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POWER ELECTRONICS

ELECTRICAL ENGINEERING

Date of Test : 16/10/2025

ANSWER KEY ➤

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

DETAILED EXPLANATIONS

1. (c)

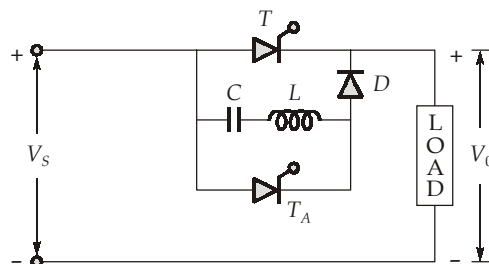
We know in case of Snubber circuit,

$$\left(\frac{di}{dt}\right)_{\max} = \frac{V_m}{L} \quad \text{Where, } V_m = 220\sqrt{2} \text{ V}$$

$$\therefore \left(\frac{di}{dt}\right)_{\max} = \frac{220\sqrt{2}}{40 \times 10^{-6}} = 7.78 \text{ A}/\mu\text{sec}$$

2. (b)

In class B commutation



Peak current through capacitor,

$$I_P = V_S \sqrt{\frac{C}{L}} = 230 \sqrt{\frac{20}{5}} = 460 \text{ A}$$

The conduction time of auxiliary thyristor,

$$T_A = \frac{\pi}{\omega_r}$$

The resonant frequency,

$$\begin{aligned} \omega_r &= \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{5 \times 10^{-6} \times 20 \times 10^{-6}}} \\ &= \frac{1}{10 \times 10^{-6}} = 0.1 \times 10^6 \text{ rad/s} \end{aligned}$$

$$\therefore T_A = \frac{\pi}{\omega} = \frac{\pi}{0.1 \times 10^6} = 10 \pi \mu\text{sec}$$

3. (c)

For boost converter peak to peak ripple voltage,

$$\Delta V_0 = \frac{\alpha I_0}{fC} = \frac{0.40 \times 10}{50 \times 10^3 \times 120 \times 10^{-6}} = 0.66 \text{ V}$$

4. (b)

For single phase PWM inverter pulse width,

$$2d = 140^\circ$$

$$d = 70^\circ$$

$$\text{Ratio} = \frac{\text{Maximum value of third harmonics output voltage}}{\text{Maximum value of fundamental output voltage}}$$

$$= \frac{\frac{4V_s}{3\pi} \sin(3 \times 70^\circ) \sin\left(\frac{3\pi}{2}\right)}{\frac{4V_s}{\pi} \sin\left(\frac{\pi}{2}\right) \sin(70^\circ)} = \frac{1}{3} \frac{(-0.5) \times (-1)}{1 \times 0.9397} = 0.177 \approx 0.18$$

$$\text{Ratio} = 0.18$$

5. (d)

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

$$nd = \pi$$

For eliminating third harmonic

$$3d = \pi$$

$$d = \frac{\pi}{3} = 60^\circ$$

$\therefore$ pulse width

$$2d = 120^\circ$$

$$V_{01, \text{rms}} = \frac{2\sqrt{2}V_s}{\pi} \times \sin 60^\circ = \frac{\sqrt{6}V_s}{\pi} \text{ V}$$

6. (b)

For natural turn-off, peak resonant current $\left(\frac{V_s}{Z_0} \text{ or } V_s \sqrt{\frac{C}{L}} \right)$ must be greater than load current I_0 .

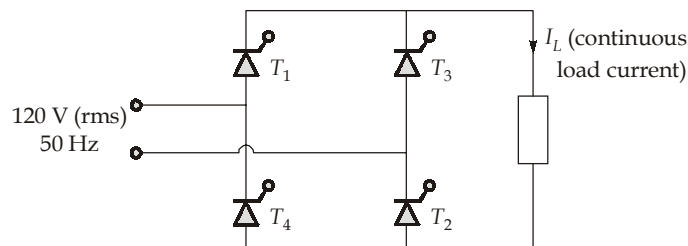
7. (d)

Amplitude of the 60 Hz fundamental frequency component of the output voltage is

$$V_1 = m_a V_{dc} = 0.8 \times 100 = 80 \text{ V}$$

8. (b)

For a single phase fully controlled bridge circuit



$$V_{\text{mean}} = \frac{2}{\pi} \times V_m \cos \alpha - 2V_T$$

Where, V_m is peak sinusoidal value, α is firing angle and V_T is thyristor voltage drop

For

$$V_m = 120\sqrt{2} \text{ V ,}$$

$$\alpha = 45^\circ$$

$$\begin{aligned} V_{\text{mean}} &= \frac{2}{\pi} \times 120\sqrt{2} \cos 45^\circ - 2 \times (1.5) \\ &= \frac{2}{\pi} \times 120\sqrt{2} \times \frac{1}{\sqrt{2}} - 3 = 73.39 \text{ V} \end{aligned}$$

Peak value of voltage across each thyristor = V_{max}

$$= 120\sqrt{2} = 169.71 \text{ V}$$

9. (d)

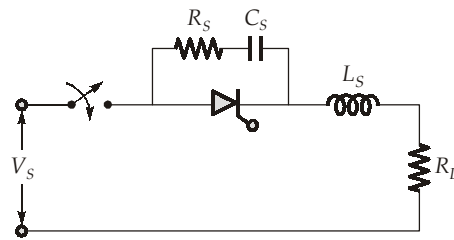
If factor of safety = 2

Allowable values:

$$I_p = \frac{250}{2} = 125 \text{ A}$$

$$\left(\frac{di}{dt}\right)_{\max} = \frac{60}{2} = 30 \text{ A}/\mu\text{s}$$

$$\left(\frac{dv}{dt}\right)_{\max} = \frac{200}{2} = 100 \text{ V}/\mu\text{s}$$



Also know, $V_S = L_S \left(\frac{di}{dt}\right)$

$$400 = L_S \left(\frac{60}{2}\right)$$

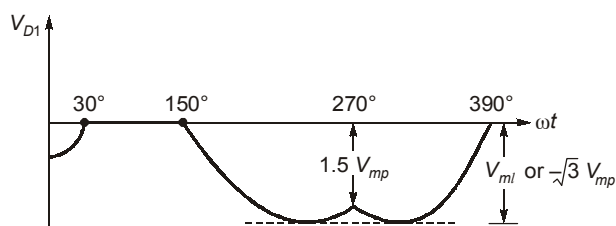
$$L_S = \frac{800}{60} = 13.33 \mu\text{H}$$

We know, $V_S = \frac{L_S}{R_S} \left(\frac{dV}{dt}\right)$

So, $R_S = \frac{800}{60 \times 400} \times \frac{200}{2} = 3.33 \Omega$

10. (b)

PIV of a diode in 3-phase bridge rectifier is V_{ml} or $\sqrt{3}V_{mp}$.



11. (b)

Maximum value of line voltage,

$$V_{ml} = \sqrt{2}V_l = 230\sqrt{2} \text{ V}$$

Average output voltage,

$$V_0 = \frac{3V_{ml}}{\pi} = 310.60 \text{ V}$$

$$V_0 = E + I_0 R$$

$$\frac{V_0 - E}{R} = I_0 = \frac{310.60 - 240}{8} = 8.82 \text{ A}$$

As current is ripple free,

$$I_{0r} = I_0 = 8.82 \text{ A}$$

RMS value of fundamental component of source current,

$$I_{s1} = \frac{2\sqrt{3}}{\pi} \times \frac{I_0}{\sqrt{2}}$$

RMS value of source current,

$$I_s = \left[\frac{I_0^2 \times 2\pi}{\pi \times 3} \right]^{1/2} = \sqrt{\frac{2}{3}} I_0$$

Current distortion factor,

$$CDF = \frac{I_{s1}}{I_s} = \frac{2\sqrt{3}I_0}{\sqrt{2}\pi} \times \frac{\sqrt{3}}{\sqrt{2}I_0} = \frac{3}{\pi} = 0.955$$

12. (b)

Due to source inductance,

Average reduction in output voltage,

$$\begin{aligned} \Delta V_{d0} &= 4f L_s I_0 \\ &= 4 \times 50 \times (12 \times 10^{-3}) \times 16 = 38.4 \text{ V} \end{aligned}$$

$$\Delta V_{d0} = \frac{V_m}{\pi} [\cos \alpha - \cos(\alpha + \mu)]$$

As $\alpha = 0^\circ$ for diodes

$$38.4 = \frac{V_m}{\pi} [1 - \cos \mu]$$

$$38.4 = \frac{230\sqrt{2}}{\pi} [1 - \cos \mu]$$

$$\cos \mu = 1 - 0.37$$

$$\mu = \cos^{-1} 0.63$$

$$\mu = 50.95^\circ$$

$\therefore$ Conduction angle of diode

$$= 180^\circ + 50.95^\circ$$

$$= 230.95^\circ$$

13. (c)

Output voltage of Buck boost converter,

$$\begin{aligned} V_0 &= \frac{-DV_s}{1-D} = \frac{-0.3 \times 28}{1-0.3} \\ &= \frac{-0.3 \times 28}{0.7} = -12 \text{ V} \end{aligned}$$

Average current through inductor,

$$I_L = \frac{V_s D}{R(1-D)^2} = \frac{28 \times 0.3}{5(1-0.3)^2} = 3.42 \text{ A}$$

14. (b)

$$m_i = \text{modulation index} < 1$$

$$V_{01(\text{peak})} = \frac{m_i V_{dc}}{2} = \frac{0.8 \times 200}{2} = 80 \text{ V}$$

$$I_{01(\text{peak})} = \frac{V_{01\text{peak}}}{\sqrt{R^2 + (\omega L)^2}} = \frac{80}{\sqrt{8^2 + (12)^2}}$$

$$= \frac{80}{14.422} = 5.547 \approx 5.55 \text{ A}$$

15. (d)

Total energy loss, $E_{\text{total}} = E_{t1} + E_{t2}$

$$E_{t1} = \int_0^{t_1} V_i \cdot dt$$

As voltage across the switch is constant ie. 500 V

$$= 500 \int_0^{t_1} i \cdot dt = 500 \times \frac{1}{2} \times (0.4 \times 10^{-6}) \times 40 = 4 \text{ mJ}$$

Similarly $E_{t2} = \int_0^{t_2} V_i \cdot dt$

As switch current is constant ie. 30 A

$$E_{t2} = 30 \int_0^{t_2} V \cdot dt = 30 \times \frac{1}{2} \times (0.4 \times 10^{-6}) \times 500 = 3 \text{ mJ}$$

∴ total energy loss in process

$$= 4 \text{ mJ} + 3 \text{ mJ} = 7 \text{ mJ}$$

16. (c)

For given 3-φ rectifier,

$$V_{0, \text{rms}} = \frac{V_{ml}}{2\sqrt{\pi}} \left[\left(\frac{5\pi}{6} - \alpha \right) + \frac{1}{2} \sin \left(2\alpha + \frac{\pi}{3} \right) \right]^{1/2}$$

As $\alpha = \frac{\pi}{4} = 0.785$

$$= \frac{220\sqrt{2}}{2\sqrt{\pi}} \left[(2.618 - 0.785) + \frac{1}{2} \sin(90^\circ + 60^\circ) \right]^{1/2}$$

$$= \frac{220\sqrt{2}}{2\sqrt{\pi}} \left[(1.833) + \frac{1}{2} \times \frac{1}{2} \right]^{1/2} = 126.67 \text{ V}$$

The rms current $I_{0, \text{rms}} = \frac{V_{0, \text{rms}}}{R} = \frac{126.67}{20} = 6.33 \text{ A}$

Power consumed by the load,

$$= (6.33)^2 \times 20$$

$$= 801.38 \text{ W}$$

17. (d)

Current distortion factor for single phase semi converter,

$$\text{CDF} = \frac{2\sqrt{2} \cos\left(\frac{\alpha}{2}\right)}{\sqrt{\pi(\pi - \alpha)}} = \frac{2\sqrt{2} \cos\left(\frac{45}{2}\right)}{\sqrt{\pi\left(\pi - \frac{\pi}{4}\right)}} = \frac{2.613}{\sqrt{\frac{3\pi^2}{4}}} = \frac{2.613}{2.721} = 0.960$$

18. (b)

With T as the time of a cycle,

$$\text{The average power loss} = \frac{1}{T} \int_0^{2T/3} V_f \cdot I_f dt$$

$$P = \frac{2}{3} \cdot V_f \cdot I_f$$

and

$$V_f = 0.80 + (0.015 \times 50)$$

$$V_f = 1.55 \text{ V}$$

 $\therefore$

$$P = \frac{2}{3} \times 1.55 \times 50 = 51.67 \text{ W}$$

$$I_{\text{rms}} = \sqrt{\frac{1}{T} \int_0^{2T/3} (50)^2 dt}$$

$$I_{\text{rms}} = 50 \sqrt{\frac{2}{3}} = 40.82 \text{ A}$$

19. (a)

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

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

Since, back emf

$$E \propto N$$

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

$$E_1 = 2E_2 \quad \left(\because N_2 = \frac{1}{2} N_1 \right)$$

So,

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

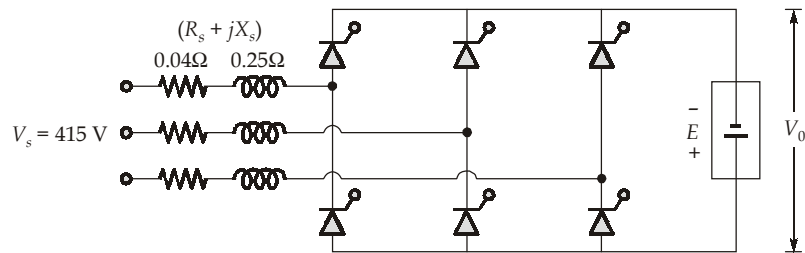
$$\frac{3 \times \sqrt{2} \times 440}{\pi} \cos \alpha = 220$$

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

Input power factor of the supply

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

20. (b)



$$V_{0x} = \frac{3V_{mL}}{\pi} \cos \alpha - 2I_0 R_s - 2V_T - \frac{3\omega L_s I_0}{\pi}$$

$$= \frac{3 \times \sqrt{2} \times 415}{\pi} \cos 145^\circ - (2 \times 80 \times 0.04) - (2 \times 1.5) - \left(\frac{3 \times 0.25 \times 80}{\pi} \right)$$

$$= -487.5898 = -E$$

$$\therefore E = 487.5898 \approx 487.6 \text{ V}$$

21. (c)

Given, for single phase full converter,

$$V_0 = 146.42 \text{ V}$$

$$I_0 = \frac{V_0}{R} = \frac{146.42}{10} = 14.64 \text{ A}$$

$$\text{Reactive power } Q = V_0 I_0 \tan \alpha$$

$$2.143 \times 10^3 = 146.42 \times 14.64 \tan \alpha$$

$$\tan \alpha = 0.9997$$

$$\alpha = 45^\circ$$

22. (b)

The given chopper is a step down chopper,

$$V_0 = \alpha V_s$$

$$V_0 = I_0 (R_a + R_{se}) + E_b = \alpha V_s = 200 (0.06 + 0.04) + 200 = \alpha \cdot 440$$

$$\alpha = \frac{220}{440}$$

$$\alpha = 0.5$$

$$T_{\text{on}} = \alpha \cdot T = 0.5 \times \frac{1}{500} = 1 \text{ ms}$$

23. (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,

$$140 = \alpha \cdot 200$$

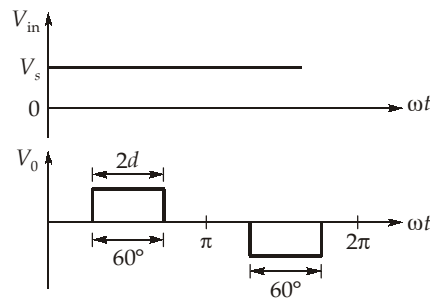
$$\alpha = \frac{140}{200} = 0.7$$

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

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

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

24. (a)



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

$$V_{0\text{ rms}} = 300 \sqrt{\frac{60^\circ}{180^\circ}} = 173.20 \text{ V}$$

25. (b)

$$I_0 = 50 \sin(\omega t - 30^\circ) \text{ A}$$

The given current have only fundamental component so only fundamental voltage component will be responsible for power.

$$V_{01} = \frac{4V_s}{\sqrt{2\pi}} = \frac{4 \times 200}{\sqrt{2\pi}}$$

$$= 180.06 \text{ V}$$

Taking voltage as reference,

$$\phi = 30^\circ$$

$$\text{Active power, } P = V_{01} I_{01} \cos \phi$$

$$= \frac{180.06 \times 50}{\sqrt{2}} \times \cos 30^\circ = 5513.19 \text{ W} \approx 5.51 \text{ kW}$$

$$P = 5.51 \text{ kW}$$

26. (b)

Output voltage Buck-boost converter,

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

$$V_0 = \frac{-0.4}{1-0.4} \times 24 = -16 \text{ V}$$

Average current through inductor,

$$I_L = \frac{V_s D}{R(1-D)^2} = \frac{24 \times 0.4}{5(1-0.4)^2}$$

$$I_L = 5.33 \text{ A}$$

$$\Delta i_L = \frac{V_s D T}{L} = \frac{24 \times 0.4}{20 \times 10^{-6} \times 100 \times 10^3} = 4.8 \text{ A}$$

$$I_{L, \text{ max}} = I_L + \frac{\Delta i_L}{2} = 5.33 + \frac{4.8}{2} = 7.73 \text{ A}$$

$$I_{L,\min} = I_L - \frac{\Delta i_L}{2} = 5.33 - \frac{4.8}{2} = 2.93 \text{ A}$$

The ratio of inductor currents,

$$\frac{I_{L,\max}}{I_{L,\min}} = \frac{7.73}{2.93} = 2.63$$

27. (c)

Given, source voltage, $V_s = 230 \text{ V}$

Peak current, $I_p = 2 I_0$ (load current)
 $= 2(200) = 400 \text{ A}$

and
$$I_p = V_s \sqrt{\frac{C}{L}}$$

$$\sqrt{\frac{C}{L}} = \frac{I_p}{V_s} = \frac{400}{230}$$

or,
$$\sqrt{\frac{L}{C}} = \frac{230}{400} \quad \dots(i)$$

Peak capacitor voltage, $V_{cp} = V_s + I_0 \sqrt{\frac{L}{C}}$

From equation (i), we get

Peak capacitor voltage, $V_{cp} = V_s + I_0 \sqrt{\frac{L}{C}}$

$$\begin{aligned} V_{cp} &= 230 + 200 \left(\frac{230}{400} \right) \\ &= 230 + 115 = 345 \text{ V} \end{aligned}$$

28. (c)

Output voltage,
$$\begin{aligned} V_0 &= D V_s \\ 5 &= D \times 12 \\ D &= 0.416 \end{aligned}$$

Peak to peak ripple current, $\Delta I = \frac{V_s D(1-D)}{L f}$

$$0.8 = \frac{12 \times 0.416(1-0.416)}{25 \times 10^3 \times L}$$

$$L = 0.145 \times 10^{-3} \text{ H}$$

We know that

Peak to peak ripple voltage, $\Delta V = \frac{V_s D(1-D)}{8 L C f^2}$

$$C = \frac{V_s D(1-D)}{8 L f^2 \times \Delta V} = \frac{12 \times 0.416(1-0.416)}{0.145 \times 10^{-3} \times (25 \times 10^3)^2 \times 20 \times 10^{-3} \times 8} = 201.06 \mu\text{F}$$

29. (d)

$$V_0 = 80 \text{ V}$$

$$V_{in} = 100 \text{ V}$$

for buck boost converter,

$$V_0 = \frac{V_{in} D}{1 - D}$$

or

$$80 = \frac{100D}{1 - D}$$

or

$$D = 0.44$$

$$\frac{T_{on}}{T} = 0.44$$

$$T = \frac{1}{f} = \frac{1}{10 \times 10^3} = 100 \mu\text{s}$$

$$T_{on} = 0.44 \times 100 = 44 \mu\text{s}$$

$$T_{off} = T - T_{on}$$

$$T_{off} = 100 - 44 = 56 \mu\text{s}$$

30. (a)

It is single phase half bridge inverter

$$\frac{V_s}{2} = 20$$

or

$$V_s = 40 \text{ V}$$

The fundamental component of output voltage is

$$V_{01} = \frac{2V_s}{\sqrt{2}\pi} = \frac{2 \times 40}{\sqrt{2} \times \pi} = 18 \text{ V}$$

$$Z = \sqrt{1^2 + 1^2} = \sqrt{2} \Omega$$

$$I_{01} = \frac{18}{\sqrt{2}} = 12.728 \text{ A}$$

$$P = I_{01}^2 R = (12.728)^2 \times 1$$

$$P = 162.00 \text{ W}$$

