All India Mock GATE Test Series
Test series 4
Electrical Engineering

Answer Keys and Explanations

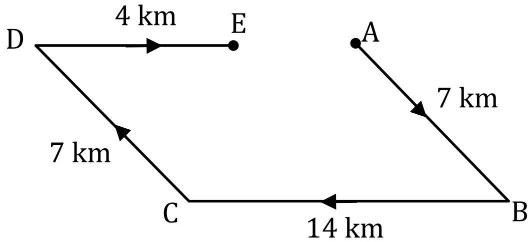
General Aptitude:

1. **[Ans. A]**
Meaning: slow to move or act
Part of Speech: Adjective

2. **[Ans. *] Range: 9 to 9**
Clearly $5 \times 2 = 10, 10 \times 2 = 20, 20 \times 2 = 40, \ldots$
So, the series is a G.P. in which $a_1 = 5$ and $r = 2$
To find the n^{th} term of a Geometric progression, the formula is $a_n = a_1 r^{n-1}$
Let 1280 be the n^{th} term of the series
Then, $5 \times 2^{n-1} = 1280 \Leftrightarrow 2^{n-1} = 256 = 2^8 \Leftrightarrow n - 1 = 8 \Leftrightarrow n = 9$

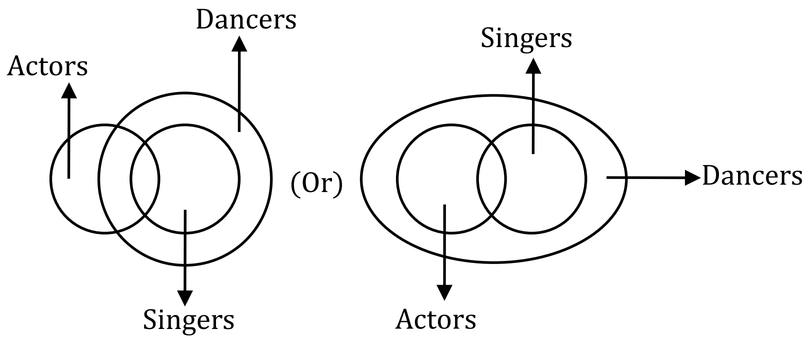
3. **[Ans. A]**
For this type of question take the LCM of speeds and assume the LCM as the distance
Then the time taken at speed of 60 km/hr $= \frac{300}{60} = 5$ hrs
Again the time taken at speed of 50 km/hr $= \frac{300}{50} = 6$ hrs
Thus we see that in place of 5 hrs trains take 6 hrs. Its means train takes 1 hr extra and this one hour is stopping period in the total time of 6 hrs. Thus in 6 hrs train halts for 1 hr. so in 1 hr train will stop for $1/6$ hours or 10 minutes.

4. **[Ans. *] Range: 10 to 10**
Let assume, Radha is at Point 'A'



Required distance $= AE = AD - DE$
Since ABCD is a parallelogram
AD= BC
$\therefore AE = BC - DE$
$= 14 - 4 = 10$

5. **[Ans. A]**



Only (1) Follows

6. **[Ans. *] Range: 6 to 6**

Given:

$R \to x + 10$ | x | | $x + 5$ | ⑤$^+$
$L \to x + 6$ | x | | $x + 5$ | ①$^+$
$B \to x + 5$ | $x +$ | 25 | $x + 5$ | ①$^-$
$H \to x + 4$ | x | | $x + 5$ | ⑤$^-$
$A \to x$ | x | | $x + 5$ |

Thus total 6 coins have to be transferred.

7. **[Ans. B]**

The numbers are given in pair of 4 and 9.

The unit digit of each pair is 4, and there are 50 such pairs which are mutually multiplied together.

Unit digit $\underbrace{4 \times 9^2}_{4} \times \underbrace{4^3 \times 9^4}_{4} \times \underbrace{4^5 \times 9^6}_{4} \times \ldots . \underbrace{4^{99} \times 9^{100}}_{4}$

Again $4 \times 4 \times 4 \times 4 \ldots 4$(upto 50 times)

i.e., the unit digit of 4^{50}, which is 6

[Since unit digit of 4^{2n} is 6 for $n = 1, 2, 3, \ldots$etc]

8. **[Ans. B]**

16.66 18.75

17.5

(Boys) (Girls)

$\Rightarrow$ $\frac{50}{3}\times\frac{4}{4}$ $\frac{75}{4}\times\frac{3}{3}$ … … (Making Denominator equal)

$\frac{35}{2}\times\frac{6}{6}$

B G

200/12 225/12

$\Rightarrow$ 210/12

15/12 10/12

$\Rightarrow$ 3 : 2

$\therefore$ Boys $= 3x$; Girls $= 2x$

Given $3x - 2x = 8$

$\therefore x = 8$

Thus the number of Girls = 16 and number of Boys = 24

9. **[Ans. D]**

Let there be x voters and k votes goes to loser then

$0.8x - 120 = k + (k + 200)$ … …. ①

Also, $k + 200 = 0.41x$ … …. ②

From equation ① and ②

$0.8x - 120 = 0.41x - 200 + 0.41x$

$0.02x = 80$

$x = 4000$

$\therefore k = 0.41 \times 4000 - 200$

$\Rightarrow k = 1440$

And $(k + 200) = 1640$

Number of voters voted = $x - 0.2x$

$0.8x = 0.8 \times 4000 = 3200$

Therefore, percentage of votes for defeated candidates $= \frac{1440}{3200} \times 100 = 45\%$

10. **[Ans. *] Range: 40 to 40**

Given

$W_2 = 1.5\ W_1$ ... . (50% Increase in walk)

$D_1 = D_2$

$\because \frac{M_1 \times D_1}{W_1} = \frac{M_2 \times D_2}{W_2}$

$\therefore M_2 = 1.5\ M_1$

$\therefore$ If the efficiency of M_1 and M_2 is same, then 50% more work force is required.

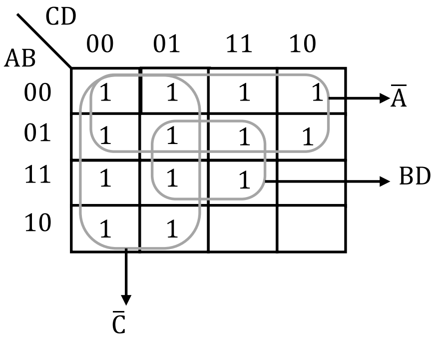
But it is given the productivity of new labour is 25% more (i.e., 5/4 times efficient)

$\therefore$ Actual % increase in work force required $= \frac{50\%}{5/4} = 40\%$

Technical:

1. **[Ans. D]**

$$f(A,B,C,D) = Y = \overline{A} + A\,\overline{C} + \overline{A}\,\overline{B}\,C + AB\,\overline{C}\,D + ABCD$$
$$= \overline{A} + A\,\overline{C} + \overline{A}\,\overline{B}\,C + ABD(C + \overline{C})$$
$$= \overline{A} + A\,\overline{C} + \overline{A}\,\overline{B}C + ABD$$



$$Y = \overline{A} + \overline{C} + BCD$$

2. **[Ans. D]**

$$V_o = (s) = V_1(s)\left(\frac{-R_2}{R_1}\right) + V_1(s)\left(\frac{1/CS}{R + \frac{1}{CS}}\right)\left(1 + \frac{R_1}{R_1}\right)$$

$$\Rightarrow \frac{V_o(s)}{V_1(s)} = -1 + \frac{2}{1 + RCS}$$

$$= \frac{1 - RCS}{1 + RCS}$$

The above function is all pass filter

3. **[Ans. A]**

$L_1 = P_1 N_1^2$

$L_2 = P_2 N_2^2$

Given that permeance is same

So, $P_1 = P_2$

$$\frac{L_1}{N_1^2} = \frac{L_2}{N_2^2}$$

$$\frac{N_2}{N_1} = \sqrt{\frac{L_2}{L_1}} = \sqrt{\frac{100m}{25m}} = 2$$

4. **[Ans. C]**

From diagram,

$$\frac{y(s)}{x(s)} = \frac{\frac{1}{s}+\frac{1}{s^2}}{1+\frac{5}{s}+\frac{6}{s^2}}$$

$$\frac{y(s)}{x(s)} = \frac{\frac{s+1}{s^2}}{\frac{s^2+5s+6}{s^2}}$$

$$\frac{y(s)}{x(s)} = \frac{s+1}{s^2+5s+6}$$

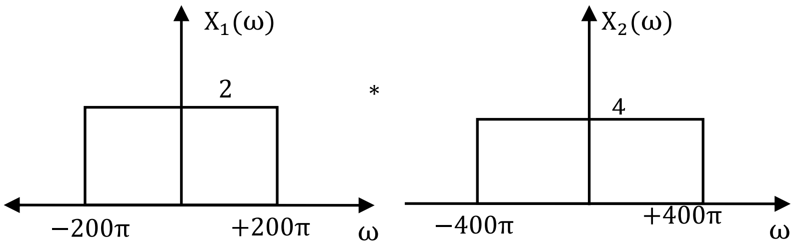
$$\frac{y(s)}{x(s)} = \frac{(s+1)}{(s+2)(s+3)} \qquad x(s) = \frac{1}{s} \rightarrow \text{Unit step}$$

$$y(s) = \frac{1}{s}\frac{(s+1)}{(s+2)(s+3)}$$

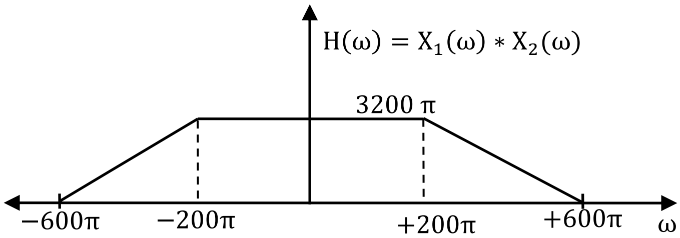
$$y(s) = \frac{1/6}{s} + \frac{1/2}{s+2} - \frac{2/3}{s+3}$$

$$y(t) = \left(\frac{1}{6}+\frac{1}{2}e^{-2t}-\frac{2}{3}e^{-3t}\right)u\,(t)$$

5. **[Ans.*]Range: 599 to 601**



⇒ Convolution of two rectangular pulses is a trapezoidal pulse



$$\boxed{\omega_m = 600\pi}$$

$$f_m = \frac{\omega_m}{2\pi} = \frac{600\pi}{2\pi} = 300$$

$$N.R = 2\,f_m$$

$$= 2 \times 300 \Rightarrow 600\text{ Hz}$$

6. **[Ans. A]**

The general solution of the non-homogeneous system is of the form,

$x = p + xf_1 h_1 + xf_2 h_2 + \ldots + xf_{n-r}\, h_{n-r}$

Where $xf_1, xf_2 \ldots xf_{n-r}$ are the free variables and p, h_1, h_2, h_{n-r} are $n \times 1$ columns

$$\left[\frac{A}{b}\right] = \begin{pmatrix} 1 & 2 & 2 & 3 & 4 \\ 2 & 4 & 1 & 3 & 5 \\ 3 & 6 & 1 & 4 & 7 \end{pmatrix}$$

$$= \begin{pmatrix} 1 & 2 & 2 & 3 & 4 \\ 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

$\Rightarrow x_3 = 1 - x_4$

$x_1 = 2 - 2x_2 - x_4$, x_2 and x_4 are free variables

$$\begin{pmatrix} 2 - 2x_2 - x_4 \\ x_2 \\ 1 - x_4 \\ x_4 \end{pmatrix} = \begin{pmatrix} 2 \\ 0 \\ 1 \\ 0 \end{pmatrix} + x_2 \begin{pmatrix} -2 \\ 1 \\ 0 \\ 0 \end{pmatrix} + x_4 \begin{pmatrix} -1 \\ 0 \\ -1 \\ 1 \end{pmatrix}$$

$\therefore$ The particular solution is $\begin{pmatrix} 2 \\ 0 \\ 1 \\ 0 \end{pmatrix}$.

7. **[Ans. A]**

$$\oint_c \frac{f(z)}{(z - z_0)^{n+1}} dz = 2\pi i \frac{f^n(z_0)}{n!}$$

$$= 2\pi i \frac{81 \cos h(0)}{4!}$$

$$= \frac{27}{4} \pi i$$

8. **[Ans. *]Range: 9.3 to 9.5**

$$H(\omega) = 9\int_{-\infty}^{\infty}\left|\frac{\sin\left(\frac{\omega}{3}\right)}{\omega}\right|^2 d\omega$$

Let,

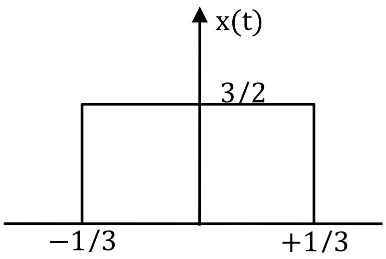
$$x(\omega) = \left(\frac{\sin\left(\frac{\omega}{3}\right)}{\left(\frac{\omega}{3}\right)}\right) = \text{Sa}\left[\frac{\omega}{3}\right]$$

$$x^2(\omega) = \left(\frac{\sin\left(\frac{\omega}{3}\right)}{\left(\frac{\omega}{3}\right)}\right)^2 = \text{Sa}^2\left[\frac{\omega}{3}\right]$$

$$H(\omega) = 1\int_{-\infty}^{\infty}\text{Sa}^2\left[\frac{\omega}{3}\right]\cdot d\omega$$

Perceval's Theorem:

$$\int_{-\infty}^{\infty}|x(t)|^2 dt = \frac{1}{2\pi}\int_{-\infty}^{\infty}|x(\omega)^2 d\omega|$$



$\overset{F\cdot T}{\longleftrightarrow}$ $|x(\omega) = \text{Sa}\left(\frac{\omega}{3}\right)$

$A\tau = 1$

$\tau/2 = 1/3$

$\tau = 2/3$

$$\Rightarrow \int_{-\infty}^{\infty}\text{Sa}^2\left(\frac{\omega}{3}\right)\cdot d\omega = 2\pi\int_{-\infty}^{\infty}\left(x(t)\right)^2 dt$$

$$= 2\pi\int_{-1/3}^{+1/3}\left(\frac{3}{2}\right)^2 dt \Rightarrow 2\pi\frac{9}{4}[t]_{-1|3}^{+1|3}$$

$$\Rightarrow 2\pi\times\frac{9}{4}\times\left[\frac{2}{3}\right]$$

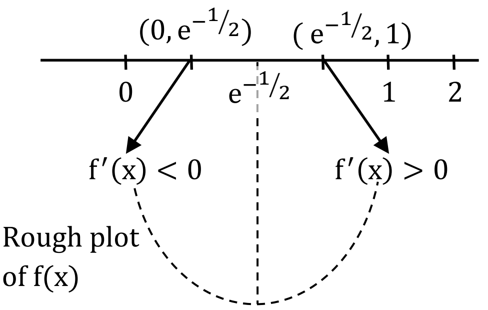
$$\Rightarrow 3\pi = 9.42$$

9. **[Ans. *] Range: 0.59 to 0.61**

$f(x) = x^2 \ln(x)$

$f'(x) = x + 2x\ln(x) = 0 \Rightarrow x = 0, e^{-1/2}$

Clearly the function is defined by for $x > 0$



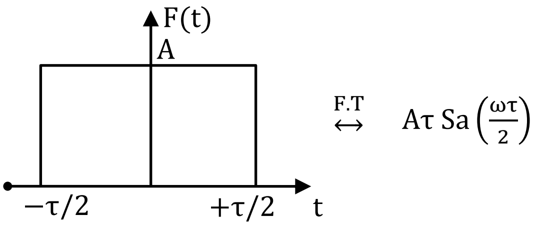
Hence absolute minima at $x = e^{-1/2}$

10. **[Ans. *]Range: 2.45 to 2.55**

$F(\omega) = 25 \text{ sinc}\left[\frac{5\omega}{\pi}\right] e^{+2j\omega}$

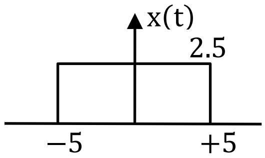
$\text{sinc}\left[\frac{5\omega}{\pi}\right] = Sa(5\omega)$

$F(\omega) = \frac{25\sin(5\omega)}{5\omega} e^{+2j\omega}$

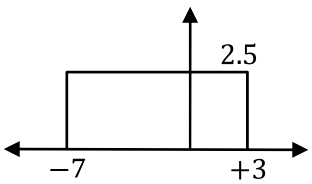


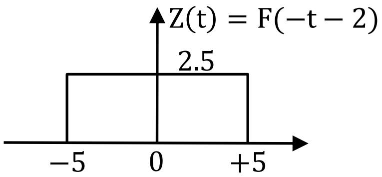
Let,

$x(\omega) = 25\, Sa(S\omega) \overset{I.F.T}{\longleftrightarrow}$



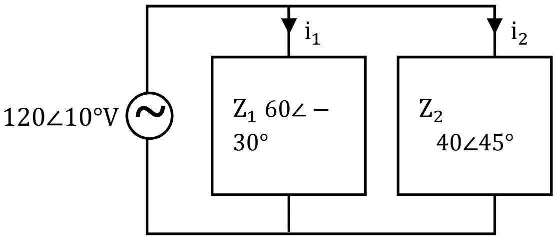
$F(\omega) = x(\omega) \cdot e^{+2j\omega} \leftrightarrow x(t + 2) = F(t)$





$Z(t)|_{t=3} = 2.5$

11. **[Ans. *] Range: 461 to 463**



$I_1 = \frac{120\angle 10°}{60\angle -30°} = 2\angle 40°A$

$I_2 = \frac{120\angle 10°}{40\angle 45°} = 3\angle -35°A$

$I = I_1 + I_2$

Total complex power $S = V.I^*$

$= 120\angle 10°[2\angle -40° + 3\angle 35°]$

$S = 240\angle -30° + 360\angle 45°$

$S = 462.4 + j134.6 \Rightarrow P + jQ$

$P = 462.4$ watts[Real Power]" Absorbed Power"

12. **[Ans. C]**

Apparent power $= V_{rms} \cdot I_{rms}$

$= \frac{120}{\sqrt{2}} \cdot \frac{4}{\sqrt{2}} = \frac{480}{2} = 240$

Apparent power=240 VA

Power factor $= \cos[\theta_v - \theta_i]$

$= \cos[-20 - 10] = \cos(-30)$

$= 0.866$

Here current is leading by voltage. So, power factor will be leading.

13. **[Ans.*]Range: 1.5 to 2.0**

$P_e = |V||I|\cos\phi$

$0.8 = (1.0)(I)(0.8)$

$|I| = 1$ p.u.

$\bar{I} = 1\angle -36.86°$ p.u

$\bar{E}_f = 1\angle 0° + (1\angle -36.86)(j\,0.2 + j\,0.5 + j\,0.15)$

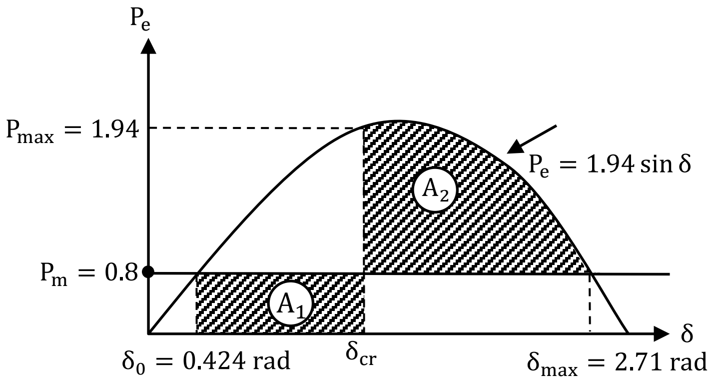
$\bar{E}_f = 1\angle 0° + (1\angle -36.86)(j\,0.85)$

$= 1.65\angle 24.24°$ p.u

$\delta_0 = 24.24° = 0.424$ rad $\Rightarrow \delta_{max} = \pi - \delta_0 = 2.71$ rad

$$P_{max} = \frac{|E_f||V|}{X} = \frac{(1.65)(1.0)}{0.85} = 1.94\sin\delta$$

$P_e = P_{max}\sin\delta = 1.94\sin\delta$



$A_1 = [\delta_{cr} - 0.424](0.8)$

$$A_2 = \int_{\delta_{cr}}^{2.71} (1.94\sin\delta - 0.8)\,d\delta$$

For stable system $A_1 = A_2$

$0.8[\delta_{cr} = 0.424] = 1.94[\cos\delta]_{2.71}^{\delta_{cr}} - 0.8[2.71 - \delta_{cr}]$

$-(0.33) = 1.94[\cos\delta_{cr} + 0.90] - 2.168$

$\cos\delta_{cr} = 0.047$

$\delta_{cr} = 1.523$ rad

14. **[Ans.*]Range: 0.60 to 0.70**

$$\frac{I}{P} = \frac{80}{0.85} = 94.1 \text{ kW}$$

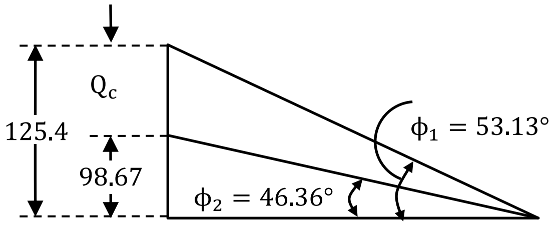
$\cos\phi_1 = 0.6$; $\sin\phi_1 = 0.8$

$$\text{KVAR} = \frac{\text{kW}}{\text{p.f.}}\sin\phi_1$$

$$= \frac{94.1}{0.8}(0.6)$$

$= 125.4$ KVAR

$\cos\phi_2 = 1.15 \times 0.6$



From the figure $Q_c = 26.73$ KVAR

$$Q_c = 3\frac{V_{ph}^2}{X_c}$$

$V_{ph} = 6.6 \times 10^3$ Volts(Delta)

$Q_c = 26.73 \times 10^3$ VAR

$$X_c = \frac{1}{\omega c} = \frac{1}{(314)(c)}$$

Solving above we get

$C = 0.65\ \mu F$

15. **[Ans. C]**

Ferranti effect takes place due to excessive Ferranti effect. This must be absorbed by emplacing shunt inductive compensation

16. **[Ans. A]**

$$V_{AB} = -\int_A^B E\, dl$$

$$= +\int_A^B 10^5\, x\, dx$$

$$= +10^5\left(\frac{x^2}{2}\right)_0^{10^{-3}}$$

$$= +10^5\frac{(10^{-6})}{2} = +0.05\text{ V}$$

17. **[Ans.*]Range: 369 to 369**

Total Buses = 200 − 170 = 30 − 5 = 25

PQ buses = 0.85 × 200 =170

$$\text{PV buses} = \underbrace{24}_{\text{Gen. BUS}} + \underbrace{5}_{\text{Voltage controlled bus}} = 29$$

And one reference bus

Size of Jacobian $= 2\,N_{PQ} + N_{PV}$

$= 2 \times 170 + 29$

$= 369$

18. **[Ans. D]**

From diagram,

$$X(t) = 2u(t) + r(t) - r(t-2) - 7u(t-2) + \frac{5}{4}r(t-4) - \frac{5}{4}r(t-8) - 2u(t-8)$$

$$x(s) = \frac{2}{s} + \frac{1}{s^2} - \frac{1}{s^2}e^{-2s} - \frac{7}{s}e^{-2s} + \frac{5}{4}\frac{e^{-4s}}{s^2} - \frac{5}{4}\frac{e^{-8s}}{s^2} - \frac{2}{s}e^{-8s}$$

$$\Rightarrow \frac{1}{s}[2 - 7e^{-2s} - 2e^{-8s}] + \frac{1}{s^2}\left[1 - e^{-2s} + \frac{5}{4}e^{-4s} - \frac{5}{4}e^{-8s}\right]$$

19. **[Ans. *]Range: 9.00 to 9.50**

$$V_o = (\alpha)(V_s)$$
$$= (0.65)(500)$$
$$= 325 \text{ volts}$$
$$I_o = \frac{V_o - E}{R}$$
$$= \frac{325 - 60}{10}$$
$$= 26.5 \text{ Amp}$$
$$i_{fd_{(avg)}} = (1-\alpha)I_o$$
$$= (1 - 0.65)(26.5)$$
$$= 9.27 \text{ Amp}$$

20. **[Ans. A]**

This module can block both the voltages (+Ve and − Ve) but allows only positive current.

21. **[Ans. C]**

From figure b

[BX+A]Y=AG+B

BXY+AY=AG+B

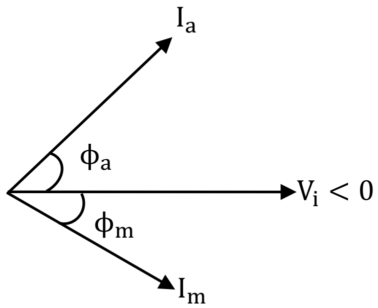
Comparing on both sides, we get

XY=1 and Y=G

$$\therefore X = \frac{1}{G} \text{ and } Y = 9$$

22. **[Ans. *] Range: 148 to 155**

After inserting the capacitor in series with the auxiliary winding, the current is expected to lead the voltage source.



Given:

$|\phi_a| + |\phi_m| = 90°$

$\phi_m \rightarrow$ Lagging

$\phi_m = \tan^{-1}\frac{4}{8} = 26.5$

$\phi_a \rightarrow$ Leading

$\therefore \phi_a = \tan^{-1}\left(\frac{X_c - X_a}{R_a}\right)$

$\phi_a = \tan^{-1}\frac{X_c - 5}{8}$

Now,

$|\phi_m| + |\phi_a| = 90°$

$\therefore |\phi_a| = 63.43°$

$\Rightarrow \tan^{-1}\left|\frac{X_c - X_a}{8}\right| = 63.43°$

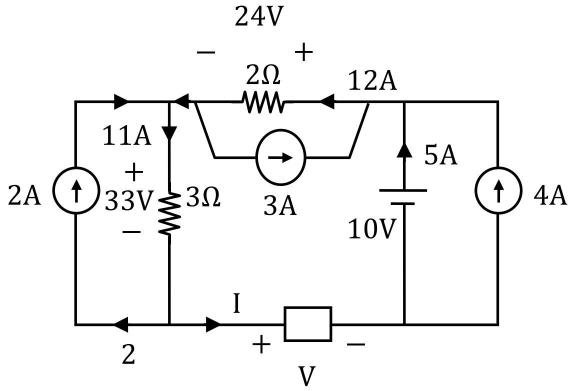
$\Rightarrow X_c - 5 = 16$

$\Rightarrow X_c = 21$

$\because X_c > X_a$ as has to be leading power factor

$\Rightarrow \frac{1}{2\pi fc} = 21 \Rightarrow c = 151.57\ \mu F$

23. **[Ans. *]Range: -423.5 to -422.5**



From figure,

$I = 9A$

Now apply the mesh analysis

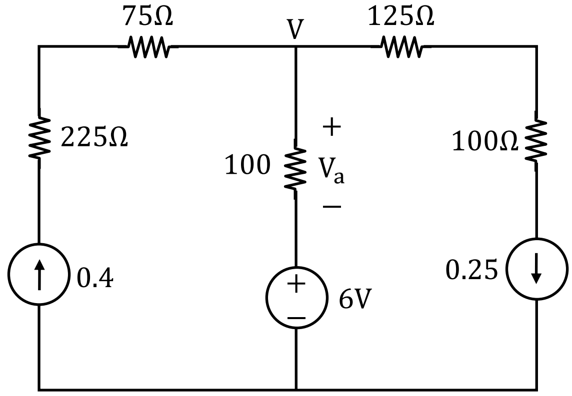
$V - 10 + 24 + 33 = 0$

$V = -47$

$P = -(9 \times 47)$

$P = -423$ Watts

24. **[Ans. C]**



$V - 6 = V_a$

$$\frac{V-6}{100} + 0.25 = 0.4$$

$V = 0.15 \times 100 + 6$

$V = 21; V_a = 21 - 6 = 15V$

25. **[Ans. A]**

$\vec{B} = \nabla \times \vec{A}$

$$= \left[\frac{1}{r}\frac{\partial A_z}{\partial \phi} - \frac{\partial A_\phi}{\partial z}\right]\overrightarrow{a_z} + \left[\frac{\partial Ar}{\partial z} - \frac{\partial Az}{\partial r}\right]\overrightarrow{a_\phi} + \frac{1}{r}\left[\frac{\partial (rA\phi)}{\partial r} - \frac{\partial A_r}{\partial \phi}\right]\overrightarrow{a_z}$$

Now, $A\phi = 0$, $A_r = 0$, $A_Z = 100r^2$

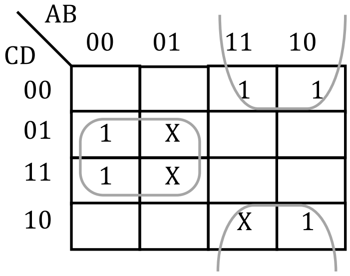
$$\therefore \vec{B} = \left[\frac{1}{r}\cdot\frac{\partial}{\partial \phi}(100r^2) - 0\right]\overrightarrow{a_r} + \left[0 - \frac{\partial (100r^2)}{\partial r}\right]\overrightarrow{a_\phi} + \frac{1}{r}[0-0]\overrightarrow{a_z}$$

$$= -200r\overrightarrow{a_\phi}\ \text{Wb/m}^2$$

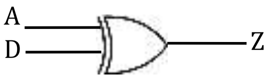
26. **[Ans. *] Range: 1 to 1**

Decimal	BCD[5421]	BCD[8421]
	ABCD	WXYZ
0	0000	0000
1	0001	0001
2	0010	0010
3	0011	0011
4	0100	0100
5	1000	0101
6	1001	0110
7	1010	0111
8	1011	1000
9	1100	1001

K –Map for Z



$$Z = \bar{A}D + A\bar{D} = A \oplus D$$



27. **[Ans. B]**

$$I = I_o\left(e^{V/V_T} - 1\right) = \frac{0-(-1)}{100k}$$

$$\Rightarrow 10^{-6}\left[e^{\frac{V}{25\times10^{-3}}} - 1\right] = \frac{1}{10^5}$$

$$\Rightarrow V = 0.06V$$

$$\Rightarrow \frac{V_o - V}{4k} = \frac{1}{100k}$$

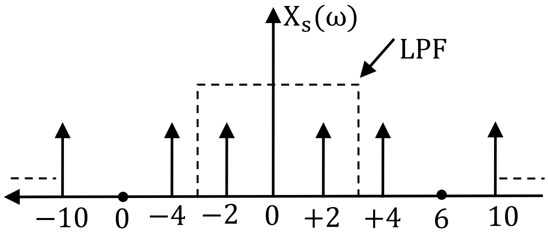
$$\Rightarrow \frac{V_o - 0.06}{4k} = \frac{1}{100k}; \Rightarrow V_o = 0.1 \text{ Volt}$$

28. **[Ans. B]**

$x(t) = 3\sin(8000\pi t)$

$F_m = 4000Hz = 4\ kHz$

The sampling frequency is $F_s = 6000Hz = 6\ kHz$



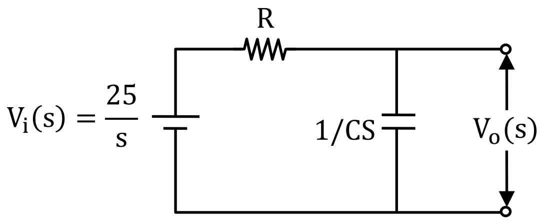
Thus, the only 2 kHz frequency component present in reconstructed signal.

29. **[Ans. A]**

$$F(\omega) = \frac{5}{\omega}\cos 3\omega \cdot \sin 5\omega$$

$$\int_{-\infty}^{\infty} F(t)\cdot dt = F(\omega)|_{\omega=0} \Rightarrow \text{Area Under time domain}$$

$$\int_{-\infty}^{\infty} F(t)\cdot dt \Rightarrow \lim_{\omega \Rightarrow 0} 25\cos 3\omega\ Sa(5\omega) = 25$$



$$\frac{V_o(s)}{V_i(s)} = \frac{1/CS}{R + \frac{1}{CS}} \qquad \begin{bmatrix} R = 10^4\Omega \\ C = 10^{-4}F \end{bmatrix}$$

$$\frac{V_o(s)}{V_i(s)} = \frac{1}{RCS + 1} = \left(\frac{1}{S+1}\right)$$

$$V_o(s) = \frac{25}{S}\frac{1}{(S+1)}$$

$$= \frac{25}{S} - \frac{25}{S+1}$$

$$V_o(t) = (25 - 25e^{-t})u(t)$$

30. **[Ans. D]**

Given $\theta = \pi$ to 2π

$r = 2$

Let $z = re^{i\theta} = 2e^{i\theta}$

$dz = rie^{i\theta}d\theta = 2ie^{i\theta}\,d\theta$

$$\int_C \frac{2z+3}{z}dz = \int_{\pi}^{2\pi} \frac{2\cdot 2e^{i\theta}+3}{2e^{i\theta}} \times 2ie^{i\theta}d\theta$$

$$= i\int_{\pi}^{2\pi}\left(4e^{i\theta}+3\right)d\theta$$

$$= i\left(\frac{4e^{i\theta}}{i}+3\theta\right)_{\pi}^{2\pi}$$

$$= i\left(\frac{4}{i}e^{i2\pi}+6\pi-\frac{4}{i}e^{i\pi}-3\pi\right)$$

$$= i\left(\frac{4}{i}\times 1+3\pi-\frac{4}{i}(\pi)\right)$$

$$= i\left(\frac{8}{i}+3\pi\right) = 8+3\pi i$$

31. **[Ans. *] Range: 0 to 0**

For odd 'n' order of matrix determinant of an $n \times n$ Skew symmetric matrix has the value 0.

32. **[Ans. *] 166.5 to 166.7**

Parabola intersects the x-axis at -6 and 4 also at $x = 0, y = 24$.

$y = x^2 + 2x + 24$ is the equation of the given curve.

$$\int_{-6}^{4} ydx = \int_{-6}^{4} x^2+2x+24 = \frac{x^3}{3}+x^2+24x\Big|_{-6}^{4}$$

$$= \frac{500}{3} = 166.666$$

33. **[Ans. C]**

$$\oint \frac{\sin z}{z^2-2iz}dz = \frac{1}{2i}\left(\oint \frac{\sin z}{z-2i} - \oint \frac{\sin z}{2}\right)$$

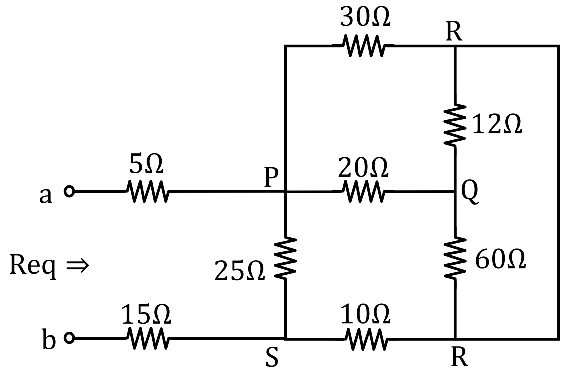
$$= \frac{1}{2i}\ 2\pi i\,[\sin 2i - 0]$$

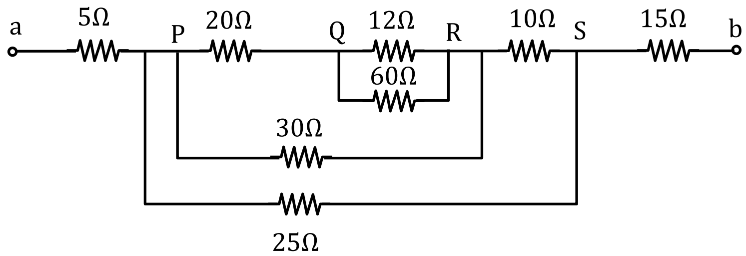
$$= \pi \sin 2i = \pi\frac{e^{i(2i)}-e^{-i(2i)}}{2i}$$

$$= \frac{\pi.e^{-2}-e^{2}}{2i}$$

$$= \frac{\pi}{2}i\,(e^2-e^{-2})$$

34. **[Ans. *]Range: 32.4 to 32.6**





$\text{Resistance}_{QR} = 12 \parallel 60 = 10\Omega$

$\text{Resistance}_{PR} = (10 + 20) \parallel 30 = 15\Omega$

$\text{Resistance}_{PS} = (15 + 10) \parallel 25 = 12.5\Omega$

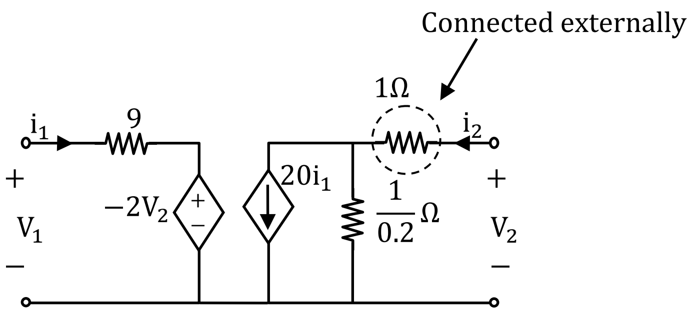
$\text{Resistance}_{ab} = 5 + 12.5 + 15 = 32.5\Omega$

35. **[Ans. *]Range: 16.55 to 16.75**

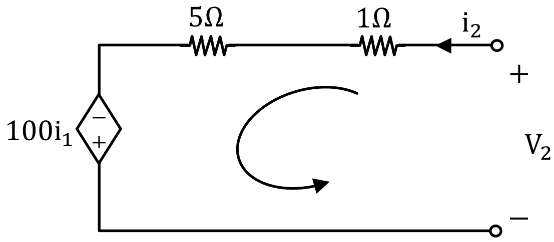
For given h-parameter,

$$h = \begin{bmatrix} 9 & -2 \\ 20 & 0.2 \end{bmatrix}$$

Equivalent Circuit



For new h_{21} at output side,



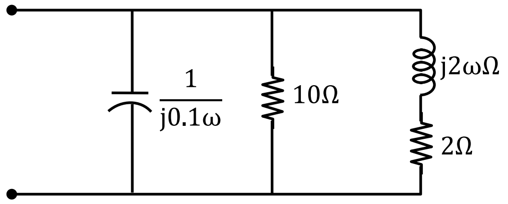
$$6i_2 - 100i_1 - V_2 = 0$$

$$h_{21} = \left.\frac{i_2}{i_1}\right|_{V_2=0}$$

$$6i_2 = 100i_1$$

$$\frac{i_2}{i_1} = \frac{100}{6} = 16.67$$

36. **[Ans. *] Range: 1.9 to 2.1**



$$y = j\,0.1\,\omega + \frac{1}{10} + \frac{1}{2(1+j\omega)}$$

For resonance imaginary part must have to few

$$y = \frac{1}{10} + j\,0.1\omega + \frac{1}{2}\frac{(1-j\omega)}{(1+\omega^2)}$$

Imaginary Part

$$0.1\omega - \frac{\omega}{2(1+\omega^2)} = 0$$

$$0.1 = \frac{1}{2(1+\omega^2)}$$

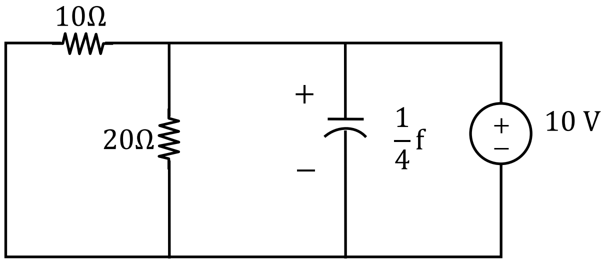
$$1+\omega^2 = 5$$

$$\omega^2 = 4$$

$$\omega = 2 \text{ rad/s}$$

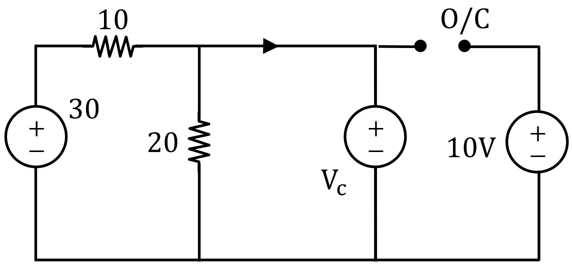
37. **[Ans. A]**

At $t = 0^-$

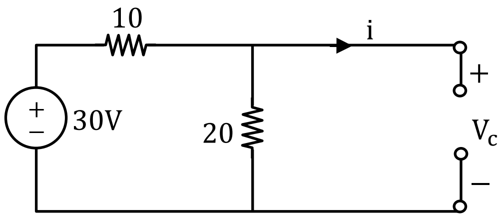


$V_c(0^-) = 10V = V_c(0^+)$

at $t = 0^+$



At $t \to \infty$

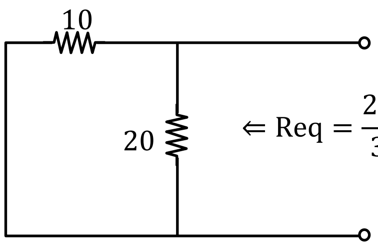


$$V_c = \frac{30 \times 20}{30} = 20V$$

$$i_c(t) = C \cdot \frac{dv_c(t)}{dt} = \frac{1}{4} \cdot \frac{dv_c(t)}{dt}$$

$$V_c(t) = V_c(\infty) - [V_c(\infty) - V_c(0^+)]e^{-\frac{t}{R_{eq} \cdot C}} \ldots\ldots (i)$$

$R_{eq} = R_{th} \Rightarrow$ Equivalent resistance across 'C' after switching



$$\Leftarrow Req = \frac{200}{30} = \frac{20}{3}\Omega$$

$$V_c(t) = 20 - (20 - 10)e^{-\frac{t}{\frac{20}{3} \cdot \frac{1}{4}}} = 20 - 10e^{-\left(\frac{3t}{5}\right)}$$

$$i_c(t) = \frac{1}{4} \times 10 \times \frac{3}{5} e^{-(3t/5)}$$

At t=1 sec

$V_c(t) = 14.52$

$i(t) = 0.823$

38. **[Ans. C]**

$P = \frac{|E_f||V|}{X_s} . \sin\delta$

$0.75 = \frac{(1.4)(1.0)}{1.2} \sin\delta$

$\delta = 40°$(leading for generator)

$Q = \frac{|E_f||V|}{X_s} \cos\delta - \frac{|V|^2}{X_s}$

$= \frac{(1.4)(1.0)}{1.2} \cos 40° - \frac{(1)^2}{1.2}$

$= 0.06$ p. u

39. **[Ans. C]**

From the bode plot

$-20 = 20\log k + 20\log 1$

$\Rightarrow k = 10^{-1} = \frac{1}{10} = 0.1$

Transfer Function $= \frac{0.1 \times s}{\left(\frac{s}{10}+1\right)^2} = \frac{0.1s \times 10}{(s+10)} = \frac{10s}{(s+10)^2}$

40. **[Ans. *]Range: 444.0 to 447.0**

$N_s = \frac{120 \times 50}{4} = 1500$ rpm

$W_s = \frac{(2\pi)(1500)}{60} =$ rad/s

under steady state $p_m = p_e = 700$ mW

Accelerating power

$P_a = P_m - P_e = 700$ mW

($P_e \rightarrow 0$ due to fault)

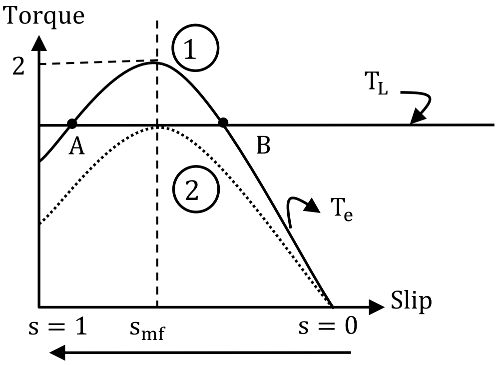
$p_a = \tau_a W_s = 700$ mW

$\tau_a \cong 445$ kNm

41. **[Ans. C]**

There can be two operating points for a constant load torque, A and B

We know B is the stable operating point



At steady state, $T_e = T_L = \text{Constant (Given)}$

$T_e \propto V^2 S$

$\therefore V_1^2 s_1 = V_2^2 s_2$

Now, if we decrease the input voltage, the maximum torque value will decrease but the slip at which maximum torque occurs won't change as $s_{mf} = \frac{r_2}{x_2}$ and is independent of source voltage. Here $s_2 = s_{mf} = 0.10$

$\therefore$ At rated input voltage $V_1 = 1$ pu, $s_1 = 0.05$

$$\therefore V_2^2 = V_1^2 \frac{s_1}{s_2} = 1^2 \times \frac{0.05}{0.10}$$

$$V_2 = \frac{1}{\sqrt{2}} = 0.707 \text{ pu}$$

42. **[Ans. A]**

At 80 kVA and rated voltage means 80% loading, $\eta = 98\%$

$$\therefore \text{Total losses in transformer} = \text{output}\left(\frac{1}{\eta} - 1\right) = \left(\frac{1}{0.98} - 1\right) \times 80 \text{ kVA} = 1632.65 \text{ W}$$

$\because$ This is maximum kVA

$$\therefore \text{Iron loss} = \text{Ohmic loss} = \frac{1632.65}{2} = 816.325\text{W}$$

$\therefore$ Full load ohmic loss (i.e., at 100 kVA)

$$= \left(\frac{1}{0.8}\right)^2 \times 816.3 = 1275.5 \text{ W}$$

$$\therefore \eta_{\text{at rated load}} = \frac{100000 \times 0.8}{80{,}000 + 816.3 + 1275.5} \times 100 = 97.45\%$$

43. **[Ans. D]**

$f_2 = 36.7\ \text{Hz}$

$r_2' = 3\Omega, T_{\rho l} = 23.5\ \text{Nm}$

$\frac{V}{f} = \text{Constant}, N_{r2} = 1000\ \text{rpm}$

$\therefore V_2 = \frac{V_1}{f_1} \times f_2 = \left(\frac{400}{\sqrt{3}}\right) \times \frac{f_2}{50} = 4.6\ f_2$

$(S_{fl})_2 = \frac{\omega_s - \omega_r}{\omega_s} = 1 - \frac{\frac{1000}{60} \times 2\pi}{\left(\frac{120\ f_2}{P60}\right) \times 2\pi} = 1 - \frac{104.7}{\pi f_2}$

$\therefore (S_{fl})_2 = \frac{f_2 - 33.3}{f_2}$

Now, at full load slip value is very low

$\therefore \frac{r_2'}{s} \gg (x_2' + x_1)$

$T_{\rho l} \approx \frac{3}{\omega_s} \frac{V_2^2}{r_2} (S_{fl})_2$

$23.5 = \frac{3}{\pi f_2} \times \times \frac{(4.6)^2 f_2^2}{(3\Omega)} \left(\frac{f_2 - 33.3}{f_2}\right)$

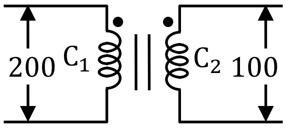
$f_2 = 33.3 + \left(\frac{23.5 \times 3}{3 \times (4.5)^2}\right) = 36.7\ \text{HZ}$

44. **[Ans. B]**

Note: The maximum kVA for a autotransformer is when the coils carry the rated current

Given

2-winding transformer



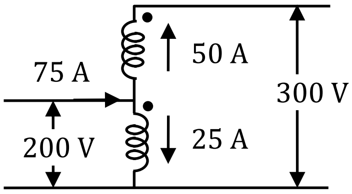
C_1 and C_2 are the primary and secondary conductors. Rated current in C_1 and C_2

$$C_1 = \frac{5\text{kVA}}{200} = 25\text{ A}$$

$$C_2 = \frac{5\text{kVA}}{100} = 50\text{ A}$$

Given

Auto-transformer voltage rating 200V/300V.We can say that this is an additive polarity



For maximum kVA rated current will flow in the coils

$\therefore$ I/P kVA $= 200 \times 75 = 15$kVA

$\therefore$ O/P kVA $= 50 \times 300 = 15$kVA

$\therefore$ Maximum kVA $= 15$ kVA for this connection

$\therefore$ kVA Transferred magnetically is due to mmf produced by the coils$=200 \times 25 = 150 \times 50 = 5$kVA

(Primary coil) (Secondary coil)

$\therefore$ kVA Transferred by conduction $= (15 - 5) = 10$ kVA

45. **[Ans. *] Range: 19.50 to 20.00**

Average output voltage

$$V_o = \frac{2V_m}{\pi}\cos\alpha$$

$$= 2\frac{(230\sqrt{2})}{\pi}\cos 30°$$

$$= 179.33\text{ V}$$

Average output current

$$I_o = \frac{V_o - E}{R} = \frac{179.33 - 40}{5}$$

$$= 27.86\text{ Amp}$$

RMS Thyristor current

$$I_{Th_{(rms)}} = \frac{I_o}{\sqrt{2}} = \frac{27.86}{\sqrt{2}}$$

$$\cong 19.7\text{ Amp}$$

46. **[Ans. *] Range: 8.5 to 9.5**

Load phase voltage $V_{ph} = \frac{V_s\sqrt{2}}{3} = \frac{200\sqrt{2}}{3}$ V

$P_{load} = \frac{3(V_{ph})^2}{R} = 9$ kW

47. **[Ans. B]**

$V_o = \frac{\alpha V_s}{1-\alpha} = \frac{0.4(240)}{1-0.4} = 160V$

$T = \frac{1}{2} = 0.5$ ms; $T_{on} = \alpha T = 0.2$ ms

During T_{on}

$V_s = L\frac{\Delta I}{T_{on}} \Rightarrow 240 = (20)\frac{\Delta I}{0.2}$

$\Delta I = 2.4$ Amp

48. **[Ans. D]**

Inductive V. R $= \frac{1-\cos\mu}{2}$

49. **[Ans. C]**

The state equation is given:

$\dot{X} = \begin{pmatrix} 0 & 1 \\ -20 & -9 \end{pmatrix} X + \begin{pmatrix} 0 \\ 1 \end{pmatrix} u$

$|A - \lambda I| = 0$ given the poles

$\begin{vmatrix} \lambda & -1 \\ 20 & \lambda + 9 \end{vmatrix} = 0$

$\Rightarrow \lambda^2 + 9\lambda + 20 = 0$

$\Rightarrow (\lambda + 4)(\lambda + 5) = 0$

$\lambda = -4, -5$

50. **[Ans. *]Range: 2.2 to 2.6**

$G(s) = \frac{k(s+2)}{(s+1)(s+3)}$

$\frac{Y(s)}{R(s)} = \frac{k(s+2)}{(s+1)(s+3)}$

$Y(s) = \frac{1\ k(s+2)}{s(s+1)(s+3)}$

$Y_{ss} = \lim_{s\to 0} \frac{s\ \ k(s+2)}{s\ (s+1)(s+3)}$

$2 = \frac{k.2}{(1)\ (3)}$

$k = 3$

$G(s) = \frac{3(s+2)}{(s+1)(s+3)}$

$Y(s) = \frac{3(s+2)}{(s+1)(s+3)}$

$R(s) = 1 \Rightarrow$ Impulse input

$Y(s) = \frac{3/2}{(s+1)} + \frac{3/2}{(s+3)}$

$Y(t) = \left(\frac{3}{2}\ e^{-t} + \frac{3}{2}\ e^{-3t}\right) u(t)$

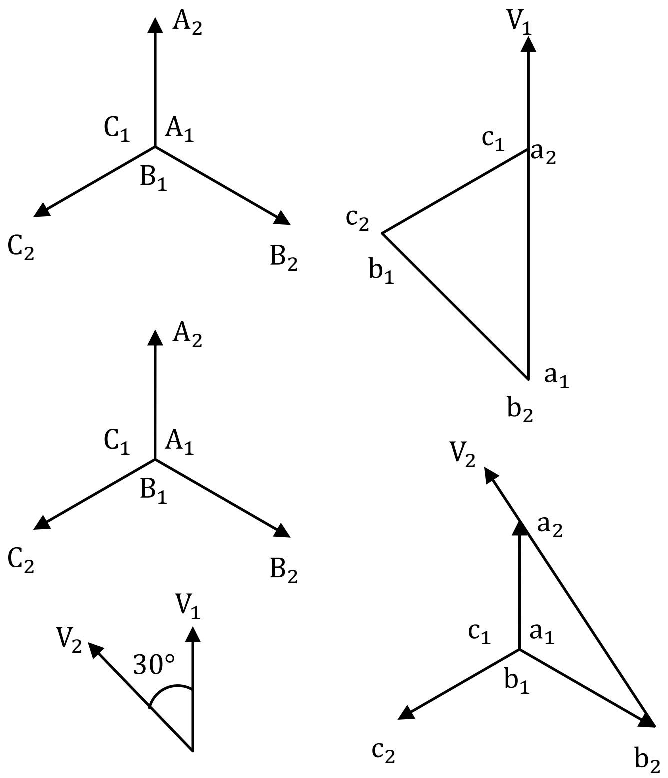
$= \frac{3}{2}\ e^{-0.1} + \frac{3}{2}\ e^{-0.3}$

$= 1.357 + 1.111$

$= 2.468$

51. **[Ans. B]**

The Phasor Diagram of the Transformer



We can see V_2 leads V_1 by 30°

52. **[Ans. D]**

$$60 = 10\log\frac{P_o}{P_i}$$

$$\Rightarrow \frac{P_o}{P_i} = 10^6$$

$$\Rightarrow P_o = 10^6 \times 2 \times 10^{-6} = 2 \text{ Watts}$$

53. **[Ans.*]Range: 2235 to 2237**

$$SIL_{new} = \frac{V_s^2}{(Z_s)_{new}} \quad SIL_{old} = \frac{V_s^2}{Z_{s_{old}}}$$

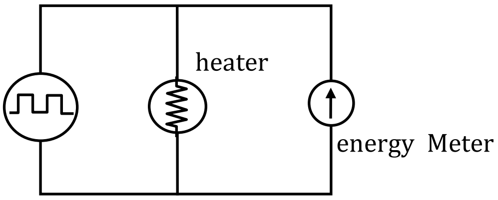
$$Z_{s_{old}} = \sqrt{\frac{L}{C}} \Rightarrow Z_{s_{new}} = \sqrt{\frac{L}{C + C_{sh}}} = \sqrt{\frac{L}{C\underbrace{\left(1 + \frac{C_{sh}}{C}\right)}_{1+k}}} = \frac{Z_{sold}}{\sqrt{1+k}}$$

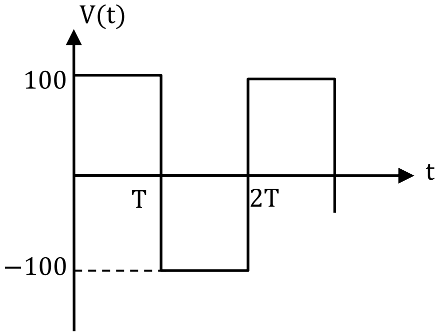
$$SIL_{new} = \frac{Vs^2}{Z_{s_{new}}} = \frac{Vs^2}{Z_{sold}}\sqrt{1+k} = SIL_{old}\sqrt{1+k}$$

Given $k = 25\% \Rightarrow 0.25$

$$SIL_{new} = 2000 \times \sqrt{1 + 0.25} = 2236.067977$$

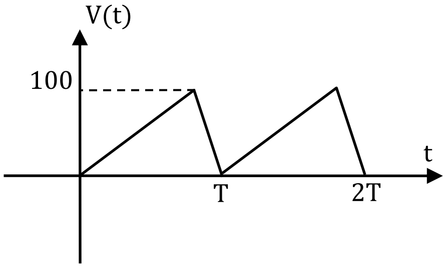
54. **[Ans. B]**





$$\text{energy} = \frac{V^2}{R} \times t \times 10^{-3} = 3$$

$$\Rightarrow \frac{100^2}{R} \times 2 \times 10^{-3} = 3$$



Resistance of heater $\boxed{R = 6.667\ \Omega}$

$$\text{Power dissipated by heat} = \frac{V^2}{R}$$

$$= \frac{\left(\frac{100}{\sqrt{3}}\right)^2}{6.667}$$

$$\simeq 500\text{W}$$

55. **[Ans. B]**

$d\vec{s} = (rdrd\phi)\overrightarrow{a_z}$

$$\text{Total flux } \phi = \int_s \vec{B}\cdot d\vec{s} = \int_{\phi=0}^{2\pi}\int_{r=0}^{0.2} [(0.6\sin 10^3 t)\overrightarrow{a_z}]\cdot[(rdrd\phi)\overrightarrow{a_z}]$$

$$= 0.6\sin 10^3 t\cdot[\phi]_0^{2\pi}\cdot\left[\frac{r^2}{2}\right]_0^{0.2}$$

$$= 0.6\sin 10^3 t[2\pi]\cdot\left[\frac{0.04}{2}\right]$$

$$= 75.4\sin 10^3 t \text{ mWb}$$

$$\therefore \text{Induced current} = \frac{1}{R}\cdot[\text{Induced Voltage}] = -\frac{1}{R}\left(\frac{d\phi}{dt}\right)$$

$$= \frac{-1}{100}\times 75.4\times 1000\times\cos 10^3 t$$

$$= -0.754\cos 10^3 t \text{ A}$$