20\times 10^{-6}} T_{on}$$

Where, $$T_{on} = \frac{1}{2f} = \frac{1}{2\times 500} = 1\times 10^{-3}\text{ s}$$

$$V_C = \frac{30}{20\times 10^{-6}}\times 1\times 10^{-3} = 1500\text{ V}$$



Peak to peak of output voltage is 1500 V.

The reverse voltage that appears across thyristor is 750 V.

16. (a)

To eliminante the 5th harmonic content,

$$2d = \frac{2\pi}{5}$$

$$d = \frac{\pi}{5} = 36°$$

The 7th harmonic rms value is,

$$V_{07\,(\text{rms})} = \frac{4V_S}{7\pi\sqrt{2}}\sin\frac{7\pi}{2}\sin(7\times 36°)$$

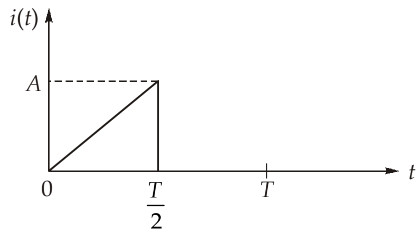
$$= 0.122\ V_S$$

17. (b)

$$\text{Average ON state loss} = I_{\text{rms}}^2 R_{ON}$$

Where, $I_{\text{rms}} \rightarrow$ rms value current,

$R_{\text{ON}} \rightarrow$ On state resistance of MOSFET



$$i(t) = \frac{A}{T/2}t = \frac{2A}{T}t$$

$$i_{\text{rms}} = \sqrt{\frac{1}{T}\int_0^{T/2}[i(t)]^2\,dt} = \sqrt{\frac{1}{T}\int_0^{T/2}\frac{4A^2}{T^2}t^2\,dt}$$

$$= \sqrt{\frac{1}{T}\times\frac{4A^2}{T^2}\left(\frac{t^3}{3}\right)_0^{T/2}} = \sqrt{\frac{1}{T}\times\frac{4A^2}{T^2}\times\frac{T^3}{8\times 3}} = \frac{A}{\sqrt{6}}$$

$$\text{Average ON state loss} = \left(\frac{15}{\sqrt{6}}\right)^2\times 0.25 = 9.375\text{ W}$$

18. (a)

$$\text{Gate-cathode characteristic slope} = \frac{V_g}{I_g}$$

Where, V_g = Allowable voltage across SCR

I_g = Allowable current across SCR

$$\frac{V_g}{I_g} = 120$$

$$V_g = 120\ I_g \quad \text{...(i)}$$

Allowable gate power dissipation = 0.4 watt

$$V_g I_g = 0.4\text{ Watt}$$

Put value of 'V_g' from equation (i)

$$(120 I_g)I_g = 0.4$$

$$I_g = \sqrt{\frac{0.4}{120}}A = 0.0577 \text{ A}$$

$$V_g = 120 \times 0.0577 = 6.92 \text{ V}$$

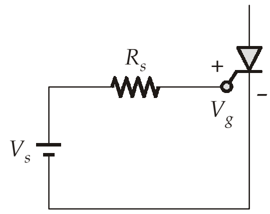
We know,

$$V_s = V_g + R_s I_g$$

$$20 = 6.928 + 0.0577R_s$$

$$0.0577R_s = 13.071$$

$$R_s = 226.54\ \Omega$$



19. **(c)**

The diode will start conducting at an angle θ_1 , where

$$\theta_1 = \sin^{-1}\frac{E}{(V_s)_{\max}} = \sin^{-1}\frac{120}{230\times\sqrt{2}} = 21.64°$$

Average value of charging current,

$$I_{0\text{ avg}} = \frac{1}{2\pi R}[2V_m\cos\theta_1 - E(\pi - 2\theta_1)]$$

$$= \frac{1}{2\pi\times 10}\left[2\times 230\times\sqrt{2}\times\cos 21.64° - 120\left(\pi - \frac{2\times 21.64°\times\pi}{180}\right)\right]$$

$$= 5.071 \text{ A}$$

Power delivered to battery

$$= EI_{0\text{ avg}} = 120 \times 5.071 = 608.82 \text{ W}$$

(Power delivered to battery) × (Charging time in hours) = Battery capacity

$$(608.52) \times \text{charging time} = 8850 \text{ Wh}$$

$$\text{Charging time} = \frac{8850}{608.52}\text{hours} = 14.54 \text{ hours}$$

20. **(d)**

For 1-ϕ semiconverter,

$$\text{Supply rms current, } I_{\text{rms}} = I_{dc}\left[\frac{\pi-\alpha}{\pi}\right]^{1/2} = I_{dc}\left[\frac{\pi - \pi/4}{\pi}\right]^{1/2} = 0.866\ I_{\text{dc}}$$

The rms value of the supply fundamental component of input current

$$I_{\text{rms, 1}} = \frac{2\sqrt{2}}{\pi}I_{dc}\cos\left(\frac{\alpha}{2}\right)$$

$$= \frac{2\sqrt{2}}{\pi}I_{dc}\cos\left(\frac{\pi}{4\times 2}\right) = 0.83178\ I_{dc}$$

$$\text{Harmonic factor } (Hf) = \left[\left(\frac{I_{\text{rms}}}{I_{\text{rms,1}}}\right)^2 - 1\right]^{1/2} = \left[\left(\frac{0.866I_{dc}}{0.83178I_{dc}}\right)^2 - 1\right]^{1/2} = 28.98\%$$

21. (c)

Case-I,

$$T_j = 110° \text{ C}, \qquad T_s = 80° \text{ C}$$

$$P_{av\,1} = \frac{110-80}{0.16+0.05} = 142.85 \text{ W}$$

Case-II,

$$T_j = 110° \text{ C}, \qquad T_s = 50° \text{ C}$$

$$P_{av\,2} = \frac{110-50}{0.16+0.05} = 285.71 \text{ W}$$

Thyristor rating is proportional to the square root of average power loss

$$\% \text{ increase in rating} = \frac{\sqrt{285.71}-\sqrt{142.85}}{\sqrt{142.85}} \times 100 = 41.42\%$$

22. (b)

For Buck-converter

$$\text{Average output voltage} = DV_s$$

Where, D = Duty ratio, V_s = input voltage

$$V_s = 40 \text{ V}, \qquad V_0 = 16 \text{ V}$$

$$f = 20 \text{ kHz}$$

$$16 = D \times 40$$

$$D = \frac{16}{40} = 0.4$$

Peak to peak ripple current,

$$\Delta I_L = \frac{V_s D(1-D)}{L\,f}$$

$$0.8 = \frac{40 \times 0.4 \times 0.6}{L \times 20 \times 10^3}$$

$$L = 600 \text{ μH}$$

23. (b)

$$V_s = 250 \text{ V}, \qquad V_0 = 625 \text{ V}$$

For boost converter,

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

$$625 = \frac{250}{1-D}$$

$$\Rightarrow \qquad D = 0.6$$

$$I_{L\,min} = I_L - \frac{\Delta I_L}{2} = \frac{3125}{250} - \frac{250 \times 0.6}{2 \times 10 \times 10^{-3} \times 25 \times 10^3}$$

$$= 12.2 \text{ A} > 0$$

It is operating in continuous conduction, Now $$I_0 = \frac{3125}{625} = 5\text{ A}$$

$$\frac{V_0}{V_s} = \frac{I_s}{I_0} = \frac{1}{1-D}$$

$$\Rightarrow \quad I_s = \frac{I_0}{1-D} = \frac{5}{1-0.6} = 12.5\text{ A}$$

$$R_{in} = \frac{V_s}{I_s} = \frac{250}{12.5} = 20\ \Omega$$

24. (d)

Output voltage (V_0) = 36 V

Input voltage (V_s) = 24 V

For Buck-boost converter

$$V_0 = \frac{DV_s}{1-D}$$

$$36 = \frac{24D}{1-D}$$

$$\Rightarrow \quad 36 - 36D = 24D$$

$$60D = 36$$

$$\Rightarrow \quad D = 0.6$$

$$\Delta I_L = \frac{DV_s}{Lf}$$

At the boundary,

$$I_{Lavg} - \frac{\Delta I_L}{2} = 0$$

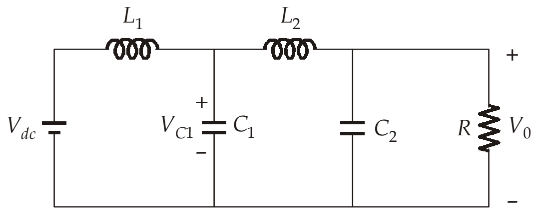
$$\frac{I_0}{1-D} = \frac{\Delta I_L}{2} \qquad \left[I_{Lavg} = \frac{I_0}{1-D}\right]$$

$$\frac{144/36}{1-0.6} = \frac{0.6 \times 24}{2 \times 20 \times 10^3 \times L}$$

$$L = \frac{0.4}{4} \times \frac{0.6 \times 24}{2 \times 20 \times 10^3} = 36\ \mu\text{H}$$

25. (d)

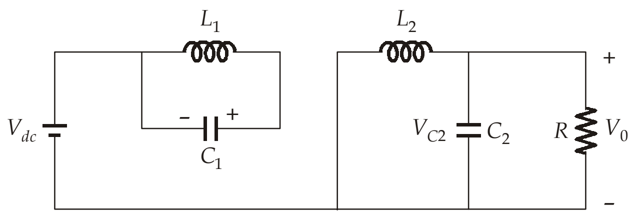
For ON period:



$$V_{L1} = (V_{dc} - V_{c1})$$

$$V_{L2} = (V_0 - V_{c1})$$

For OFF-period



$$V_{L1} = -V_{C1}\ , \qquad V_{L2} = -V_{C2} = -V_0$$

Now, for inductor 'L_1'

$$(V_L)_{avg} = 0$$

$$(V_{dc} - V_{C1})DT - V_{C1}(1 - D)T = 0$$

$$V_{C1} = DV_{dc}$$

Similarly for inductor 'L_2'

$$(V_{C1} - V_0)DT - V_0(1 - D)T = 0$$

$$V_0 = DV_{c1} = D^2V_{dc}$$

So, $$V_0 = D^2V_{dc} = (0.75)^2 \times 80 \text{ V} = 45 \text{ V}$$

26. (b)

$$P_{avg} = I_{rms}^2 \cdot R_{ON}$$

$$R_{ON} = 0.15\ \Omega \text{ and } I_{rms} = \sqrt{\frac{1}{2\pi}\int_0^{\pi} 10t\,dt} = \frac{10}{\sqrt{6}}$$

$$P_{avg} = \frac{100}{6} \times 0.15 = 2.50 \text{ W}$$

27. (a)

For 1-ϕ full bridge inverter

$$V_{dc} = 60 \text{ V}, \qquad R = 12\ \Omega$$

$$V_{01\ rms} = \frac{2\sqrt{2}\,V_{dc}}{\pi} = \frac{2\sqrt{2}}{\pi} \times 60 = 54.046 \text{ V}$$

$$\text{Power} = \frac{V_{01\,rms}^2}{R} = \frac{(54.046)^2}{12} = 243.41 \text{ W}$$

28. (d)

Pole voltage, phase voltage,

$$V_{pole} = V_R \rightarrow \text{quasi square wave } 2d = \frac{2\pi}{3} \text{ rad}$$

$$n = 6K \pm 1 = 1, 5, 7, 11, 13\ .....$$

Line voltage $\rightarrow$ 6 step :

$$n = 6K \pm 1 = 1, 5, 7, 11, 13\ .....$$

29. (b)

Average output voltage of the converter,

$$V_0 = \frac{3V_{mL}}{\pi}\cos\alpha$$

Load current, $I_0 = 20$ A

Back emf, $E_b = 180$ V

$R_a = 1\ \Omega$

Applying KVL,

$$V_0 - 1 \times I_0 - 180 = 0$$

$$V_0 = 180 + 1 \times 20 = 200 \text{ V}$$

Now, $$\frac{3V_{mL}}{\pi}\cos\alpha = 200$$

$$\frac{3 \times 400 \times \sqrt{2}}{3.14} \times \cos\alpha = 200$$

$$\cos\alpha = 0.37$$

$$\alpha = 68.28°$$

30. (d)

$$V_i = 200\sqrt{2}\sin(120\pi t)\text{V}$$

$$i_i = \left(20\sqrt{2}\sin\left(120\pi t - \frac{\pi}{3}\right) + 10\sqrt{2}\sin\left(360\pi t + \frac{\pi}{4}\right)\right) + 4\sqrt{2}\sin\left(840\pi t - \frac{\pi}{6}\right)\text{A}$$

Fundamental component of input voltage,

$$(V_i)_1 = 200\sqrt{2}\sin(120\pi t)\text{V}$$

$$(V_i)_{rms} = 200 \text{ V}$$

Fundamental component of current,

$$(i_L)_{1,\ rms} = \frac{20\sqrt{2}}{\sqrt{2}} = 20$$

Phase difference between the two components

$$\phi_1 = \frac{\pi}{3}$$

Active power due to fundamental component

$$P_1 = (V_i)_{1\ rms} \times (i_i)_{1\ rms} \cos\phi_1$$

$$P_1 = 200 \times 20 \times \cos\left(\frac{\pi}{3}\right) = 2000 \text{ W}$$

rms value of input voltage $= 200$ V

$$\text{rms value of current} = \sqrt{\left(\frac{20\sqrt{2}}{\sqrt{2}}\right)^2 + \left(\frac{10\sqrt{2}}{\sqrt{2}}\right)^2 + \left(\frac{4\sqrt{2}}{\sqrt{2}}\right)^2} = \sqrt{400 + 100 + 16} = \sqrt{516}$$

$$= 22.71 \text{ A}$$

Let input power factor $\cos\phi$

$$200 \times 22.71 \times \cos\phi = 2000$$

$$\cos\phi = \frac{10}{22.71} = 0.44$$

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