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POWER ELECTRONICS

ELECTRICAL ENGINEERING

Date of Test : 23/09/2026**ANSWER KEY ➤**

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

DETAILED EXPLANATIONS

1. (d)

Slope of load line gives gate source resistance,

$$R_s = 128 \, \Omega$$

$$V_g I_g = 0.5$$

$$V_g = \frac{0.5}{I_g}$$

By applying KVL in the loop

$$-V_{GS} + I_g R_s + V_g = 0$$

$$16 = I_g 128 + \frac{0.5}{I_g}$$

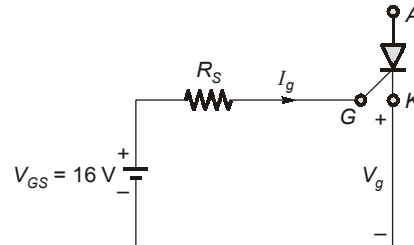
$$128 I_g^2 - 16 I_g + 0.5 = 0$$

Solving the quadratic equation, we get

$$I_g = 62.5 \, \text{mA}$$

(Taking lower value of I_g)

$$V_g = \frac{0.5}{62.5 \times 10^{-3}} = 8 \, \text{V}$$



2. (c)

Maximum voltage across SCRs in mid point connection is $2 V_m$. So the maximum voltage of SCR

$$= \frac{1000}{2.5 \times 2} = 200 \, \text{V}$$

Maximum average power that the mid point converter can handle is

$$P_{\text{avg (max)}} = \left(\frac{2V_m}{\pi} \cos \alpha \times I_{T \text{ avg.}} \right)$$

$$= \frac{2V_m}{\pi} (\cos 0^\circ) \times 40$$

$$= \frac{2 \times 200 \times 40}{\pi} = \frac{16}{\pi} \, \text{kW}$$

3. (c)

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

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

Rms value of the fundamental voltage in the output,

$$V_{01} = \frac{2V_s}{\sqrt{2}\pi} = \frac{2 \times 192}{\sqrt{2}\pi} = 86.43 \, \text{V}$$

Fundamental power in the output

$$= \frac{(V_{01})^2}{R} = \frac{(86.43)^2}{10} = 747 \, \text{W}$$

4. (c)

The given circuit is a tank circuit.

The current in the circuit is,

$$i(t) = V_s \sqrt{\frac{C}{L}} \sin \omega_0 t$$

Where,

$$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{2 \times 10^{-3} \times 20 \times 10^{-6}}} = 5000 \text{ rad/s}$$

$$\begin{aligned} \text{Peak current, } I_m &= V_s \sqrt{\frac{C}{L}} \\ &= 200 \sqrt{\frac{20 \times 10^{-6}}{2 \times 10^{-3}}} = 20 \text{ A} \end{aligned}$$

Hence, the current through the circuit is $i(t) = 20 \sin (5000t) \text{ A}$

5. (a)

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

$$\text{i.e., } \left(\frac{f_c}{2f} - 1 \right) \text{ pulses per half cycle}$$

or $(m - 1)$ pulses per half cycle.

6. (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

$$\begin{aligned} \text{H.F.} &= \frac{V_{3, \text{rms}}}{V_{1, \text{rms}}} \\ \text{H.F.} &= \frac{V_{3, \text{rms}}}{V_{1, \text{rms}}} = \frac{\frac{2 \times 48}{\sqrt{2} \times 3\pi}}{\frac{2 \times 48}{\sqrt{2} \pi}} \times 100 \\ &= \frac{1}{3} \times 100 = 33.33\% \end{aligned}$$

7. (b)

The given chopper is a step down chopper,

$$\begin{aligned} V_0 &= \alpha V_s \\ V_0 &= I_0 (R_a + R_{se}) + E_b = \alpha V_s \\ &= 200 (0.06 + 0.04) + 200 = \alpha \cdot 440 \\ \alpha &= \frac{220}{440} \\ \alpha &= 0.5 \end{aligned}$$

$$T_{\text{on}} = \alpha \cdot T$$

$$= 0.5 \times \frac{1}{500} = 1 \text{ ms}$$

8. (b)

The waveform of voltage across diode,

$$V_m = V_{\text{rms}} \sqrt{2}$$

$$V_m = 280 \times \sqrt{2} = 395.97 \text{ V}$$

Peak value of waveform shown above is

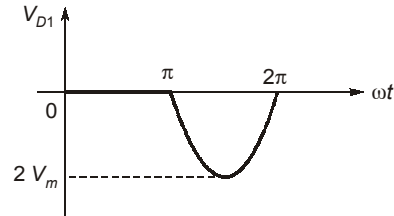
$$2 V_m = 2 \times 395.97$$

$$2 V_m = 791.94 \text{ V}$$

The rms value of the wave form shown above is,

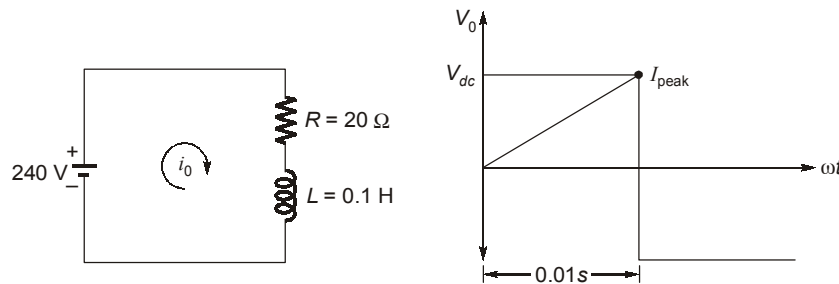
$$V_{D1, \text{rms}} = \left(\frac{\text{peak value}}{\sqrt{2}} \right) \times \sqrt{\frac{\pi}{2\pi}} = \frac{791.94}{\sqrt{2} \times \sqrt{2}}$$

$$= 395.97 \text{ V}$$



9. (a)

During the positive half cycle the circuit is,



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

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

10. (b)

Hence in the question it is given output is balanced.

 V_b will be lagging V_a by $\frac{2\pi}{3}$ radians.

$$\text{So, } V_b = V_{1m} \sin\left(\omega t - \frac{2\pi}{3}\right) + V_{5m} \sin\left(5\left(\omega t - \frac{2\pi}{3}\right)\right) + V_{7m} \sin\left(7\left(\omega t - \frac{2\pi}{3}\right)\right)$$

this can be written as,

$$V_b = V_{1m} \sin\left(\omega t - \frac{2\pi}{3}\right) + V_{5m} \sin\left(5\omega t + \frac{2\pi}{3}\right) + V_{7m} \sin\left(7\omega t - \frac{2\pi}{3}\right)$$

11. (a)

By applying current division rule,

$$I_1 = I_T \left(\frac{R_2}{R_1 + R_2} \right)$$

$$I_1 = 24 \left(\frac{0.2}{0.6} \right) = 8 \text{ A}$$

$$I_2 = 16 \text{ A}$$

$$\text{Power loss in MOSFET 1} = I_1^2 R = 8^2 \times 0.4 = 25.6 \text{ W}$$

$$\text{Power loss in MOSFET 2} = I_2^2 R = 16^2 \times 0.2 = 51.2 \text{ W}$$

12. (b)

At no load voltage is

$$V_{0NL} = \frac{V_m}{\pi} = \frac{\sqrt{2} \times 230}{\pi} = 103.53 \text{ V}$$

At full load, voltage is

$$\begin{aligned} V_{0FL} &= \frac{V_m}{\pi} \times \left(\frac{R_L}{R_L + R_D} \right) \\ &= 103.53 \times \left(\frac{1500}{1500 + 50} \right) = 100.19 \text{ V} \\ &= \frac{V_{0NL} - V_{0FL}}{V_{0FL}} \times 100 = \frac{103.53 - 100.19}{100.19} \times 100 = 3.33\% \end{aligned}$$

13. (a)

Hence it is mentioned in the given data that there is no losses.

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

Since

$$E \propto N$$

$$\frac{E_1}{E_2} = \frac{N_1}{N_2}$$

$$E_1 = 2E_2$$

$$E_2 = \frac{E_1}{2} = \frac{V_0}{2} = 220 \text{ V}$$

$$\frac{3 \times \sqrt{2} \times 440}{\pi} \cos \alpha = 220$$

$$\cos \alpha = \frac{220 \times \pi}{3 \times \sqrt{2} \times 440} = 0.3702$$

Input power factor of the supply

$$= \frac{3}{\pi} \cos \alpha = \frac{3}{\pi} \times 0.3702 = 0.353$$

14. (a)

Hence the load current is continuous,

The average output voltage of the waveform will be,

$$V_0 = \frac{2V_m}{\pi}$$

$$= \frac{2 \times \sqrt{2} \times 220}{\pi} = 198.07 \text{ V}$$

The rms value of output voltage

$$= \frac{V_m}{\sqrt{2}} = \frac{\sqrt{2} \times 220}{\sqrt{2}} = 220 \text{ V}$$

$$\text{The ripple voltage} = V_r = \sqrt{V_{0,\text{rms}}^2 - V_0^2}$$

$$= \sqrt{220^2 - 198.07^2} = 95.75 \text{ V}$$

15. (c)

When thyristor is turned on at $t = 0$, the voltage equation of the circuit is,

$$L \frac{di}{dt} + \frac{1}{C} \int i dt = V_s$$

Laplace transform is,

$$sL \cdot I(s) + \frac{1}{C} \left[\frac{I(s)}{s} + \frac{CV_c(0)}{s} \right] = \frac{V_s}{s}$$

$$I(s) = \frac{V_s - V_{c0}}{L} \cdot \frac{1}{s^2 + \frac{1}{LC}} = \frac{300}{L} \cdot \frac{\frac{1}{\sqrt{LC}}}{\frac{1}{\sqrt{LC}} \left(s^2 + \frac{1}{LC} \right)}$$

Taking inverse laplace,

$$i(t) = \frac{300}{\omega_0 L} \sin \omega_0 t \quad \text{where } \omega_0 = \frac{1}{\sqrt{LC}}$$

$$V_L = L \frac{di}{dt} = 300 \cos \omega_0 t$$

$$V_c = V_s - V_L = 200 - 300 \cos \omega_0 t$$

16. (d)

Voltage regulation due to source inductance

$$= \frac{3\omega L_s I_0}{\pi} \times \frac{1}{V_0 \text{ at no load}} \times 100 = \frac{3\omega L_s I_0}{\pi} \times \frac{\pi}{3V_{mL} \cos \alpha} \times 100$$

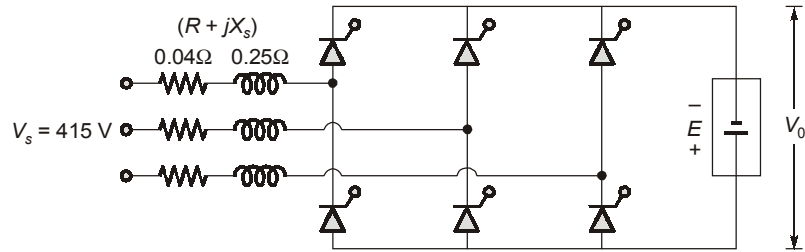
$$= \frac{\omega L_s I_0}{V_{mL} \cos \alpha} \times 100$$

$$= \frac{2\pi \times 50 \times 4 \times 10^{-3} \times 20}{\sqrt{2} \times \sqrt{3} \times 230 \times \cos 30^\circ} \times 100$$

% voltage regulation due to source inductance

$$= 5.15\%$$

17. (b)

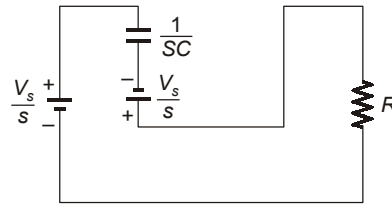


$$\begin{aligned}
 V_{0x} &= \frac{3V_{mL}}{\pi} \cos \alpha - 2I_0 r_s - 2V_T - \frac{3\omega L_s I_0}{\pi} \\
 &= \frac{3 \times \sqrt{2} \times 415}{\pi} \cos 145^\circ - (2 \times 80 \times 0.04) - (2 \times 1.5) - \left(\frac{3 \times 0.25 \times 80}{\pi} \right) \\
 &= -487.5898 = -E \\
 \therefore E &= 487.5898 \approx 487.6 \text{ V}
 \end{aligned}$$

18. (d)

When auxiliary thyristor T_A is turned on, main thyristor T_1 is turned off by means of capacitor voltage V_s appearing as reverse bias. After T_1 is off, KVL for the circuit V_s , C , T_A and R in series.

$$\begin{aligned}
 \frac{V_s}{s} + \frac{V_s}{s} &= \left(\frac{1}{sC} + R \right) I(s) \\
 I(s) &= \frac{2V_s}{R} \cdot \frac{1}{s + \frac{1}{RC}}
 \end{aligned}$$



Taking inverse Laplace,

$$i(t) = \frac{2V_s}{R} e^{-t/RC}$$

The voltage across capacitor C is

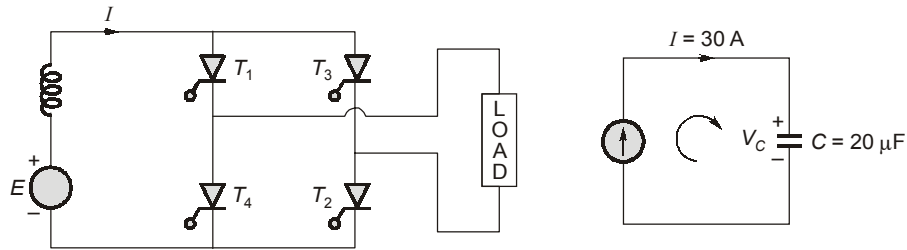
$$\begin{aligned}
 V_c(t) &= \frac{1}{C} \int i(t) dt + \text{initial voltage across capacitor} \\
 V_c(t) &= \frac{1}{C} \int_0^t \frac{2V_s}{R} e^{-t/RC} dt - V_s \\
 &= V_s (1 - 2e^{-t/RC})
 \end{aligned}$$

The circuit turn off time is, time taken by V_c to change from $-V_s$ to zero.

$$\begin{aligned}
 0 &= V_s (1 - 2e^{-t/RC}) \\
 t_c &= RC \ln(2) \\
 &= 5 \times 10 \times 10^{-6} \times \ln(2) \\
 &= 34.657 \mu\text{s}
 \end{aligned}$$

19. (b)

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



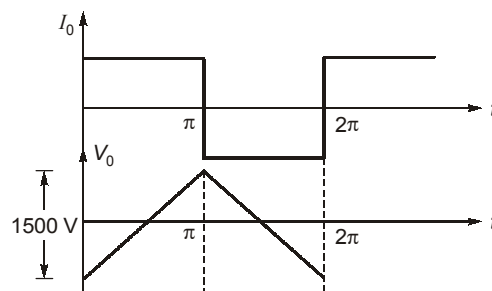
$$V_C = \frac{1}{C} \int_0^{t_{on}} i dt$$

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

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.

20. (b)

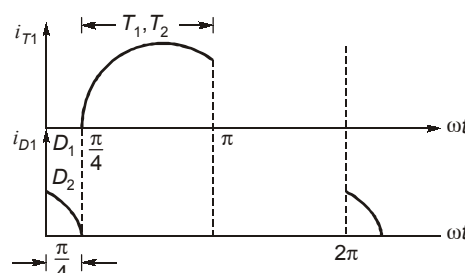
Rms value of fundamental component of the load current,

$$I_{01} = \frac{V_{01}}{\sqrt{R^2 + (X_L - X_C)^2}} = \frac{230}{\sqrt{4 + 4}}$$

$$I_{01} = 81.317 \text{ A}$$

$$\text{Phase angle, } \phi = \tan^{-1} \left(\frac{X_L - X_C}{R} \right) = \tan^{-1}(1)$$

$$\phi = 45^\circ$$



The rms value of diode current,

$$\begin{aligned} I_{D \text{ rms}} &= \sqrt{\frac{1}{2\pi} \int_0^{\pi/4} (I_m \sin \omega t)^2 d\omega t} \\ &= \sqrt{\frac{I_m^2}{2\pi} \int_0^{\pi/4} \left[\frac{1 - \cos 2\omega t}{2} \right] d\omega t} \\ I_{D \text{ rms}} &= I_m 0.1507 \\ &= \sqrt{2} \times 81.317 \times 0.1507 \\ I_{D \text{ rms}} &= 17.33 \text{ A} \end{aligned}$$

21. (b)

The line current of a 3-phase fully controlled converter is,

$$i_{sn} = \sum_{n=1,3,5,\dots}^{\infty} \frac{4I_0}{n\pi} \sin \frac{n\pi}{3} \sin(n\omega t - n\alpha)$$

Rms value of 5th harmonic current,

$$I_{s5} = \frac{4I_0}{\sqrt{2} \times 5\pi} \sin\left(\frac{5\pi}{3}\right) = -0.15593 I_0$$

and,

$$I_{s1} = \frac{4I_0}{\sqrt{2} \pi} \sin\left(\frac{\pi}{3}\right) = 0.7796 I_0$$

Percentage of 5th harmonic to fundamental

$$= \frac{I_{s5}}{I_{s1}} \times 100 = \frac{-0.15593}{0.7796} \times 100 = -20\%$$

22. (d)

$$\begin{aligned} V_{03} &= \frac{4V_s}{3\pi} \sin 3(\omega t) = \frac{4 \times 230}{3 \times \pi} \sin 3(\omega t) \\ &= 97.6150 \sin (942.47t) \end{aligned}$$

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

$$\begin{aligned} &= 4 + j\left(3 \times 2\pi \times 50 \times 35 \times 10^{-3} - \frac{1}{3 \times 2\pi \times 50 \times 155 \times 10^{-6}}\right) \\ &= 4 + j(32.986 - 6.8453) \Omega \end{aligned}$$

$$|Z_3| = \sqrt{4^2 + (26.1407)^2} \Omega$$

$$|Z_3| = 26.44 \Omega$$

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

23. (a)

$$V_r = 4 \text{ V}$$

$$V_c = 6 \text{ V}$$

$$\text{Total pulse width} = 2d$$

$$\frac{2d}{N} = \left(1 - \frac{V_r}{V_c}\right) \frac{\pi}{N} \quad (\text{Where } N \text{ is number of pulses per half cycle})$$

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

$$2d = \left(1 - \frac{4}{6}\right) 180^\circ = 60^\circ$$

24. (b)

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

For value of θ_1

$$V_m \sin \theta_1 = E$$

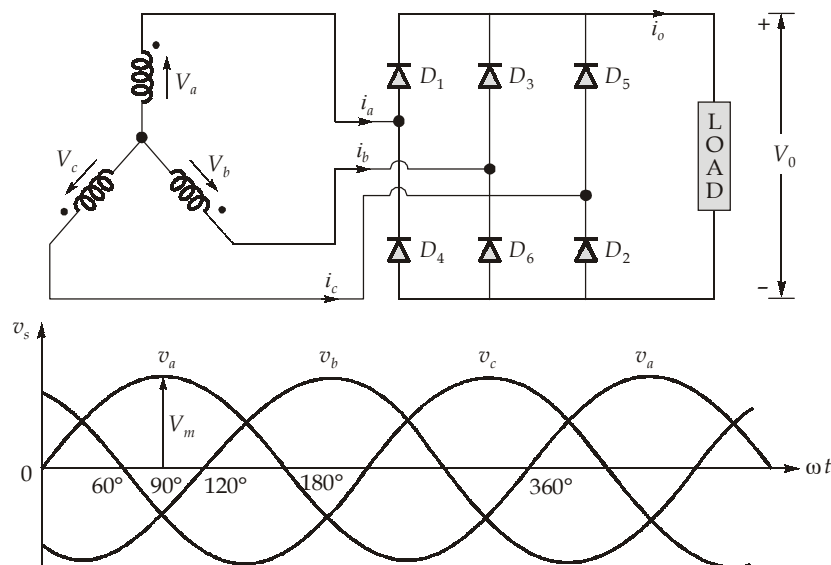
$$\text{or} \quad 230\sqrt{2} \sin \theta_1 = 100$$

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

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

$$= 11.99 \text{ ms}$$

25. (d)



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

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

$$V_0 = V_A - V_B$$

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

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

$$V_0 = 1.5 V_m$$

26. (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 $L \leq 0.0625 \text{ H}$

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

27. (d)

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

$$V_1 = 10 D_1$$

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 $D_1 + 3 D_2 = 3$

28. (b)

The waveform of voltage across diode,

$$V_m = V_{\text{rms}} \sqrt{2}$$

$$V_m = 280 \times \sqrt{2} = 395.97 \text{ V}$$

Peak value of waveform shown above is

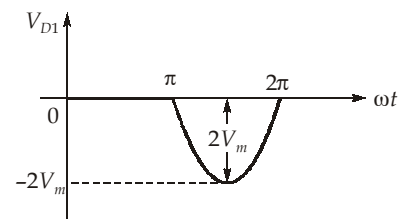
$$2 V_m = 2 \times 395.97$$

$$2 V_m = 791.94 \text{ V}$$

The rms value of the wave form shown above is,

$$V_{D1, \text{rms}} = \left(\frac{\text{peak value}}{\sqrt{2}} \right) \times \sqrt{\frac{\pi}{2\pi}}$$

$$= \frac{791.94}{\sqrt{2} \times \sqrt{2}} = 395.97 \text{ V}$$



29. (d)

This is buck converter circuit

The critical value of inductor L_C is,

$$L_C = \frac{(1 - \alpha)R}{2f}$$

Where,

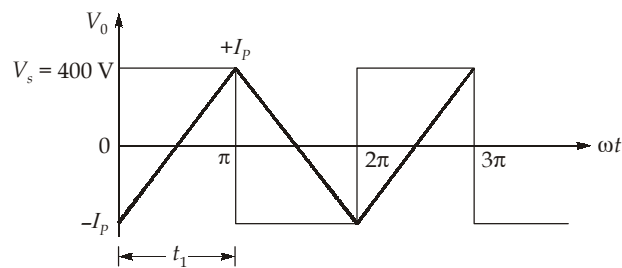
$$\alpha = \frac{V_0}{V_s} = \frac{5}{12} = 0.4166$$

$$L_C = \frac{(1 - 0.4166)500}{2 \times 25 \times 10^3} = 5.83 \text{ mH}$$

Critical value of capacitance,

$$C_c = \frac{1 - \alpha}{16L_c f^2} = \frac{1 - 0.4166}{16 \times 5.83 \times 10^{-3} \times (25 \times 10^3)^2} = 10 \text{ nF}$$

30. (a)

From $0 < \omega t < \pi$ the load current tends to peak value.At t_1 peak value of output current is I_p .

$$t_1 = \frac{\pi}{\omega} = \frac{\pi}{2\pi \times 50} = \frac{1}{100} \text{ s}$$

At $t = 0$,

$$i_0 = -I_p$$

$$V_0 = L \frac{di}{dt}$$

$$400 = 0.5 \left(\frac{I_p - (-I_p)}{t_1 - 0} \right)$$

$$400 = 0.5 \times \frac{2I_p}{t_1}$$

$$\frac{400}{0.5 \times 2} \times \frac{1}{100} = I_p = 4 \text{ A}$$

