

## GATE 2024

### **ELECTRONICS ENGINEERING**

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

Memory based

Questions & Solutions









#### **SECTION - A GENERAL APTITUDE**

- Highest prime factor of  $3^{199} 3^{196}$  is \_\_\_\_\_. Q.1
  - (a) 3
  - (c) 13

- (b) 17
- (d) 11

Ans. (c)

$$= 3^{196}(3^3 - 1) = 3^{196} \times 26 = 2 \times 3^{196} \times 13$$

Highest prime factors = 13

**End of Solution** 

 $\frac{1}{\log_2 x} + \frac{1}{\log_3 x} + \frac{1}{\log_4 x} = 1$ Q.2

If x > 1, then value of x is \_\_\_\_

- (a) 4 (c) 24

- (b) 12 (d) 36
- Ans. (c)

$$\log_{x}^{2} + \log_{x}^{3} + \log_{x}^{4} = 1$$

$$\log_x^{24} = 1$$

$$x = 24$$

**End of Solution** 

Q.3 For the given rectangular sheet



Condition 1: Paper fold parallel to longer side two times. Condition 2: Paper fold parallel to smaller side two times.

Ratio of perimeter of condition 1 to condition 2.

- (a) 16:18

(b) 11:14

(c) 14:11

(d) 18:16

Ans. (C)

#### Condition 1:

Folding first time

24

Folding first time

24

Perimeter = 2(24 + 4) = 56 cm



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**Forenoon Session** 

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Folding first time

12

Folding second time



Perimeter = 2(16 + 6) = 44 cm Ratio = 56 : 44 = 14 : 11

**End of Solution** 

- Q.4 Five years ago, son's and father's age ratio was 1 : 4. After five years the ratio is 2 : 5. Find the father age at the birth of son.
  - (a) 30 years

(b) 36 years

(c) 28 years

(d) 32 years

Ans. (a)

Five year ago

Son's age = xFather's age = 4x

Five year after

Son's age = x + 10

$$\frac{x+10}{4x+10} = \frac{2}{5}$$

$$5x + 50 = 8x + 20$$

$$3x = 30$$

$$x = 10$$

Son's age five year ago = 10

Father's age five year age = 40

At the time of son's birth father's age = 40 - 10 = 30 year

**End of Solution** 

Q.5 P, Q, R, S and T have launched a new startup. Two of the team are sibling. The office of the startup has just three rooms. All of them agree that the sibling should not share the same room If S and Q are single children and PR TS Q PQ RT S. Then which one of the given options is the sibling.

PR TS Q

PQ RT S

(a) T and Q

(b) T and S

(c) T and R

(d) P and T

Ans. (d)

End of Solution



**Forenoon Session** 

### **SECTION - B**

### **TECHNICAL**

### **SIGNALS AND SYSTEMS**

Q.1 For the given Causal LTI System,

Transfer function 
$$H(z) = \frac{2z^2 + 3}{\left(z + \frac{1}{3}\right)\left(z - \frac{1}{3}\right)}$$

which of the following statement(s) is/are correct?

- (a) System is minimum phase
- (b) Final value of impulse response is 0
- (c) Initial value of impulse response is 2
- (d) System is stable

Ans. (b, c, d)

Given: 
$$H(z) = \frac{2z^2 + 3}{\left(z + \frac{1}{3}\right)\left(z - \frac{1}{3}\right)}$$

System is non-minimum phase system. Since zero are lying outside the unit circle.

Final value: 
$$h(\infty) = \lim_{z \to 1} (z - 1) \frac{2z^2 + 3}{\left(z + \frac{1}{3}\right)\left(z - \frac{1}{3}\right)} = 0$$

Initial value: 
$$h(0) = \lim_{z \to \infty} \frac{\left(2z^2 + 3\right)}{\left(z + \frac{1}{3}\right)\left(z - \frac{1}{3}\right)} = \lim_{z \to \infty} \frac{z^2 \left[2 + \frac{3}{z^2}\right]}{z^2 \left[1 + \frac{1}{3z}\right] \left[1 - \frac{1}{3z}\right]}$$
$$= \lim_{z \to \infty} \frac{\left[2 + \frac{3}{z^2}\right]}{\left[1 + \frac{1}{2z}\right] \left[1 - \frac{1}{2z}\right]} = \frac{2}{1 \times 1} = 2$$

$$z = -\frac{1}{3}, \ z = \frac{1}{3}$$

$$|z| = \frac{1}{3} = 0.33$$

System is stable. Since pole < 1 i.e. pole are lying inside the unit circle.



## GATE 2024 Electronics Engineering

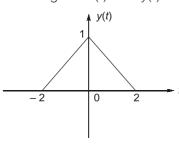
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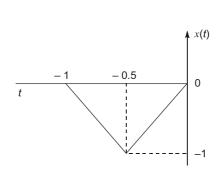
Questions & Solutions

Exam held on: 11-02-2024

**Forenoon Session** 

**Q.2** For the given x(t) and y(t).





If  $x(t) \leftrightarrow X(f)$  and  $y(t) \leftrightarrow Y(f)$ . Find Y(f) in terms of X(f).

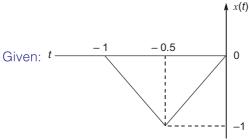
(a) 
$$-\frac{1}{4}X(4f)e^{-jf\pi}$$

(b) 
$$-4X\left(\frac{f}{4}\right)e^{-j4\pi f}$$

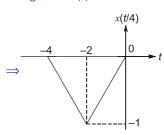
(c) 
$$-4X(4f)e^{-j4\pi f}$$

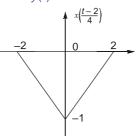
(d) 
$$-4X\left(\frac{f}{4}\right)e^{-j4\pi f}$$

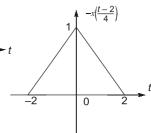
Ans. (c)



Length of x(t) is 1 and length of y(t) is 4.







$$y(t) = -x \left(\frac{t-2}{4}\right)$$

$$y(t) = -x\left(\frac{t}{4} - \frac{2}{4}\right) = -x\left(\frac{t}{4} - \frac{1}{2}\right)$$

On taking Fourier transform, we get

$$x(t) \leftrightarrow X(t)$$

$$x\left(\frac{t}{4} - \frac{1}{2}\right) \leftrightarrow 4X(4f)e^{-j4\pi f}$$

$$-x\left(\frac{t}{4} - \frac{1}{2}\right) \leftrightarrow -4X(4f)e^{-j4\pi f}$$



Q.3 Causal and stable LTI system with impulse response h(t) produces output y(t) for input x(t).

A signal x(0.5t) is applied to another Causal and Stable LTI system with impulse response h(0.5t), output y(t) is?

(a) 4y(0.5t)

(b) 2y(0.5t)

(c) 0.25y(0.25t)

(d) 0.25y(0.5t)

Ans. (b)

$$y(t) = x(t) * h(t)$$

$$x(t) \leftrightarrow X(\omega)$$

$$x(0.5t) \leftrightarrow 2 \times (2\omega)$$

$$h(0.5t) \leftrightarrow 2H(2\omega)$$

$$y(t) \leftrightarrow Y(\omega)$$

$$Y(\omega) \leftrightarrow X(\omega) \times H(\omega)$$

After scaling,

$$Y_1(\omega) = 2 X(2\omega) \times 2 H(2\omega)$$

 $= 4 X(2\omega) \times H(2\omega)$  After taking inverser Fourier transform

$$y_1(t) = 2y(0.5t)$$

**End of Solution** 

- **Q.4** If y(n) = DFT(DFT(DFT(x(n)))) and  $x(n) = \{1, 1, 2, 3\}$ , then find y(0) is \_\_\_\_\_
- Ans. (16)

$$y(n) = DFT DFT DFT DFT \{x(n)\}$$

$$x(n)$$
  $\xrightarrow{2 \text{ times DFT}} Nx(-n)$   $\xrightarrow{2 \text{ times DFT}} N^2x(n)$   
 $y(n) = N^2\{x(n)\} = 16 \ x(n)$   
 $= \{16, 16, 32, 48\}$ 

y(0) = 16

End of Solution

Q.5 If  $x(t) = 2\cos\left(8\pi t + \frac{\pi}{3}\right)$  as input signal to an LTI system x(t) sample at rate 15 Hz then

 $x_s(t)$ .  $x_s(t)$  pass through  $h(t) = \frac{\sin 2\pi t}{\pi t} \cos \left(38\pi t - \frac{\pi}{2}\right)$ . The output  $x_o(t)$  of LTI system is

equal to

- (a)  $15\cos\left(38\pi t \frac{\pi}{6}\right)$
- (b)  $15\cos\left(38\pi t + \frac{\pi}{3}\right)$
- (c)  $15\sin\left(38\pi \frac{\pi}{3}\right)$
- (d)  $15\sin\left(38\pi t + \frac{\pi}{6}\right)$



**Forenoon Session** 



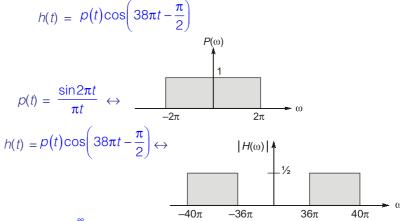
$$x(t) = 2\cos\left(8\pi t + \frac{\pi}{3}\right), \quad \omega_o = 8\pi$$

$$f_s = 15 \text{ Hz}$$

$$x(t) \xrightarrow{\text{sample}} x_s(t) \xrightarrow{h(t)} x_o(t)$$

$$\Rightarrow h(t) = \frac{\sin 2\pi t}{\pi t} \cos\left(38\pi t - \frac{\pi}{2}\right)$$

Let 
$$p(t) = \frac{\sin 2\pi t}{\pi t}$$



After sampling: 
$$X_s(\omega) = f_s \sum_{n=-\infty}^{\infty} X(\omega - n\omega_s)$$

Frequency components present in sampler output  $n\omega_s \pm \omega_o$ 

$$\omega_o$$
,  $\omega_s$  + ±  $\omega_o$ ,  $2\omega_s$  ±  $\omega_o$ , ....

 $8\pi$ ,  $30\pi \pm 8\pi$ ,  $60\pi \pm 8\pi$ , ...

 $8\pi$ ,  $22\pi$ ,  $38\pi$ , 52p,  $68\pi$ , ... (rad/sec)

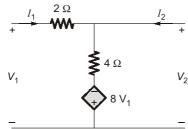
System will pass ' $38\pi$ ' component of input.

$$x_o(t) = 2 \times \frac{f_s}{2} \cos \left[ 38\pi t + \frac{\pi}{3} - \frac{\pi}{2} \right] = 15 \cos \left( 38\pi t - \frac{\pi}{6} \right)$$

**End of Solution** 

#### **NETWORK THEORY**

Q.6 For the 2-port network shown in figure, the parameter  $Y_{21}$  is \_\_\_\_\_\_



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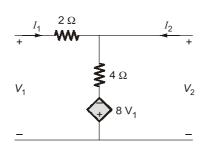
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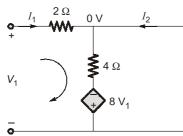
**Forenoon Session** 

Ans. (1.5)

Given two-port network,



$$Y_{21} = \frac{I_2}{V_1} \Big|_{V_2 = 0}$$



by applying KVL in the loop,

$$V_1 - 2I_1 - 4(I_1 + I_2) + 8V_1 = 0$$
  
 $9V_1 - 6I_1 - 4I_2 = 0$ 

but

$$I_1 = \frac{V_1 - 0}{2} \Rightarrow \frac{V_1}{2} = I_1$$

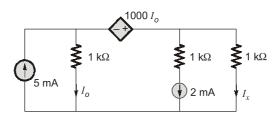
$$\therefore 9V_1 - 6\left(\frac{V_1}{2}\right) - 4I_2 = 0$$

$$6V_1 = 4I_2$$

$$\frac{I_2}{V_c} = \frac{6}{4} = \frac{3}{2} = 1.5 \text{ } \odot$$

**End of Solution** 

Q.7 Calculate the value of  $I_x$  from the circuit shown below.



Ans.

 $V_1$  and  $V_2$  are super node. KCL at  $V_1$  and  $V_2$ .

$$\frac{V_1}{10^3} + \frac{V_2}{1 \times 10^3} + 2 \times 10^{-3} = 5 \times 10^{-3} \tag{1}$$



$$I_0 = \frac{V_1}{10^3}$$

$$V_2 - V_1 = 10^3 I_0 = 10^3 \times \frac{V_1}{10^3} = V_1$$

$$V_2 = 2V_1$$

$$V_1 = \frac{V_2}{2}$$
...(ii)

Put in equation (i)

$$\frac{1}{2}V_2 + V_2 = 3$$

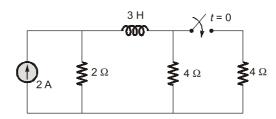
$$V_2 = 2 \text{ V}$$

$$I_x = \frac{V_2}{10^3} = 2 \text{ mA}$$

$$I_x = 2 \text{ mA}$$

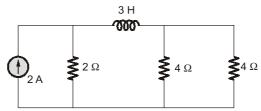
End of Solution

Q.8 For the circuit shown in the figure, the value of time constant  $(\tau)$  is \_\_\_\_\_\_

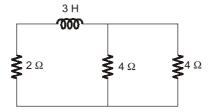


Ans. (0.75)

After the switch closed



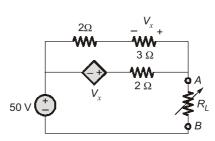
For time constant, current source is open circuit.



$$\tau = \frac{L_{eq}}{R_{eq}} = \frac{3}{2+2} = \frac{3}{4} = 0.75 \text{ sec}$$

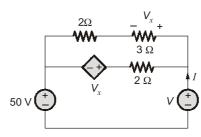


Q.9 Consider the network shown below:



Find  $R_{l}$  such that maximum power absorbed by load is \_\_\_\_\_  $\Omega$ .

Ans. (2.5)



$$I = \frac{V - V_x}{2} + \frac{V}{5} = \frac{V}{2} - \frac{V_x}{2} + \frac{V}{5}$$

$$I = \frac{V}{2} - \frac{1}{2} \times \frac{3V}{5} + \frac{V}{5} = \frac{V}{2} - \frac{3V}{10} + \frac{V}{5}$$

$$I = \frac{5V - 3V + 2V}{10} = \frac{4V}{10}$$

 $V_x = \frac{V}{5} \times 3$ 

$$\frac{V}{I} = \frac{10}{4} = 2.5 \,\Omega$$

End of Solution

#### **ENGINEERING MATHEMATICS**

If  $y(t) = (At + B)e^{-2t}$  is complementary function of differential equation. The differential Q.10 equation then find it.

(a) 
$$\frac{d^2y}{dx^2} + 5\frac{dy}{dx} + 6y = f(t)$$
 (b)  $\frac{d^2y}{dx^2} + 4\frac{dy}{dx} + 4y = f(t)$ 

(b) 
$$\frac{d^2y}{dx^2} + 4\frac{dy}{dx} + 4y = f(t)$$

(c) 
$$\frac{d^2y}{dx^2} - 2\frac{dy}{dx} + 1 = f(t)$$

(c) 
$$\frac{d^2y}{dx^2} - 2\frac{dy}{dx} + 1 = f(t)$$
 (d)  $\frac{d^2y}{dx^2} + 2\frac{dy}{dx} - 1 = f(t)$ 



## GATE 2024 Electronics Engineering

Exam held on: **11-02-2024** 

**Forenoon Session** 

Ans. (b)

CF = 
$$(At + B)e^{-2t} \approx (C_1 + C_2t)e^{-2t}$$

i.e. roots of auxiliary equation are m = -2, -2

So, AE is 
$$(m + 2) (m + 2) = 0$$

$$m^2 + 4m + 4 = 0$$

Replace  $m \to D$  we get,

$$(D^2 + 4D + 4)y = 0$$

i.e. the required different

$$\frac{d^2y}{dx^2} + 4\frac{dy}{dx} + 4y = f(t)$$

**End of Solution** 

Q.11 The value of  $\oint_{|z|=3} \frac{\sin \pi z}{z^2(z-2)} dz$ ?

(a) 
$$-\pi^2 i$$

(b) 
$$2\pi^2 i$$

(c) 
$$-2\pi^2 i$$

(d) 
$$0.5\pi^2 i$$

Ans. (a)

Poles of 
$$f(z)$$
 are  $z = 2$  and  $0$  Double pole

 $R_1$  = Residue of f(z) = at (z = 2)

$$= \lim_{z\to 2} (z-2)f(z) = \lim_{z\to 2} \left(\frac{\sin \pi z}{z^2}\right) = 0$$

 $R_2$  = Residue of f(z) (at(z = 0, m = 2)

$$R_2 = \frac{1}{[2-1]} \left[ \frac{d^{2-1}}{dz^{2-1}} (z-0)^2 f(z) \right]_{z=0}$$

$$\left[\frac{d}{dz} \left[\frac{\sin \pi z}{z - 2}\right]\right]_{z = 0} = \left[\frac{(z - 2)\cos \pi z(\pi) - \sin \pi z}{(z - 2)^2}\right]_{z = 0}$$
$$= \frac{(0 - 2)\cos(2\pi) \cdot \pi - \sin 0}{(0 - 2)^2} = \frac{-2\pi}{4} = \frac{-\pi}{2}$$

By C - R.T,

$$I = \oint_{c} f(z)dz = 2\pi i (R_1 + R_2)$$
$$= 2\pi i \left(0 - \frac{\pi}{2}\right) = -\pi^2 i$$



- **Q.12** Eigen vectors of the matrix  $\begin{bmatrix} 1 & K \\ 2 & 1 \end{bmatrix}$  are
  - (a) x

(b) x

(c) x

(d) x

Ans. (\*)MSQ

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

or 
$$\lambda^2 - 2\lambda + (1 - 2K) = 0$$

$$\lambda = 1 \pm \sqrt{2K}$$

E vector for  $\lambda = 1 \pm \sqrt{2K}$ :

$$AX = \lambda X$$

$$(A - \lambda I)X = 0$$

$$\begin{bmatrix} -\sqrt{2K} & K \\ 2 & -\sqrt{2K} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

$$\Rightarrow \qquad -\sqrt{2K}\,x_1 + K\,x_2 = 0$$

$$x_1 = \sqrt{\frac{K}{2}}x_2$$

$$X = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} \sqrt{K/2} \\ 1 \end{bmatrix} \approx \begin{bmatrix} 1 \\ \sqrt{\frac{2}{K}} \end{bmatrix}$$

Similarly other E vector is

$$X = \begin{bmatrix} -\sqrt{\frac{K}{2}} \\ 1 \end{bmatrix} = \begin{bmatrix} 1 \\ -\sqrt{\frac{2}{K}} \end{bmatrix}$$

End of Solution

- Q.13 The following vectors do not forms basis for any vector space then find a = ? (2-3 a), (3-1 3), (1-5 7)
  - (a) 5

(b) 8

(c) 7

(d) 9

Ans. (a)

: given vectors form basis so there must be L.I and its condition is,

$$|A| \neq 0$$

or

$$\begin{vmatrix} 2 & 3 & 1 \\ -3 & -1 & -5 \\ a & 3 & 7 \end{vmatrix} \neq 0$$



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$$2[-7 + 15] - 3[-21 + 5a] + 1[-9 + a] \neq 0$$
  
 $16 + 63 - 15a - 9 + a \neq 0$   
 $-14a \neq -70$   
 $\Rightarrow \qquad \qquad a \neq 5$ 

End of Solution

Q.14 Consider the equation  $\frac{\partial \rho}{\partial t} + \vec{\nabla} \cdot (\rho \vec{u}) = 0$  where  $\rho$  is scalar function of (x, y, z, t) and  $\vec{u}$  is vector function (x, y, z, t) then which are true?

(a) 
$$\int_{V} \frac{\partial \rho}{\partial t} dV = -\int_{V} \vec{\nabla} \cdot (\rho \vec{u}) dV$$

(b) 
$$\int \frac{\partial \rho}{\partial t} dV = \int_{S} \rho(\vec{u}) \hat{n} dS$$

(c) 
$$\int_{V} \frac{\partial \rho}{\partial t} dV = -\int_{S} \rho \vec{u} \cdot (\hat{n} ds)$$

(d) 
$$\int_{V} \frac{\partial \rho}{\partial t} dV = \int_{S} \vec{\nabla} \cdot (\rho \vec{u}) ds$$

Ans. (c)

Option (a) is obviously true by given statement Now using Gauss Divergence theorem in RHS of (a) i.e

$$\int_{V} \frac{\partial P}{\partial t} dV = -\int_{V} \vec{\nabla} \cdot (\rho \vec{u}) dV = -\int_{S} (\rho \vec{u}) \cdot d\vec{s} = -\int_{S} (\rho \vec{u}) \cdot \hat{n} d\vec{s}$$

Hence option (c) is correct.

End of Solution

### **ELECTRONIC DEVICES AND CIRCUITS**

Q.15 In a solar cell, voltage corresponds to maximum voltage point is 0.3 V. The photocurrent is 1 mA. The thermal voltage is 30 mV. then find the reverse saturation current \_\_\_\_ (nA).

Ans. (45.3)

$$\begin{aligned} &V_{oc} = 0.3 \text{ V} \\ &I_{ph} = I_{sc} = 1 \text{ mA} \\ &V_{th} = 30 \text{ mV} \end{aligned}$$
 
$$V_{OC} = V_{th} \ln \left( 1 + \frac{I_{sc}}{I_s} \right)$$
 
$$V_{OC} \simeq V_{th} \ln \left( \frac{I_{sc}}{I_s} \right)$$

$$e^{\frac{V_{OC}}{V_{th}}} = \frac{I_{sc}}{I_{s}}$$

$$e^{\frac{0.3}{30\times 10^{-3}}} = \frac{10^{-3}}{I_{s}}$$

$$I_{s} = 45.30 \text{ nA}$$

**End of Solution** 

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**Forenoon Session** 

Q.16 P-substrate MOS capacitor with  $t_{ox}$  (oxide thickness) = 100 nm and  $Q_{OX}$  (oxide charge) = 10<sup>-8</sup> C/cm² Work function energy of metal  $q\phi_m$  = 4.6 eV,  $\epsilon_{ox}$  = 4 $\epsilon_0$ ,  $\epsilon_0$  = 8.85 × 10<sup>-14</sup> F/cm. If flat band voltage is zero then work function energy of semiconductor is \_\_\_\_\_eV.

Ans. (4.32)

$$C_{ox} = \frac{\varepsilon_{ox}}{t_{ox}} = \frac{4 \times 8.85 \times 10^{-14}}{100 \times 10^{-9} \times 100}$$

$$= 4 \times 8.85 \times 10^{-14} \times 10^{5} = 35.4 \times 10^{-9} \text{ F/cm}^{2}$$

$$V_{FB} = \frac{Q_{ox}}{C_{ox}} + \phi_{ms}$$

$$0 = \frac{Q_{ox}}{C_{ox}} + \phi_{ms}$$

$$\frac{Q_{ox}}{C_{ox}} = \frac{10^{-8}}{35.4 \times 10^{-9}} = \frac{10}{35.4} \text{ volt}$$

 $Q_{ox} \rightarrow Positive$ 

$$\therefore \quad \frac{Q_{ox}}{C_{ox}} \to \text{Negative}$$

$$0 = \frac{-10}{35.4} + \phi_{ms}$$

$$\phi_{ms} = \frac{10}{35.4}$$

$$\phi_{m} - \phi_{s} = \frac{10}{35.4}$$

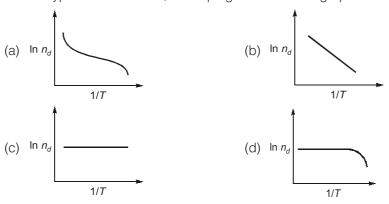
$$\phi_{s} = \phi_{m} - \frac{10}{35.4} = 4.6 - \frac{10}{35.4} = 4.317 \text{ volt}$$

$$q\phi_{s} = 4.317 \approx 4.32 \text{ eV}$$

Work function energy of semiconductor.

**End of Solution** 

For a n-type semiconductor, the doping concentration graph with temperature is given as

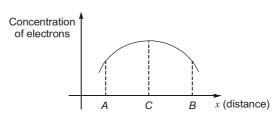


Ans. (a)



**Forenoon Session** 

Q.18 In a semiconductor the concentration graph with the distance *x* is given then which of the following option(s) is/are correct?



- (a) In between B and C, the diffusion current is from C to B.
- (b) In between B and C, the diffusion current is from B to C.
- (c) In between A and C, the drift current is from A to C.
- (d) In between A and C, the electric field is from C to A.

Ans. (b, d)

**End of Solution** 

- Q.19 Which of the following option(s) is/are correct?
  - (a) In low level injection the  $\beta$  decreases with increases collector current.
  - (b) In high level injection the  $\beta$  decreases with increases collector current.
  - (c)  $\beta$  in saturation region is less than in active region.
  - (d)  $\beta$  decreases with increases breakdown collector emitter voltage.

Ans. (b, c)

End of Solution

Q.20 MOS is in linear region with operating point  $I_{DS} = 5~\mu\text{A}$  and  $V_{DS} = 0.1~\text{volt}$ ,  $\mu_n C_{ox} \frac{W}{L} = 50~\mu\text{A/V}^2$ . when  $V_{GS} = \text{constant}$  and  $V_{DS} = 1.5~\text{V}$ , then find it's transconductance at operating point \_\_\_\_\_  $\mu\text{A/V}$ .

Ans. (52.5)
For linear region of MOS,

$$I_D = \mu_n C_{ox} \left(\frac{W}{L}\right) \left[ (V_{GS} - V_T)V_{DS} - \frac{1}{2}V_{DS}^2 \right]$$

$$5 \times 10^{-6} = 50 \times 10^{-6} \left[ (V_{GS} - V_T)0.1 - \frac{1}{2}(0.1)^2 \right]$$

$$\frac{1}{10} = (V_{GS} - V_T)0.1 - \frac{1}{2} \times 0.1^2$$

$$0.1 + 0.5(0.1)^2 = (V_{GS} - V_T)0.1$$

$$1 + 0.5(0.1) = (V_{GS} - V_T)$$

$$1.05 \text{ volt} = V_{GS} - V_T$$

Now:  $V_{GS} \rightarrow \text{fix}$ 



### **GATE 2024** Electronics Engineering

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**Forenoon Session** 

$$g_{m \text{ (sat)}} = \mu_n C_{ox} \left(\frac{W}{L}\right) (V_{GS} - V_T)$$
  
= 50 × 10<sup>-6</sup> × 1.05  
= 52.5 × 10<sup>-6</sup> A/V = 52.5  $\mu$ A/V

**End of Solution** 

### **ELECTROMAGNETICS**

 $\overline{E} = A_v e^{-j\frac{2\pi}{3}x} \hat{a}_v$  is travelling in air in +ve x direction is incident on perfect conductor Q.21 normally at x = 0. Value of x where magnetic field is zero for first time.

(a) 
$$-\frac{3}{2}$$

(b) 
$$-\frac{3}{4}$$

$$(c) - 6$$

(d) 
$$-2.5$$

Ans. (b)

At perfect conductor,

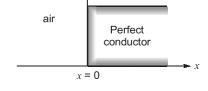
$$\Gamma = -1$$

$$\Rightarrow$$

$$\Gamma = 1 | \underline{\pi}$$

As we know that  $H_{\min}$  occurs at  $E_{\max}$ . Hence,

 $E_{\text{max}} = E_0[1 + |\Gamma|]$ 



$$H_{\min} = \frac{E_0}{\eta} [1 + |\Gamma|]$$
 at  $2\beta x_{\max} = 2n\pi + \theta_{\Gamma}$ 

$$2\beta x_{\text{max}} = 2n\pi + \theta_{\Gamma}$$

$$\Rightarrow$$

$$\frac{4\pi}{\lambda}x_{\text{max}} = 2n\pi + \pi$$

$$\Rightarrow$$

$$x_{\text{max}} = (2n+1)\frac{\lambda}{4}$$
;  $n = 0, 1, 2, 3...$ 

So, for  $1^{st}$  value of x for H-field to be zero is

$$x_{\text{max}} = \frac{\lambda}{4}$$
 [at  $n = 0$ ]

Now, from the equation given,

$$\beta = \frac{2\pi}{3}$$

$$\Rightarrow$$

$$\frac{2\pi}{\lambda} = \frac{2\pi}{3}$$

$$\Rightarrow$$

$$\lambda = 3$$

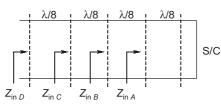
$$x_{\text{max}} = \frac{3}{4}$$

If the reference is not at interference then  $x = -\frac{3}{4}$ .



**Forenoon Session** 

The load impedance is short circuited.



Normalised impedance

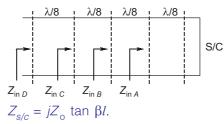
$$\overline{Z}_{\text{in }A}, \overline{Z}_{\text{in }B}, \overline{Z}_{\text{in }C}, \overline{Z}_{\text{in }D}$$
?

(b) 
$$0.4i \infty -0.4i$$

(c) 
$$\infty$$
 1j 0  $-1j$ 

(d) 
$$\infty$$
 0.4*j* 0 -0.4*j*

Ans. (a)



Normalized impedance,

$$\begin{split} & \bar{Z}_{S/C} = \frac{Z_{S/C}}{Z_0} = j \tan \beta I \\ & \bar{Z}_{\text{in }A} = j \tan \left( \frac{2\pi}{\lambda} \cdot \frac{\lambda}{8} \right) = j \tan \left( \pi/4 \right) = j1. \\ & \bar{Z}_{\text{in }B} = j \tan \left( \frac{2\pi}{\lambda} \cdot \frac{\lambda}{4} \right) = \infty \\ & \bar{Z}_{\text{in }C} = j \tan \left( \frac{2\pi}{\lambda} \cdot \frac{3\lambda}{8} \right) = -j1 \\ & \bar{Z}_{\text{in }D} = j \tan \left( \frac{2\pi}{\lambda} \cdot \frac{\lambda}{2} \right) = 0 \end{split}$$

Q.23 A lossless transmission line,  $Z_0$  = 50  $\Omega$  terminated with unknown load.

$$|\Gamma| = 0.6$$

As one moves towards generator from the load, max. value of input impedance magnitude looking towards the load is  $\_\_\_$   $\Omega$ .



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Ans. (200)

As we know that

$$Z_{\text{max}} = SZ_0$$

Now,

$$S = \frac{1+|\Gamma|}{1-|\Gamma|} = \frac{1+0.6}{1-0.6} = \frac{1.6}{0.4} = 4$$

*:*.

$$Z_{\text{max}} = 4 \times 50 = 200 \ \Omega.$$

**End of Solution** 

Q.24 For the given,

 $\vec{F}_1 = A(y\hat{i} + x\hat{j})$  and  $\vec{F}_2 = A(y\hat{i} - x\hat{j})$ , then which is electrostatic field?

- (a) Both  $\vec{F}_1$  and  $\vec{F}_2$
- (b)  $\vec{F}_1$  is electrostatic not  $\vec{F}_2$
- (c)  $\vec{F}_1$  is not and  $\vec{F}_2$  is electrostatic
- (d) Neither  $\vec{F}_1$  nor  $\vec{F}_2$

Ans. (b)

For an electrostatic field,  $\nabla \times \overline{F} = 0$ 

$$\overline{F}_1 = A \left[ y \hat{i} + x \hat{j} \right]$$

$$\Rightarrow$$

$$\Delta \times \overline{F}_{1} = A \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ y & x & 0 \end{vmatrix}$$
$$= A \left[ 0\hat{i} - 0\hat{j} + (1 - 1)\hat{k} \right]$$

$$\overline{F}_2 = A \left[ y \hat{i} - x \hat{j} \right]$$

$$\Rightarrow$$

$$\Delta \times \overline{F}_{2} = A \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ y & -x & 0 \end{vmatrix}$$
$$= A \Big[ 0\hat{i} - 0\hat{j} + (-1 - 1)\hat{k} \Big]$$

$$= -2A\hat{k}$$

Hence,  $\overline{F}_1$  is electrostatic,  $\overline{F}_2$  is not electrostatic (b)



### **DIGITAL CIRCUITS**

**Q.25** F =  $\Sigma m(0.2, 5, 7, 8, 10, 12, 13, 14, 15)$ , then Essential prime implicants are

(a)  $BD, \overline{B}\overline{D}$ 

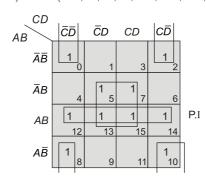
(b)  $AB.\overline{B}\overline{D}$ 

(c) BD, AB

(d)  $BD, \overline{B}\overline{D}, AB$ 

Ans. (a)

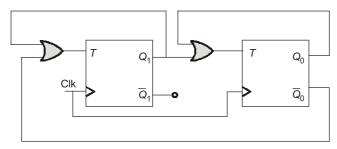
 $f(A, B, C, D) = \Sigma m(0.2, 5, 7, 8, 10, 12, 13, 14, 15)$ 



*BD* <u>B</u>D E.P.I

End of Solution

Q.26 Consider the sequential circuit:



The sequence of  $Q_1Q_0$  is

(a) 
$$11 \to 00 \to 10 \to 01$$

(b) 
$$00 \to 10 \to 01 \to 00$$

(c) 
$$00 \to 01 \to 10 \to 00$$

(d) 
$$01 \to 10 \to 11 \to 01$$

Ans. (b)

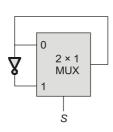
$$\begin{array}{c|ccccc}
 & Q_1 + \overline{Q}_0 & Q_1 + Q_0 \\
\hline
 & Clk & T_1 & T_0 & Q_1 & Q_0 \\
\hline
 & & & & 0 & 0 \\
\hline
 & 1 & 0 & 1 & 0 \\
 & 1 & 1 & 0 & 1 \\
\hline
 & 0 & 1 & 0 & 0
\end{array}$$

 $00 \rightarrow 10 \rightarrow 01 \rightarrow 00$ 



**Forenoon Session** 

Q.27 Given MUX delay -10 ns

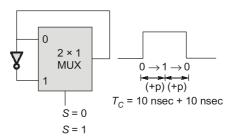


If S is select 1 then Y is

- (a) constant 1
- (c) 50 MHz

- (b) 100 MHz
- (d) Zero

(c) Ans.



For S = 1,

$$T_C = 20 \text{ nsec}$$

$$f_c = \frac{1}{20} \times 10^9 = 0.05 \times 10^6 \times 10^3 = 50 \text{ MHz}$$

**End of Solution** 

### **CONTROL SYSTEMS**

Q.28 40 dB/dec is similar to

(a) 12 dB/oct

(b) 6 dB/oct

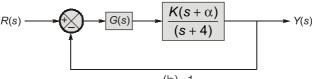
(c) 10 dB/oct

(d) 5 dB/oct

Ans. (a)

$$20 \times \text{ndB/decade} = 6 \times \text{n dB/octave}$$
  
 $40\text{dB/decade} = 12 \text{dB/octave}$ 

For the system shown below, where input  $R(s) = \frac{1}{s^2}$ , for poles are present at  $-1 \pm j\sqrt{3}$ , Q.29 then find the value of  $\alpha$ .



(a) 0

(b) 1

(c) 2

(d) 3



**Forenoon Session** 

Ans. (b)

G(S)C(s) = 
$$\frac{1}{S^2} \frac{k(S+\alpha)}{(S+4)}$$

Characteristic equation is

$$S^3 + 4S^2 + kS + \alpha = 0$$
 ...(I)

Poles of the system present at =  $-1 \pm i\sqrt{3}$ 

Characteristic equation is

$$(S + a)[(S + 1)^{2} + 3] = 0$$

$$(S + a)(S^{2} + 2S + 4) = 0$$

$$S^{3} + (2 + a)S^{2} + (4 + 2a)S + 4a = 0$$

Compare equation (I) and (II)

on (i) and (ii)  

$$2 + a = 4$$

$$a = 2$$

$$4 + 2a = k$$

$$k = 8$$

$$k\alpha = 4a$$

$$\alpha = \frac{8}{8} = 1$$

 $\alpha = 1$ 

End of Solution

...(11)

Q.30 Consider the feedback control system shown below:



where

$$G(s) = \frac{6}{s(s+1)(s+2)}$$

If r(t) = u(t), then e(t) is equal to

(a) 
$$\lim_{t \to \infty} e(t) = \frac{1}{3}$$

(b) 
$$\lim_{t\to\infty} e(t) = 0$$

(c) 
$$\lim_{t \to \infty} e(t) = \frac{1}{4}$$

(d) Not exist because e(t) is oscillatory.

Ans. (d)

Given system is





$$G(s) = \frac{6}{s(s+1)(s+2)}$$

The characteristic equation,

$$1 + G(s) = 0$$

$$1 + \frac{6}{s(s+1)(s+2)} = 0$$

$$s(s + 1) (s + 2) + 6 = 0$$
  
 $s^3 + 3s^2 + 2s + 6 = 0$ 

Clearly, here the internal coefficient product is equal to external coefficient product i.e.,

$$3 \times 2 = 6 \times 1$$

Hence, the given system is marginally stable system.

 $\therefore$  e(t) not exist because system is oscillatory system.

**End of Solution** 

Q.31 Consider the state space representation of a system,

$$\dot{x}(t) = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} U(t)$$

$$y(t) = \begin{bmatrix} -2 & -5 \end{bmatrix} x(t)$$

Find transfer function of the system.

(\*)MSQ Ans.

Transfer function  $T(s) = C[SI - A]^{-1}B + D$ 

$$A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}, \quad B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

$$C = \begin{bmatrix} -2 & -5 \end{bmatrix}; \quad [SI - A] = \begin{bmatrix} S & -1 \\ 2 & S+3 \end{bmatrix}$$

$$[SI - A]^{-1} = \frac{1}{S^2 + 3S + 2} \begin{bmatrix} S+3 & 1 \\ -2 & S \end{bmatrix} = \begin{bmatrix} \frac{S+3}{S^2 + 3S + 2} & \frac{1}{S^2 + 3S + 2} \\ \frac{-2}{S^2 + 3S + 2} & \frac{S}{S^2 + 3S + 2} \end{bmatrix}$$

$$[S1 - A]^{-1}B = \begin{bmatrix} \frac{1}{S^2 + 3S + 2} \\ \frac{S}{S2 + 3S + 2} \end{bmatrix}$$

C[SI - A]<sup>-1</sup>B = 
$$\begin{bmatrix} -2 - 5 \end{bmatrix}$$
  $\begin{bmatrix} \frac{1}{S^2 + 3S + 2} \\ \frac{S}{S^2 + 3S + 2} \end{bmatrix}$ 



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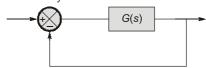


**Forenoon Session** 

$$T(s) = \frac{-2 - 5s}{S^2 + 3S + 2} = \frac{-(5S + 2)}{S^2 + 3S + 2}$$
$$T(s) = \frac{-(5S + 2)}{S^2 + 3S + 2}$$

End of Solution

Q.32 Consider the unity feedback system shown below:



where.

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

Find K so that at impulse response of closed loop system decays faster than  $e^{-t}$ .

(a) 
$$-24 \le K \le -6$$

(b) 
$$-4 \le K \le -1$$

(c) 
$$7 \le K \le 21$$

(d) 
$$1 \le K \le 5$$

Ans. (d)

Given, 
$$G(s) = \frac{K}{(S+1)(S+2)(S+3)}$$

Impulse response of system is

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

Given: At impulse response of closed loop system decay faster than  $e^{-t}$ Hence, put s = s - 1,

.. The new characteristic equation is,

$$(s-1+1)(s-1+2)(s-1+3)+K=0$$
  
 $s(s+1)(s+2)+K=0$   
 $s^3+3s^2+2s+K=0$ 

By RH criterion,

$$\begin{vmatrix} s^3 & 1 & 2 \\ s^2 & 3 & K \\ s^1 & \frac{6-K}{3} & \\ s^0 & K \end{vmatrix}$$

$$\therefore K > 0; \qquad \frac{6-K}{3} > 0 \Rightarrow K < 6$$

$$\therefore \qquad 0 < K < 6$$

Hence, option (d) satisfies above range of K.



**Forenoon Session** 

#### **COMPUTER ORGANIZATION**

Q.33 For a machine supporting 32 bit micro instructions. It supports 26 registers and 40 bit instruction length. The instruction supported by the machine having 5 instructions sets containing 3 registers field, one opcode field and one is for data then the maximum unsigned value of data is \_\_\_\_

Ans. (1048575)

Total instruction length → 40 bits

32 bit microinstruction, hence opcode length in 5 bits

$$2^n = 32 = 2^5$$

n = 5 bits

Total Registers = 26

Each register field would be  $2^n = 26$ 

$$n = \log_2(26)$$

*:*.

 $n \approx 5$  bits

Number of fields in the instruction  $\rightarrow$  5

opcode field  $\rightarrow$  1 i.e., 5 bits

3 register fields  $\rightarrow$  i.e., 3 (5 bits) = 15 bits

Immediate data field  $\rightarrow$  1; i.e., x bits

:. Number of bits for immediate field = Total - (5 + 15)

$$= 40 - 20 = 20$$
 bits

 $\therefore$  The range of immediate data operand = 0 to  $2^n - 1$ 

Here n = 20.

Hence maximum unsigned value =  $2^{20} - 1 = (1048575)_{10}$ 

**End of Solution** 

#### **COMMUNICATION SYSTEMS**

Q.34 A source r is transmitting 3 symbols {-4, 0, 4} with equal probabilities over a Gaussian channel having 0 mean and variance 4. The optimum probability of error is :

(where 
$$Q(x) = \frac{1}{\sqrt{2\pi}} \int_{x}^{\infty} e^{-t^2/2} dt$$

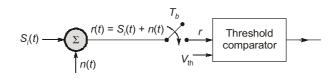
(a) 
$$\frac{2}{3}Q(2)$$

(b) 
$$\frac{4}{3}Q(1)$$

(c) 
$$\frac{2}{3}Q(1)$$

(d) 
$$\frac{4}{3}Q(2)$$

Ans. (b)



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$$f_N(n) = \frac{1}{\sqrt{2\pi}}e^{\frac{-n^2}{2\times 4}} = N(0, 4)$$

transmission of  $-4 \rightarrow r = -4 + n$ 

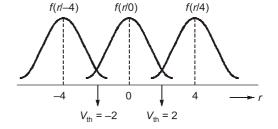
$$f(r/-4) = \frac{1}{\sqrt{2\pi}}e^{\frac{-(r+4)^2}{2\times 4}}$$

transmission of  $0 \rightarrow r = n$ 

$$f(r/0) = \frac{1}{\sqrt{2\pi}} e^{-\frac{r^2}{2\times 4}}$$

transmission of  $4 \rightarrow r = 4 + n$ 

$$f(r/4) = \frac{1}{\sqrt{2\pi}} e^{\frac{-(r-4)^2}{2\times 4}}$$



$$P_e = P(-4) P_{e-4} + P(0) P_{e0} + P(4) P_{e4}$$

Given

$$P(-4) = P(0) = P(4) = \frac{1}{3}$$

$$\begin{split} P_{e-4} &= P(r > -2) \\ &= 1 - (1 - F_r(2)) \\ &= 1 - \left(1 - Q\left(\frac{-2 + 4}{2}\right)\right) \\ &= Q(1) \\ P_{e0} &= P(r < -2) + P(r > 2) \\ &= F_r(-2) + \{1 - F_r(2)\} \\ &= \left(1 - Q\left(\frac{-2 - 0}{2}\right)\right) + Q\left(\frac{2 - 0}{2}\right) \\ &= [1 - Q(-1)] + Q(1) = 2Q(1) \\ P_{e4} &= P(r < 2) \\ &= F_r(2) \\ &= 1 - Q\left(\frac{2 - 4}{2}\right) \\ &= 1 - Q(-1) \\ &= Q(1) \\ P_{e} &= \frac{1}{3}Q(1) + \frac{2}{3}Q(1) + \frac{1}{3}Q(1) \\ &= \frac{4}{3}Q(1) \end{split}$$



**Forenoon Session** 

Q.35 For the given amplitude modulated signal

$$X_{AM}(t) = A\cos 400\pi t + B\cos 360\pi t + B\cos 440\pi t$$

Ratio of side band to total power = 
$$\frac{1}{9}$$

Then find the value of B = ?

Ans. (2.5)

$$P_{C} = \frac{A^{2}}{2} = 50$$

$$A = 10$$

$$\frac{P_{SB}}{P_{t}} = \frac{\mu^{2}}{2 + \mu^{2}} = \frac{1}{9}$$

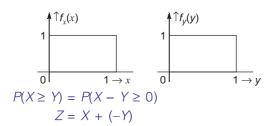
$$\mu = \frac{1}{2}$$

$$B = \frac{A_{c}\mu}{2} = \frac{10}{2} \times \frac{1}{2} = 2.5$$

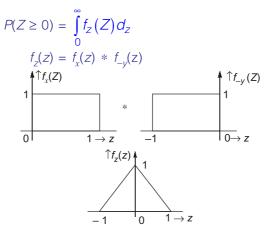
**End of Solution** 

Q.36 Suppose X and Y are two identically independent uncorrelated random variables distributed uniformly in [0, 1]. Then the probability that  $(X \ge Y) = \underline{\hspace{1cm}}$ 

Ans. (0.5)



Let



 $P(Z \ge 0) = \frac{1}{2}$ 



A source transmits symbols from an alphabet of size 16. The value of maximum Q.37 achievable entropy (in bits) is\_\_\_\_\_.

Ans. (4)

$$H_{\text{max}} = \log_2 16 = 4$$

**End of Solution** 

A white Gaussian W(t) with zero mean and PSD =  $\frac{N_o}{2}$ , when applied to a 1<sup>st</sup> order RC Q.38

LPF produces on output n(t). At a particular time  $t = t_k$ , the variance of the RV  $n(t_k)$  is

(b)  $\frac{N_o}{4BC}$ 

(c)  $\frac{N_o}{RC}$ 

(d) None of these

Ans. (b)

White noise 
$$W(t)$$
 RC  $E[W(t)] = 0$  RC  $n(t)$ 

$$E[n(t)] = E[W(t)] \cdot H(0)$$

$$E[n(t)] = 0$$

$$E[n^2(t)] = \{E(n(t))^2 + \text{var}[n(t)]$$

$$var[n(t)] = E[n^2(t)]$$

at  $t = t_k$ 

$$var[n(t)]|_{t=t_k} = E[n^2(t_k)] = E[n(t_k) \cdot n(t_k)] = R_n(0)$$

$$S_n(t) = S_N(t) \cdot |H(t)|^2$$

$$= \frac{N_0}{2} \cdot \frac{1}{1 + (\omega RC)^2}$$

$$R_n(\tau) = IFT[S_n(f)] = \frac{N_0}{4RC} \cdot e^{\frac{-|\tau|}{RC}}$$

$$R_n(0) = \frac{N_0}{4RC}$$

**End of Solution** 

Q.39 Random process signal

$$x(t) = A \cos (2\pi f_0 t + \theta)$$

A &  $\theta \rightarrow$  Independently in random process

 $A \rightarrow Uniformly distributed [-2, 2]$ 

 $\theta \rightarrow \text{Uniformly distributed } [0, 2\pi]$ 

$$R_{x}(t) = \frac{2}{3}\cos 2\pi f_{o}\tau$$

x(t) is 8 bits mid rise quantizer, then SNR = \_\_\_\_\_. (in dB)

Page



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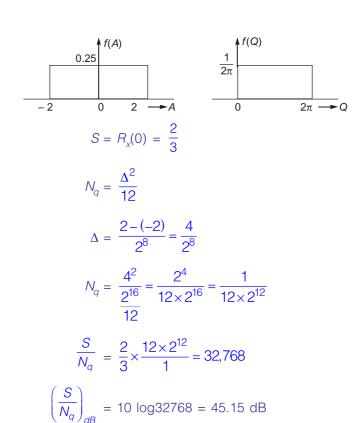


## GATE 2024 Electronics Engineering

Exam held on: **11-02-2024** 

**Forenoon Session** 

Ans. (45.15)



End of Solution

Q.40 A digital communication system transmits through a noiseless bandlimited channel [-w, w]. The received signal z(t) at output of receiving filter is given by y(t) = t

 $\sum_{n} b(n)x(t-nT)$  where, b(n) are the symbols and x(t) is the overall system response to single symbol the received signal at t = mT the Fourier transform x(t) is X(t), the Nyquist condition that X(t) must satisfy for zero inter symbol interference at the receiver is

(a) 
$$\sum_{m=-\infty}^{\infty} X\left(f + \frac{m}{T}\right) = \frac{1}{T}$$

(b) 
$$\sum_{m=-\infty}^{\infty} X(f+mT) = \frac{1}{T}$$

(c) 
$$\sum_{m=-\infty}^{\infty} X\left(f + \frac{m}{T}\right) = T$$

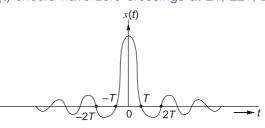
(d) 
$$\sum_{m=-\infty}^{\infty} X(f+mT) = T$$

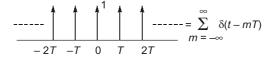


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Ans. (c)

For zero ISI, x(t) should have zero crossings at  $\pm T$ ,  $\pm 2T$ ,  $\pm 3T$ ....





$$x(t) \sum_{m = -\infty}^{\infty} \delta(t - mT) = x(0)\delta(t)$$

$$\frac{1}{T} \sum_{m=-\infty}^{\infty} X \left( f - \frac{m}{T} \right) = x(0)$$

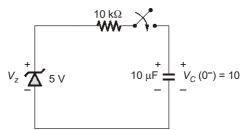
$$\sum_{m=-\infty}^{\infty} X \left( f - \frac{m}{T} \right) = x(0)T$$

(or) 
$$\sum_{m=-\infty}^{\infty} X \left( f + \frac{m}{T} \right) = x(0)T$$

**End of Solution** 

### **ANALOG CIRCUITS**

Q.41 For the circuit shown below:



Power dissipation in zener diode is \_\_\_\_\_ mW.

Ans. (2.5)

$$I = \frac{10-5}{10k} = 0.5 \text{ mA}$$



**Forenoon Session** 

Maximum power dissipation in zener diode is

$$P_D = V_z \times I_{\text{max}}$$
  
= 5 × 0.5  
= 2.5 m Watt  
 $P_D = 2.5$  m Watt

End of Solution

For the NMOS operating in the linear region having operating point  $I_{DS}$  = 5  $\mu$ A and Q.42  $V_{DS} = 0.1 \text{ V}$  and  $\mu_n C_{ox} \text{ W/L} = 50 \text{ } \mu\text{A/V}^2$ . For  $V_{GS}$  being constant and  $V_{DS} = 1.5 \text{ V}$ , then transconductance at operating point is  $\_\_\_$   $\mu\text{A/V}$ .

Ans. (52.5)

$$I_{DS} = \mu_{n}C_{Ox} \frac{W}{L} \left[ (V_{GS} - V_{TH})V_{DS} - \frac{V_{DS}^{2}}{2} \right]$$

$$V_{GS} - V_{TH} = 1.05 \text{ V}$$

$$V_{DS} = 1.5 \text{ V} > V_{GS} - V_{TH} \rightarrow \text{Saturation region}$$

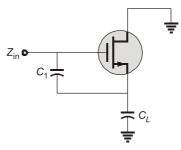
$$g_{m} = \mu_{n}C_{Ox} \frac{W}{L} (V_{GS} - V_{Th})$$

$$= 50 \times \frac{\mu A}{2} \times 1.05$$

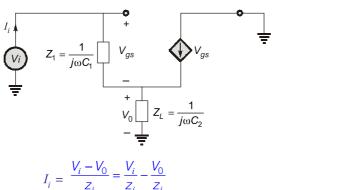
$$= 52.5 \mu \text{A/V}$$

End of Solution

Q.43 For the given MOSFET circuit shown in figure find the input impedance as shown in the figure.



Ans. (\*)



...(1)



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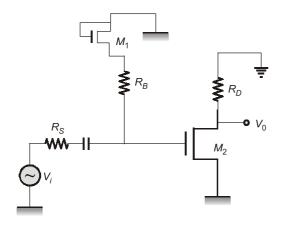
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$$\begin{split} V_{0} &= \left(I_{i} + g_{m}V_{gs}\right)z_{L} \\ V_{0} &= I_{i}Z_{L} + g_{m}V_{gS}Z_{L} \\ V_{0} &= I_{i}\left(Z_{L} + g_{m}Z_{1}Z_{L}\right) \\ I_{i} &= \frac{V_{1}^{i}}{Z_{1}} - \frac{I_{i}\left(Z_{L} + g_{m}Z_{1}Z_{L}\right)}{Z_{1}} \\ I_{i} &= \frac{V_{L}^{i}}{Z_{1}} &= \frac{V_{L}^{i}}{Z_{1}} \\ \frac{V_{L}^{i}}{Z_{1}} &= Z_{1} + Z_{L} + g_{m}Z_{1}Z_{L} \\ Z_{in} &= \frac{1}{j\omega C_{1}} + \frac{1}{j\omega C_{L}} - \frac{g_{m}}{\omega^{2}C_{1}C_{L}} \end{split}$$

**End of Solution** 

Q.44 Find  $\frac{V_0}{V_{in}} =$ \_\_\_\_\_\_. (Assume channel length is negligible)

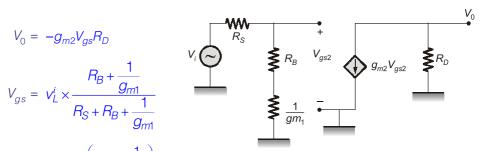


Ans. ()

$$V_{0} = -g_{m2}V_{gs}R_{D}$$

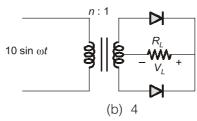
$$V_{gs} = v_{L}^{i} \times \frac{R_{B} + \frac{1}{g_{m1}}}{R_{S} + R_{B} + \frac{1}{g_{m1}}}$$

$$\left| \frac{V_0}{V_{in}} \right| = \frac{g_{m2} R_D \left( R_B + \frac{1}{g_{m1}} \right)}{R_S + R_B + \frac{1}{g_{m1}}}$$





Q.45 For a center tapped full wave rectifier having both the diodes are idea. Then the value of 'n' is, if the input voltage is 10 sin  $\omega t$  and the average voltage across  $R_L$  is  $\frac{2.5}{\pi}$  volt.



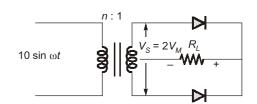
- (a) 8
- (c) 2

٠.

(d) 16

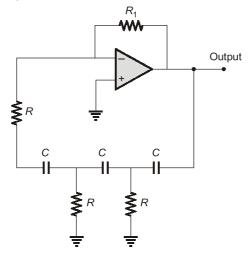
Ans. (b)

Given,  $V_{DC} = \frac{2V_M}{\pi} = \frac{2.5}{\pi}$   $V_M = \frac{2.5}{2}$   $2V_M = V_S = 2.5 \text{ V}$   $n: 1 = \frac{V_P}{V_S}: 1$   $= \frac{10}{2.5}: 1$ 



End of Solution

Q.6 For the given op-amp circuit shown below:



The frequency of oscillation and the relationship between  $R_1$  and R is \_\_\_\_\_.

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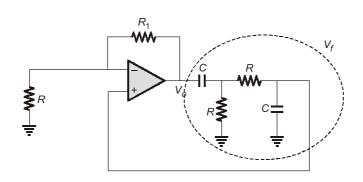












$$\beta = \frac{V_f}{V_o} = \frac{1}{3 + j \left(\omega RC - \frac{1}{\omega RC}\right)}$$

For sustained frequency of oscillaton,

$$\omega RC - \frac{1}{\omega RC} = 0$$

$$\omega_o = \frac{1}{RC} \text{ or } f_o = \frac{1}{2\pi RC}$$

$$\beta = \frac{1}{3} ; \quad A = 3$$

$$1 + \frac{R_1}{R} = 3$$

$$\frac{R_1}{R} = 2$$

$$R_1 = 2R$$