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Heading

sol 1

In small signal model of the transistor

$$r_\pi = \frac{\beta V_T}{I_C}$$ $V_T \to$ Thermal voltage

$$= \frac{V_T}{I_C/\beta} = \frac{V_T}{I_B}$$ $\frac{I_C}{\beta} = I_B$

$$= \frac{V_T}{I_B}$$

So, $r_\pi = \frac{25\,mV}{1\,mA} = 25\,\Omega$ $V_T = 25\,mV$

$I_B = 1\,mA\,(DC)$

Hence (c)

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The power spectral density consists of two components

1) A delta function centered at $\omega_0 = 10^4$ rad/s and amplitude of 400 whose inverse fourier transform is

$$400\delta(\omega - 10^4) \xleftrightarrow{f^{-1}} \frac{400}{\pi} e^{j10^4 t}$$

2) A triangular component of amplitude 6 and width $\tau = 10^3$ rad/s Center at $\omega_0 = 10^4$ rad/se

$$6\,\mathrm{tri}\left(\frac{\omega}{10^3}\right) \xleftrightarrow{f^{-1}} \frac{6\times10^3}{\pi} \operatorname{sinc}^2\left(\frac{t\tau}{2\pi}\right)$$

Correlation function

$$R_x(\tau) = \frac{400}{\pi} e^{j10^4\tau} + \frac{(6\times10^3)}{\pi} \operatorname{sinc}^2\left(\frac{t\tau}{2\pi}\right)$$

$$E[x^2(t)] = R_x(0)$$

$$= \frac{400}{\pi} + \frac{6\times10^3}{\pi}$$

$$= \frac{6400}{\pi}$$

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Soln For raised cosine spectrum transmission Bandwidth is given as

$$B_T = \cancel{2} W(1+\alpha) \qquad \alpha \rightarrow \text{Roll of factor}$$

$$B_T = \frac{R_b}{2}(1+\alpha) \qquad R_b \rightarrow \text{Maximum signaling rate}$$

$$3500 = \frac{R_b}{2}(1+0.75)$$

$$R_b = \frac{3500 \times 2}{1.75} = 4000$$

Hence (C)

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Incident wave

$$E_i = (8\hat{a}_x + 6\hat{a}_y - 5\hat{a}_z)\, e^{j(\omega t + 3x - 4y)}$$

$E_r = \tau E_i$ ($\tau \to$ reflection Coefficient)

~~$E_x = 8\cos[\omega t - (3$~~

$$E_{ix} = 8\, e^{j[\omega t - (-3x+4y)]}\, \hat{a}_x$$

$$E_{iy} = 6\, e^{j[\omega t - (-3x+4y)]}\, \hat{a}_y$$

For reflected wave ($\tau = -1$ for perfect Conductor)

$$E_{rx} = -8\, e^{j[\omega t + (-3x+4y)]}\, \hat{a}_x$$

$$= -8\, e^{j[\omega t - 3x + 4y]}\, \hat{a}_x$$

$$E_{ry} = -6\, e^{j[\omega t + (-3x+4y)]}\, \hat{a}_y$$

$$= -6\, e^{j[\omega t - 3x + 4y]}\, \hat{a}_y$$

$$E_{rz} = -5\, e^{j[\omega t + (-3x+4y)]}$$

$$= -5\, e^{j[\omega t - 3x + 4y]}\, \hat{a}_z$$

Hence (C)

Heading

The field in circular polarization is found to be

$$E_s = E_0 (a_x \pm j a_y) e^{-j\beta z}$$

where plus sign is used for left circular polarization and minus sign for right circular polarization.

The ~~□~~ given problem has left circular polarization.

$$\beta = 25 = \frac{\omega}{c}$$

$$25 = \frac{2\pi f}{c}$$

$$f = \frac{25 \times c}{2\pi} = \frac{25 \times 3 \times 10^8}{2 \times 3.14}$$

$$= 1.2 \text{ GHz}$$

Hence (A)

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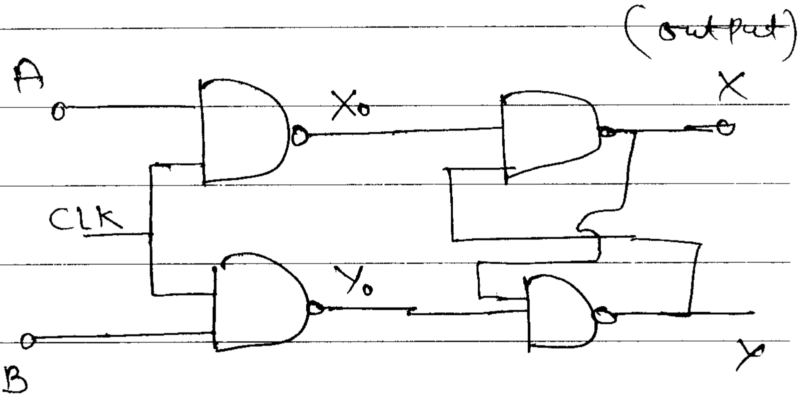
Race around condition occurs when output oscillates between 0 and 1 for a stable input.

Now, we consider all the given options

(B) CLK = 0



$X_0 = Y_0 = 1$ (always)

$\left.\begin{array}{l} Y = \bar{X} \\ X = \bar{Y} \end{array}\right\}$ True

(C) CLK = 1 & A = B = 1

If CLK = 1, then $X_0 = Y_0 = 0$

So, $X = Y = 1$

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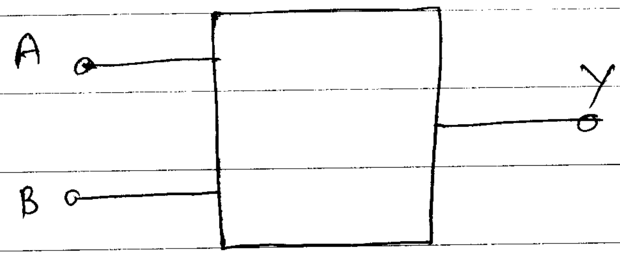

$Y = 1$, when $A > B$

$A = a_1 a_0$ $\quad$ $B = b_1 b_0$

a_1	a_0	b_1	b_0	Y
0	1	0	0	1
1	0	0	0	1
1	0	0	1	1
1	1	0	0	1
1	1	0	1	1
1	1	1	0	1

Total combination = 6

Hence (B) ————

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Let $v > 0.7\,V$ and diode is in FW bias.

By applying Kirchoff's voltage law

$$10 - i \times 1k - v = 0$$

$$10 - \left[\frac{v-0.7}{500}\right](1000) - v = 0$$

$$10 - (v-0.7)2 - v = 0$$

$$10 - 3v + 1.4 = 0$$

$$v = \frac{11.4}{3} = 3.8\,v$$ (Assumption is true)

So $$i = \frac{v-0.7}{500} = \frac{3.8-0.7}{500} = 6.2\,mA$$

Hence (D)

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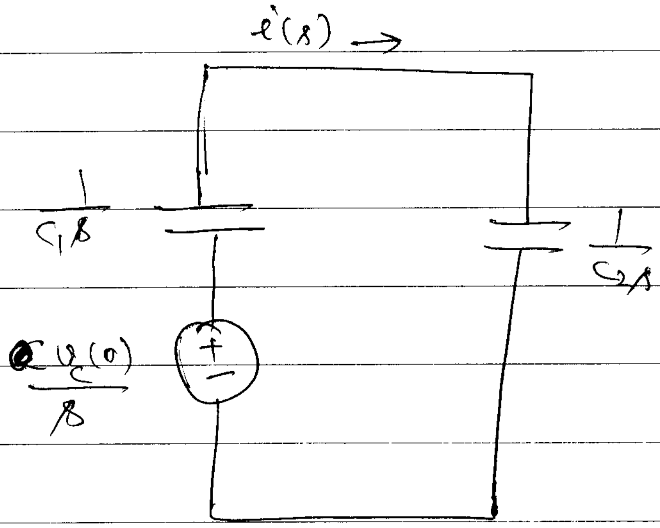
The s-domain equivalent circuit is shown as below



$$I(s) = \frac{v_c(0)/s}{\frac{1}{C_1 s} + \frac{1}{C_2 s}} = \frac{v_c(0)}{\frac{1}{C_1} + \frac{1}{C_2}}$$

$$I(s) = \left(\frac{C_1 C_2}{C_1 + C_2}\right)(12\,V)$$

~~tan~~ $I(s) = 12\,C_{eq}$

taking inverse Laplace transform

$i(t) = 12\,C_{eq}\,\delta(t)$ (Impulse)

~~Theoriticaly:-~~ Hence (D) ———.

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In phasor form

$$Z = 4 - j3$$

$$Z = 5 \angle -36.86^0 \ \Omega$$

$$I = 5 \angle 100^0 \ A$$

Average power delivered

$$P_{avg} = \frac{1}{2} |I|^2 Z \cos\theta$$

$$= \frac{1}{2} 25 \times 5 \angle \cancel{30.80}^0 \cos 36.86^0$$

$$= 50 \text{ W}$$

Hence B

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Using s-domain differentiation property of Laplace transform

If $f(t) \xleftrightarrow{\mathcal{L}} F(s)$

$t f(t) \xleftrightarrow{\mathcal{L}} -\dfrac{dF(s)}{ds}$

So, $\mathcal{L}[t f(t)] = -\dfrac{d}{ds}\left[\dfrac{1}{s^2+s+1}\right]$

$= \dfrac{2s+1}{(s^2+s+1)^2}$

Hence (B) ———.

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$$t\frac{dx}{dt} + x = t$$

$$\frac{dx}{dt} + \frac{x}{t} = 1$$

$$\frac{dx}{dt} + Px = Q \quad \text{(General Form)}$$

Integrating factor, $IF = e^{\int P dt}$

$$= e^{\int \frac{1}{t} dt}$$

$$= e^{\ln t} = t$$

Solution has the form

$$x\,IF = \int Q\,IF + c$$

$$xt = \int (1)(t)\,dt + c$$

$$xt = \frac{t^2}{2} + c$$

$x(1) = 0.5$

$$0.5 = \frac{1}{2} + c$$

$$c = 0$$

So $xt = \frac{t^2}{2} \Rightarrow x = \frac{t}{2}$

Hence (D) ______

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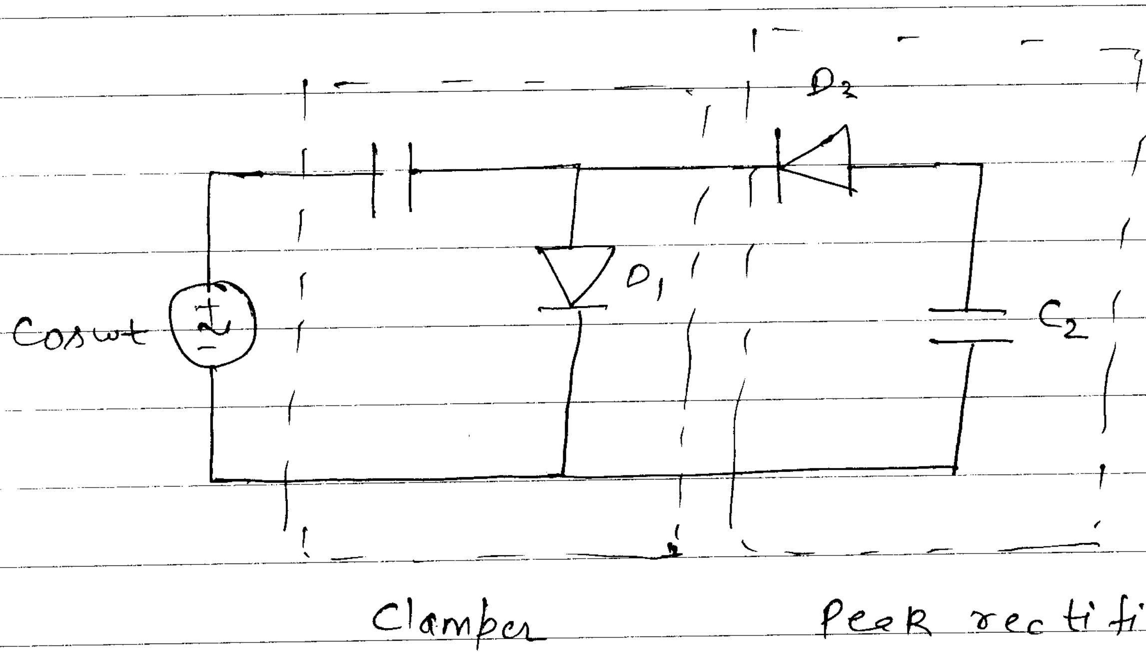
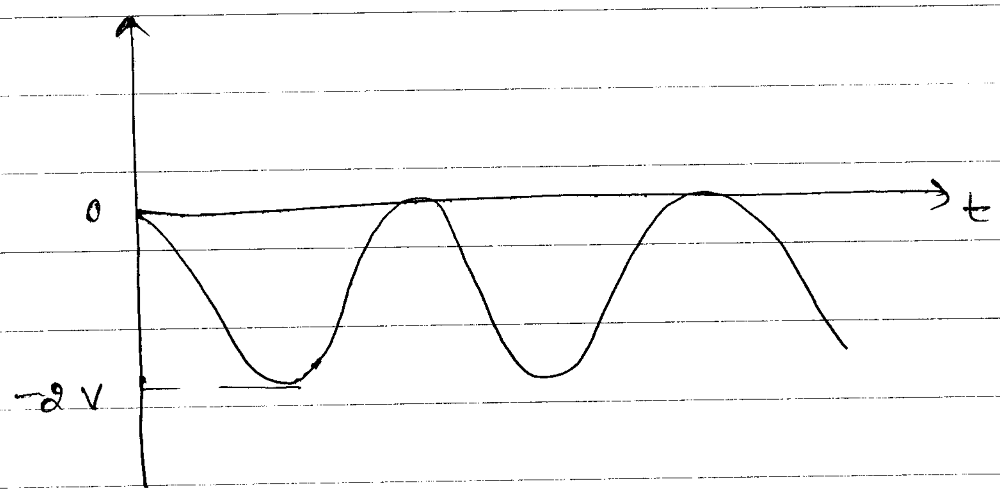
The circuit composed of a clamper and a peak rectifier as shown



Clamper clamps the voltage to zero volt.



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The peak rectifier adds +1 to peak voltage, so the overall peak voltage slowers down by -1 volt.

$$V_0 = \cos\omega t - 2 + 1$$

$$= \cos\omega t - 1$$

Hence (A) —— .

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Parallel connection of MOS ⇒ OR operation

Series connection of MOS ⇒ AND operation

The pull-up network acts as an inverter. From pull down network

$$Y = \overline{(A+B)\,C}$$

$$Y = \overline{(A+B)} + \overline{C}$$

$$= \overline{A}\cdot\overline{B} + \overline{C}$$

Hence (A)

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Entropy function of a discrete memory less system is given as

$$H = \sum_{k=0}^{N-1} P_k \log\left(\frac{1}{P_k}\right)$$

where P_k is probibality of symbol s_k.

For first two symbols probability is same, so

$$H = P_1 \log\left(\frac{1}{P_1}\right) + P_2 \log\left(\frac{1}{P_2}\right) + \sum_{k=3}^{N-1} P_k \log\left(\frac{1}{P_k}\right)$$

$$= -\left(P_1 \log P_1 + P_2 \log P_2 + \sum_{k=3}^{N-1} P_k \log P_k\right)$$

$$= -\left(2P \log P + \sum_{k=3}^{N-1} P_k \log P_k\right) \qquad (P_1 = P_2 = P)$$

Now, $P_1 = P + \varepsilon$, $P_2 = P - \varepsilon$

so $$H_0 = -\left[(P + \varepsilon)\log(P+\varepsilon) + (P-\varepsilon)\log(P-\varepsilon) + \sum_{k=1}^{N-1} P_k \log P_k\right]$$

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By comparing

$H_0 < H$

Entropy of source decreases.

Hence (D)

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Characteestic impedance

$$Z_0 = \sqrt{\frac{\mu}{\varepsilon}} \ln\left(\frac{b}{a}\right)$$

b → Outer diameter

a → inner diameter

$$Z_0 = \sqrt{\frac{\mu_0}{\varepsilon_0 \varepsilon_r}} \ln\left(\frac{b}{a}\right)$$

$$= \sqrt{\frac{4\pi \times 10^{-7} \times 36\pi}{10^{-9} \times 10.89}} \ln\left(\frac{2.4}{1}\right)$$

$$= 100\Omega$$

Hence B

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The directivity is defined as

$$D = \frac{F_{max}}{F_{ave}}$$

$$F_{max} = 1$$

$$F_{ave} = \frac{1}{4\pi}\int F(\theta,\phi)\, d\Omega$$

$$= \frac{1}{4\pi}\left[\int_0^{2\pi}\int_0^{2\pi} F(\theta,\phi)\sin\theta\, d\theta\, d\phi\right]$$

$$= \frac{1}{4\pi}\left[\int_0^{2\pi}\int_0^{\pi/2} \cos^4\theta \sin\theta\, d\theta\, d\phi\right]$$

$$= \frac{1}{4\pi}\left[\int_0^{\pi/2} \cos^4\theta \sin\theta\, d\theta\, d\phi\right]$$

$$= \frac{1}{4\pi}\left[2\pi\frac{\cos^5\theta}{5}\right]_0^{\pi/2}$$

$$= \frac{1}{4\pi}\times\frac{2\pi}{5} = \frac{1}{10}$$

$$D = \frac{1}{1/10} = 10$$

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Or, $D\,(\text{in dB}) = 10 \log 10 = 10 \text{ dB}$

Hence A

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$$x[n] = \left(\frac{1}{3}\right)^{|n|} - \left(\frac{1}{2}\right)^{n} u[n]$$

$$x[n] = \left(\frac{1}{3}\right)^{n} u[n] + \left(\frac{1}{3}\right)^{-n} u[-n-1] - \left(\frac{1}{2}\right)^{n} u[n]$$

Taking z- transform

$$X(z) = \sum_{n=-\infty}^{\infty} \left(\frac{1}{3}\right)^{n} z^{-n} u[n] + \sum_{n=-\infty}^{\infty} \left(\frac{1}{3}\right)^{-n} z^{-n} u[-n-1]$$

$$- \sum_{n=-\infty}^{\infty} \left(\frac{1}{2}\right)^{n} z^{-n} u[n]$$

$$= \cancel{\sum_{n=0}^{\infty} \left(\frac{1}{3}\right)^{n} z^{-n}} + \cancel{\sum \frac{1}{3}}$$

$$= \sum_{n=0}^{\infty} \left(\frac{1}{3}\right)^{n} z^{-n} + \sum_{n=-\infty}^{-1} \left(\frac{1}{3}\right)^{-n} z^{-n} - \sum_{n=0}^{\infty} \left(\frac{1}{2}\right)^{n} z^{-n}$$

$$= \underbrace{\sum_{n=0}^{\infty} \left(\frac{1}{3z}\right)^{n}}_{\mathrm{I}} + \underbrace{\sum_{m=1}^{\infty} \left(\frac{1}{3} z\right)^{m}}_{\mathrm{II}} - \underbrace{\sum_{n=0}^{\infty} \left(\frac{1}{2z}\right)^{n}}_{\mathrm{III}}$$

Series I converges if $\left|\frac{1}{3z}\right| < 1$ or $|z| > \frac{1}{3}$

Series II converges if $\left|\frac{1}{3} z\right| < 1$ or $|z| < 3$

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Series [II] Converges if $\left|\frac{1}{2z}\right| < 1$ or $|z| > \frac{1}{2}$

Region of Convergence of $X(z)$ will be intesection of above three

So,

ROC: $\frac{1}{2} < |z| < 3$

Hence (c)

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Prime impicants are the numcer of terms that we get by solving kmap

$x \backslash yz$	00	01	11	10
1	1	1		
0			1	1

$$F = \underbrace{x\bar{y} + \bar{x}y}_{\text{prime implicants}}$$

Hence A is correct option.

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$$G(s) = \frac{(s^2+9)(s+2)}{(s+1)(s+3)(s+4)}$$

$$G(j\omega) = \frac{(-\omega^2+9)(j\omega+2)}{(j\omega+1)(j\omega+3)(j\omega+4)}$$

The steady state output will be zero if

$$|G(j\omega)| = 0$$

$$-\omega^2+9 = 0$$

$$\omega = 3 \text{ rad/sec}$$

Hence (c)

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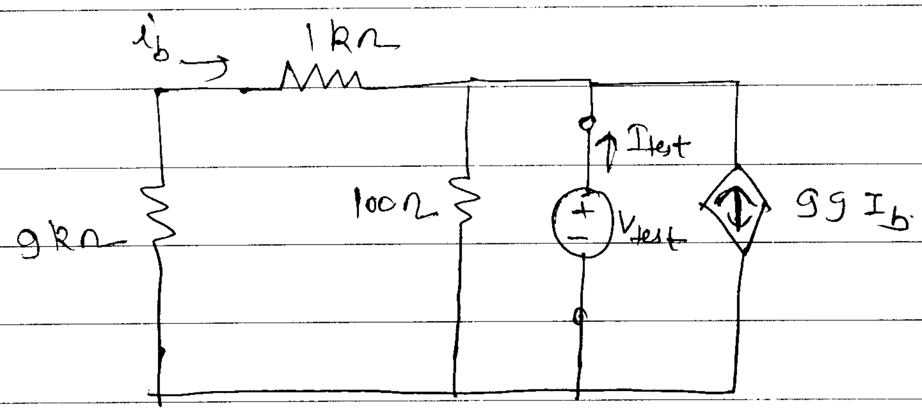
Soln:- We put a test source between terminal a-b to obtain equivalent impedance



$$Z_{Th} = \frac{V_{test}}{I_{test}}$$

By applying KCL at top right node

$$\frac{V_{test}}{9k+1k} + \frac{V_{test}}{100} - 99 I_b = I_{test}$$

But $I_b = \frac{-V_{test}}{9k+1k}$

So $$\frac{V_{test}}{9k+1k} + \frac{V_{test}}{100} + \frac{99 V_{test}}{9k+1k} = I_{test}$$

$$\frac{100 V_{test}}{10\times10^3} + \frac{V_{test}}{100} = I_{test}$$

$$\frac{2 V_{test}}{100} = I_{test} \Rightarrow Z_{Th} = \frac{V_{test}}{I_{test}} = 50\,\Omega$$

Hence (A)

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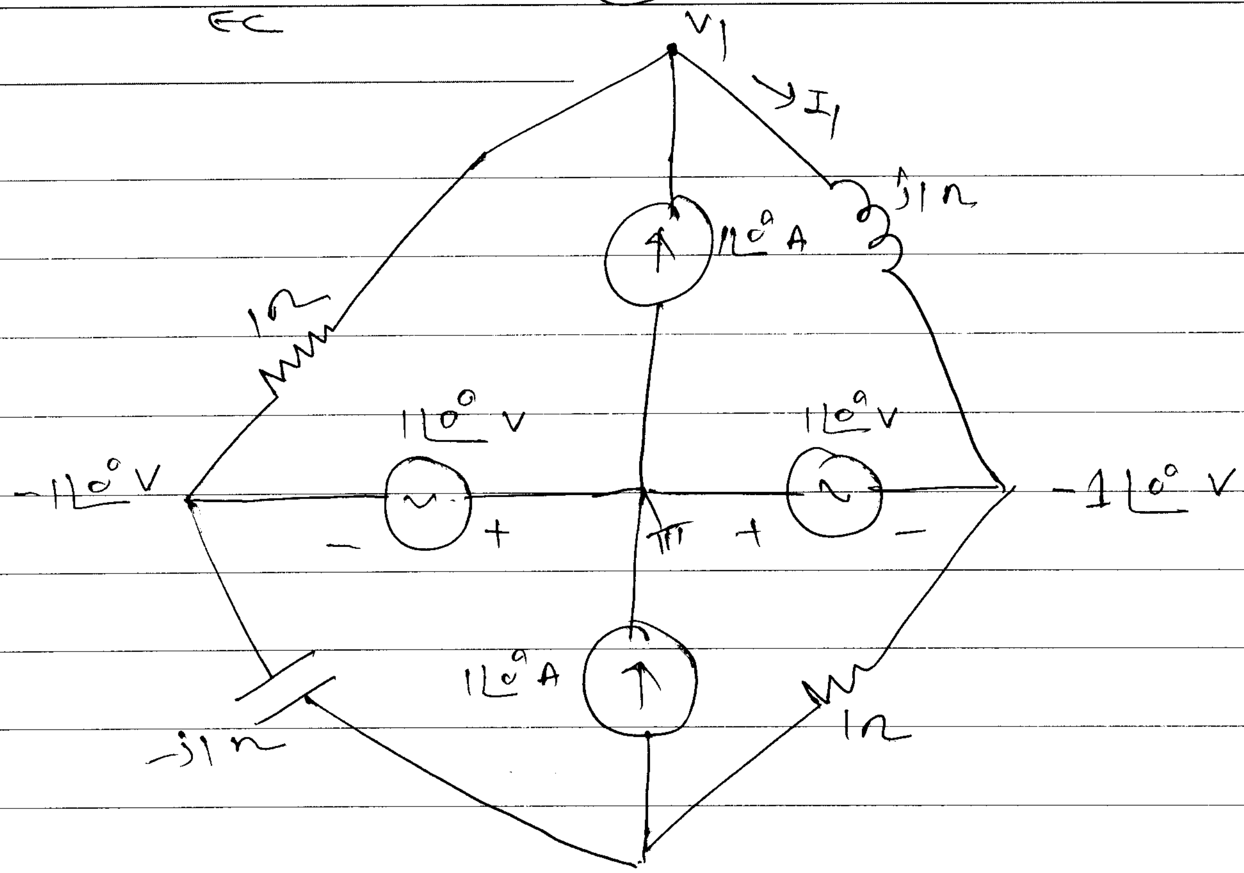

Applying nodal analysis at top node

$$\frac{V_1 + 1\angle 0^\circ}{1} + \frac{V_1 + 1\angle 0^\circ}{j1} = 1\angle 0^\circ$$

$$V_1 (j1+1) + j1 + 1\angle 0^\circ = 1\angle 0^\circ \, j1$$

$$V_1 = \frac{-1}{1+j1}$$

Current $I_1 = \dfrac{V_1 + 1\angle 0^\circ}{j1} = \dfrac{\frac{-1}{1+j}+1}{j1}$

$$= \frac{j}{(1+j)\,j}$$

$$= \frac{1}{1+j} A$$

Hence (B)

Heading

$$f(z) = \frac{1}{z+1} - \frac{2}{z+3}$$

$\frac{1}{2\pi j} \oint_C f(z)\,dz$ = sum of the residues of the poles which lie inside the given closed region

$C \Rightarrow |z+1| = 1$

only pole $z = -1$ lies inside the circle, so residue at $z = -1$ is

$$f(z) = \frac{-z+1}{(z+1)(z+3)}$$

$$= \lim_{z \to -1} \frac{(z+1)(-z+1)}{(z+1)(z+3)} = \frac{2}{2} = 1$$

So $\frac{1}{2\pi j} \oint_C f(z)\,dz = 1$

Hence (C) ______.

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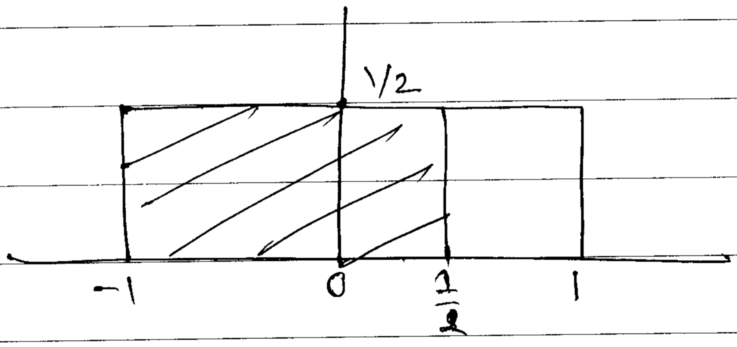
Probability density function of uniformly distributed variables X and Y is shown as



$P[\max(x, y)] < \frac{1}{2}$

Since X and Y are independent

$\left\{P[\max(x, y)] < \frac{1}{2}\right\} = P(X < \frac{1}{2}) \cdot P(X < \frac{1}{2})$

$P(X < \frac{1}{2})$ = shaded area = $\frac{3}{4}$

So $P\left\{[\max(x, y)] < \frac{1}{2}\right\} = \frac{3}{4} \cdot \frac{3}{4} = \frac{9}{16}$

Hence (B)

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$x = \sqrt{-1} = i = \cos\frac{\pi}{2} + i\sin\frac{\pi}{2}$

So $x = e^{j\pi/2}$

$x^x = \left(e^{j\pi/2}\right)^x = \left(e^{i\pi/2}\right)^i = e^{-\pi/2}$

Hence A

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For the semiconductor

$$n_o p_o = n_i^2$$

$$p_o = \frac{n_i^2}{n_o} = \frac{10^{20}}{10^{19}} = 10 \text{ per } cm^3$$

Volume of given device

$$V = \text{Area} \times \text{depth}$$

$$= 1\,\mu m^2 \times 1\,\mu m$$

$$= 10^{-8}\,cm^2 \times 1 \times 10^{-4}\,cm$$

$$= 10^{-12}\,cm^3$$

So total no. of holes is

$$P = p_o \times V$$

$$= 10 \times 10^{-12}$$

$$= 10^{-11}$$

which is approximatly equal to zero.

Hence (D).

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In a coherent binary PSK system, the pair of signals $s_1(t)$ and $s_2(t)$ used to represent binary system 1 and 0 respectively

$$S_1(t) = \sqrt{\frac{2E}{T}}\ \sin\omega_c t$$

$$S_2(t) = -\sqrt{\frac{2E}{T}}\ \sin\omega_c t$$

where $0 \le t \le T$, E is the transmitted energy per bit.

General Function of local oscillator

$$\phi_1(t) = \sqrt{\frac{2}{T}}\ \sin(\omega_c t), \quad 0 \le t < T$$

But here local oscillator is ahead with 45°, so,

$$\phi_1(t) = \sqrt{\frac{2}{T}}\ \sin(\omega_c t + 45^\circ)$$

~~Transmitted signal $S_1(t)$ and $s_2(t)$ in terms of $\phi_1(t)$ are~~

~~$S_1(t) = 1$~~

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Since $Z_0 = \sqrt{Z_1 Z_2}$

$$100 = \sqrt{50 \times 200}$$

This is quarter wave matching. The length would be odd multiple of $\lambda/4$

$$l = (2m+1)\frac{\lambda}{4}$$

$f_1 = 429$ MHZ, $l_1 = \frac{c}{f_1 \times 4} = \frac{3\times10^8}{429\times10^6\times4} = 0.174$ m

$f_2 = 1$ GHZ, $l_2 = \frac{c}{f_2 \times 4} = \frac{3\times10^8}{1\times10^9\times4} = 0.075$ m

Only option (c) is odd multiple of both l_1 and l_2.

$$(2m+1) = \frac{1.58}{l_1} \simeq 9$$

$$(2m+1) = \frac{1.58}{l_2} \simeq 21$$

Hence (c)

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$$y(t) = \int_{-\infty}^{t} x(\tau)\cos(3\tau)\,d\tau$$

Time invariance:

Let $x(t) = \delta(t)$

$$y(t) = \int_{-\infty}^{t} \delta(t)\cos(3\tau)\,d\tau$$

$$= u(t)\cos(0)$$

$$= u(t)$$

For a delayed input $\delta(t-t_0)$ output is

$$y(t, t_0) = \int_{-\infty}^{t} \delta(t-t_0)\cos(3\tau)\,d\tau$$

$$= u(t)\cos(3t_0)$$

Delayed output

$$y(t-t_0) = u(t-t_0)$$

$$y(t, t_0) \neq y(t-t_0)$$

System is not time-invariant.

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Stability :

Consider a bounded input $x(t) = \cos 3t$

$$y(t) = \int_{-\infty}^{t} \cos^2 3t = \int_{-\infty}^{t} \frac{1-\cos 6t}{2}$$

$$= \frac{1}{2}\int_{-\infty}^{t} 1 \cdot dt - \frac{1}{2}\int_{-\infty}^{t} \cos 6t \, dt$$

As $t \to \infty$, $y(t) \to \infty$ (unbounded)

System is not stable.

Hence (D) ——

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Heading

$$Y(s) = \frac{k(s+1)}{s^3+as^2+2s+1}\left[R(s)-Y(s)\right]$$

$$Y(s)\left[1+\frac{k(s+1)}{s^3+as^2+2s+1}\right] = \frac{k(s+1)}{s^3+as^2+2s+1}R(s)$$

$$Y(s)\left[s^3+as^2+s(2+k)+(1+k)\right] = k(s+1)R(s)$$

Transfer Function

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

Routh table:

s^3	1	$2+k$
s^2	a	$1+k$
s^1	$\frac{a(2+k)-(1+k)}{a}$	0

For oscillation $\frac{a(2+k)-(1+k)}{a} = 0$

$$a = \frac{k+1}{k+2}$$

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Auxiliary equation

$$A(s) = as^2 + (k+1) = 0$$

$$s^2 = -\frac{k+1}{a}$$

$$s^2 = \frac{-k+1}{(k+1)}(k+2)$$

$$s^2 = -(k+2)$$

$$s = j\sqrt{k+2}$$

$$j\omega = j\sqrt{k+2}$$

$$\omega = \sqrt{k+2} = 2$$ (Oscillation frequency)

$$k = 2$$

and $a = \frac{2+1}{2+2} = \frac{3}{4} = 0.75$

Hence (A) ____.

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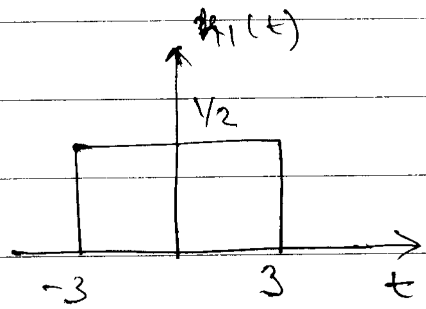
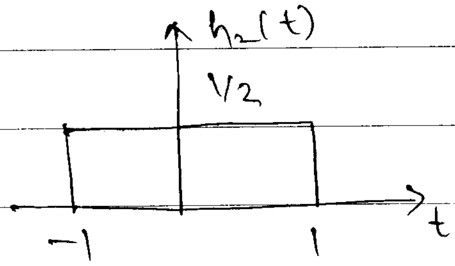
$$H(j\omega) = \frac{(2\cos\omega)(\sin 2\omega)}{\omega}$$

$$= \cancel{\cos}\cdot \frac{\sin 3\omega}{\omega} + \frac{\sin\omega}{\omega}$$

we know that inverse fourier transform of sinc function is a rectangular function.



$$\xleftrightarrow{f} \quad \frac{\sin 3\omega}{\omega}$$



$$\xleftrightarrow{f} \quad \frac{\sin\omega}{\omega}$$

So Inverse FT of $H(j\omega)$

$$h(t) = h_1(t) + h_2(t)$$

$$h(0) = h_1(0) + h_2(0)$$

$$= \frac{1}{2} + \frac{1}{2} = 1$$

Hence (c)

Heading

General form of state equations

$$\dot{x} = Ax + Bu$$

$$y = Cx + Du$$

For the given problem

$$A = \begin{bmatrix} 0 & a_1 & 0 \\ 0 & 0 & a_2 \\ a_3 & 0 & 0 \end{bmatrix}, \quad B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$$

$$AB = \begin{bmatrix} 0 & a_1 & 0 \\ 0 & 0 & a_2 \\ a_3 & 0 & 0 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} 0 \\ a_2 \\ 0 \end{bmatrix}$$

$$A^2B = \begin{bmatrix} 0 & 0 & a_1 a_2 \\ a_2 a_3 & 0 & 0 \\ 0 & a_3 a_1 & 0 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} a_1 a_2 \\ 0 \\ 0 \end{bmatrix}$$

For controllability it is necessary that the following matrix has a rank of $n = 3$.

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$U = [B : AB : A^2B]$

$$= \begin{bmatrix} 0 & 0 & a_1 a_2 \\ 0 & a_2 & 0 \\ 1 & 0 & 0 \end{bmatrix}$$

so $a_2 \neq 0$

$a_1 a_2 \neq 0 \Rightarrow a_1 \neq 0$

a_3 may be zero or not.

Hence (D).

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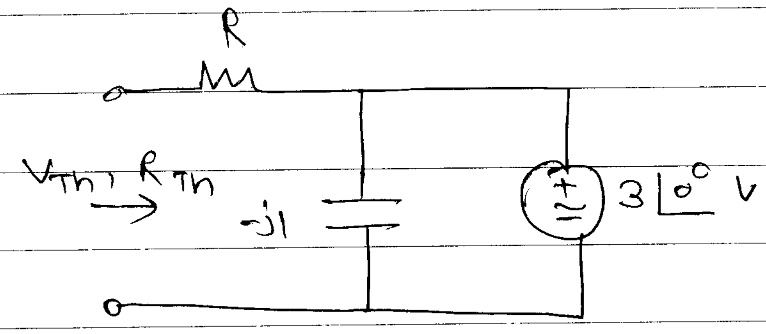
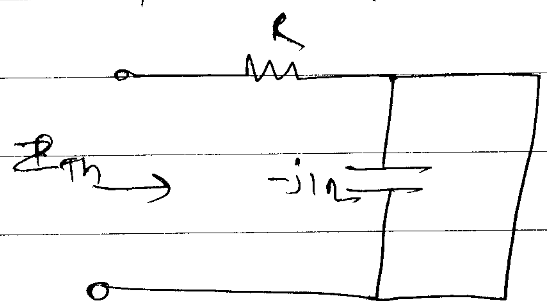
EC

we obtain thevenin equivalent of circuit B



Thevenin Impedance:

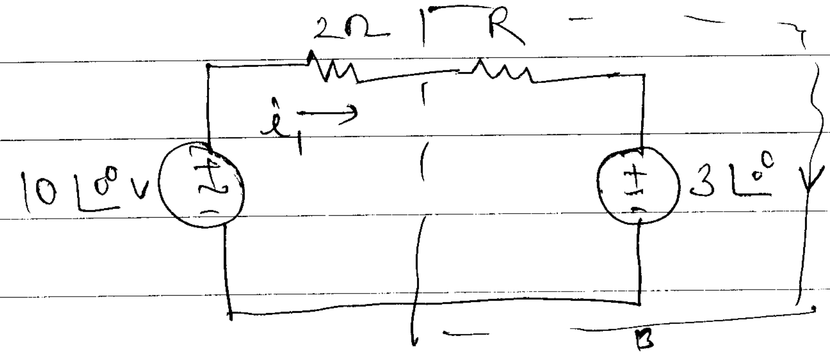


$Z_{Th} = R$

Thevenin Voltage:

$V_{Th} = 3\angle 0^\circ$ V

Now, circuit becomes as



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Power transfer from circuit A to B

$$P = (i_1^2)^2 R + 3 i_1$$

$$P = \left[\frac{10-3}{2+R}\right]^2 R + 3\left[\frac{10-3}{2+R}\right]$$

$$P = \frac{49R}{(2+R)^2} + \frac{21}{(2+R)}$$

$$P = \frac{49R + 21(2+R)}{(2+R)^2}$$

$$= \frac{42 + 70R}{(2+R)^2}$$

$$\frac{dP}{dR} = \frac{(2+R)^2 70 - (42+70R)2(2+R)}{(2+R)^4} = 0$$

$$(2+R)\left[(2+R)70 - (42+70R)2\right] = 0$$

$$140 + 70R - 84 - 140R = 0$$

$$56 = 70R$$

$$R = 0.8\ \Omega$$

Hence (A) ——

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$$\frac{d^2y(t)}{dt^2} + 2\frac{dy(t)}{dt} + y(t) = \delta(t)$$

By taking Laplace transform with initial conditions

$$\left[s^2Y(s) - sy(0) - \frac{dy}{dt}\bigg|_{t=0}\right] + 2\left[sY(s) - y(0)\right] + Y(s) = 1$$

$$\left[s^2Y(s) + 2s - 0\right] + 2\left[sY(s) + 2\right] + Y(s) = 1$$

$$Y(s)\left[s^2 + 2s + 1\right] = 1 - 2s - 4$$

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

we know that

if $y(t) \xleftrightarrow{L} Y(s)$

$$\frac{dy(t)}{dt} \xleftrightarrow{L} sY(s) - y(0)$$

So, $sY(s) - y(0) = \frac{(-2s-3)s}{(s^2+2s+1)} + 2$

$$= \frac{-2s^2 - 3s + 2s^2 + 4s + 2}{(s^2+2s+1)}$$

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$$sY(s) - y(0) = \frac{s+2}{(s+1)^2} = \frac{s+1}{(s+1)^2} + \frac{1}{(s+1)^2}$$

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

By taking inverse Laplace transform

$$\frac{dy(t)}{dt} = e^{-t}u(t) + t\,e^{-t}u(t)$$

at $t = 0^+$

$$\left.\frac{dy}{dt}\right|_{t=0^+} = e^0 + 0 = 1$$

Hence D

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Divergence of $\vec{A}$ in spherical coordinates is given as

$$\nabla \cdot \vec{A} = \frac{1}{r^2}\frac{\partial}{\partial r}(r^2 A_r)$$

$$= \frac{1}{r^2}\frac{\partial}{\partial r}(k r^{n+2})$$

$$= \frac{k}{r^2}(n+2) r^{n+1}$$

$$= k(n+2) r^{n-1} = 0 \quad \text{(given)}$$

$$n+2 = 0$$

$$n = -2$$

Hence (A)

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Probability of appearing a head is $1/2$.
If the number of required tosses is odd, we have following sequence of events

H, TTH, TTTTH, ---

Probability $P = \frac{1}{2} + \left(\frac{1}{2}\right)^3 + \left(\frac{1}{2}\right)^5 + \cdots$

$$P = \frac{\frac{1}{2}}{1 - \frac{1}{4}} = \frac{2}{3}$$

Hence (C)

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General equation of FM and PM

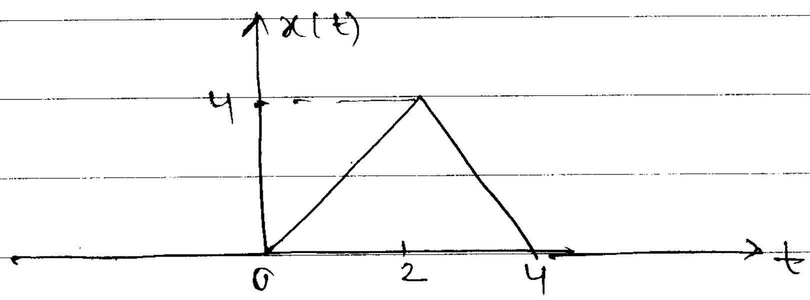
$$\phi_{FM}(t) = A_c \cos\left[\omega_c t + 2\pi k_f \int_0^t m(\tau)\,d\tau\right]$$

$$\phi_{PM}(t) = A_c \cos\left[\omega_c t + k_p m(t)\right]$$

For same maximum phase deviation

$$k_p [m(t)]_{max} = 2\pi k_f \left[\int_0^t m(\tau)\,d\tau\right]_{max}$$

$$k_p (2) = 2\pi k_f \cdot [x(t)]_{max}$$



$$x(t) = \int_0^t m(\tau)\,d\tau$$

$$[x(t)]_{max} = 4$$

So, $k_p (2) = 2\pi k_f (4)$

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$$\frac{k_p}{k_f} = 4\pi$$

Hence B

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$$H_z = 3\cos(2.094\times10^2 x)\cos(2.618\times10^2 y)\cos(6.283\times10^{10}t - \beta z)$$

$\beta_x = 2.094\times10^2$

$\beta_y = \cancel{6.}\ 2.618\times10^2$

$\omega = 6.283\times10^{10}$ rad/s

For the wave propogation

$$\beta = \sqrt{\frac{\omega^2}{c^2} - (\beta_x^2 + \beta_y^2)}$$

Substituting above values

$$\beta = \sqrt{\left(\frac{6.283\times10^{10}}{3\times10^8}\right)^2 - (2.094^2 + 2.618^2)\times10^4}$$

$\simeq j261$

β is Imaginary so mode of operation is non-propogating

$v_p = 0$

Hence (D)

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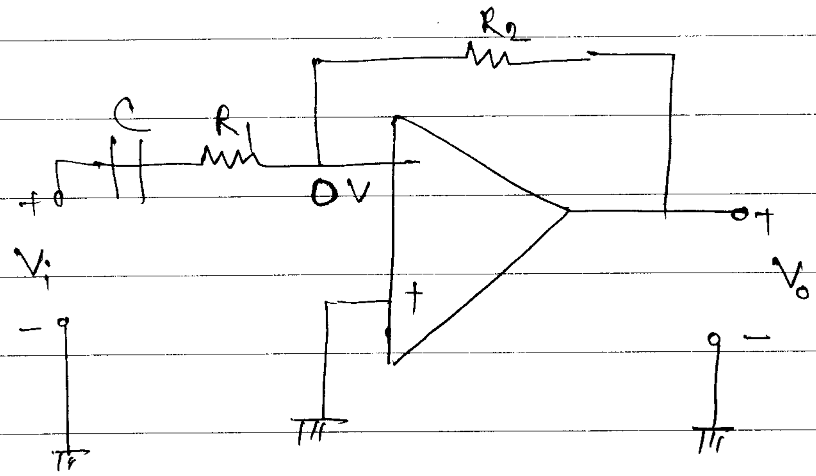
2012

First we obtain the transfer function



$$\frac{0 - V_i}{\frac{1}{j\omega C} + R_1} + \frac{0 - V_o}{R_2} = 0$$

$$\frac{V_o}{R_2} = \frac{-V_i}{\frac{1}{j\omega C} + R_1}$$

$$V_o = \frac{-V_i}{\frac{R_1}{R_2} + \frac{1}{j\omega C R_2}} = \frac{-V_i R_2}{R_1 - j\frac{1}{\omega C}}$$

At $\omega \to 0$ (Low frequencies)

$$\frac{1}{\omega C} \to \infty, \text{ so } V_o = 0$$

At $\omega \to \infty$ (higher frequencies)

$$\frac{1}{\omega C} \to 0, \text{ so } V_o = \frac{-V_i R_2}{R_1}$$

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The filter passes high frequencies so it is a high pass filter.

$$H(j\omega) = \frac{V_0}{V_i} = \frac{-R_2}{R_1 - j\frac{1}{\omega C}}$$

$$|H(\infty)| = \left|-\frac{R_2}{R_1}\right| = \frac{R_2}{R_1}$$

~~For~~ At 3 dB frequency

$$|H(j\omega_1)| = \frac{1}{\sqrt{2}}|H(\infty)|$$

$$\frac{R_2}{\sqrt{R_1^2 + \frac{1}{\omega^2 C^2}}} = \frac{1}{\sqrt{2}} \cdot \frac{R_2}{R_1}$$

$$2R_1^2 = R_1^2 + \frac{1}{\omega^2 C^2}$$

$$R_1^2 = \frac{1}{\omega^2 C^2}$$

$$\omega = \frac{1}{R_1 C}$$

Hence B ______ .

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Convolution sum is defined as

$$y[n] = h[n] * g[n] = \sum_{k=-\infty}^{\infty} h[n]\, g[n-k]$$

For causal sequence

$$y[n] = \sum_{k=0}^{\infty} h[n]\, g[n-k]$$

$$y[n] = h[n]\,g[n] + h[n]\,g[n-1] + h[n]\,g[n-2] + \cdots$$

for $n = 0$

$$y[0] = h[0]\,g[0] + h[1]\,g[-1] + \cdots$$

$$y[0] = h[0]\,g[0] \quad \text{—— (i)} \qquad g[-1] = g[-2] = \cdots 0$$

For $n = 1$

$$y[1] = h[1]\,g[1] + h[1]\,g[0] + h[1]\,g[-1] + \cdots$$

$$y[1] = h[1]\,g[1] + h[1]\,g[0]$$

$$\frac{1}{2} = \frac{1}{2}\,g[1] + \frac{1}{2}\,g[0] \qquad h[1] = \left(\frac{1}{2}\right)^1 = \frac{1}{2}$$

$$1 = g[1] + g[0]$$

$$g[1] = 1 - g[0]$$

From eq (i)

$$g[0] = \frac{y[0]}{h[0]} = \frac{1}{1} = 1$$

So $g[1] = 1 - 1 = 0$

Hence (A)

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Let Q_{n+1} is next state and Q_n is the present state. From the given figure

$$D = Y = \bar{A} X_0 + A X_1$$

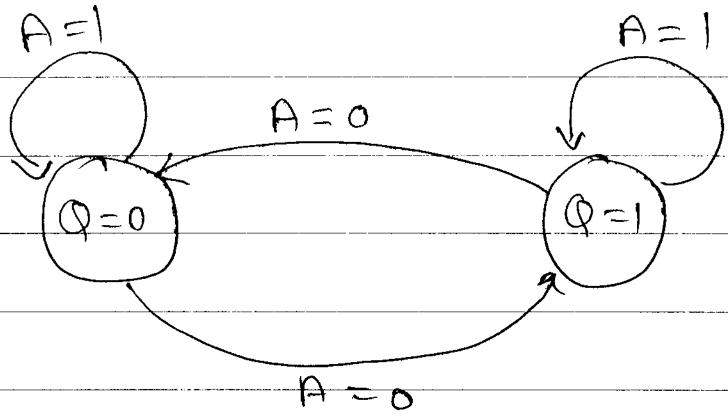
$$Q_{n+1} = D = \bar{A} X_0 + A X_1$$

$$Q_{n+1} = \bar{A} \bar{Q}_n + A Q_n \qquad X_0 = \bar{Q},\ X_1 = Q$$

If $A = 0$, $Q_{n+1} = \bar{Q}_n$ (toggle of previous state)

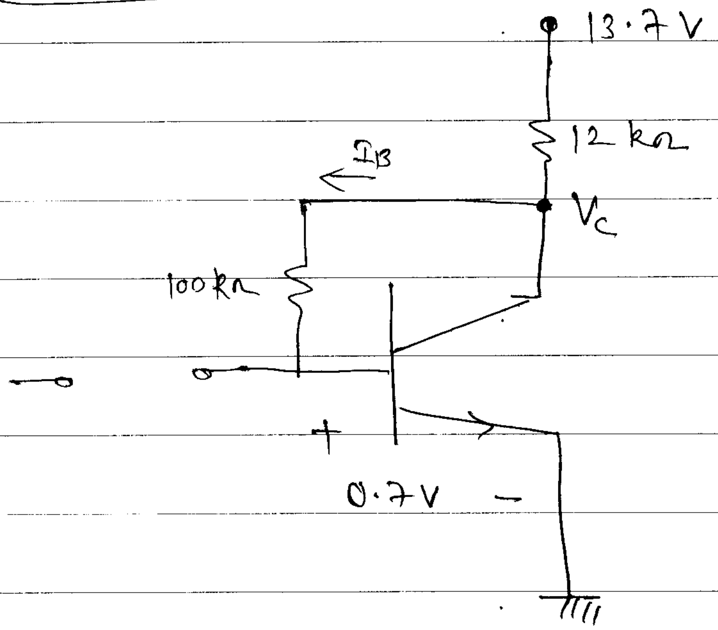
If $A = 1$, $Q_{n+1} = Q_n$

So state diagram is



Hence (D) ______.

DC Analysis :-



using KVL in input loop

$$V_c - 100\, I_B - 0.7 = 0$$

$$V_c = 100\, I_B + 0.7 \quad \text{——— (i)}$$

$$I_C \simeq I_E = \frac{13.7 - V_c}{12k} = (\beta + 1) I_B$$

$$\frac{13.7 - V_c}{12 \times 10^3} = 100\, I_B \quad \text{——— (ii)}$$

Solving (i) & (ii)

$$I_B = 0.01\, mA$$

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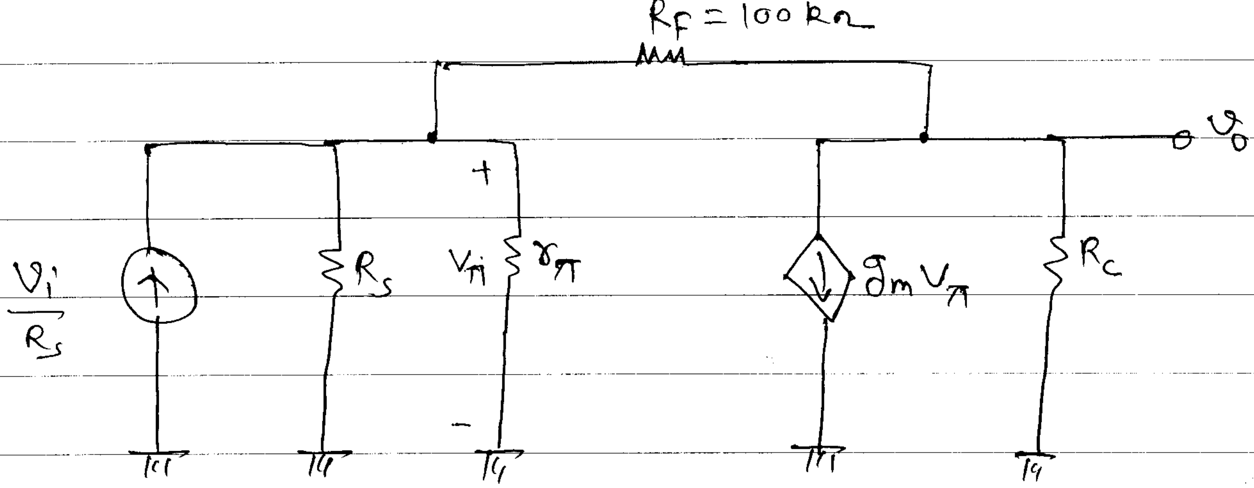
Small Signal Analysis :-

Transforming given input voltage source into equivalent current source



This is a shunt - shunt feedback aamplifier.
Given parameters

- $r_\pi = \frac{V_T}{I_B} = \frac{25mv}{0.01mA} = 2.5\,k\Omega$

$$g_m = \frac{\beta}{r_\pi} = \frac{100}{2.5\times 1000} = 0.04\,S$$

writing KCL at output node

$$\frac{V_0}{R_c} + g_m V_\pi + \frac{V_0 - V_\pi}{R_F} = 0$$

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$$V_o\left[\frac{1}{R_C}+\frac{1}{R_F}\right]+V_\pi\left[g_m-\frac{1}{R_F}\right]=0$$

Substituting $R_c = 12\,k\Omega$, $R_F = 100\,k\Omega$, $g_m = 0.04\,S$,

$$V_o(9.33\times10^{-5}) + V_\pi(0.04) = 0$$

$$V_o = -428.72\,V_\pi \quad \text{——(1)}$$

writing KCL at input node

$$\frac{V_i}{R_S} = \frac{V_\pi}{R_S} + \frac{V_\pi}{r_\pi} + \frac{V_\pi - V_o}{R_F}$$

Substituting all values

$$\frac{V_i}{R_S} = V_\pi\left[\frac{1}{R_S}+\frac{1}{r_\pi}+\frac{1}{R_F}\right] - \frac{V_o}{R_F}$$

$$\frac{V_i}{R_S} = V_\pi(5.1\times10^{-4}) - \frac{V_o}{R_F}$$

Substituting V_π from equation (1)

$$\frac{V_i}{R_S} = \frac{-5.1\times10^{-4}}{428.72}V_o - \frac{V_o}{R_F}$$

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$$\frac{v_i'}{10\times10^3} = -1.16\times10^{-6}\, v_o - 1\times10^{-5}\, v_o$$

$$\frac{v_i'}{10\times10^3} = -1.116\times10^{-5}$$

$$|A_v| = \left|\frac{v_o}{v_i}\right| = \frac{1}{10\times10^3\times1.116\times10^{-5}} \simeq 8.96$$

Hence (D)

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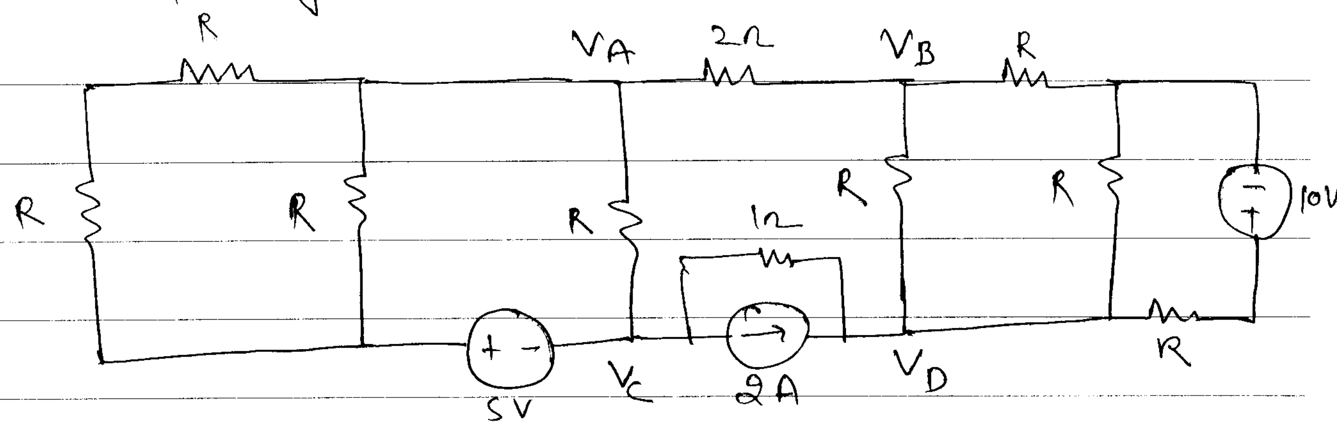
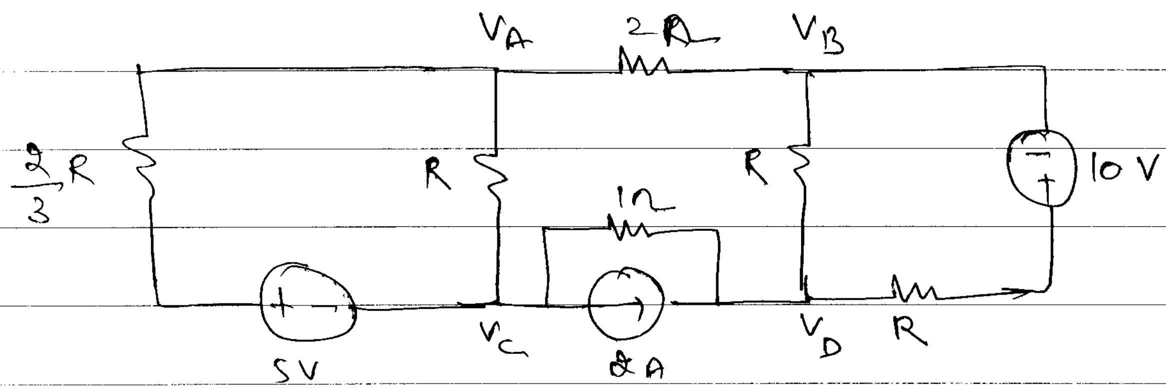
Simplifying the circuit



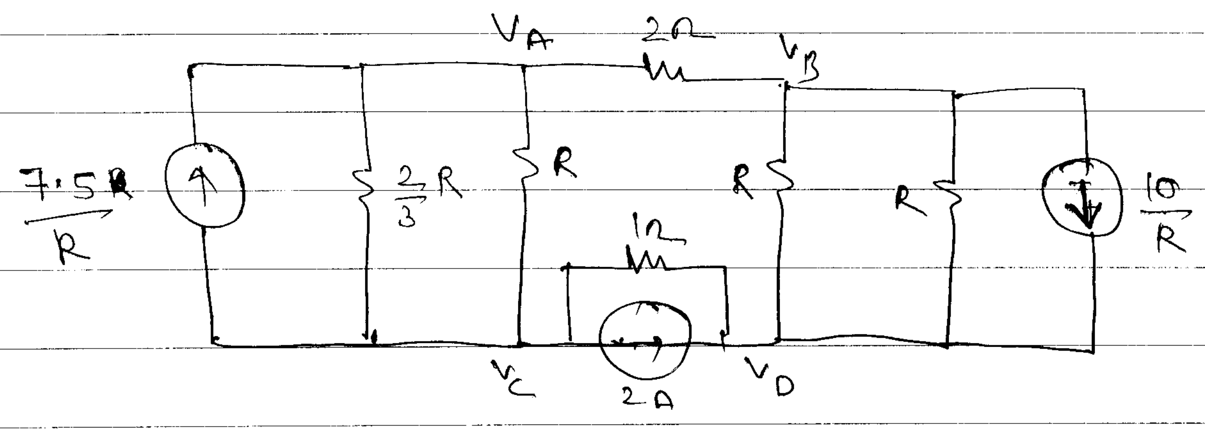
Combining resistances

$$R + R = 2R$$

$$2R \,||\, R = \frac{2}{3}R$$



using source transformation



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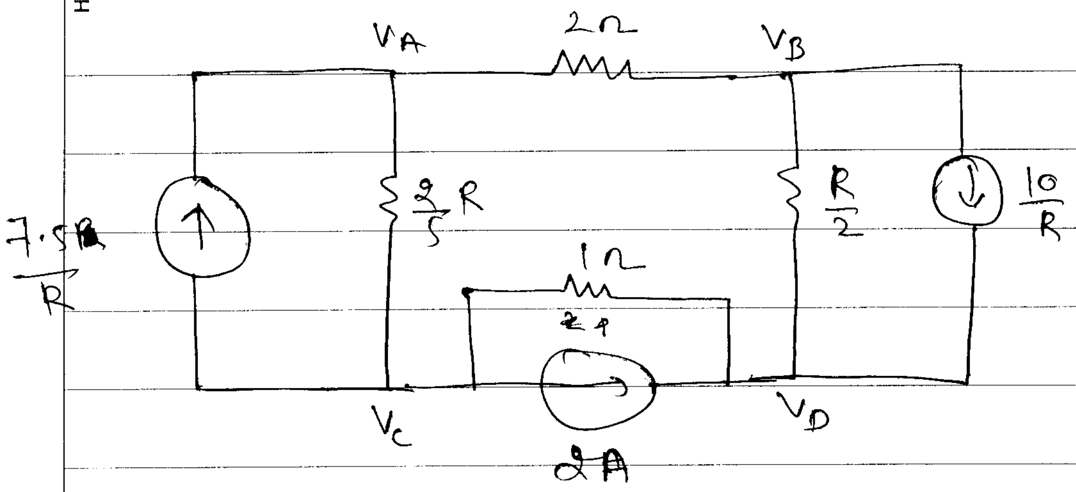
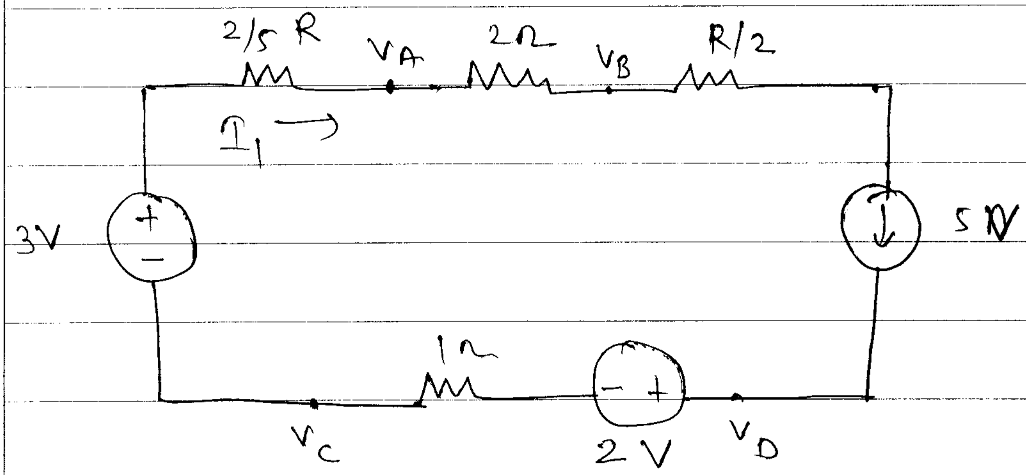


Again using source transformation of all the current sources



$$I_1 = \frac{V_A - V_B}{2} = \frac{6}{2} = 3\ A$$

$$V_C - V_D = -1 I_1 - 2$$ (Carefully)

$$= -1(3) - 2$$

$$= -5\ V$$

Hence (A) ___

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$$f(x) = x^3 - 9x^2 + 24x + 5$$

$$\frac{df(x)}{dx} = 3x^2 - 18x + 24 = 0$$

$$x^2 - 6x + 8 = 0$$

$$x = 6, \quad x = 2$$

$$\frac{d^2f(x)}{dx^2} = 6x - 18$$

for $x = 2$, $\frac{d^2f(x)}{dx^2} = 12 - 18 = -6 < 0$

so at $x = 2$, $f(x)$ will be maximum

$$f(x)\Big|_{max} = (2)^3 - 9(2)^2 + 24(2) + 5$$

$$= 8 - 36 + 48 + 5$$

$$= 25$$

Hence (B)

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Heading

Characteristic equation

$$|A - \lambda I| = 0$$

$$\begin{vmatrix} -5-\lambda & -3 \\ 2 & -\lambda \end{vmatrix} = 0$$

$$5\lambda + \lambda^2 + 6 = 0$$

$$\lambda^2 + 5\lambda + 6 = 0$$

Since every characteristic equation satisfies its own matrix, so

$$A^2 + 5A + 6 = 0 \Rightarrow A^2 = -5A - 6I$$

Multiplying with A

$$A^3 + 5A^2 + 6A = 0$$

$$A^3 + 5(-5A - 6I) + 6A = 0$$

$$A^3 = 19A + 30I$$

Hence (B)

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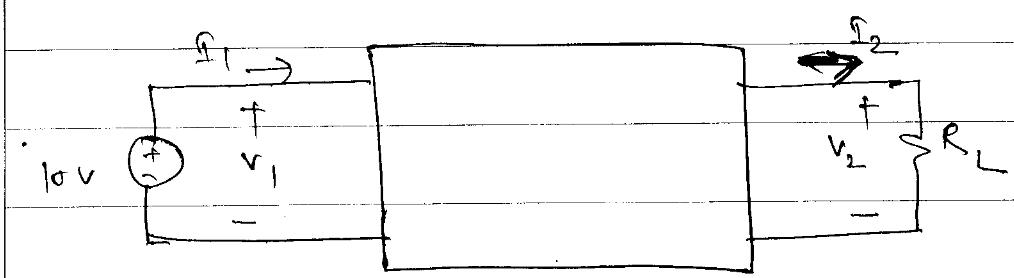
Let y-parameter matrix of the given two-port network

$$y = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix}$$

$$I_1 = y_{11} V_1 + y_{12} V_2$$

$$I_2 = y_{21} V_1 + y_{22} V_2$$



(i) $R_L = 1\Omega$, $I_2 = 3$ A

$$3 = y_{21}(10) + y_{22}(3)(1) \qquad (V_2 = I_2 R_L)$$

(ii) $R_L = 2.5\Omega$, $I_2 = 2$ A

$$2 = y_{21}(10) + y_{22}(2)(2.5)$$

from above two equation

$$1 = y_{22}(-2)$$

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$$y_{22} = -0.5\ S$$

$$y_{21} = 0.45\ S$$

So, when $R_L = 7\Omega$

$$I_2 = 0.45(10) - 0.5(7)I_2$$

$$4.5\,I_2 = 4.5$$

$$I_2 = 1A$$

Hence (c)

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Gate source overlap capacitance

$$C_0 = \frac{\delta W \varepsilon_{ox} \varepsilon_0}{t_{ox}} \quad (\text{medium } SiO_2)$$

$$= \frac{20 \times 10^{-9} \times 1 \times 10^{-6} \times 3.9 \times 8.9 \times 10^{-12}}{1 \times 10^{-9}}$$

$$= 0.69 \times 10^{-15} \text{ F}$$

Hence B

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Source body junction capacitance

$$C_s = \frac{A \varepsilon_r \varepsilon_0}{d}$$

$A = (0.2\,\mu m + 0.2\,\mu m + 0.2\,\mu m) \times 1\,\mu m$

$+ 2(0.2\,\mu m \times 0.2\,\mu m)$

$= 0.68\,\mu m^2$

$d = 10\,nm$ (depletion width of all junction)

$$C_s = \frac{0.68 \times 10^{-12} \times 11.7 \times 8.9 \times 10^{-12}}{10 \times 10^{-9}}$$

$= 7 \times 10^{-15}\,F$

Hence B

Heading

For $r > a$

$$I_{enclosed} = (\pi a^2) J$$

$$\oint H \cdot dl = I_{enclosed}$$

$$H \times 2\pi r = (\pi a^2) J$$

$$H = \frac{I_0}{2\pi r} \quad , \quad I_0 = (\pi a^2) J$$

$$H \propto \frac{1}{r} \quad \text{for } r > a$$

For $r < a$

$$I_{enclosed} = \frac{J(\pi r^2)}{\pi a^2} = \frac{J r^2}{a^2}$$

So, $\oint H \cdot dl = I_{enclosed}$

$$H \times 2\pi r = \frac{J r^2}{a^2}$$

$$H = \frac{J r}{2\pi a^2}$$

$$J \propto r \quad \text{for } r < a$$

Hence (C)

Heading

$$G_c(s) = \frac{s+a}{s+b} = \frac{j\omega + a}{j\omega + b}$$

Phase lead angle

$$\phi = \tan^{-1}\left(\frac{\omega}{a}\right) - \tan^{-1}\left(\frac{\omega}{b}\right)$$

$$\phi = \tan^{-1}\left(\frac{\frac{\omega}{a} - \frac{\omega}{b}}{1 + \frac{\omega^2}{ab}}\right)$$

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

For phase-lead compensation $\phi > 0$

$$b - a > 0$$

$$b > a$$

Hence (A)

Note: For phase lead compensator zero is nearer to the origin as compared to origin so option (c) can no be true.

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$$\phi = \tan^{-1}\left(\frac{\omega}{a}\right) - \tan^{-1}\left(\frac{\omega}{b}\right)$$

$$\frac{d\phi}{d\omega} = \frac{1/a}{1+\left(\frac{\omega}{a}\right)^2} - \frac{1/b}{1+\left(\frac{\omega}{b}\right)^2} = 0$$

$$\frac{1}{a} + \frac{1}{a}\frac{\omega^2}{b^2} = \frac{1}{b} + \frac{1}{b}\frac{\omega^2}{a^2}$$

$$\frac{1}{a} - \frac{1}{b} = \frac{\omega^2}{ab}\left(\frac{1}{a} - \frac{1}{b}\right)$$

$$\omega = \sqrt{ab}$$

$$\omega = \sqrt{1 \times 2} = \sqrt{2} \text{ rad/sec}$$

Hence (A) —