CLASS TEST

SL. : 01_SK_ABCD_14042023

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POWER ELECTRONICS

ELECTRICAL ENGINEERING

Date of Test : 14/04/2023

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)**

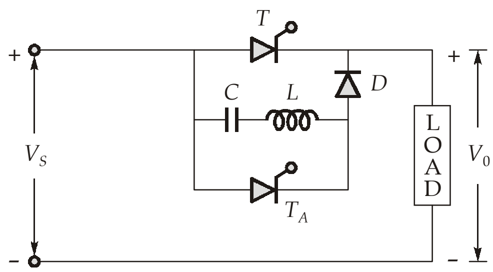
We know in case of Snubber circuit,

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

$$\therefore \quad \left(\frac{di}{dt}\right)_{max} = \frac{220\sqrt{2}}{40\times10^{-6}} = 7.78\text{ A/}\mu\text{sec}$$

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,

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

The resonant frequency,

$$\omega_r = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{5\times10^{-6}\times20\times10^{-6}}}$$

$$= \frac{1}{10\times10^{-6}} = 0.1\times10^6\text{ rad/s}$$

$$\therefore \quad T_A = \frac{\pi}{\omega} = \frac{\pi}{0.1\times10^6} = 10\,\pi\ \mu\text{sec}$$

3. **(c)**

For boost converter peak to peak ripple voltage,

$$\Delta V_0 = \frac{\alpha I_0}{fC} = \frac{0.40\times10}{50\times10^3\times120\times10^{-6}} = 0.66\text{ V}$$

4. **(b)**

For single phase PWM inverter pulse width,

$$2d = 140°$$

$$d = 70°$$

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

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

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

$$3d = \pi$$

$$d = \frac{\pi}{3} = 60°$$

∴ pulse width $2d = 120°$

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

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.

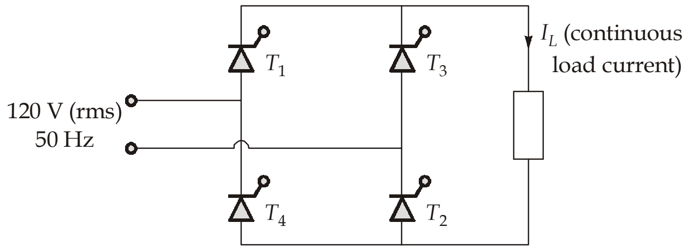
7. (d)

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

$$\alpha = 45°$$

$$V_{\text{mean}} = \frac{2}{\pi}\times 120\sqrt{2}\cos 45° - 2\times(1.5)$$

$$= \frac{2}{\pi}\times 120\sqrt{2}\times\frac{1}{\sqrt{2}} - 3 = 73.39\text{ V}$$

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

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

9. (d)

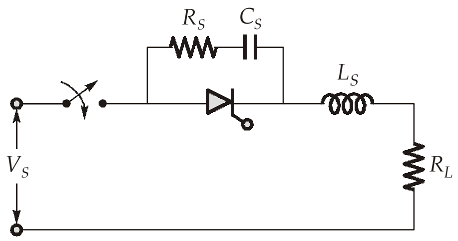
If factor of safety = 2

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

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

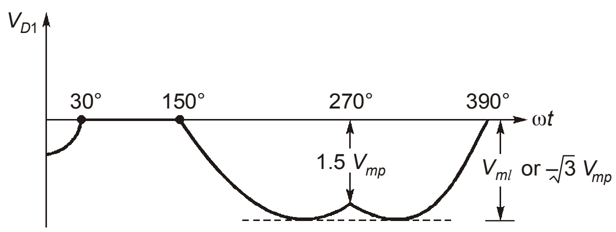
$$L_S = \frac{800}{60} = 13.33 \text{ }\mu\text{H}$$

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

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

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,

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

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

As $\alpha = 0°$ for diodes

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

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

$$\cos\mu = 1 - 0.37$$
$$\mu = \cos^{-1} 0.63$$
$$\mu = 50.95°$$

∴ Conduction angle of diode

$$= 180° + 50.95°$$
$$= 230.95°$$

13. (c)

Output voltage of Buck boost converter,

$$V_0 = \frac{-D}{1-D}V_S = \frac{-0.3 \times 28}{1 - 0.3}$$
$$= \frac{-0.3}{0.7} \times 28 = -12 \text{ V}$$

Average current through inductor,

$$I_L = \frac{V_S D}{R(1-D)^2} = \frac{28 \times 0.3}{5(0.7)^2} = 3.42 \text{ A}$$

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

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

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

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

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

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

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

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

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

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 $\quad E \propto N$

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

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

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

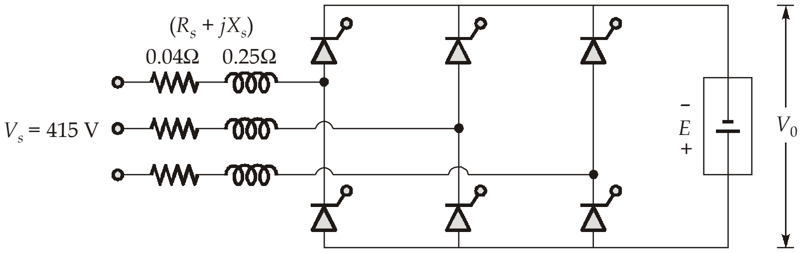
$$\frac{3 \times \sqrt{2} \times 440}{\pi}\cos\alpha = 220$$

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

Input power factor of the supply

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

20. (b)



$$V_{0x} = \frac{3V_{mL}}{\pi}\cos\alpha - 2I_0R_s - 2V_T - \frac{3\omega L_s I_0}{\pi}$$

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

$$= -487.5898 = -E$$

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

21. (c)

Given, for single phase full converter,

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

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

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

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

$$\tan\alpha = 0.9997$$

$$\alpha = 45°$$

22. (b)

The given chopper is a step down chopper,

$$V_0 = \alpha\, V_s$$

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

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

$$\alpha = 0.5$$

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

23. (d)

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

$$\text{Average load voltage} = V_0 = I_0R = 14 \times 10 = 140 \text{ V}$$

$$V_0 = \alpha\, V_s$$

Since the chopper is step down or type-A,

$$140 = \alpha\, 200$$

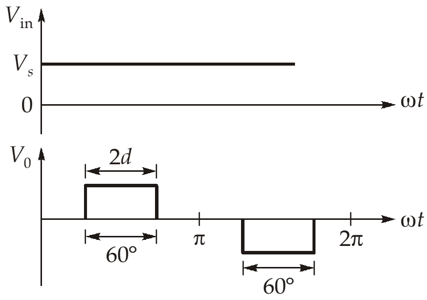
$$\alpha = \frac{140}{200} = 0.7$$

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

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

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

24. (a)



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

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

25. (b)

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

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,

$$\phi = 30°$$

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

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

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

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,

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

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

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

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

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

The ratio of inductor currents,

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

27. (c)

Given, source voltage, $V_s = 230$ V

Peak current, $I_p = 2\, I_0$ (load current)

$= 2(200) = 400$ A

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

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

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

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

From equation (i), we get

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

$$V_{cp} = 230 + 200\left(\frac{230}{400}\right)$$

$= 230 + 115 = 345$ V

28. (c)

Output voltage, $V_0 = DV_s$

$5 = D \times 12$

$D = 0.416$

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

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

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

We know that

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

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

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

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

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

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

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

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

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