MADE EASY

GATE 2024

ELECTRICAL ENGINEERING

Exam held on
11/02/2024
(Afternoon Session)

Memory based
Questions & Solutions

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SECTION - A GENERAL APTITUDE

Q.1 If $\frac{x}{y} = \frac{a+1}{a-1}$, then $(x^2 - y^2) : (x^2 + y^2) =$ ____?

Ans. $\left(\frac{-2a}{a^2+1}\right)$

Given: $\frac{x}{y} = \frac{a-1}{a+1}$

$$x^2 - y^2 : x^2 + y^2 = \frac{\left(\frac{x}{y}\right)^2 - 1}{\left(\frac{x}{y}\right)^2 + 1}$$

$$= \frac{\left(\frac{a-1}{a+1}\right)^2 - 1}{\left(\frac{a-1}{a+1}\right)^2 + 1} = \frac{(a-1)^2 - (a+1)^2}{(a-1)^2 + (a+1)^2}$$

$$= \frac{-4a}{2a^2+2} = \frac{-2a}{(a^2+1)}$$

End of Solution

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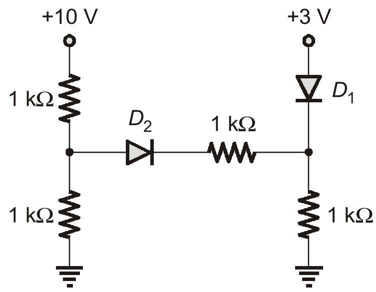
SECTION - B TECHNICAL

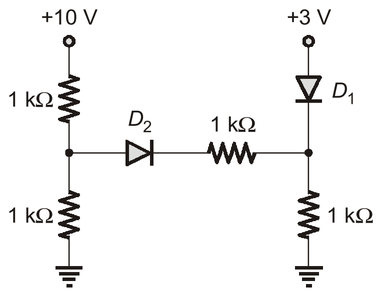
Analog Electronics

Q.1 For the figure shown below, diodes are ideal

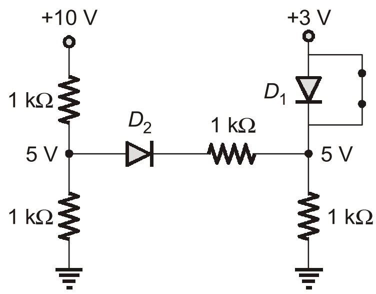


current flowing through diode D_1 is ____mA.

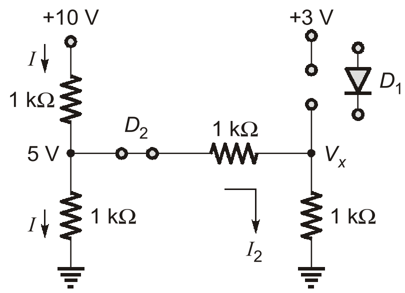
Ans. (1.67)

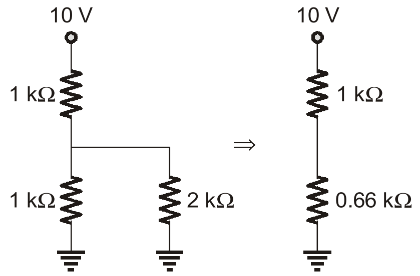


Assume D_2 OFF



Tested : D_2 ON
Assume D_1 OFF





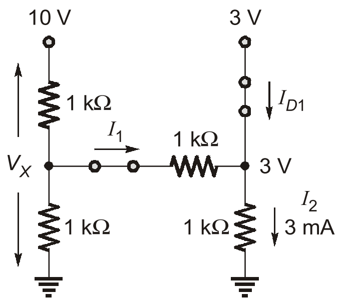
$$I = \frac{10}{1.66\text{ K}} = 6.02\text{ mA}$$

$$I_2 = I \times \frac{1\text{k}\Omega}{3\text{k}\Omega} = 6.02\text{ mA} \times \frac{1}{3} = 2\text{ mA}$$

Tested : D_1 ON

$$V_X = 2\text{ mA} \times 1\text{ k}\Omega$$
$$= 2\text{ V}$$

States: D_1 and D_2 ON



$$\frac{V_X - 10}{1\text{k}\Omega} + \frac{V_X - 3}{1\text{k}\Omega} + \frac{V_X}{1\text{k}\Omega} = 0$$

$$3V_X = 13$$

$$V_X = \frac{13}{3} = 4.33\text{ V}$$

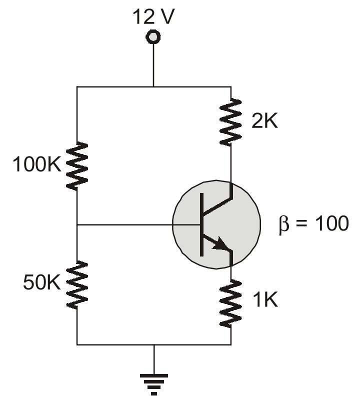
$$I_1 + I_{D1} = I_2$$

$$\frac{4.33 - 3}{1\text{k}\Omega} + I_{D1} = 3\text{ mA}$$

$$I_{D1} = 3\text{ mA} - 1.33\text{ mA}$$
$$= 1.67\text{ mA}$$

End of Solution

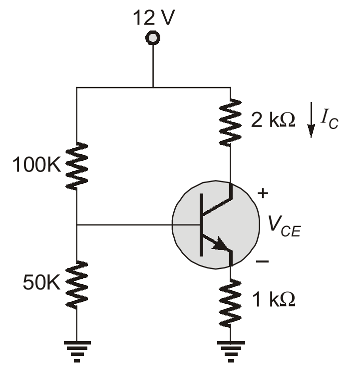
Q.2 Consider the circuit shown below :



$V_{BE} = 0.7$

Find Quisent point V_{CE} and I_C.

Ans. (2.1)



$$V_{BE} = 0.7 \text{ V}$$
$$\beta = 100$$

As β is large, I_B neglected.

$$V_B = V_{CC} \times \frac{R_2}{R_1 + R_2} = 12 \times \frac{50 \text{ K}}{150 \text{ K}} = 4 \text{ V}$$

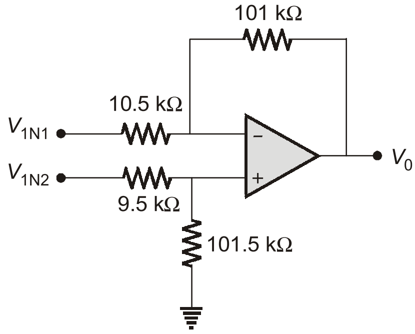
$$V_E = V_B - 0.7 \text{ V} = 4 - 0.7 = 3.3 \text{ V}$$

$$I_E = \frac{V_E}{R_E} = \frac{3.3 \text{ V}}{1 \text{ k}\Omega} = 3.3 \text{ mA}$$

$$I_C \approx I_E = 3.3 \text{ mA}$$
$$V_{CE} = V_{CC} - I_C(R_C + R_E)$$
$$= 12 - 3.3 \text{ mA } (3 \text{ K})$$
$$= 12 - 9.9 = 2.1 \text{ V}$$

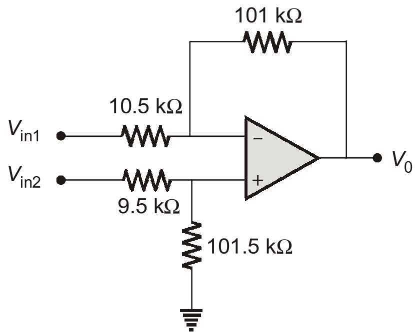
End of Solution

Q.3 Consider the circuit shown below :



Find CMRR (in dB)

Ans. (40.52)



$$V_o = \left(1+\frac{101}{10.5}\right)V^{+} + \frac{-101}{10.5}V_{in1}$$

$$= 10.62\times V_{in2}\times\frac{101.5}{101.5+9.5}+\frac{-101}{10.5}V_{in1}$$

$$= \underbrace{9.71}_{A_1}V_{in2} + \underbrace{-9.619}_{A_2}V_{in1}$$

$$\text{CMRR} = \frac{A_d}{A_c}$$

$$A_d = \frac{A_1 - A_2}{2}$$

$$= \frac{9.71+9.619}{2} = 9.6645$$

$$A_c = A_1 + A_2$$

$$= 9.71 - 9.619 = 0.091$$

$$\text{CMRR} = \frac{9.6645}{0.091} = 106.20$$

$$\text{CMRR} = 20\log(106.20) = 40.52\text{ dB}$$

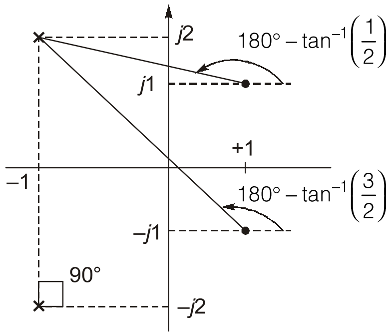
Control Systems

Q.4 Consider the open loop system

$$G(s)H(s) = \frac{K(s^2 - 2s + 2)}{(s^2 + 2s + 5)}$$

The angle of departure at $-1 + 2j$ is ____ (in degrees).

Ans. (7)



$$\phi_D = \pm(180 + \phi)$$

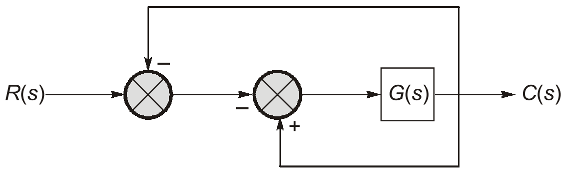
$$\phi = \Sigma\phi_z - \Sigma\phi_p$$

$$= \left\{\left[180 - \tan^{-1}\left(\frac{1}{2}\right)\right] + \left[180 - \tan^{-1}\left(\frac{3}{2}\right)\right] - 90°\right\}$$

$$\phi_D = \pm 7°$$

End of Solution

Q.5 Consider the block diagram shown below :



Then the transfer function $\frac{C(s)}{R(s)}$ is ____.

Ans. $\left(\frac{G}{1-2G}\right)$

Transfer function, $\frac{C(s)}{R(s)} = \frac{G}{1-G-G} = \frac{G}{1-2G}$

End of Solution

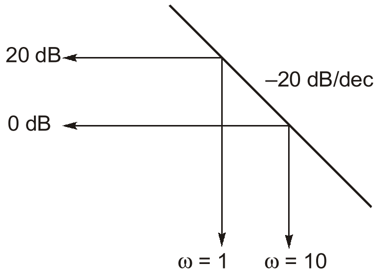
Q.6 Consider the stable close loop system shown in the figure. the asymptotic bode magnitude plot G(s) has a constant slope of –20 dB/dec at least till 100 rad/sec with the gain crossover frequency being 10 rad/sec. The asymptotic bode pahse plot remains constant at –90° at least, ω = 10 rad/sec. The steady state error of the closed system for a unit ramp input is ____. (Rounded off to 2 decimal phase).

Ans. (0.10)

Initial slppe = –20 dB/sec

Open loop transfer function $= \frac{k}{s}$

$$20 \log_{10} k = 20$$
$$k = 10$$

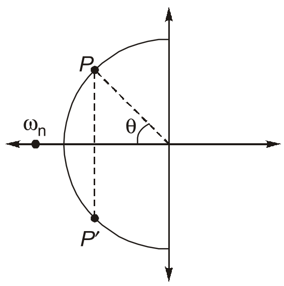


e_{ss} for type -1 system for ramp input

$$e_{ss} = \frac{1}{k_v} = \frac{1}{10} = 0.1$$

End of Solution

Q.7 For a second order system $\frac{C(s)}{R(s)} = \frac{\omega_n^2}{s^2 + 2\xi\omega_n + \omega_n^2}$, diagram is shown



System (1) is given as ω_n = 3 rad/s, θ = 60°

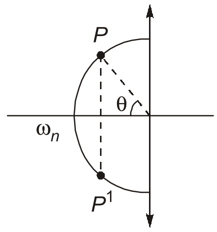
System (2) is given as ω_n = 1 rad/s, θ = 70°

Which of the following is true?
(a) System (1) has more settling time than system (2)
(b) System (2) has more settling time than system (1)
(c) Both have same settling time.
(d) None of the above

Ans. (b)

In system -1

$$\xi_1 = \cos\theta = \cos 60° = 0.5$$
$$\omega_{n1} = 3 \text{ rad/sec}$$



$$\text{Settling time} - t_{s1} = \frac{4}{\xi\omega_n} = \frac{4}{0.5 \times 3} = \frac{8}{3} = 2.67 \text{ sec}$$

In system -2

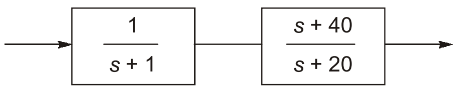
$$\xi_2 = \cos\theta_2 = \cos 70°$$
$$\omega_{n2} = 1 \text{ rad/sec}$$

$$\text{Settling time} - t_{s2} = \frac{4}{\xi\omega_n} = \frac{4}{\cos 70° \times 1} = 11.69 \text{ sec}$$

So, $t_{s2} > t_{s1}$

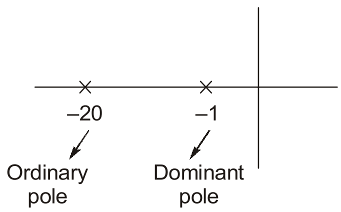
End of Solution

Q.8 Consider he cascaded system:



Which of the following option is the first order pole only approximation such a system having no effect of steady state value.

Ans. $\left(\frac{2}{s+1}\right)$



$$\text{Transfer function} \rightarrow \frac{40\left(1+\frac{s}{40}\right)}{20\left(1+\frac{s}{40}\right)(1+s)}$$

$$\text{Answer} = \frac{2}{s+1}$$

End of Solution

Digital Electronics

Q.9 $F(P, Q, R, S) = \bar{P}\bar{Q} + \bar{P}QS + P\bar{Q}\bar{R}\bar{S} + P\bar{Q}R\bar{S}$ minimize the function will be

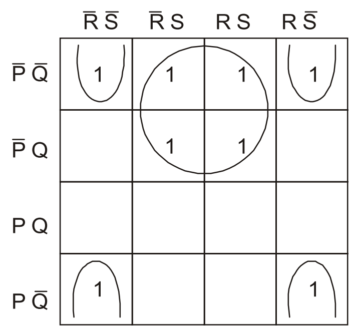
(a) $\bar{P}Q + R\bar{S}$

(b) $\bar{P}\bar{Q} + \bar{Q}\bar{S}$

(c) $P\bar{S} + \bar{Q}R$

(d) $\bar{P}S + \bar{Q}\bar{S}$

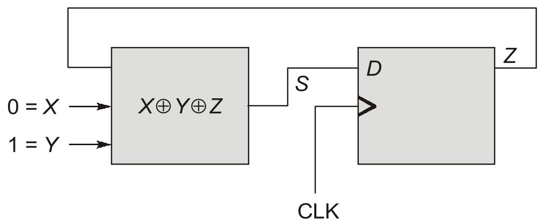
Ans. (d)



Minimize function = $\bar{Q}\bar{S} + \bar{P}S$

End of Solution

Q.10 Consider the digital logic circuit shown below,



Assume no transportation delay. After are cycle of clock, the value of Z and S is (Initially Z = 1)

Ans. (0)

Based on this trick

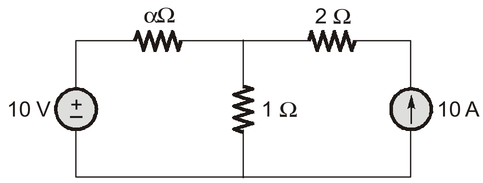
$$x \oplus x = 0$$
$$x \oplus \bar{x} = 1$$
$$x \oplus 1 = \bar{x}$$
$$x \oplus 0 = x$$

$$\overline{x \oplus y} = x \odot y = 0 \odot 1 = 0$$

End of Solution

Electric Circuits

Q.11 Consider the figure shown below :

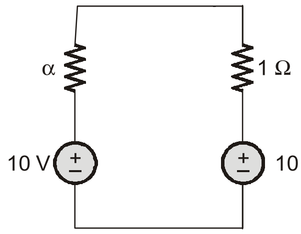


Power delivered by voltage source is ____.

(a) 0 W
(b) cannot be determined because α is unknown
(c) 1 W
(d) 10 W

Ans. (a)

Neglect resistance connected series with current source, and applying source transformation.

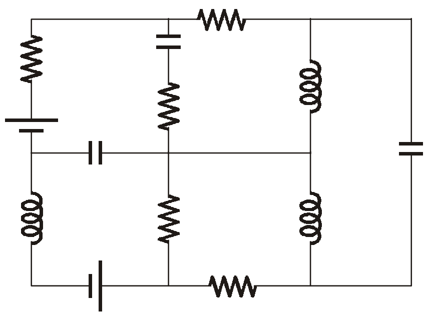


$$I = \frac{V_{eq}}{R_{eq}} = \frac{10-10}{R_{eq}} = 0 \text{ A}$$

So, power delivered is 0 W.

End of Solution

Q.12 For the circuit shown below :

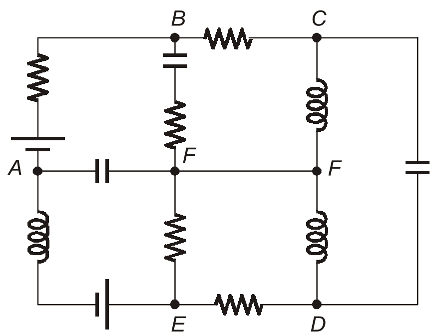


Find the number of junction.

(a) 9
(b) 8
(c) 6
(d) 7

Ans. (c)

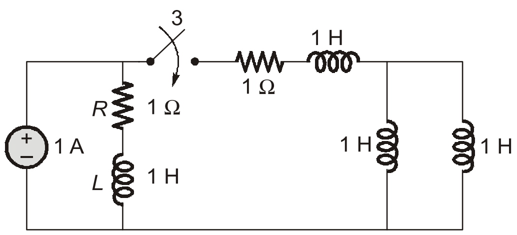
A point at which more than two elements are joints together is called junction.



Number of junction = 6

End of Solution

Q.13 For the circuit shown below :



Switch is open for long time and closed at t = 0, then time constant is ____.

(a) 1.25
(b) 1.5
(c) 0
(d) #

Ans. **(a)**

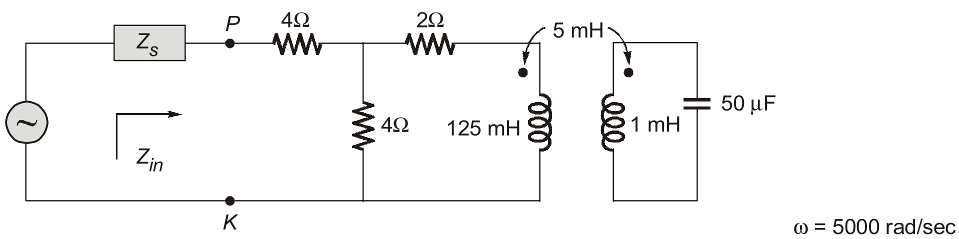
$$\text{Time constant, } \tau = \frac{L_{eq}}{R_{eq}} = \frac{2.5}{2} = 1.25$$

$$L_{eq} = 1 + 1 + 1\|1 = 2.5 \text{ H}$$

$$R_{eq} = 2\ \Omega$$

End of Solution

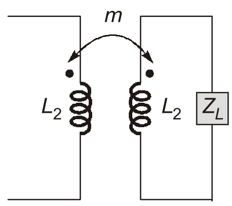
Q.14 For the circuit shown below :



Z_{in} is ____.

Ans. (5)

Given: ω = 5000 rad/sec

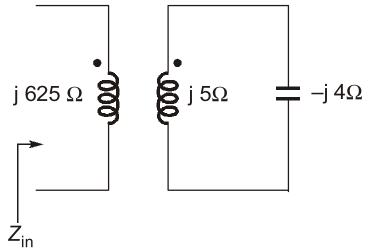


$$z_{in} = jX_{L1} + \frac{(\omega m)^2}{jX_{L1} + z_L}$$

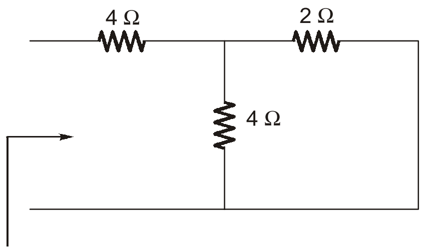
$$jX_{L1} = 125 \text{ mH} \times 5000 = j625\ \Omega$$

$$\frac{j}{\omega c} = \frac{-j}{5000 \times 50 \times 10^{-6}} = -j4\Omega$$

$$jX_{L2} = 1 \text{ mH} \times 5000 = +j5\ \Omega$$



$$z_{in} = j625 + \frac{(5000 \times 5 \times 10^{-3})^2}{j5 - j4} = j625 - j625 = 0\ \Omega$$



$$z_m = \frac{4 \times 2}{4+2} + 4 = \frac{16}{3}\Omega$$

End of Solution

Electrical Machine

Q.15 A 3-ϕ, 50 Hz, 6 pole, induction motor runs at 960 rpm, neglected stator copper and stator core losses then, % efficiency is

(a) 96% (b) 94%

(c) 95% (d) 92%

Ans. (a)

$$s = \frac{1000 - 960}{1000} = 0.04$$

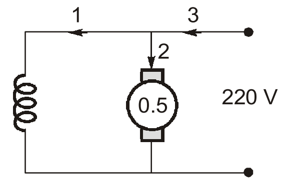
$$\frac{\text{Rotor output}}{\text{Rotor input}} = 1 - s$$

$$\eta = 1 - 0.04 = 0.96 \text{ or } 96\%$$

End of Solution

Q.16 A DC shunt motor 5 kW, 220 V. Armature resistance including brush drop is 0.5 Ω. The DC machine takes 3 A on no load the shunt current is 1 A. Neglect the rotational loss and current is independent of load. If machine is operating for rated current and rated power. Find the current drawn for best possible efficiency.

Ans. (37.276)



$$E_{b0} = 200 - 2(0.5) = 219$$
$$I_{ao} = 2$$
$$\text{Rotational loss} = 219 \times 2 = 438 \text{ W}$$
$$\text{Constant loss} = \text{Variable loss}$$
$$(438) + (220 \times 1) = I_a^2 (0.5)$$
$$\Rightarrow \quad I_a = 36.27 \text{ A}$$
$$\therefore \quad I_{drawn} = 37.27 + 1 = 37.27 \text{ A}$$

End of Solution

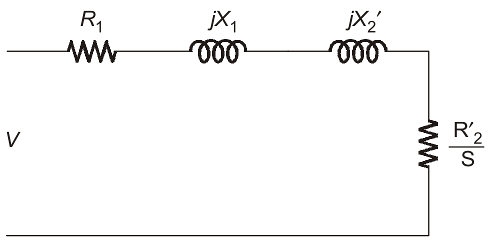
Q.17 A 3-phase star connected slip ring induction motor has the following parameter referred to the stator.

$R_S = 3\Omega$, $X_S = 2\Omega$, $X_r' = 2\Omega$, $R_r' = 2.5\Omega$

the per phase stator to rotor effective tern ratio 3 : 1, the rotor winding is also star connected the magnetizers reactance and core less of the motor can be neglected to have maximum torque at starting the value of the extra resistance in ohms (referred to rotor side) to be connected in series with each phase of the rotor winding is _______. [2 decimals]

Ans. (0.277)

Condition for the maximum torque



$$\frac{R_2'}{s} = \sqrt{3^2 + 4^2} = 5$$

Substituting, s = 1

As maximum torque at starting

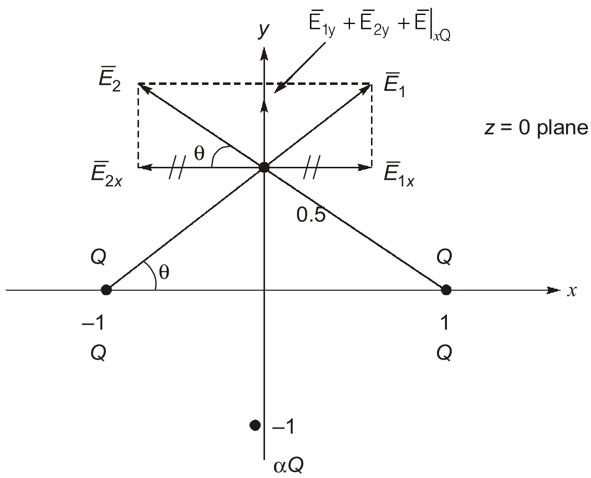
$$R_2' + R_{ext}' = 5$$
$$R_{ext}' = 5 - 2.5 = 2.5 \ \Omega$$
$$\frac{2.5}{3^2} = 0.277 \ \Omega$$

End of Solution

EMT

Q.18 Three charges, Q, Q, αQ are placed at (–1, 0, 0), (1, 0, 0) and (0, –1, 0). If electric field is zero at point (0, 0.5, 0) then value of α is ____.

Ans. (–1.61)



From the figure,

$$\bar{E}_{net} = \bar{E}_{1y}+\bar{E}_{2y}+\bar{E}|_{\alpha Q} = 0 \text{ [as per question]}$$

Here, $$\bar{E}_{1y} = \bar{E}_{2y} = \bar{E}|_Q \text{ (say)}$$

∴ $$\bar{E}_{net} = 2E|_Q + 2E|_{\alpha Q} = 0$$

Now, $$\bar{E}|_Q = \frac{kQ}{\left[\sqrt{1+0.5^2}\right]^2}\sin\theta\hat{a}_y; \qquad k=\frac{1}{4\pi\epsilon_o}$$

⇒ $$\bar{E}|_Q = \frac{kQ}{1.25}\times\frac{0.5}{\sqrt{1+0.5^2}}\hat{a}_y = 0.357\,kQ\hat{a}_y$$

Also, $$\bar{E}|_{\alpha Q} = \frac{k(\alpha Q)}{(1.5)^2}\hat{a}_y = 0.444k(\alpha Q)\hat{a}_y$$

Hence, $$\bar{E}_{net} = 2\times 0.357kQ\hat{a}_y + 0.444k(\alpha Q)\hat{a}_y = 0$$

⇒ $$0.715kQ = -0.444\,k(\alpha Q)$$

⇒ $$\alpha = \frac{-0.715}{0.444} = -1.61$$

∴ $$\alpha = -1.61$$

End of Solution

Q.19 For the $\vec{H}(r,\theta,\phi) = \frac{1}{r^3}(P\cos\theta\hat{a}_r + \sin\theta\hat{a}_\theta)$, then P = ?

Ans. (2)

$$\nabla \cdot \bar{B} = 0$$

$$\nabla \cdot \bar{H} = 0$$

Spherical coordinate system,

$$h_1\ h_2\ h_3 = r^2\sin\theta$$

On substituting $P = 2$.

End of Solution

Engg. Mathematics

Q.20 If $A = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}^2$, the sum of eigen values of matrix A is ____.

Ans. (29)

$$A = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}\begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix} = \begin{bmatrix} 7 & 10 \\ 15 & 22 \end{bmatrix}$$

$$\lambda_1 + \lambda_2 = \text{Trace (A)}$$
$$= 22 + 7$$
$$= 29$$

End of Solution

Q.21 $f(z) = e^{z^2} + \cos z$, find the coefficient of z^5 in Taylor series?

Ans. (0)

$$f(z) = \left(1 + z^2 + \frac{z^4}{\lfloor 2} + \frac{z^6}{\lfloor 6} + ...\right) + \left(1 - \frac{z^2}{\lfloor 2} + \frac{z^4}{\lfloor 4} + ...\right)$$

It is series is of even powers.

∴ Coefficient of $z^5 = 0$.

End of Solution

Q.22 $f = 2\log(xy) + \log(yz) + 3\log(xz)$, find the directional derivative of 'f' in the direction of $\vec{a} = 2\hat{i} + \hat{j} + 2\hat{k}$ at point (1, 1, 1)?

Ans. (7)

We know that: directional derivative of 'f' at P(1, 1, 1) in the direction of $\vec{a}$ is given by

$$\text{Directional derivative} = \nabla f \cdot \frac{\hat{a}}{|\vec{a}|}$$

$$\nabla f = \hat{i}\frac{\partial f}{\partial x} + \hat{j}\frac{\partial f}{\partial y} + \hat{k}\frac{\partial f}{\partial z}$$

$$\nabla f = i\frac{5}{x} + j\frac{3}{y} + k\frac{4}{z}$$

$$(\nabla f)_{(1,1,1)} = 5i + 3j + 4k$$

$$\therefore \text{ Directional derivative } = \overline{\nabla f}\cdot\frac{\bar{a}}{|\bar{a}|} = (5i+3j+4k)\cdot\frac{(2i+j+2k)}{\sqrt{2^2+1^2+2^2}} = \frac{21}{3} = 7$$

End of Solution

Q.23 Given $f(x) = [\max(0, x)]^2$ in $-\infty < x < \infty$, then which of the following is/are true?

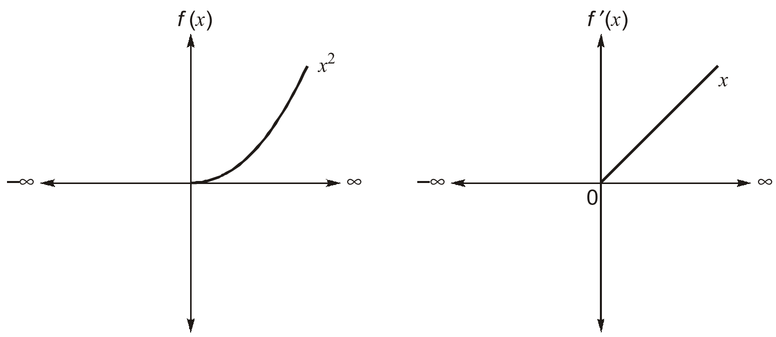
(a) $f(x)$ is differentiable but $f'(x)$ is not continuous

(b) $f(x)$ is not differentiable but $f'(x)$ is continuous

(c) $f(x)$ and $f'(x)$ both differentiable

(d) $f(x)$ is differentiable and $f'(x)$ is continuous

Ans. (d)



$\therefore$ $f(x)$ is differential and $f'(x)$ is continuous but $f''(x)$ is not continuous.

End of Solution

Q.24 Which of the following is analytic in entire complex plane?

(a) $f(z) = z^2 - z$

(b) $\text{Re}(z) = f(z)$

(c) $f(z) = i\,Img(z)$

(d) $f(z) = e^{|z|}$

Ans. (a)

Let us take (a), $f(z) = z^2 - z$

$$u + iv = x^2 - y^2 + i(2xy) - x - iy$$

$\Rightarrow$ $u = x^2 - y^2 - x,\ V = 2xy - y$

Now by C–R equation,

$$u_x = V_y \text{ and } u_y = -V_x$$

$\Rightarrow$ $(2x - 1) = (2x - 1)$ and $-2y = -(2y)$

i.e. C-R equation are satisfied. Hence (a) is analytic rest are not analytic.

End of Solution

Q.25 If X = {–10, –9, –8, ..., 0, 1, 2, ..., 9, 10} is uniformly distributed RV then which of the following will also be uniformly distributed?

(a) X^3 (b) X^2

(c) $(X + 10)^2$ (d) $(X – 5)^2$

Ans. **(a, c)**

$$X^2 = \{100, 81, 64, ..., 4, 1, 0, 1, 4, 9, ..., 81, 100\}$$

$$P(\text{Choosing } 0) = \frac{1}{21}, \ P(\text{choosing } 1) = \frac{2}{21}$$

So, X^2 is not uniformly distributed.

$$(X - 5)^2 = \{225, 199, ..., 4, 1, 0, 1, 4, 9, 16, 25\}$$

Again probability of choosing any number is not equal so

$(X – 5)^2$ is also not uniformly - distributed.

$$(X + 10)^2 = \{0, 1, 4, 9, 16, ... 81, 100, 121, ..., 400\}$$

$P(\text{Choosing any number}) = \frac{1}{21}$ so is it uniformly-distributed

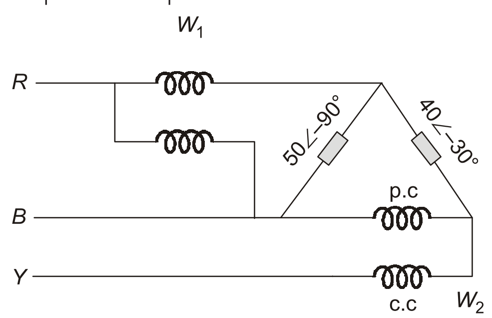
Now, $X^3 = \{-1000, -729, -512, ..., -8, -1, 0, 1, 8, ... 729, 1000\}$

Again $P(\text{Choosing any number}) = \frac{1}{21} = \text{Constant}$

So, it is also uniformly-distributed.

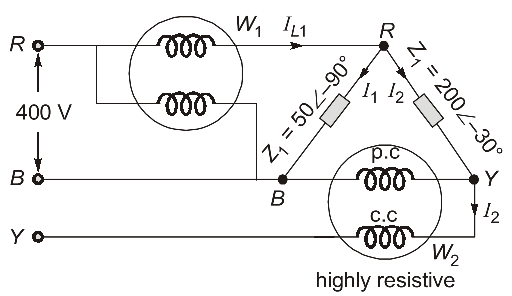
Measurement

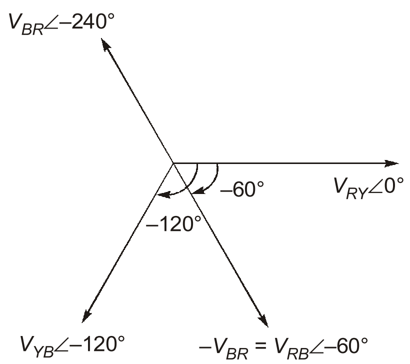
Q.26 Supply is 400 V and phase sequence is RYB.



The difference between the readigns of wattmeter W_1 and W_2 is

Ans. **(692.8)**





$$V_{RY} = 400\angle 0°$$
$$V_{YB} = 400\angle -920$$
$$V_{BR} = 400\angle -240°$$

$W(1) \Rightarrow$ $$V_{PC} = V_{RB} = 400\angle -60°$$

$$I_1 = \frac{V_{RB}}{Z_1} = \frac{400\angle -60°}{50\angle -90°} = 8\angle 30°$$

$$I_2 = \frac{V_{RY}}{Z_2} = \frac{400\angle 0°}{200\angle -30°} = 2\angle 30° \Rightarrow I_{CC\,(2)}$$

$$I_{L1} = I_{CC\,(1)} = I_1 + I_2 = 8\angle 30° + 2\angle 30°$$
$$= 10\angle 30° \Rightarrow I_{CC\,(1)}$$
$$W = V_{RB} \times I_{2\theta} \cos(\angle V_{RB} \text{ and } I_{LO})$$
$$W_1 = 400 \times 10 \times \cos(-60° - 30°) = 0 \text{ Watt}$$
$$W_2 = V_{YB} \times I_2 \cos(\angle V_{YB} \text{ and } I_2)$$
$$= 400 \times 2 \times \cos(-120° - 30°) = -692.8 \text{ Watt}$$
$$W_1 - W_2 = 0 - (-692.8) = 692.8 \text{ Watt}$$

End of Solution

Power Electronics

Q.27 A 1-ϕ time based AC voltage controller feeds a series RL load, the i/P AC supply is 230 V, 50 Hz. The value of R and L are 10 Ω and 18.37 mH. The minimum triggering angle to obtain controllable output voltage is

(a) 15° (b) 45°
(c) 60° (d) 30°

Ans. (d)

Output voltage is controlled if

$$\alpha > \theta$$

Given: $f = 50$ Hz, $R = 10\,\Omega$, $L = 18.37$ mH

$$\theta = \tan^{-1}\left(\frac{\omega L}{R}\right)$$

$$\theta = \tan^{-1}\left(\frac{2\pi \times 50 \times 18.37 \times 10^{-3}}{10}\right)$$

$$\theta = 29.989°$$

So, α_{min} can be 30°. Hence answer is (d).

End of Solution

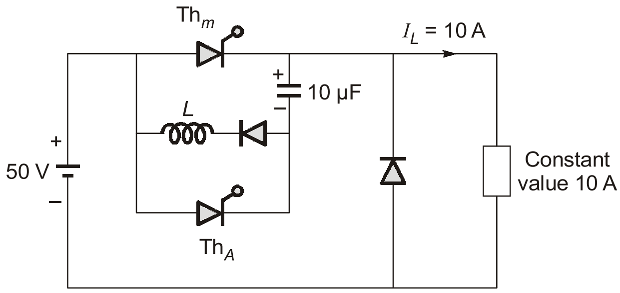
Q.28 If the following switching devices have similar power ratings, then which of the following is fastest device?

(a) Power mosfet (b) IGBT
(c) GTO (d) SCR

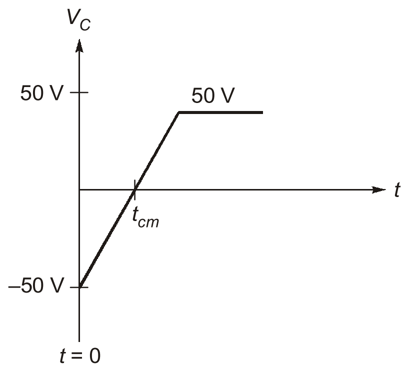
Ans. (a)

End of Solution

Q.29 A load connected thyristerized step down chopper is in figure. Neglect on state drop across the power device. Assume the capacitor is initially charged to with polarity shown to 50 V. With polarity shown in figure. The load connected in is to constant of 10 A. Initially, Th_m is on and Th_A is OFF. The time to turn off to Th_m in milliseconds when Th_A is thyristerized is ____.



Ans. (0.05)



Given: $V_s = 50$, $T_A \rightarrow$ ON

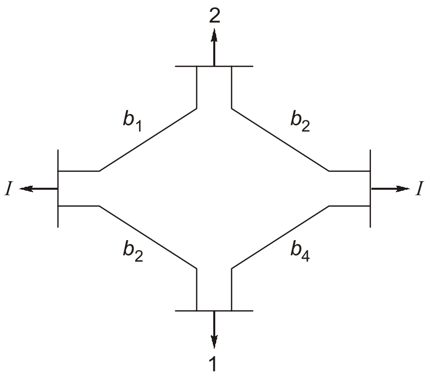
$$t_{cm} = \frac{C}{I_o}V_s = \frac{10\times10^{-6}}{10}\times 50$$

$$= 50\ \mu\text{sec} = 0.05\ \text{msec}$$

End of Solution

Power Systems

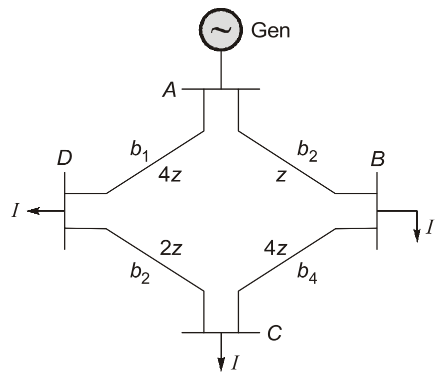
Q.30



The figure shows single line diagram of a 4-bar power N/ω. Branch b_1, b_2, b_3 and b_4 have Impedance of 4z, z, 2z and 4z per unit (p.u.) respectively where $z = r + jx$ with $r > 0$. The current drawn from loads (marked as arrow) is equal to 'I' p.u. were $I \neq 0$. It network is to operate with minimum loss, the branch should be opened is

(a) b_4 (b) b_3
(c) b_2 (d) b_1

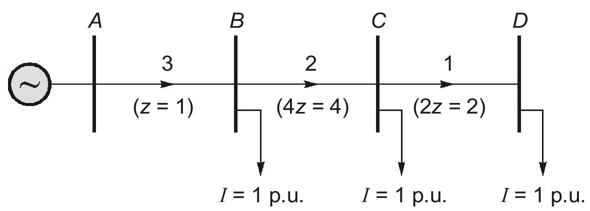
Ans. (b)



Assume, $|z| = |r + jX| = 1$ p.u.,

$I = 1$ p.u.

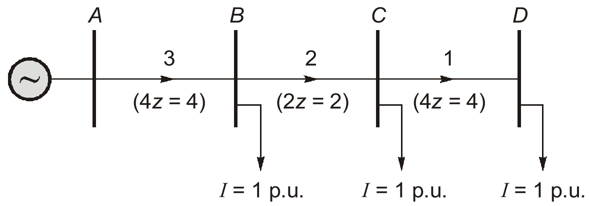
By opening branches ring becomes radial open b_1



Total power loss,

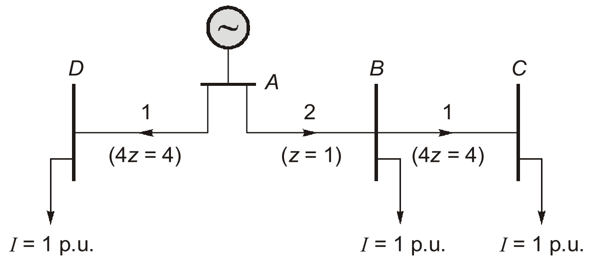
$$P_{L1} = 1^2 \times 2 + 2^2 \times 4 + 3^2 \times 1$$
$$= 27 \text{ p.u.}$$

Open b_2 :



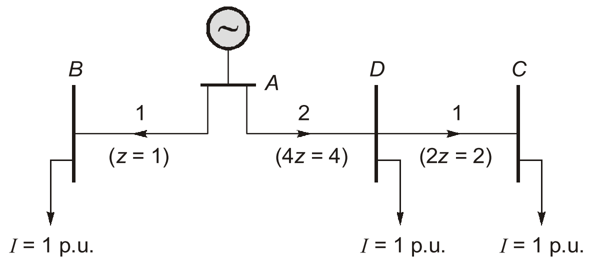
$$P_{L2} = (3^2 \times 4 + 2^2 \times 2 + 1^2 \times 4)$$
$$= 48 \text{ p.u.}$$

Open b_3 :



$$P_{L3} = (2^2 \times 1 + 1^2 \times 4 + 1^2 \times 4)$$
$$= 12 \text{ p.u.} \leftarrow \text{mininum power loss}$$

Open b_4 :

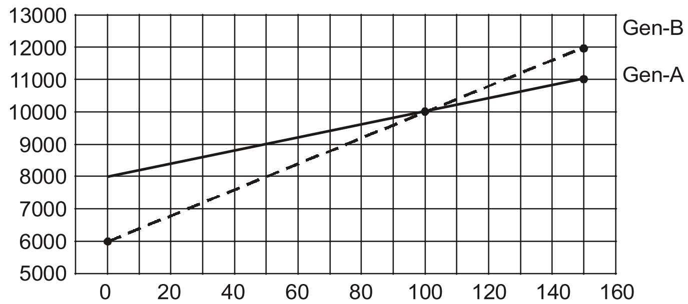


$$P_{L4} = (1^2 \times 1 + 2^2 \times 4 + 1^2 \times 2)$$
$$= 19 \text{ p.u.}$$

By opening branch b_3 Power loss is minimum.

End of Solution

Q.31 The increments cost curves of the two generators (Gen-A and Gen-B) in a plant supplying a common load are shown in figure. If the increments cost of supplying the common load is Rs 7400 per Mwhr then common load in MW is ______ . (Rounded off upto two decimal digit)



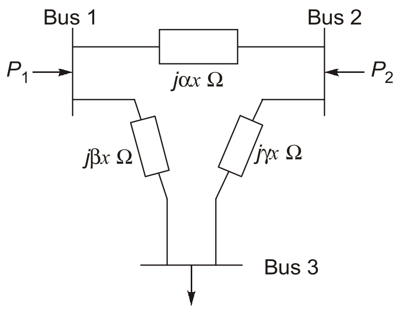
Ans. (35)

Given, $\lambda = 7400$ Rs/MWhr

$$I_{CA}(P_{GA}) = \frac{2000}{100}P_{GA} + 8000$$
$$I_{CB}(P_{GB}) = 40P_{GB} + 6000$$
$$\lambda = I_{CA} = I_{CB} = 7400$$
$$200P_{GA} + 8000 = 7400$$
$$P_{GA} = -600$$
$$P_{GA} < 0$$
$$P_{GB} = \frac{7400-6000}{40} = 35$$
$$P_{GA} + P_{GB} = 35 \text{ MW}$$

End of Solution

Q.32 For the 3 bus lossless power network shown in the figure the voltage magnate at all the buses are equal to 1 per unit (PU) and the difference of the voltage phase angles are very small and the reactances are marked in the figure where α, β, γ and x are strictly positive the bus inglection P_1 and P_2 are in P.U. If $P_1 = mP_2$ where $m > 0$ and the real power flow from bus 1 to bus 2 is 0 p.u, then which one of the following options is correct?



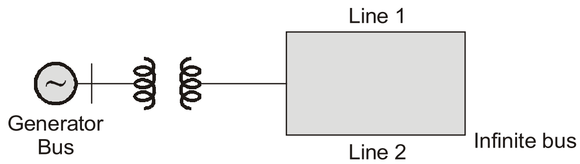
(a) $\alpha = m\beta$
(b) $\alpha = mr^2$
(c) $\beta = mr^2$
(d) $\gamma = m\beta$

Ans. (d)

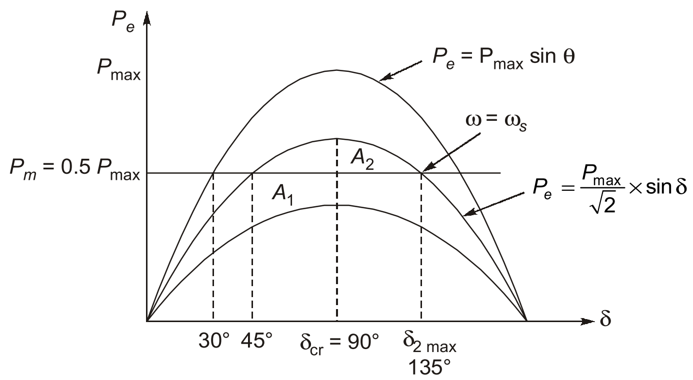
$$P_1 = mP_2$$
$$P_1 = \frac{1\times 1}{\beta x}\sin\theta$$
$$P_2 = \frac{1\times 1}{\gamma x}\sin\theta$$
$$\frac{1\times 1}{\beta x}\sin\theta = m\frac{1\times 1}{\gamma x}\sin\theta$$
$$\frac{1}{\beta} = \frac{m}{\gamma}$$
$$\gamma = m\beta$$

End of Solution

Q.33 The single line diagram of a loss less system is shown in the figure. The system is operating in steady state at a stable equilibrium point with the power output of the generator being $P_{max} \sin \delta$, where δ is the load angle and the mechanical power input is $0.5P_{max}$. A fault occurs on line 2 such that the power output of the generator is less than $0.5P_{max}$ during the fault. After fault is cleared by opening line 2, the power output of the generation is $(P_{max}/\sqrt{2}) \sin \delta$. If the critical fault clearing angle is $\frac{\pi}{2}$ radians, the accelerating area on the power angle curve is _____ times P_{max}.



Ans. (0.1)



$$A_1 = A_2$$

$$\int_{90°}^{135°} \left(\frac{P_{max}}{\sqrt{2}} \sin \delta - 0.5P_{max} \right) d\delta = 0.1\ P_{max}$$

End of Solution

Signals and Systems

Q.34 Given signal $x(t) = e^{t^2}[u(t-1) - u(t-10)]$. ROC of the signal is _____.

(a) $-\infty < \sigma < \infty$
(b) $1 < \sigma < 10$
(c) $\sigma > 10$
(d) $\sigma < 1$

Ans. (a)

Since $x(t)$ is finite duration signal. So ROC will be $-\infty < \sigma < \infty$.

End of Solution

Q.35 If $x(t)$ is signal $y(t) = x(-t)$ then the convoution of $x(t) * y(t)$ will be

(a) even
(b) odd
(c) causal
(d) anti-causal

Ans. (a)

$$z(n) = x[n] * y[n]$$
$$z(n) = x[n] * x[-n]$$

Replace n with $-n$

$$z[-n] = x[-n] * x[n]$$
$$z[-n] = x[n] * x[-n]$$
$$z[-n] = z[n]$$

even function.

End of Solution

Q.36 $X(\omega)$ is fourier transform of $e^{-t^4}\cos t$ then $\left.\frac{dX(\omega)}{d\omega}\right|_{\omega=0} = ?$

Ans. (0)

$$tx(t) \rightleftarrows j\frac{dX(\omega)}{d\omega}$$
$$f(t) = \frac{tx(t)}{j} \rightleftarrows \frac{dX(\omega)}{d\omega} = F(\omega)$$
$$\left.\frac{dX(\omega)}{d\omega}\right|_{\omega=0} = F(\omega)|_{\omega=0} = \text{area of } f(t)$$
$$= \int_{-\infty}^{\infty}\frac{tx(t)}{j}dt = \text{area of odd-function}$$
$$= 0$$

$$\left[\begin{array}{l} \because x(t) = \text{even-function} \\ \therefore \frac{t}{j}x(t) = \text{odd-function} \end{array}\right]$$

End of Solution

Q.37 The energy of $x(t)$ is E, then the energy of $2x(2t-1)$ is CE, then the value of 'C' is ____.

Ans. (2)

$$x(t) \to E\text{ (energy)}$$
$$x(t-1) \to E$$
$$2x(2t-1) \to 2^2 \times \frac{E}{2} = 2E = CE,\quad x(2t-1) \to \frac{E}{2}$$
$$C = 2$$

End of Solution

Q.38 Let $x(n) \xleftrightarrow{Z.T.} X(z)$, the z-transform of $y(n) = x(2n)$ is

(a) $Y(z) = X(z^2)$

(b) $Y(z) = \frac{1}{2}[X(z^2) + X(-z^2)]$

(c) $Y(z) = \frac{1}{2}[X(z^{-1/2}) + X(-z^{-1/2})]$

(d) $Y(z) = \frac{X(z^{1/2}) + X(-z^{1/2})}{2}$

Ans. (d)

$$Y(z) = \sum_{n=-\infty}^{\infty} y(n) z^{-n} = \sum_{n=-\infty}^{\infty} x(2n) z^{-n}$$

Let $2n = m$

then $n = \frac{m}{2}$ $= \sum_{m=\text{even-int.}} x(m) z^{-m/2}$

$$= \sum_{m=-\infty}^{\infty} \left[\frac{x(m) + (-1)^m x(m)}{2} \right] z^{-m/2}$$

$$= \frac{1}{2}\left[\sum_{m=-\infty}^{\infty} x(m) z^{-m/2} + \sum_{m=-\infty}^{\infty} (-1)^m x(m) z^{-m/2} \right]$$

$$= \frac{1}{2}\left[\sum_{m=-\infty}^{\infty} x(m) (z^{1/2})^{-m} + \sum_{m=-\infty}^{\infty} x(m) (-z^{1/2})^{m} \right]$$

$$= \frac{1}{2}\left[x(z^{1/2}) + x(-z^{1/2}) \right]$$

End of Solution

Q.39 If $x(t)$ is input and $y(t)$ is O/P,

$$y(t) = e^{-t} \int_{-\infty}^{t} e^{\tau} x(\tau) d\tau; \ -\infty < t < \infty$$

then system is

(a) linear and time invariant

(b) Linear but not time invariant

(c) Non-linear

(d) Non-causal

Ans. (a)

- System will follow law of superposition. Therefore, system will be linear.
- Time-invariance check:

$$y(t - t_o) = e^{-(t-t_o)} \int_{-\infty}^{t-t_o} e^{\tau} \cdot x(\tau) d\tau \quad \text{... (i)}$$

For input $x(t - t_o)$, output will be

$$y'(t) = e^{-t} \int_{-\infty}^{t} e^{\tau} \cdot x(\tau - t_o) d\tau$$

Put $\tau - t_o = k$, then $d\tau = dk$ and for $\tau = t$, $k = t - t_o$

$$= e^{-t}\int_{-\infty}^{t-t_o} e^{k+t_o}\cdot x(k)dk$$

$$= e^{-t}\times e^{to}\times\int_{-\infty}^{t-t_o} e^{k}\cdot x(k)dk = e^{-(t-t_o)}\times\int_{-\infty}^{t-t_o} e^{k}\cdot x(k)dk$$

$$= e^{-(t-t_0)}\times\int_{-\infty}^{t-t_0} e^{\tau}\cdot x(\tau)d\tau \quad \text{... (ii)}$$

Since, $y'(t) = y(t - t_o)$

So, the system is time-invariant.

End of Solution

■■■■

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