GATE 2019
Electrical Engineering Solutions

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General Aptitude

1. Newspapers are a constant source of delight and recreation for me. The only (what bother's) trouble is that I read too (a lot/ large) many of them.

2. $343 = 7^3$
$1331 = 11^3$
$4913 = 17^3$
All numbers given are cube of prime numbers so $13^3 = 2917$ satisfy the missing number.

3. The passengers were angry with the airline staff about the delay.

4. Time taken by X to now the lawn = 2 hrs.

∴ Work done by X in $1hr = \frac{1}{2}$

Similarly,
Work done by 4 in hr = ¼

Work done by x + 4 in 1 hr = $\frac{1}{2}+\frac{1}{4}=\frac{3}{4}$

∴Total time taken by X & 4 together = $\frac{4}{3} hours$

$$= \frac{4}{3} \times 60 \text{ min}utes$$

= 80 Minutes

5. I am not sure if the bus that has been booked will be able to accommodate (occupy) all the students.

6. Given that X = {1, 2, 3}
4 = {2, 3, 4}

$$Z = \left\{\frac{1}{2},\frac{1}{3},\frac{1}{4},\frac{2}{2},\frac{2}{3},\frac{2}{4},\frac{3}{2},\frac{3}{4},\frac{3}{3}\right\}$$

Minimum value in $z = \frac{1}{4}$

Maximum value in $z = \frac{3}{2}$

$$Product = \frac{3}{8}$$

7. Let number of boys participated = 4x
Number of girls participated = 3x
Total number of students participated = 7x

Total passed candidates = $\frac{80}{100} \times 7x = \frac{28}{5}x$

Girls candidate who passed = $\frac{90}{100} \times 3x = \frac{27}{10}x$

Boys candidate who passed = Total passed candidate – Girls candidate who passed

$$= \frac{28}{5}x - \frac{27}{10}x$$

$$= \frac{29}{10}x$$

$$= \frac{29x}{10 \times 4x} \times 100 = 72.5\%$$

8. The correct statement can be concluded from Venn diagram or using the Syllogism.

9.For all digits of a number which lie between 100 and 1000 are even,
Unit and tens digits can be filled from the set {0, 2, 4, 6, 8}
But hundred's digit does not include 0 as it will not remain a number which lie between 100 and 1000
∴ Hundreds digit set is {2, 4, 6, 8}
Total integer be = 5 × 5 × 4

$$\begin{matrix} \textit{Total choies} \\ \textit{for} \end{matrix} \left\{ \begin{matrix} \uparrow & \uparrow & \uparrow \\ \textit{Units} & \textit{Tens} & \textit{Hundreds} \\ \textit{digit} & \textit{digit} & \textit{digit} \end{matrix} \right.$$

Total integer = 100 numbers

10. Given that
Ganga > Rekha, Lakshmi
Lakshmi > Sana
Mita > Ganga
∴ Mita > Ganga > Rekha, Lakshmi > Sana
∴ 2 and statement 4 are correct

Electrical Engineering

1. Given that

Mean square of random process $= E(x^2) = \dfrac{kt}{C}$

Mean is given zero ⇒ E (x) = 0
We know that $E(x^2) - [E(x)]^2$ = variance

$$Variance = \frac{KT}{C}$$

Standard deviation = $\sqrt{\text{variance}} = \sqrt{\dfrac{KT}{C}}$

2. Applying R.H criteria for stability

$\Delta(S) = S^4 + 3S^3 + 3S^2 + S + K = 0$

S^4	1	3	K
S^3	3	1	0
S^2	$\frac{8}{3}$	K	0
S^1	$\dfrac{\frac{8}{3} - 3K}{8/3}$	0	0
S^0	K		

For stability, first column should be greater than zero

$$\frac{\frac{8}{3} - 3K}{8/3} > 0 \quad and \quad k > 0$$

$$\therefore \quad 0 < K < \frac{8}{9}$$

3.

$$H(S) = \frac{S+3}{S^2 + 2S + 1}$$

$H(t) = L^{-1}[H(S)]$

$$= L^{-1}\left[\frac{S+3}{S^2+2S+1}\right] = L^{-1}\left[\frac{S+3}{(S+1)^2}\right]$$

$$= L^{-1}\left[\frac{S+1+2}{(S+1)^2}\right] = L^{-1}\left[\frac{1}{S+1}\right] + L^{-1}\left[\frac{2}{(S+1)^2}\right]$$

H (t) = $e^{-t}+2te^{-t}$

4. We know that

Voltage Regulation = $\dfrac{V_{NL}-V_{FL}}{V_{NL}}\times 100$

Given that V_{FL} = 95V

V_{NL} = 100 V

% VR = $\dfrac{100-95}{100}\times 100 = 5\%$

5. We know that P = VI cos φ, as load and voltage are same

∴ I cos φ = constant

$I_1 \cos \varphi_1 = I_2 \cos \varphi_2$

I_1 = 200A

Cos φ_1 = 1

Cos φ_2 = 0.5

$$I_2 = \frac{I_1 \cos\phi_1}{\cos\phi_2} = 400A$$

6. We know that

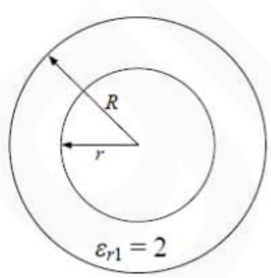


Figure (i)

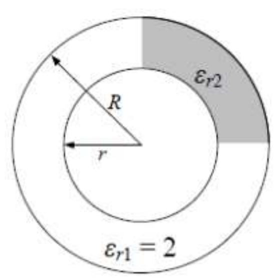
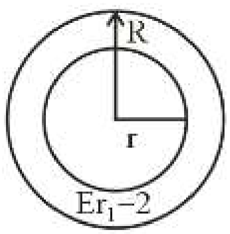


Figure (ii)

$$C_1 = \frac{2\pi \in_r}{\ln\left(\frac{b}{a}\right)} = \frac{2\pi(2 \in_o)}{\ln\left(\frac{R}{r}\right)}$$

$$C_1 = \frac{4\pi \in_o}{\ln\left(\frac{R}{r}\right)}$$



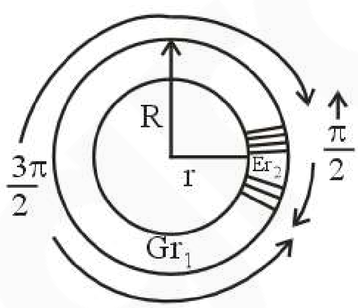
Total portion cover 2π

$$\therefore \frac{1}{4} portion\ covers = \frac{2\pi}{4} = \frac{\pi}{2}$$

$$\frac{\pi}{2} length\ for \in_{r_1}$$

$$and \frac{3\pi}{2} length\ for \in_{r_1}$$

Both are connected in parallel



$C_2 = C_{r1} + C_{r2}$

$$=\frac{2\pi(2\in_o)}{\ln\left(\frac{R}{r}\right)}\times\frac{3\pi}{2}+\frac{2\pi(\in_{r_2}\in_o)}{\ln\left(\frac{R}{r}\right)}\times\frac{\pi}{2}$$

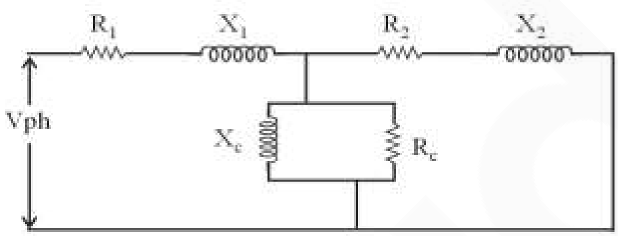
$$=\frac{\pi\in_o}{\ln\left(\frac{R}{r}\right)}[3+\frac{\in_{r_2}}{2}]$$

Given $C_2=2C_1$

$$\frac{\pi\in_o}{\ln\left(\frac{R}{r}\right)}[3+\frac{\in_{r_2}}{2}]=2(\frac{4\pi E_o}{\ln\left(\frac{R}{r}\right)})$$

$$\in_{r_2}=10$$

7.



$$\frac{V_1}{f}\alpha\phi\alpha I_m \qquad I_m\alpha\frac{V}{Xm}$$

$$\frac{V\downarrow}{f(=constt.)}\alpha\ \phi_m\downarrow$$

By reducing the rms value of supply voltage at rated frequency, magnetizing current changes which changes the magnetizing reactance

8.

$$\text{H}(s)=\frac{10}{s(s^2+s+100\sqrt{2})}$$

For finding steady state value, we will apply final value theorem

$$\lim_{t\to\infty} y(t) = \lim_{s\to 0} sY(s)$$

$$y(\infty) = \lim_{s\to 0} s \times \frac{10}{s\left(s^2 + s + 100\sqrt{2}\right)}$$

$$y(\infty) = \frac{1}{10\sqrt{2}}$$

9.

$$G(s) = \frac{\pi e^{-0.25s}}{s}$$

Nyquist plot cut the negative real
Axis at w = phase cross over frequency

$$G(j\omega) = \frac{\pi e^{-0.25j\omega}}{j\omega}$$

$$\phi = -90^\circ - 0.25\omega \times \frac{180^\circ}{\pi}$$

$$\angle G(j\omega)|_{\omega=\omega_{pc}} = -180^\circ$$

$\phi_{\omega=\omega_{pc}} = -90^\circ$ [illegible] pc [illegible] π [illegible] $^\circ$

90° [illegible] $pc \left(\frac{45^\circ}{\pi}\right)$

$$\omega_{pc} = 2\pi$$

Magnitude at cutting point

$$X = |G(j\omega)|_{\omega_{pc}}$$

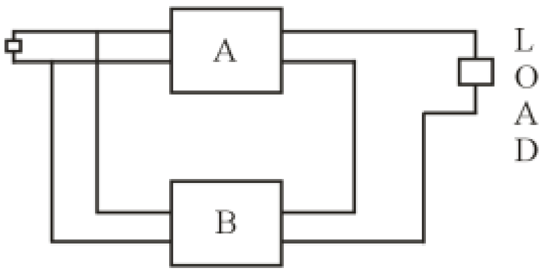
$$= \frac{\pi}{\omega_{pc}} = \frac{\pi}{2\pi}$$

$$\boxed{x = \frac{1}{2}}$$

Then, the co-ordinates becomes (-0.5, j0).

10. Given Z_{in} = 10Ω, $Z_{o/p}$ = 100Ω

For CCCS



Series connection is output

$Z_{o/p} = Z_{o/p}(1+A\beta) = 100(1+9)$

= 100 KΩ

11. We know that,

For 6-pulse converter harmonic present in AC current are 6K ± 1

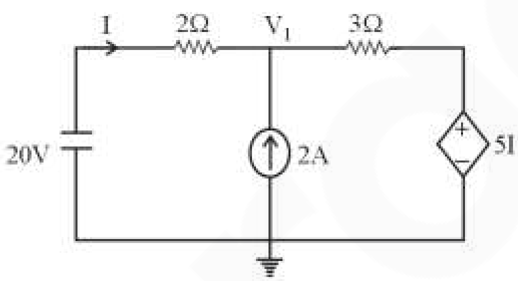
General expression NK ± 1 [k = 0, 1, 2, 3]

For 6 pulse n = 6

Lowest order harmonic = 5

Lower harmonic frequency = 5 × 50 = 250 Hz

12.



Applying nodal analysis at point 1 whose voltage is assumed as V_1.

$$\frac{V_1-20}{2}-2+\frac{V_1-5I}{3}=0.......(1)$$

$$I=\frac{20-V_1}{2}..........................(2)$$

Solving (1) and (2)

$$-I-2+\frac{V_1-5I}{3}=0$$

$8I = V_1 - 6$

8I = 20 – 2I – 6
10I = 14
I = 1.4 A

13.

$$\textit{Wave equation } \frac{d^2u}{dt^2} = c^2\left(\frac{d^2u}{dx^2} + \frac{d^2u}{dy^2}\right)$$

$$\textit{Laplace equation } \nabla^2 U = \frac{d^2u}{dx^2} + \frac{d^2u}{dy^2} = 0$$

$$\textit{Poission equation } \nabla^2 U = f$$

$$\textit{Heat equation } \frac{du}{dt} - \alpha\left(\frac{d^2u}{dy^2} + \frac{d^2u}{dy^2} + \frac{d^2u}{dz^2}\right) = 0$$

14.

For $\frac{z^2-1}{z+2}$, the singularity z = –2 lies outside the |Z| ≤ |

∴ By Cauchy's integral theorem

$$\int \frac{z^2-1}{z+2} dz = 0 \quad for\ |z| \leq |$$

15.

Given that
$y = 2x^3 + 3y^2 + 4z$

$$\int grad\ f.dr = ?$$

$$\overrightarrow{dr} = dx\hat{i} + dy\hat{j} + dz\hat{k}$$

$$grad\ f = \frac{df}{dx}\hat{i} + \frac{df}{dy}\hat{j} + \frac{df}{dz}\hat{k}$$

$$= 6x^2\hat{i} + 6y\hat{j} + 4\hat{k}$$

$$\int grad\ f.\overrightarrow{dr} = \int 6x^2 dx + \int 6y dy + \int 4z dz$$

Applying the limits

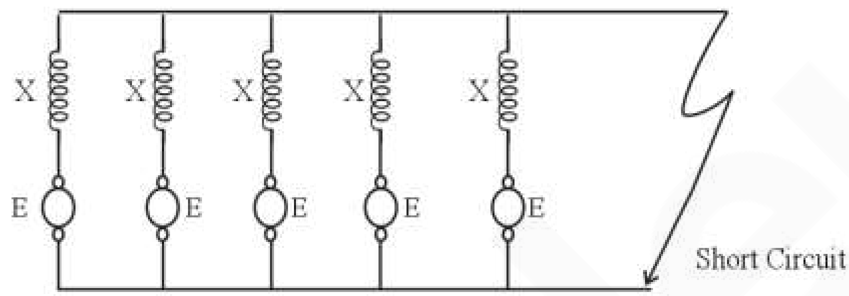
$$\int_C grad\ f.dr = [\int_{-3}^{2} 6x^2dx + \int_{-3}^{-3} 6ydy + \int_{2}^{2} 4dz]$$

$$= [\int_{2}^{2} 6x^2dx + \int_{-3}^{6} 6ydy + \int_{2}^{2} 4dz] + [\int_{2}^{2} 6x^2 + \int_{6}^{6} 6ydy + \int_{2}^{-1} 4dz]$$

$$= [2x^3]_{-3}^{2} + [3y^2]_{-3}^{2} + [4z]_{2}^{-1}$$

$$= 70 + 81 - 12 = 139$$

16.



Net reactance of generator

$$X = \frac{0.25}{5} = 0.05 p.u.$$

$$I_{SC} = \frac{Pre - fault\ voltage}{X} = \frac{1}{0.05} = 20 p.u.$$

Short Circuit MVA = I_{SC} ×Base MVA

= 20 × 5 = 100 MVA

17. For NMOS transistor to be in saturation the condition will be

$V_{GS} > V_{th}$

And $V_{DS} \geq V_{GS} - V_{Th}$

18.

I_{sec} = 5 × 20 = 100 A

V = I_{sec} R = 100 × 0.01 = 1V

VA output of CT = VI_{sec} = 100 × 1 100 VA

19.

$Y_{12} = -(y_{12}) = -j20$

Series admittance of each line = $\frac{Y_{12}}{2} = \frac{-j20}{2} = -j10$

Series reactance of each line = $\dfrac{1}{-j10} = j0.1 p.u.$

20.

$$M = \begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{bmatrix}$$

Determinant of M = |M|
|M| = 0 [0 – 1] – 1 [0 – 1] + 1 [1 – 0]
|M| = 2
|M| ≠ 0
∴ Rank of M = number of columns
P (M) = 3

21. H (t) = 1 + e^{-at} u (t)

'1' is a constant and two sided so the impulse response cannot be causal as for causal it should satisfy
h (t) = 0 t < 0
≠0 t > 0
Which it is not satisfying due to presence of constant
∴ It is not causal

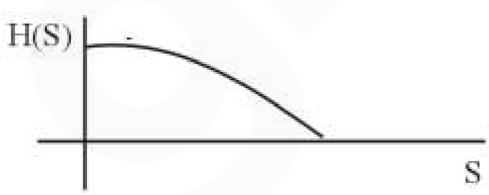
22.

$$H(s) = \frac{a_1 s^2 + b_1 s + c_1}{a_2 s^2 + b_2 s + C^2}$$

$$a_1 = b_1 = 0$$

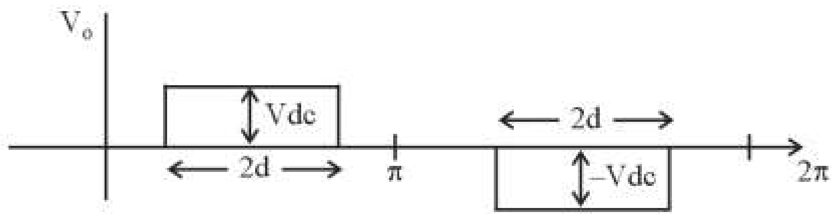
$$H(s) = \frac{C_1}{a_2 S^2 + b_2 S + C_2}$$

At s = 0
H (0) = constant
At s = ∞



∴ It is a low par filter

23. Waveform for output voltage of single phase full bridge PWM inverter



$$V_o = \sum_{n=6k\pm1} \frac{4Vdc}{n\pi} \sin nd \sin\frac{n\pi}{2} n\omega t$$

V_{o1rms} = fundamental r_{ms} output voltage

$$V_{o1} = \frac{2\sqrt{2}}{\pi} Vdc \sin d \sin\frac{\pi}{2}$$

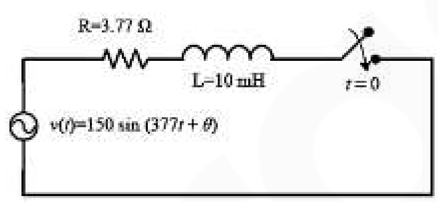
Given, $V_{o1} = 0.754\ V_{dc}$

$$0.75\ V_{dc} = \frac{2\sqrt{2}}{\pi} V_{dc} \sin d$$

$$d = \sin^{-1}\left[\frac{0.75}{0.9}\right] = 56.44$$

Pulse width = 2d = 112.88

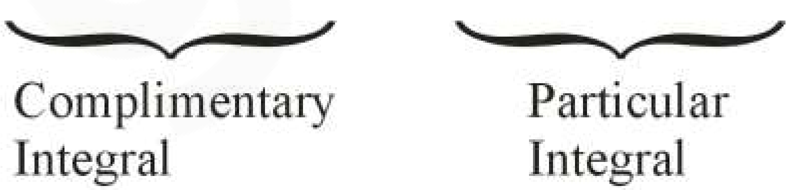
24. For series R – L circuit, I (t) expression is



A. 60 B. 90

C. -30 D. -45

$$i(t) = \left\{\frac{-V_m}{\sqrt{R^2 + X_L^2}} \sin(\theta - \phi)\right\} e^{-t/\tau} + \frac{V_m}{\sqrt{R^2 + X_L^2}} \sin(\omega t - \phi)$$



$$i(t) = Ae^{-t/\tau} + \frac{V_M}{Z}\sin(\omega t - \phi)$$

$$DC\ offset = A = \frac{-V_m}{z}\sin(\theta - \phi)$$

For Maximum value of DC offset A

θ – φ = – 90

$$\theta - \tan^{-1}\left[\frac{\omega L}{R}\right] = -90$$

$$\theta - \tan^{-1}\left[\frac{377 \times 10 \times 10^{-3}}{3.77}\right] = -90$$

$$\theta - 45° = -90°$$

$$\theta = -45°$$

25. M is a 2 × 2 Matrix with Eigen value 4 and 9 If has λ_1, λ_2 _ _ _ _ _ λ_n Eigen values

$M^n \rightarrow \lambda_1^n, \lambda_2^n$ _ _ _ λ_n^n Eigen values

$M^2 \rightarrow 4^2, 9^2$

∴ M^2 has Eigen values as 16 and 81

26. V_S = 400 KV

l = 300 km

L_1 = 1 mH / km / phase

C_1 = 0.01 μF / km / phase

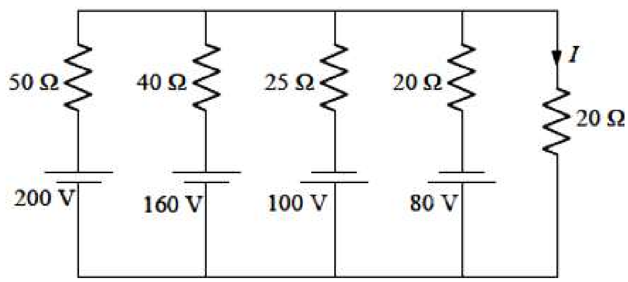
$$v = \frac{1}{\sqrt{L_1C_1}} = \frac{1}{\sqrt{1\times 10^{-3} \times 0.01 \times 10^{-6}}} = 3.16 \times 10^5\ km/s$$

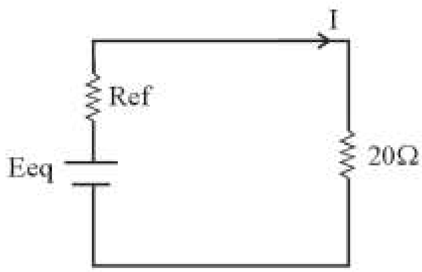
$$\beta' = \frac{2\pi fl}{v} = \frac{2\pi \times 50 \times 300}{3.16 \times 10^5} = 0.29$$

$$A = 1 - \frac{\beta^2}{2} = 1 - \frac{(0.29)^2}{2} = 0.955$$

$$V_R = \frac{V_s}{A} = \frac{400}{0.955} = 418.85KV$$

27. According to Mill man's Theorem, the equivalent circuit of the given circuit is





$$E_{eq} = \frac{E_1/R_1 + E_2/R_2 + E_3/R_3 + E_4/R_4}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}}$$

$$= \frac{\frac{200}{5} + \frac{160}{40} + \left[-\frac{100}{25}\right] + \left[-\frac{80}{20}\right]}{\frac{1}{50} + \frac{1}{40} + \frac{1}{25} + \frac{1}{20}}$$

E_{eq} = 0V

So, the current I flowing is 0 A

28. For synchronous motor

$E_g = V_1 - IZ$

$$V_t = \frac{220}{\sqrt{3}} V \text{ (Phase)}$$

Z = (0.25 + j 2.5)Ω

I = 10 ∠ –36.86 A

$$E_g = \frac{220}{\sqrt{3}} - (0.25 + j2.5) \times 10\angle -36.86$$

E_g = 141.658 ∠–8.7 V (phase)

E_g = 245.36 V (line)

29.

○ $z = 2\pi j\ (sum\ of\ residues)$

|z, -

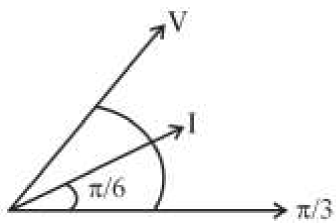
$$= 2\pi j \times \left[\lim_{z \to 2} (z+2) \frac{(z^3 + z^2 + 8}{z+2} \right]$$

$$= 2\pi j \left[\frac{-8+4+8}{1} \right] = 8\pi j$$

30.

V (t) = – 170 sin $(377t - \frac{\pi}{6})$

I (t) = 8 cos $(377t + \frac{\pi}{6})$



V(t) = – 170 sin $(377t - \frac{\pi}{6})$

V(t) = 170 cos $(377t - \frac{\pi}{6} + \frac{\pi}{2})$

V(t)=170 cos $(377t + \frac{\pi}{3})$

P = $V_{rms} I_{rms} \cos\varphi$

$$P = \frac{170}{\sqrt{2}} \frac{8}{\sqrt{2}} \cos 30$$

P = 588.89 watts

31. Given $R_1 = 5.39\Omega$, $R_2 = 5.72\Omega$, $X_1 = X_2 = 8.22\Omega$

for frequency → 10 Hz

$$X_1 = X_2 = 8.22 \times \frac{10}{50} = 1.644\Omega$$

Starting phase current at 10 Hz

$$I_{pn} = \frac{V_{pn}}{\sqrt{(R_1 + R_2)^2 + (X_1 + X_2)^2}}$$

$$= \frac{100}{\sqrt{(5.39 + 5.72)^2 (1.644 + 1.644)^2}}$$

I_{Pn} = 8.63A

Starting line current = $I_L = \sqrt{3} I_{Ph}$

$$I_L = \sqrt{3} \times 8.63$$

$$I_L = 14.95A$$

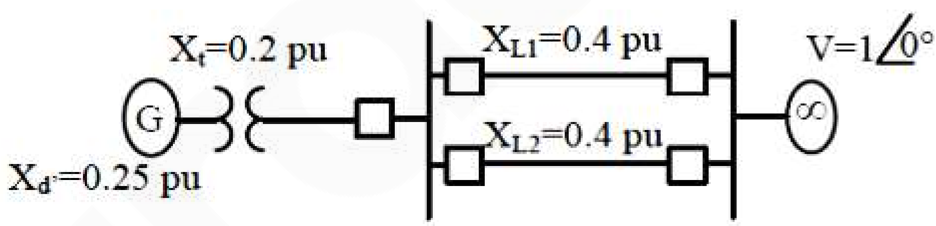
32. Given data L = 50mH, C = 0.05 μF

Critical resistance to avoid current shopping will be given as

$$R = \frac{1}{2}\sqrt{\frac{L}{C}} = \frac{1}{2}\sqrt{\frac{50 \times 10^{-3}}{0.05 \times 10^{-6}}}$$

R = 500Ω

33.



X_{eq} = 0.25 + 0.2 + $\frac{0.4}{2}$

X_{eq} = 0.65 PU

P = V_{PU} I_{PV} cosφ

0.8 = 1 × I_{PV} × 0.8

I_{PU} = 1 PU

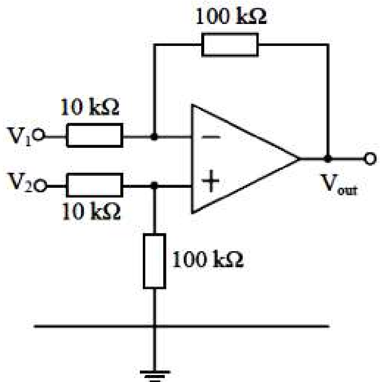
$\vec{I} = 1\angle -36.86$ [as 0.8 pf lagging]

$\vec{E} = \vec{V} + \vec{I} X_{eq}$

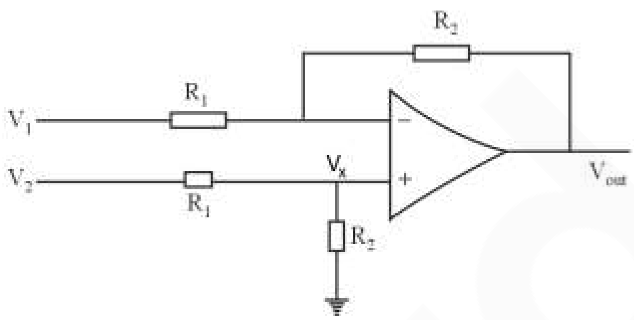
$$\vec{E} = 1 + 1\angle -36.86 \times j0.65 = 1.484\angle 20.51 Pu$$

δ = 20.51 degrees

34.



A. 600 mV
B. 500 mV
C. 400 mV
D. 100 mV



$$Vx = V2\frac{R_2}{R_1 + R_2} \quad [Voltage\ division\ Rule]$$

$$V_{out} = V_x\left[1 + \frac{R_2}{R_1}\right] - V_1\frac{R_2}{R_1}$$

$$V_{out} = V_2\frac{R_2}{R_1 + R_2}\left[1 + \frac{R_L}{R_1}\right] - V_1\frac{R_2}{R_1}$$

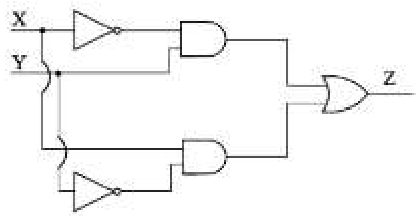
$$V_{out} = V_2\frac{R_2}{R_1 + R_2}\left[1 + \frac{R_L}{R_1}\right] - V_1\frac{R_2}{R_1}$$

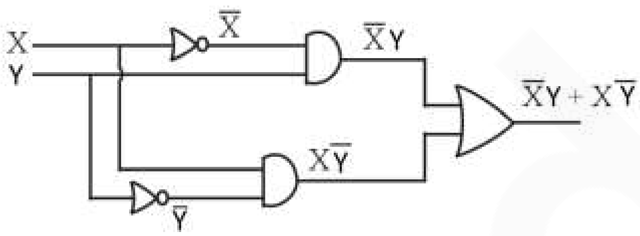
$$V_{out} = V_2 \frac{R_2}{R_1} - V_1 \frac{R_2}{R_1} = \frac{R_2}{R_1}(V_2 - V_1)$$

$$V_{out} = \frac{100}{10}(50 - 10)$$

$$V_{out} = 400 mV$$

35.





$$Output = \bar{X}Y + X\bar{Y}$$

$$= X \oplus Y$$

The above expression is for XOR gate

36. Discharging of capacitor equation

$V_C (t) = V_o e^{-t/\tau}$

Where τ = RC = (10^3) (10^{-7}) = 10^{-4} sec

V_o = 100V

$V_c(t) = 100\ e^{-104t}$

$V_c(t)$ = 1V

$1 = 100\ e^{-104t}$

T = 0.46 msec

37.

$$f(t) = a_0 + \sum_{n=1}^{\infty} a_n \cos nt + \sum_{n=1}^{\infty} b_n \sin nt.$$

$$a_n = \frac{2}{T}\int_o^T x(t)\cos n\omega t \; d(\omega t)$$

$$a_1 \mid_{\substack{\omega=1 \\ T=2\pi}} = \frac{2}{2x}\int_o^{2x} A\sin t\cos t\, dt$$

$$= \frac{A}{\pi}\int_o^{\pi} \sin t\cos t\, dt$$

$$a_1 = \frac{A}{\pi}\int_o^{\pi} \frac{\sin 2t}{2} = \frac{A}{2\pi}\left[\frac{-\cos 2t}{2}\right]_o^{\pi}$$

$$a_1 = o$$

$$b_n = \frac{2}{T}\int_o^T x(t)\sin n\omega t \; d(\omega t)$$

$$b_1 = \frac{2}{2\pi}\int_o^{\pi} A\sin t \;\sin t \; dt$$

$$b_1 = \frac{A}{\pi}\int_o^{\pi} \sin^2 t \; dt$$

$$b_1 = \frac{A}{\pi}\int_o^{\pi} (\frac{1}{2} - \frac{\cos 2t}{2})dt$$

$$b_1 = \frac{A}{2}$$

38.

$$A = 2x\hat{i} + 3y\hat{j} + 4z\hat{k},\ U = x^2 + y^2 + z^2$$

$$UA = (2x^3 + 2xy^2 + 2xz^2)\hat{i} + (3x^2y + 3y^3 + 3yz^2)\hat{j}$$

$$+(4x^2z + 4y^2z + 4z^3)\hat{k}$$

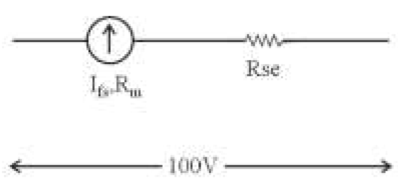
$$div(UA) = \frac{d}{dx}(2x^3 + 2xy^2 + 2xz^2) + \frac{d}{d4}(3x^2y + 3y^3 + 3yz^2)$$

$$+\frac{d}{dz}(4x^2z + 4y^2z + 4z^3)$$

div (UA) = $(6x^2 + 2y^2 + 2z^2) + (3x^2 + 9y^2 + 3z^2) + (4x^2 + 4y^2 + 12z^2)$
at (1, 1, 1) $\Rightarrow$ x = 1, y = 1, z = 1
div (UA) = 45

39. PMMC Instrument

I_{fs} = 10 mA
R_m = 10Ω



$100 = I_{fs}(R_m + R_{se})$
$100 = 10 \times 10^{-3}(10 + R_{sc})$
$R_{se} = 10000 - 10 = 9990\Omega$

40.

$$\begin{bmatrix} \dot{} \\ \dot{} \end{bmatrix} \quad \begin{bmatrix} & 1 \\ & -2\beta \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ \alpha \end{bmatrix} r$$

$$y = \begin{bmatrix} 1 & 0 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

We know

$$\dot{} \quad Bu$$

$$Y = CX + Du$$

Comparing the above equation with the given problem

$$A = \begin{bmatrix} 0 & 1 \\ -\alpha & -2\beta \end{bmatrix} \quad B = \begin{bmatrix} 0 \\ \alpha \end{bmatrix}$$

C = (1 0)
Characteristic equation is
|SI – A| = 0

$$\left|\begin{bmatrix} S & 0 \\ 0 & S \end{bmatrix} - \begin{bmatrix} 0 & 1 \\ -\alpha & -2\beta \end{bmatrix}\right| = 0$$

$$\begin{vmatrix} S & -1 \\ \alpha & S+2\beta \end{vmatrix} =$$

$s^2 + 2S\beta + \alpha = 0$ (1)

$s^2 + 2\xi\omega_n s + \omega_n^2 = 0$ (2)

Comparing (1) and (2)

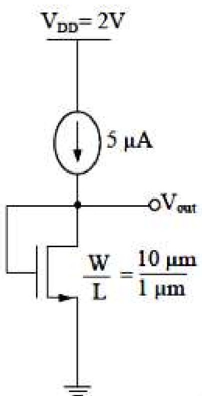
$\omega_n^2 = \alpha$

$$\omega_n = \sqrt{\alpha}$$

$2\xi\omega_n = 2\beta$

$$\xi = \frac{\beta}{\omega_n} = \frac{\beta}{\sqrt{\alpha}}$$

41.



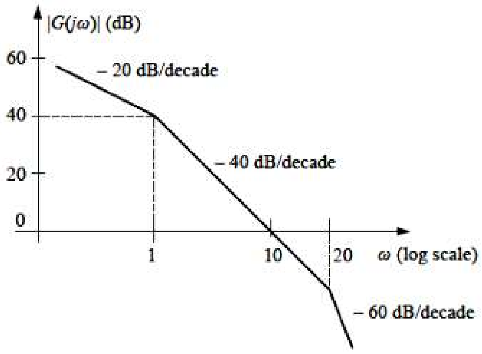
$$I_D = \frac{1}{2}(\mu_n C_{ox})\left(\frac{W}{L}\right)(V_{gs} - V_t)^2$$

$$5\times10^{-6} = \frac{1}{2}(100\times10^{-6})\times(10)\times(V_{out} - 0.5)^2$$

$$(V_{out} - 0.5)^2 = 0.01$$

$$V_{out} = 0.6\text{V} = 600\text{mV}$$

42.



From the given Bode plot,

T(S) = Transfer function = $\dfrac{K}{s\left(1+\dfrac{s}{1}\right)\left(1+\dfrac{s}{20}\right)}$

It has three poles and no zero

So, statement 1 is false

$\angle T(s) = -90 - \tan^{-1} w - \tan^{-1} \dfrac{w}{20}$

$\angle T(jw)\ |w \to \infty = -270^o$

So, statement 2 is true

43. Load supplied previously before adding extra load

12 KW at pf of 0.6

S_{Load} = 12 + j16

Now, Let P be extra load added (Q$_{extra}$ = as unity p.f)

S_{Load} = 12 + P + j16

$|S_{Load}| = \sqrt{(12+P)^2+16^2}$

Rated KVA $|S_{rated}|$ = 25

$$25=\sqrt{(12+P)^2+16^2}$$

$$25^2=(12+P)^2+16^2$$

$$P=7.5,-31.2$$

So, 7.20 KW is extra load which is added

44.

$M^{-1} M = I$

$$\begin{bmatrix} U_1^T \\ U_2^T \end{bmatrix} [V_1 \ \ V_2] = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} U_1 T_{V1} & U_1 T_{V2} \\ U_2 T_{V1} & U_2 T_{v2} \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

$$U_1^T V_1 = 1 \quad U_1^T V_2 = 0$$

$$U_2^T V_1 = 0 \quad U_2^T V_2 = 1$$

Statement 1 and 2 are both correct

45.

$V_{sr} I_{sr} \cos\varphi = V_o I_o$

For single phase fully – controlled converter

$I_o = I_{sr} = 10A$

$$\cos\phi = \frac{V_o}{V_{sr}} = \frac{180}{230} = 0.78$$

46. Given that

Switch frequency, $f_s = 250Hz$

Load resistance $R_L = 24\Omega$

Supply voltage $V_s = 48V$

$T_{ON} = 1$ msec

$$T = \frac{1}{f_s} = 4ms$$

$$\alpha = \frac{T_{ON}}{T} = 0.25$$

$$Load\ power = \frac{V_o^{\ 2}}{R} = \frac{(\alpha V_s)^2}{R} = \frac{(0.25 \times 48)^2}{24}$$

P = 6 watts

47. $P_o = 120w$, $Vs = 24V$, $V_o = 48V$

$$V_o = \frac{V_s}{1-\alpha}$$

$$1-\alpha = \frac{24}{48}$$

α = 0.5 [Duty cycle]

$P_o = V_o I_o = 120$

$$I_o = \frac{120}{48} = 2.54A$$

$V_S I_S = V_o I_o$

$$I_s = \frac{120}{24} = 5A$$

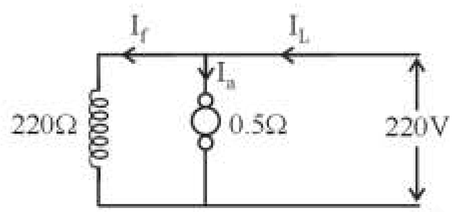
At boundary of continuous & discontinuous

$$I_L = I_S = \frac{\Delta I_L}{2}$$

$$\Delta I_L = \frac{\alpha V_S}{f^{Lc}} = 2 \times 5$$

$$L_C = \frac{0.5 \times 24}{50 \times 10^3 \times 10} = 24\mu H$$

48.



No load

$I_{NL} = 3A$

$$I_C = \frac{220}{Rf} = \frac{220}{220} = 1A$$

$I_a = I_L - I_f = 2A$

Back cmf = $Eb_N = V - I_a R_a$

$= 220 - 2 \times 0.5 = 219V$

Full load

$I_{FL} = 25A$ $\quad$ $N_f = 1500$ rpm

$I_f = 1A$

$I_a = I_{FL} - I_f = 24A$

$EbF = V - I_a R_a = 220 - 24 \times 0.5 = 208$ V

We know E α speed (N)

$$\frac{E_{bF}}{E_{bN}} = \frac{N_f}{N_N}$$ (N_N = speed at no load)

$$\frac{208}{219} = \frac{1500}{N_N}$$

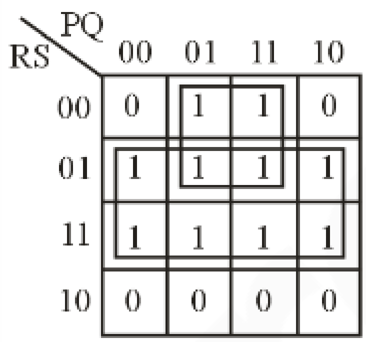
N_N = 1579.33 rpm

49.

Ac line current rms = $(I_s)_{rms}$ = $I_o\sqrt{\frac{2}{3}} = 100\sqrt{\frac{2}{3}} = 81.65A$

50.

RS \ PQ	00	01	11	10
00	0	1	1	0
01	1	1	1	1
11	1	1	1	1
10	0	0	0	0



F (P, Q, R, S) = $S + Q\bar{R}$

51.

P = 0.02

n = 50

λ = np = 50 (0.02) = 1

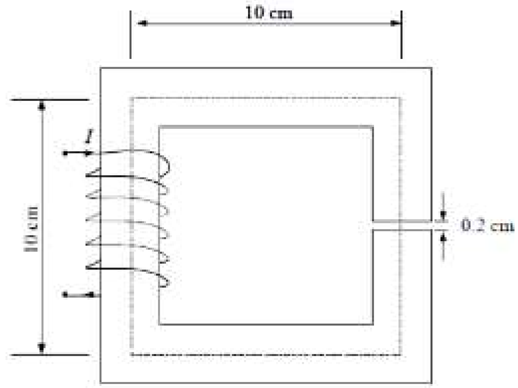
P (x ≥ 2) = 1 – P (x < 2)

= 1 – [P(x =0) + P (x = 1)]

$$= 1 - \left[\frac{e^{-\lambda}\lambda^{o}}{01} + \frac{e^{-\lambda}\lambda^{1}}{11}\right] = 1 - e^{-\lambda}(1+)$$

P (x $\geq$ 2) = 1 – e^{-1} (1 + 1) = 0.26

52.



L_{air} = 0.2 cm

L_m = 40 cm

Given B_o = 1 Tesla at $\mu_r \to \infty$

L_{core} = 40 – 0.2 = 39.8cm

Let a = uniform cross – sectional area

We know that

$$\phi = flux = \frac{MMF}{Total\,Reluctance} = \frac{NI}{S}$$

$S_T = S_{airgap} + S_{core}$

$$= \frac{L_{air}}{\mu_o (1) A} + \frac{L_{core}}{\mu_o \mu_r A}$$

$$S = \frac{1}{\mu_o A}\left[L_{air} + \frac{L_{core}}{\mu_r}\right]$$

Case 1: when $\mu_r \to \infty$, B = 1T

MMF = $NI_1 = B_1 A \left[L_{air} + \frac{L_{core}}{\mu_r} \to \infty\right]\frac{1}{\mu_o A}$

$NI_1 = 1 (a) [l_{air}] \times \frac{1}{\mu_o A} = \frac{L_{air}}{\mu_o}$

$$NI_1 = \frac{l_{air}}{\mu_o} \qquad (1)$$

Case 2:

M_r = 1000

MMF = Same

$NI_1 = B_2 A \left[L_{air} + \frac{L_{core}}{\mu_r} \right] \frac{1}{\mu_o A}$

Put NI_1 from (1)

$$\frac{L_{air}}{\mu_o} = B_2 \frac{1}{\mu_o} \left[L_{air} + \frac{L_{core}}{1000} \right]$$

$$0.2 = B_2 \left[0.2 + \frac{39.8}{1000} \right]$$

$B_L = 0.834$ Tesla

53. Fault current for SLG fault

$$I_{FIG} = \frac{3V}{X_1 + X_2 + X_0 + 3Xn}$$

Fault current for 3φ fault

$$I_{f3\phi} = \frac{V}{X_1}$$

$$\frac{3V}{X_1 + X_2 + X_0 + 3X} = \frac{V}{X_1}$$

$$Xn = \frac{2\times_1 - X_0 - X_2}{3}$$

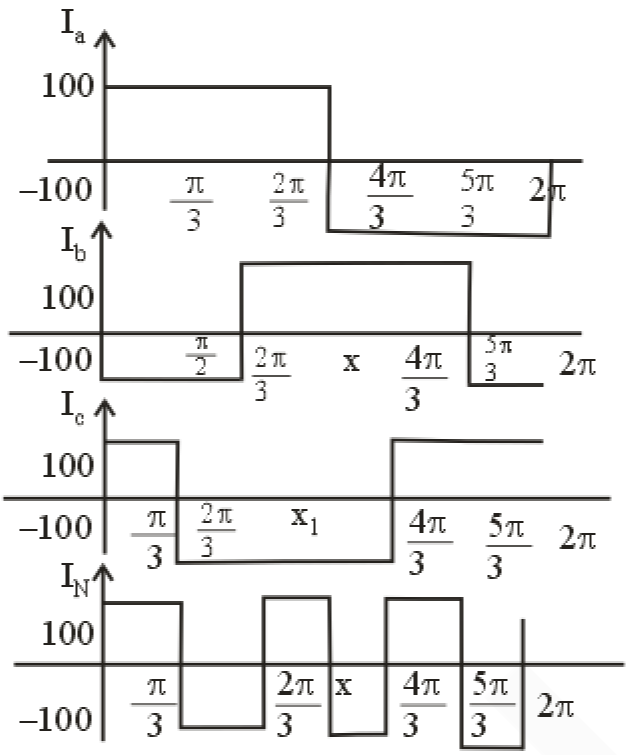
$$X_n = \frac{2(0.25) - 0.05 - 0.15}{3}$$

$X_n = 0.1$ Pu

X_n (inΩ) = $0.1 \times \frac{30^2}{50}$ $\left[Zpu = \frac{Z_{bass} \times MVA}{KVL} \right]$

X_n (inΩ) = 1.8Ω

54.



$I_N = I_a + I_b + I_c$

$(I_N)_{rms} = 100\text{A}$

55.

$$D(s) = \frac{3\left(s + \frac{1}{3T}\right)}{\left(s + \frac{1}{T}\right)}.$$

$$T\ (s) = \frac{1 + 3TS}{1 + TS}$$

Frequency at which ∠T (jw) is maximum (i)

$$W_m = \frac{1}{T\sqrt{\alpha}}$$

$$T(S) = \frac{1 + \alpha TS}{1 + TS}$$ *is* The general phase lead compensator

∴ α = 3

$$w_m = \frac{1}{T\sqrt{3}} = \frac{1}{\sqrt{3T^2}}$$