CLASS TEST

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POWER ELECTRONICS

ELECTRICAL ENGINEERING

Date of Test : 20/06/2026

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (b)

The fourier series of output voltage when single pulse modulation is used is,

$$V_o = \sum_{n=1,3,5}^{\infty} \frac{4V_s}{n\pi} \sin\frac{n\pi}{2} \sin nd \sin n\omega t$$

$$V_{o1(\max)} = \frac{4V_s}{\pi} \sin\frac{\pi}{2} \sin d$$

Since, the output voltage is free from 5th harmonic,

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

$$d = 36°$$

$$V_{o1,\max} = \frac{4 \times 400}{\pi} \cdot \sin\frac{\pi}{2} \sin(36°)$$

$$V_{o1,\max} = 299.35 \text{ V} \approx 300 \text{ V}$$

2. (c)

We know,

$$\text{String efficiency, } \eta = \frac{\text{Current rating of configuration}}{\text{Current rating of 1 SCR} \times \text{Number of SCR's in string}} \quad \text{...(i)}$$

$$\eta = \frac{960}{40 \times 30} = \frac{24}{30} = 0.80$$

$$\text{Derating factor} = 1 - \text{string efficiency}$$
$$= 1 - 0.8 = 0.2$$

For 50% decrease in rating factor

$$\text{New derating factor} = \frac{0.2 \times 50}{100} = 0.1$$

$$\therefore \quad \text{New efficiency} = 0.9$$

Using equation (i), we get

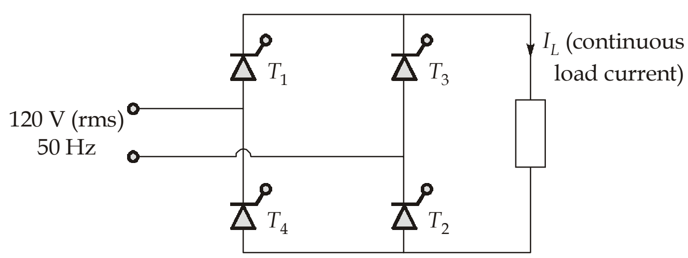
$$0.9 = \frac{960}{40 \times n}$$

$$\Rightarrow \quad n = \frac{960}{40 \times 0.9} = 26.66 \approx 27$$

Decrease in no. of parallel SCR =30 – 27 = 3

3. (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}

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

4. (b)

For 1-ϕ full bridge converter, boundary condition

$$V_m \sin \omega t = E$$

$$\sin \omega t = \frac{E}{V_m}$$

or $$\omega t = \sin^{-1}\left(\frac{E}{V_m}\right) = \sin^{-1}\left(\frac{100}{200}\right) = 30°$$

In above case ωt is given as $100t$

$\therefore$ When $100t > 30°$ then thyristors are forward biased and can be triggered.

5. (d)

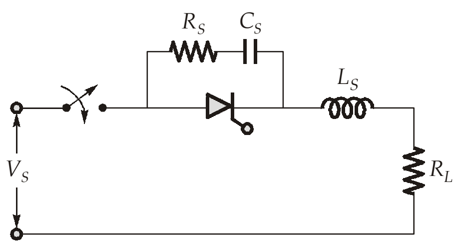
If factor of safety = 2

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

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

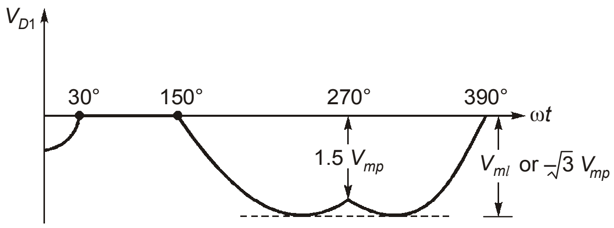
$$L_S = \frac{800}{60} = 13.33 \ \mu\text{H}$$

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

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

6. (b)

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



7. (c)

$$f_{max} = \frac{1}{4RC}$$

$$T_{min} = 4RC = 1.2 \text{ sec}$$

8. (a)

Fourier series expressions of output voltage is

$$V_{o,n} = \sum_{n=1,3,5}^{\infty} \frac{4V_{dc}}{n\pi} \sin n\omega t \text{ V}$$

Harmonic factor for 5th harmonic

$$\text{H.F.} = \frac{V_{5,rms}}{V_{1,rms}} = \frac{\frac{4 \times 64}{\sqrt{2} \times 5\pi}}{\frac{4 \times 64}{\sqrt{2} \times \pi}} \times 100 = \frac{1}{5} \times 100$$

$$\text{H.F.} = 20\%$$

9. (d)

$$V_o = V_s D\left(\frac{N_2}{N_1}\right) = 200 \times 0.35 \times 2 = 140 \text{ V}$$

$$\Delta V_o = \frac{1-D}{8L_c C f^2} \times V_o = 218.8 \text{ mV}$$

10. (a)

In a single-phase sinusoidal bipolar PWM inverter, the harmonics are of the form $Kp \pm l$ (p is the carrier ratio) where K is odd and l is even or K is even and l is odd.

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,

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

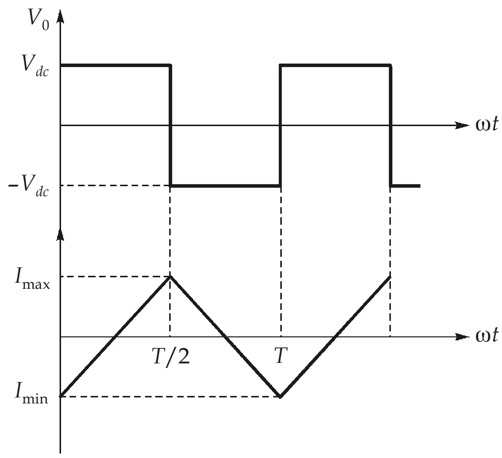
RMS value of source current,

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

Current distortion factor,

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

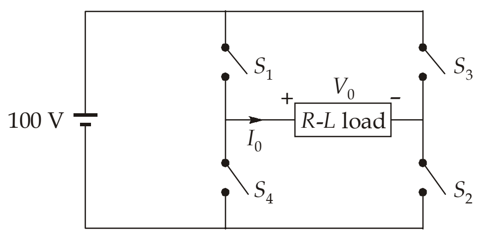
12. (c)



At $t = 0$,

S_1, S_2 : switches are closed

S_3, S_4 : switches are open



Output power, $P = I_{or}^2 R$

$$V_0 = \sum_{n=1,3,5....}^{\infty} \frac{4V_s}{n\pi} \sin n\omega t$$

$$V_{\text{on-rms}} = \frac{2\sqrt{2}}{n\pi} V_s$$

$$Z_n = \sqrt{R^2 + (n\omega L)^2}$$

$$I_{\text{on-rms}} = \frac{V_{on}}{|Z_n|}$$

n	$V_{\text{on-rms}}$	$\lvert Z_n \rvert$	$I_{\text{on-rms}}$
$n = 1$	$V_{o1} = 90\text{V}$	$\lvert Z_1 \rvert = 12.71\Omega$	$I_{o1} = 7.08\text{A}$
$n = 3$	$V_{o3} = 30\text{V}$	$\lvert Z_3 \rvert = 25.59\Omega$	$I_{o3} = 1.17\text{A}$
$n = 5$	$V_{o5} = 18\text{V}$	$\lvert Z_5 \rvert = 40.5\Omega$	$I_{o1} = 0.44\text{A}$
$n = 7$	V_{o7}		$I_{o1} = 0.23\text{A}$

$$I_{0r} = \sqrt{I_{o1}^2 + I_{o3}^2 + I_{o5}^2 + I_{o7}^2} = 7.19 \text{ A}$$

$$P = (7.19)^2 \times 10 = 516.96 \text{ W}$$

13. (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

$$= 180° + 50.95°$$

$$= 230.95°$$

14. (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,

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

15. (b)

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

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

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

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

16. (d)

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

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

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

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

17. (d)

Assuming continuous conduction mode of buck boost converter

$$V_0 = \frac{\alpha}{1-\alpha} V_d$$

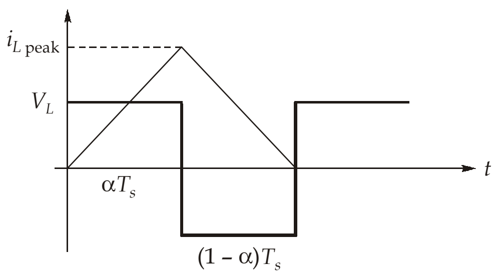
$$10 = \left(\frac{\alpha}{1-\alpha}\right) 15$$

$$\frac{\alpha}{1-\alpha} = 1.5$$

$$2.5\,\alpha = 1$$

$$\alpha = 0.4$$

Checking for boundary conditions,



$$I_{OB,\,max} = \frac{V_0}{2fL} = \frac{10}{2\times 20\times 10^3\times 50\times 10^{-6}} = 5\text{ A}$$

$$I_{OB} = I_{OB,\,max}(1-\alpha)^2 = 5(1-0.4)^2$$

$$= 5\times 0.36 = 1.8\text{ A}$$

$$P_0 = V_0 I_0$$

$$10 = 10\, I_0 \text{ or } I_0 = 1\text{ A}$$

As output current is less than calculated I_{OB}

∴ Mode of operation : Discontinuous mode and value of duty ratio,

$$\alpha' = \frac{V_0}{V_d}\sqrt{\frac{I_0}{I_{OB,max}}} = \frac{10}{15}\sqrt{\frac{1}{5}} = 0.298$$

18. (c)

For given 3-ϕ rectifier,

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

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

Power consumed by the load,

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

$$= 801.38\text{ W}$$

19. (d)

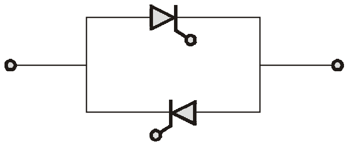
Current distortion factor for single phase semi converter,

$$\text{CDF} = \frac{2\sqrt{2}\cos\left(\frac{\alpha}{2}\right)}{\sqrt{\pi(\pi-\alpha)}}$$

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

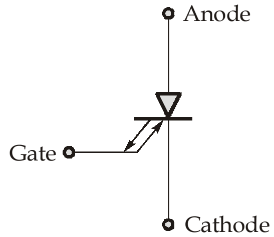
20. (a)

TRIAC



Bidirectional and Bipolar

GTO



It is also unidirectional and bipolar

21. (a)

Average voltage with internal inductance (L_s)

$$V_{0\,avg} = \frac{3V_{mL}}{\pi}\cos\alpha - \frac{3\omega L_s I_0}{\pi} \quad ...(i)$$

$$V_{0\,avg} = \frac{3V_{mL}}{\pi}\cos(\alpha+\mu) + \frac{3\omega L_s I_0}{\pi} \quad ...(ii)$$

Where,
$V_{mL} \rightarrow$ maximum line voltage
$\alpha \rightarrow$ firing angle
$\mu \rightarrow$ overlap angle
$L_s \rightarrow$ internal inductance
$I_0 \rightarrow$ load current

Subtract equation (i) from (ii),

$$\frac{3V_{mL}}{\pi}[\cos\alpha - \cos(\alpha+\mu)] = \frac{6\omega L_s I_0}{\pi}$$

$$\frac{3\times 400\times\sqrt{2}}{3.14}[\cos 36.86° - \cos(36.86°+\mu)] = \frac{6\times 2\pi\times 50\times 3.2\times 10^{-3}\times 20}{3.14}$$

$$\cos 36.86° - 0.07105 = \cos(36.86° + \mu)$$

$$36.86° + \mu = \cos^{-1} 0.729$$

$$\mu = 43.192° - 36.86°$$

$$= 6.33°$$

$$\text{Fundamental power factor} = \cos\left(\alpha + \frac{\mu}{2}\right) = \cos\left(36.86° + \frac{6.33°}{2}\right) = 0.7657$$

22. (a)

The value of softness factor,

$$\text{S.F.} = \frac{t_b}{t_a} = 0.5 = \frac{1}{2}$$

$$t_a = 2\,t_b$$

reverse recovery time,

$$t_{rr} = t_a + t_b = 8\ \mu\text{sec}$$

$$3\,t_b = 8\ \mu\text{sec}$$

$$t_b = \frac{8}{3}\mu\text{sec}$$

$$t_a = 2t_b = \frac{16}{3}\mu\text{sec}$$

$$\frac{di}{dt} = \frac{I_{RM}}{t_a}$$

$$I_{RM} = t_a\frac{di}{dt} = \frac{16}{3}\mu\text{sec}\times 10\,\text{A}/\mu\text{sec} = \frac{160}{3}\text{A}$$

$$Q_{RR} = \frac{1}{2}\times I_{RM}\times t_{rr}$$

$$= \frac{1}{2}\times\frac{160}{3}\times 8 = 213.33\ \mu\text{C}$$

23. **(b)**

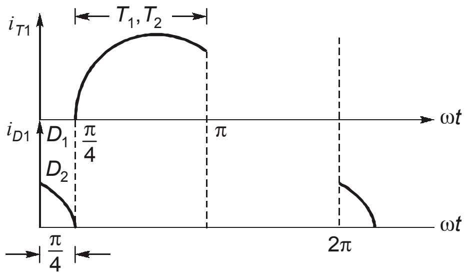
Rms value of fundamental component of the load current,

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

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

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

$$\phi = 45°$$



The rms value of diode current,

$$I_{D\text{ rms}} = \sqrt{\frac{1}{2\pi}\int_0^{\pi/4}(I_m\sin\omega t)^2\,d\omega t} = \sqrt{\frac{I_m^2}{2\pi}\int_0^{\pi/4}\left[\frac{1-\cos 2\omega t}{2}\right]d\omega t}$$

$$= \sqrt{\frac{1}{2\pi}\left[\frac{\pi}{8}-\left(\frac{\sin 2\omega t}{4}\right)_0^{\pi/4}\right]}$$

$$I_{D\text{ rms}} = I_m\,0.1507$$

$$= \sqrt{2}\times 81.317\times 0.1507$$

$$I_{D\text{ rms}} = 17.33\text{ A}$$

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,

$$I_{L\text{avg}} - \frac{\Delta I_L}{2} = 0$$

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

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

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

25. (c)

At rated condition,

$$P = 2.7 \text{ kW} = 2700 \text{ W}$$

$$V = 180 \text{ V}$$

$$I_{\text{rated}} = \frac{2700}{180} = 15 \text{ A}$$

$$\text{back emf} = E_b = 180 - 15 \times 0.5 = 172.5 \text{ V}$$

Now, at duty ratio of 0.6

$$V = 200 \times 0.6 = 120 \text{ V}$$

and at 70% of rated torque

$$\text{armature current} = 0.7 \times 15 = 10.5 \text{ A}$$

$$\text{back emf } (E_b') = 120 - 10.5 \times 0.5 = 114.75 \text{ V}$$

We know,

$$\text{back emf} \propto \text{speed}$$

$$\frac{E_b}{E_b'} = \frac{N_{\text{rated}}}{N}$$

$$\frac{172.5}{114.75} = \frac{1200}{N}$$

$$N = 798.26 \text{ rpm}$$

26. (b)

It is single phase half bridge inverter

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

or $\quad V_s = 40$ V

The fundamental component of output voltage is

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

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

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

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

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

27. (a)

$$\% \text{ THD} = \frac{\sqrt{V_{0,\text{rms}}^2 - V_{1,\text{rms}}^2}}{V_{1,\text{rms}}}\times 100$$

Rms value of output voltage = $V_s\sqrt{\frac{2d}{\pi}}$

Pulse width, $2d$ = 150° (given)

d = 75°

$$V_{0,\text{ rms}} = V_s\sqrt{\frac{2\times 75}{180}} = 0.9128V_s$$

$$V_{01,\text{ rms}} = \frac{4V_s}{\sqrt{2}\pi}\sin\frac{\pi}{2}\sin 75° = 0.87\ V_s$$

$$\% \text{ THD} = \frac{\sqrt{(0.9128V_s)^2-(0.87V_s)^2}}{0.87V_s}\times 100$$

$$\% \text{ THD} = 31.75\%$$

28. (b)

With T as the time of a cycle,

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 × 50)

V_f = 1.55 V

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

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

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

29. **(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 $E \propto N$

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

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

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

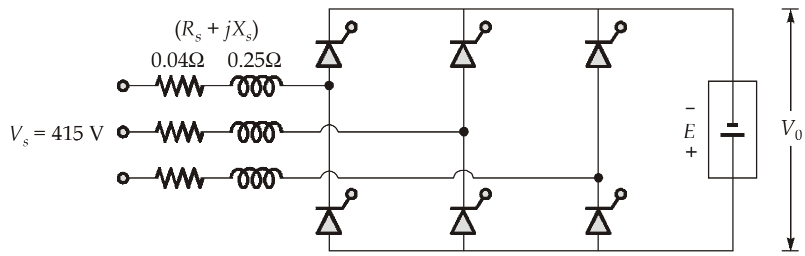
$$\frac{3\times\sqrt{2}\times 440}{\pi}\cos\alpha = 220$$

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

Input power factor of the supply

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

30. **(b)**



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

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

$$= -487.5898 = -E$$

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

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