ESE-2021
(MAINS)

QUESTIONS WITH DETAILED SOLUTIONS

ELECTRONICS & TELECOMMUNICATION ENGINEERING

PAPER-II

ACE Engineering Academy has taken utmost care in preparing the ESE-2021 MAINS Examination solutions. Discrepancies, if any, may please be brought to our notice. ACE Engineering Academy do not owe any responsibility for any damage or loss to any person on account of error or omission in these solutions. ACE Engineering Academy is always in the fore front of serving the students, irrespective of the examination type (GATE/ESE/PSUs/PSC/GENCO/TRANSCO etc.,).

All Queries related to ESE - 2021 MAINS Solutions are to be sent to the following email address hyderabad@aceenggacademy.com
Contact Us : 040-23234418,19,20

ELECTRONICS & TELECOMMUNICATION ENGINEERING

ESE_MAINS_2021_PAPER – II

Questions with Detailed Solutions

SUBJECT WISE WEIGHTAGE

S.No	NAME OF THE SUBJECT	Marks
01	COMMUNICATION SYSTEMS	110
02	(a) CONTROL SYSTEMS (b) SIGNALS & SYSTEMS	70 + 30
03	COMPUTER ORGANIZATION AND ARCHITECTURE	90
04	ELECTROMAGNETICS	70
05	ADVANCED ELECTRONICS	60
06	ADVANCED COMMUNICATIONS	50

SECTION - A

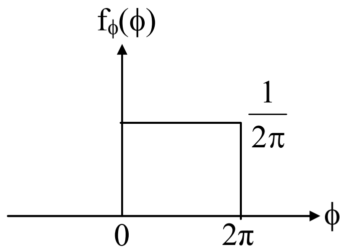
01. (a) Prove that the random process x (t, ϕ) = $\frac{\sqrt{E}}{2T}\cos(\omega_0 t+\phi)$ is ergodic, where E, T and ω_0 are constants, and ϕ is random and UDF (0, 2π). **(10 M)**

Sol: $x(t,\phi)=\frac{\sqrt{E}}{2T}\cos(\omega_0 t+\phi)$

For a random process if ensemble averages are equals to time averages, then it is called as ergodic random process.

Ensemble averages:-

(i) Mean = $M_1(t)=\int_{-\infty}^{\infty}x(t,\phi)f_\phi(\phi)d\phi$



$$=\int_0^{2\pi}\frac{\sqrt{E}}{2T}\cos(\omega_0 t+\phi).\frac{1}{2\pi}d\phi$$

$$=\frac{\sqrt{E}}{4\pi T}\left[\sin(\omega_0 t+\phi)\right]_0^{2\pi}$$

$$=\frac{\sqrt{E}}{4\pi T}\left[\sin(\omega_0 t)-\sin(\omega_0 t)\right]=0$$

$M_1(t) = 0$

(ii) MSQ [x(t, ϕ)] = $E\left[x^2(t,\phi)\right]=\int_0^{2\pi}\frac{E}{4T^2}\cos^2(\omega_0 t+\phi)\frac{1}{2\pi}d\phi$

$$=\frac{E}{8\pi T^2}\int_0^{2\pi}\left\{\frac{1+\cos(2\omega_0 t+2\phi)}{2}\right\}d\phi$$

$$= \frac{E}{16\pi T^2}[2\pi + 0]$$

$$\text{MSQ}[x(t,\phi)] = \frac{E}{8T^2}$$

(iii) Variance = MSQ[$x(t,\phi)$] – $M_1(t)^2$

$$\sigma^2 = \frac{E}{8T^2}$$

Time averages :-

(a) Mean :

$$< x(t,\phi) >= \frac{1}{t_2 - t_1}\int_{t_1}^{t_2} x(t,\phi)dt$$

$$= \frac{1}{T}\int_{-T/2}^{T/2} \frac{\sqrt{E}}{2T}\cos(\omega_0 t + \phi)dt$$

$$= 0$$

(b) Mean square value

$$< x^2(t,\phi) >= \frac{1}{T}\int_{-T/2}^{T/2} \frac{E}{4T^2}\cos^2(\omega_0 t + \phi)dt$$

$$= \frac{E}{4T^3}\int_{-T/2}^{T/2}\left[\frac{1 + \cos(2\omega_0 t + 2\phi)}{2}\right]dt$$

$$= \frac{E}{4T^3}\left[\frac{T}{2} + 0\right]$$

$$< x^2(t,\phi) >= \frac{E}{8T^2}$$

(c) Variance :

$$\sigma^2 = <x^2(t,\phi)> - \{<x(t,\phi)>\}^2$$

$$\sigma^2 = \frac{E}{8T^2}$$

As we can see ensemble averages are equals to time averages, so $x(t,\phi)$ is ergodic.

01. (b) Explain the different masking steps required in the fabrication of a simple NMOS transistor starting from a p-type substrate. (10 M)

Sol: These are basically 4 steps.

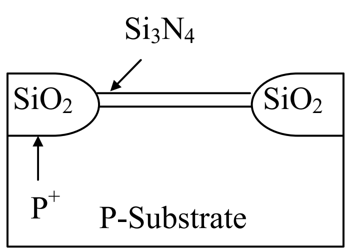
(1) By the process of chemical vapour deposition (CVD), a thin layer of $S_{i3}N_4$ is deposited on the entire wafer surface.

(2) Next the Si_3N_4 is removed by etchant that does not attack SiO_2.

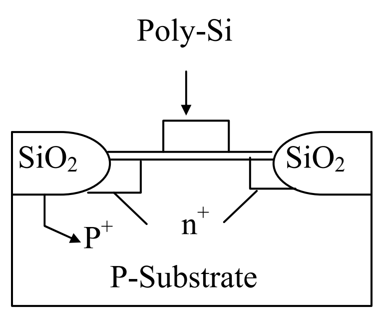
(3) Again, through CVD process, on insulating layer, SiO_2, is deposited.

(4) Al is used for the interconnection.

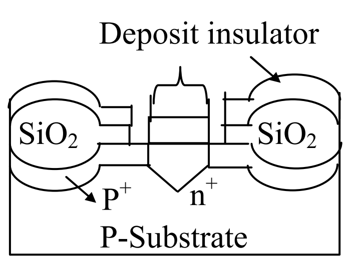
Figure shown as:-



(a) Transistor areas



(b) Poly Si gate



(c) Contact areas

01. (c) A two-word instruction is stored in memory at an address designated by the symbol A. The address field of the instruction (stored at A + 1) is designated by the symbol B. The operand used during the execution of the instruction is stored at address symbolized by 'C'. An index register contains the value X. State how 'C' is calculated from the other address if the addressing mode of the instruction is (10 M)

(i) Direct

(ii) Indirect

(iii) Relative

(iv) Indexed

Sol: Instruction stored at A+1 is designated. By symbol

Effective address is given by C.

Index register contains the value X

Direct mode Effective Address = B

Indirect mode Effective Address = M[B]

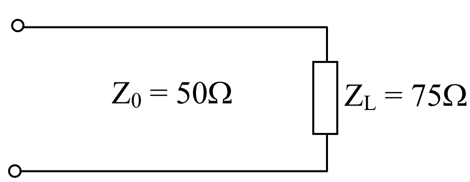
Relative mode Effective Address = $\underbrace{\text{program Counter}}_{A+2} + \underbrace{\text{Relative Value}}_{B}$

Indexed mode Effective Address = $\underbrace{\text{Index reg value}}_{X} + \underbrace{\text{base Value}}_{B}$

$$= X + B$$

01. (d) A 75 Ω resistor is connected to a transmission line of characteristic impedance of 50 Ω. Compute the VSWR at the termination. (10 M)

Sol:



Reflection coefficient, $\Gamma_L = \dfrac{Z_L - Z_o}{Z_L + Z_o} = \dfrac{75-50}{75+50} = \dfrac{25}{125} = \dfrac{1}{5}$

$$\text{VSWR}(\rho) = \frac{1+|\Gamma_L|}{1-|\Gamma_L|} = \frac{1+\frac{1}{5}}{1-\frac{1}{5}} = \frac{6}{4} = \frac{3}{2} = 1.5$$

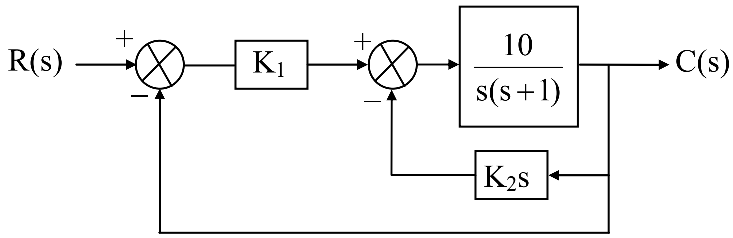
FREE **Interview Guidance Program**
for ESE-2021 MAINS Qualified Students

Details:

Mode:
Online/Offline

- Orientation Sessions on how to fill **DAF**
- Free Interview Guidance Classes for Technical Subjects, Personality Development & Interview Tips
- Free Mock Interviews
- Relevant Study Materials

01. (e) Compute the values of K_1 and K_2 to obtain a peak time of 1.6 seconds and a setting time of 3.5 seconds for the closed-loop system shown below in response to a step input. (10 M)



Sol: $t_p = 1.6\text{sec}$

$t_s = 3.5\text{sec}$

$$\text{CLTF } \frac{C(s)}{R(s)} = \frac{10K_1}{s(s+1)+10K_2 s+10K_1} = \frac{10K_1}{s^2+s(1+10K_2)+10K_1}$$

$\omega_n^2 = 10K_1$ ______(1)

$2\xi\omega_n = 1 + 10K_2$ ________(2)

$t_s = 3.5\text{sec} = 4/\xi\omega_n$

$$\xi\omega_n = \frac{4}{3.5} = 1.142 \text{ ________(3)}$$

$$t_p = \frac{\pi}{\omega_d} = \frac{\pi}{\omega_n\sqrt{1-\xi^2}}$$

$$1.6 = \frac{\pi}{\sqrt{\omega_n^2-(\xi\omega_n)^2}}$$

$$1.6\sqrt{\omega_n^2-(\xi\omega_n)^2} = \pi$$

$$2.56\left(\omega_n^2-(\xi\omega_n)^2\right) = 9.869$$

$$\omega_n^2-(1.142)^2 = 3.855$$

$$\omega_n^2 = 3.855+1.304 = 5.159$$

$$\omega_n = 2.271\text{ rad/sec}$$

$$\xi\omega_n = 1.142 \Rightarrow \xi = \frac{1.142}{2.271} = 0.502$$

$$\omega_n^2 = 5.159 = 10K_1 \Rightarrow K_1 = 0.5159$$

$2 \times 1.142 = 1 + 10K_2 \Rightarrow K_2 = 0.1284$

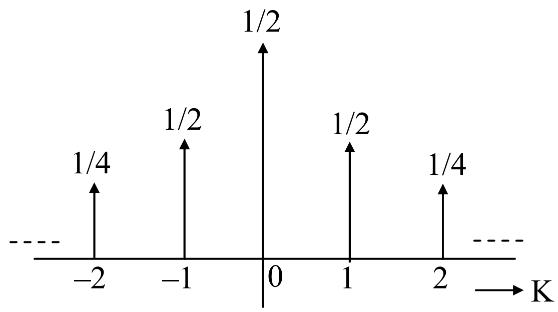
01. (f) The autocorrelation sequence of a discrete-time stochastic process is $R(K)=\left(\frac{1}{2}\right)^{|K|}$.

Determine its Power Spectral Density. **(10 M)**

Sol: $R(k)=\left(\frac{1}{2}\right)^{|K|}$

$$R(k)=\left(\frac{1}{2}\right)^{k}u[k]\ (\text{OR})\ \left(\frac{1}{2}\right)^{k}, K\geq 0$$

$$= 2^{K}\,u[-K-1]\ (\text{OR})\ 2^{k},\ K<0$$



$$R(k)\xrightarrow{\text{DTFT}}S(\omega)[\text{PSK}]$$

$$\text{For } a^{n}u(n)\xrightarrow{\text{DTFT}}\frac{1}{1-ae^{-j\omega}}$$

$$-a^{n}u[-n-1]\xrightarrow{\text{DTFT}}\frac{1}{1-ae^{-j\omega}}$$

$$\therefore\ S(\omega)=\frac{1}{1-\frac{1}{2}e^{-j\omega}}+\frac{-1}{1-2e^{-j\omega}}$$

$$S(\omega)=\frac{2e^{j\omega}}{2e^{j\omega}-1}-\frac{e^{j\omega}}{e^{j\omega}-2}$$

$$S(\omega)=\frac{2e^{j\omega}\left(e^{j\omega}-2\right)-e^{j\omega}\left(2e^{j\omega}-1\right)}{\left(2e^{j\omega}-1\right)\left(e^{j\omega}-2\right)}$$

$$S(\omega)=\frac{-3e^{j\omega}}{2e^{j2\omega}-5e^{j\omega}+2}$$

CLASSROOM COACHING

@ HYDERABAD

CE | ME | EC | EE | CS | PI | IN

ESE | GATE | PSUs - 2023

- **College Goers Batch:**

26th Nov-2021

@ ABIDS
@ KUKATPALLY
@ KOTHAPET

- **Regular Batches:**

20th Jan-2022	26th Feb-2022	13th Mar-2022
27th Mar-2022	11th Apr-2022	25th Apr-2022
08th May-2022	22nd May-2022	11th Jun-2022

- **Spark Batches:**

8th May-2022	22nd May-2022	11th Jun-2022

- **Summer Short-Term Batches:**

8th May-2022	22nd May-2022	11th Jun-2022

DISCOUNTS

10% OFF | EARLY BIRD OFFER (valid till 30th Nov. 2021)

50% OFF | ACE OLD STUDENTS

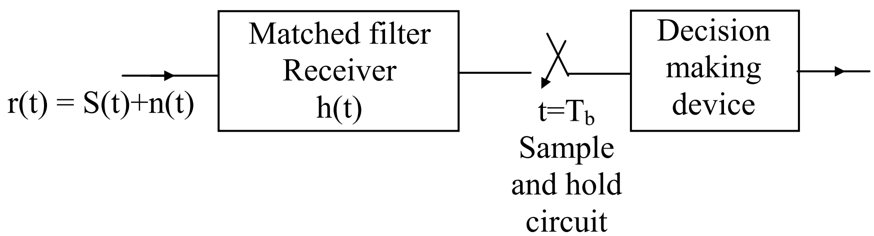
02. (a) Let s(t) be a digital NRZ signal (± A), which passes through the noisy channel. Channel introduces white Gaussian Noise (ω(t)) having PSD of $N_o/2$. Receiver was designed using Matched Filter, Sample & Hold Circuit and Decision-Making Circuit. Decision-Making Circuit uses maximum likelihood algorithm/technique. Compute the following:

(i) Output of the Sample & Hold circuit when '–A' is transmitted (5 M)

(ii) Variance of the Noisy Signal at the o/p of S & H Circuit. (5 M)

(iii) Compute the probability of error when '– A' is received/detected as '+ A' and '+A' is interpreted as '– A'. (10 M)

Sol:



S(t) = +A (OR) –A

n(t) represents AWGN

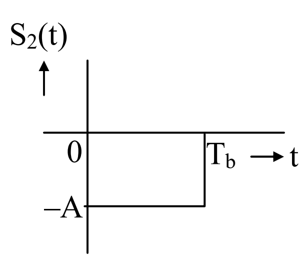
$$S_N(f) = \frac{N_0}{2}(W/Hz)$$

Since ML decoding algorithm is used

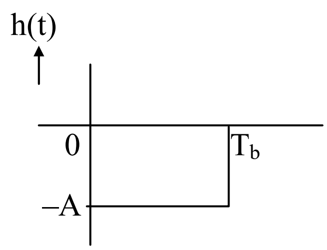
$S_1(t) = A$ $\quad$ $S_2(t) = -A$

$P(S_1) = 1/2$ $\quad$ $P(S_2) = 1/2$

$S_2(t)$ is input of receiver



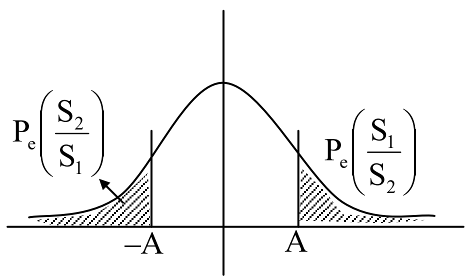
$h(t) = S_2(T_0 - t) = S_2(-t + T_0)$



(i) Output of sampled and hold circuit

$$= y(t)_{\text{at } t=T_b} = E\{S_2(t)\} = \int_0^{T_b} (-A)^2 dt$$

$$= A^2T_b$$



$r = S + n \geq V_{th} \rightarrow$ Decode S_1

$\quad\quad < V_{th} \rightarrow$ Decode S_2

$S_1 = +A$

$S_2 = -A$

$$\therefore\ P_e\left(\frac{S_2}{S_1}\right) \quad P_e\left(\frac{S_1}{S_2}\right)$$

$A + n < 0 \quad\quad -A + n \geq 0$

$\quad n < -A \quad\quad n \geq A$

$$\therefore\ P_e = \frac{1}{2}P[n < -A] + \frac{1}{2}P[n \geq A]$$

Area under both the regions is same

$\therefore\ P_e = P[n < -A]$

$= P[n = -A]$ $\qquad\qquad \therefore\ P_e = Q\left[\frac{A}{N_0}\right]$

$= 1 - Q\left[\frac{-A-0}{\sigma}\right]$

$= 1 - Q\left[\frac{-A}{\sigma}\right] = 1 - \left[1 - Q\left(\frac{A}{\sigma}\right)\right]$

$= Q\left[\frac{A}{\sigma}\right]$

(ii) $S_{N_0}(f) = S_N(f)|H(f)|^2$ [PSD of NOISE at output of matched filter]

$S_{N_0}(f) = \frac{N_0}{2}|H(f)|^2$

Variance/power of noise at output of matched filter = $\int S_{N_0}(f)df$

$= \frac{N_0}{2}\int |H(f)|^2 df$

$= \frac{N_0}{2}\int |h(t)|^2 dt$

$= \frac{N_0}{2}\int_0^{T_b} (-A)^2 dt$

$= \frac{A^2 N_0 T_b}{2}(\text{watts})$

(iii) $V_{th} = \frac{V_1 + V_2}{2} + \frac{\sigma_{n_0}^2 \ln[P(S_2)/P(S_1)]}{V_1 - V_2}$

and since $P(S_2) = P(S_1)$

$V_{th} = \frac{V_1 + V_2}{2} = 0(\text{volts})$

$\therefore\ P_e = P(S_1)P_e\left(\frac{S_2}{S_1}\right) + P(S_2)P\left(\frac{S_1}{S_2}\right)$

02. (b) The forward path transfer function of a control system with unity feedback is

$$G(s) = \frac{K}{s(s+a)(s+30)}$$

where 'a' and 'K' are real constants.

(i) Find the value of 'a' and 'K' so that the relative damping ratio of the complex roots of the characteristic equation is 0.5 and the rise time of the units step response is approximately 1 sec. (15 M)

(ii) Find the steady state errors of the system when the reference input is a unit ramp function. (5 M)

Sol: $$G(s) = \frac{K}{s(s+a)(s+30)}$$

(i) $\xi = 0.5$, $t_r = 1\text{sec}$

$$t_r = \frac{\pi - \tan^{-1}\left(\frac{\sqrt{1-\xi^2}}{\xi}\right)}{\omega_d}$$

$$\omega_d = \left[\pi - \tan^{-1}\left(\frac{\sqrt{1-0.5^2}}{0.5}\right)\right] = \frac{2}{3}\pi = 2.094$$

$$2.094 = \omega_n\sqrt{1-\xi^2}$$

$$2.094 = \omega_n\sqrt{1-0.5^2}$$

$\Rightarrow \omega_n = 2.41\text{rad/sec}$

CE for given data,

CE: $s(s+a)(s+30)+K = 0$

CE: $s^3 + s^2(30+a)+30as+K = 0$ ______(1)

$\Rightarrow$ second order CE $\Rightarrow (s^2 + 2\xi\omega_n s + \omega_n^2) = 0$

$\Rightarrow (s^2 + 2.41s + 5.8081) = 0$

Let the 3rd pole at $s = -b$

Hence $(s+b)(s^2+2.41s+5.8081) = 0$

$s^3 + s^2 (2.41+b) + s(2.41b + 5.8081) + 5.8081\, b = 0$ ______(2)

Comparing equation (1) and (2)

$30 + a = 2.41 + b$ ______(1)

$30a = 2.41b + 5.8081$ ______(2)

$K= 5.8081\, b$______(3)

From equation (2)

$$a = \frac{2.41b}{30} + \frac{5.8081}{30}$$

$a = 0.08b + 0.1936$ ______(4)

(4) in (1)

$30 + 0.08b + 0.1936 = 2.41 + b$

$\Rightarrow b = 30.1995$

From equation (3)

$K = (5.8081)(30.1995) = 175.4$

From equation (4)

$a = 0.08 (30.1995) + 0.1936$

$a = 2.6095$

$\Rightarrow$ The third pole at $s = -30.1995$ and $-\xi\omega_n = -1.205$

The third pole is insignificant pole. Hence the second order approximation is valid.

(ii) $$G(s) = \frac{K}{s(s+a)(s+30)}, \quad H(s) = 1$$

$$G(s) = \frac{175.4}{s(s+2.6095)(s+30)}, \quad H(s) = 1$$

$$K_V = \underset{s\to 0}{\text{lt}}\, s\,G(s) = \underset{s\to 0}{\text{lt}}\, s\left(\frac{175.4}{s(s+2.6095)(s+30)}\right)$$

$$K_V = \frac{175.4}{2.6095\times 30} = 2.2405$$

$$\Rightarrow e_{ss} = \frac{A}{K_V} = \frac{1}{2.2405} = 0.4463$$

UPCOMING BATCHES - CLASSROOM COACHING @ OUR CENTRES

ESE | GATE | PSUs - 2023 / 2024

@ Delhi

7838971777 (Call/WhatsApp)

- **Weekend Batches:**
  19th Dec-2021, 22nd Jan-2022,
- **Regular Batches:**
  21st Feb-2022, 27th Mar-2022, 16th Apr-2022,
  8th & 22nd May-2022, 11th Jun-2022
- **Summer Short Term Batches:**
  8th & 22nd May-2022

@ Pune

9343499966

- **Evening Batches:** 13th Dec-2021, 10th Jan-2022
- **Weekend Batch:** 8th Jan-2022
- **MPSC (Prelims) Batch:** 26th Dec-2021

@ Vijayawada

9341699966

- **Weekend Batch:** 18th Dec-2021

@ Vizag

8374808999

- **Weekend Batches:**
  18th Dec-2021, 20th Jan-2022, 26th Feb-2022

DISCOUNTS

10% OFF | EARLY BIRD OFFER (valid till 30th Nov. 2021)

50% OFF | ACE OLD STUDENTS

02. (c) Consider the following set of processes, with the length of the CPU burst given in milliseconds:-

Process	Burst Time
P_1	6
P_2	8
P_3	7
P_4	3

(i) Draw the Gantt chart for SJF scheduling. **(5 M)**

(ii) What is the waiting time for Process P_1, Process P_2 and Process P_3? **(5 M)**

(iii) Calculate the average waiting time. **(5 M)**

(iv) Calculate the average waiting time for FCFS scheduling. **(5 M)**

Sol: Given snapchat

AT	PID	BT	CT	TAT	WT
0	P_1	6	9	9	3
0	P_2	8	24	24	16
0	P_3	7	16	16	9
0	P_4	3	3	3	0

(i) SJF Gantt chart

P_4	P_1	P_3	P_2

0   3   9   16   24

0	3	9	16
P_1–6	P_1–6	P_2–8	P_2–8
P_2–8	P_2–8	P_3–7	
P_3–7	P_3–7		
P_4–3			

(ii) WT of $P_1 = 3$

WT of $P_2 = 16$

WT of $P_3 = 9$

(iii) Avg WT $= \dfrac{3+16+9+0}{4} = \dfrac{28}{4} = 7$

(iv)

PID	AT	BT	CT	TAT	WT
P_1	0	6	6	6	0
P_2	0	8	14	14	6
P_3	0	7	21	21	14
P_4	0	3	24	24	21

P_1	P_2	P_3	P_4

0   6   14   21   24

0	6	14	21
P_1–6	P_2–8	P_3–7	P_4–3
P_2–8	P_3–7	P_4–3	
P_3–7	P_4–3		
P_4–3			

$$\therefore \text{Avg WT} = \frac{0+6+14+21}{4}$$

$$= \frac{41}{4} = 10.25$$

03. (a) Let there be a transmitter source represented as [X] = $\{x_1, x_2 \ldots. x_N\}$ having N symbols. Let there be a Receiver having Destination Symbol Vector [Y] = $\{y_1, y_2, y_3 \ldots\ldots y_M\}$ having 'M' symbols. Transmitted symbols have to pass through channel.

(i) Derive the expression for I(X, Y). **(15 M)**

(ii) From the derived expression, compute Max [I (X, Y)] expression. Explain the meaning of terms. **(5 M)**

Sol:

Transmission	Receiver
X_1	Y_1
X_2	Y_2
X_3	Y_3
⋮	⋮
X_N	Y_n

(i) I[X,Y]

Let the entropy of input be defined as H(x)

$$H[X] = [P(x_1)\log_2 P(x_1) + P(x_2)\log_2 P(x_2) + \ldots.. + P[x_n]\log_2 P[x_N]]$$

$$H[X] = -\sum_{i=1}^{N} P[x_i]\log_2 P[x_i]$$

Let the entropy of output be defined as H[Y]

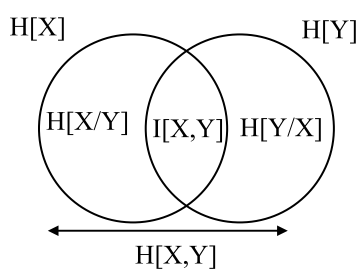
$$H[Y] = [P(y_1)\log_2 P(y_1) + P(y_2)\log_2 P(y_2) + \ldots.. + P[y_m]\log_2 P[y_M]]$$

$$H[Y] = -\sum_{J=1}^{M} P[y_J]\log_2 P[y_J]$$

Consider joint entropy between input and output given by H[X,Y]

$$H[X,Y] = -\sum_{i=1}^{N}\sum_{j=1}^{M} P[x_i, y_j]\log_2 P(x_i, y_j)$$

Consider the below venn-diagram representation



H(X,Y) = H[X] + H[Y/X]

(OR)

H[X,Y] = H[Y] + H[X/Y]

I[X,Y] = H[X] – H[X/Y]

(OR)

I[X,Y] = H[Y] – H[Y/X]

(ii) MAX [I(X,Y)] = MAX[H(x) –H(x/y] (OR) MAX[H(y) – H(y/x)]

MAX [I(X,Y)] would be MAXIMUM only when H[x]

(OR) H[Y] are MAXIMUM

$$H[x]_{MAX} = \log_2 N \text{ and } H[y]_{MAX} = \log_2 M$$

$$\therefore \text{MAX}[I(X,Y)] = \log_2 N - H[x/y]$$

(OR)

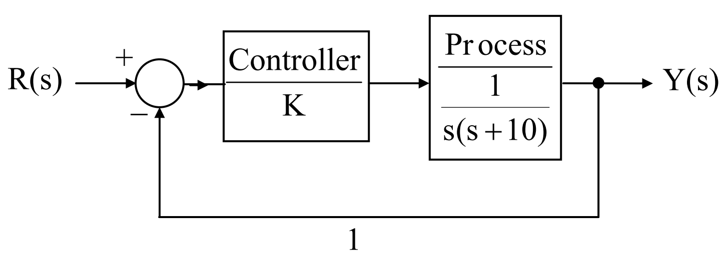
$$= \log_2 M - H[Y/X]$$

03. (b) A feedback control system is shown in the following figure. The specification for the closed loop system requires that the overshoot to a step input be less than 15%.

(i) Determine the corresponding specification M_p in the frequency domain for the closed loop transfer function $\frac{Y(j\omega)}{R(j\omega)} = T(j\omega)$. **(10 M)**

(ii) Determine the resonant frequency ω_r. **(5 M)**

(iii) Determine the bandwidth of the closed loop system. **(5 M)**



Sol: $\%M_p < 15\%$

$$\%M_p = e^{-\pi\xi/\sqrt{1-\xi^2}} \times 100\%$$

$$0.15 = e^{-\pi\xi/\sqrt{1-\xi^2}}$$

$$\xi = \sqrt{\frac{(\ell n(0.15))^2}{\pi^2 + (\ell n(0.15))^2}} = 0.5169$$

$\xi > 0.5169$

(i) M_P equivalent in frequency domain is M_r.

$$M_r = \frac{1}{2\xi\sqrt{1-\xi^2}} = \frac{1}{2\times 0.5169\sqrt{1-0.5169^2}}$$

$M_r = 1.1299 \approx 1.13$

$M_r < 1.13$

(ii) ω_r, CLTF $\dfrac{C(s)}{R(s)} = \dfrac{K}{s(s+10)+K} = \dfrac{K}{s^2+10s+K}$

$\omega_n = \sqrt{K}$ r/sec

$2\xi\omega_n = 10 \Rightarrow 2 \times 0.5169 \times \omega_n = 10$

$\Rightarrow \omega_n = 9.67$ rad/sec

$$\omega_r = \omega_n\sqrt{1-2\xi^2} = 9.67\sqrt{1-2\times 0.5169^2}$$

$= 6.599 \approx 6.6$rad/sec

(iii) $B.W = \omega_n\sqrt{1-2\xi^2+\sqrt{2-4\xi^2+4\xi^4}}$ rad/sec

$$= 9.67\sqrt{1-2\times 0.5169^2+\sqrt{2-4\times 0.5169^2+4\times 0.5169^4}}$$

$= 12.11$ rad/sec

03. (c) A digital computer has a memory unit with 28 bits per word. The instruction set consists of 235 different operations. All instruction have an operation code part (op code) and an address part. Each instruction is stored in one word memory.

(i) How many bits are reserved for operation code? (5 M)

(ii) How many bits are left for the address part of the instruction? (5 M)

(iii) What is the maximum size for the memory? (5 M)

(iv) Draw the instruction format and indicate the number of bits in each part. (5 M)

Sol: Word length = 28 bits.

235 different operations '8'-bits ($\lceil \log_2 235 \rceil$)

(i) 8 bits required for op code.

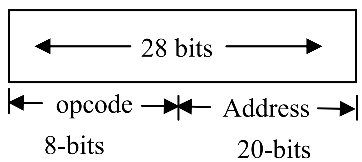
(ii) Address bits = Word length – op code

$$= 28 - 8 = 20 \text{ bits}$$

(iii) Size of Memory = $2^{(\text{no. of bits for address})}$

$$= 2^{20} = 1\text{MB}$$

(iv)



04. (a) Consider the Narrow Band FM wave.

(i) Determine the envelope of this modulated wave. What is the ratio of maximum to minimum amplitudes? (5 M)

(ii) Determine the average power of NBFM. (5 M)

(iii) By expanding the angular argument $\theta(t) = 2\pi f_c t + \phi t$ of NBFM, wave s(t) in the form of a power series and restricting the modulation index β to a maximum value of 0.3 rad, show that $\theta(t) = 2\pi f_c t + \beta \sin(2\pi f_m t) - \frac{\beta^3}{3} \sin^3(2\pi f_m t)$

Compute the value of Harmonic distortion for β = 0.3 rad. (10 M)

Sol:

(i)

$$S(t)_{NBFM} = A_c \cos[2\pi f_c + \beta \sin 2\pi f_m t]$$

$$\beta \rightarrow 0 < \beta < 1$$

$S(t)_{NBFM} = A_c \cos(2\pi f_c t) \cos(\beta \sin 2\pi f_m t) - A_c \sin(2\pi f_c t) \sin(\beta \sin 2\pi f_m t)$

considering $\theta = \beta \sin(2\pi f_m t)$

and for smaller values of θ

$$\cos(\theta) \simeq 1 \qquad \sin(\theta) \simeq \theta$$

$\therefore$ $S(t)_{NBFM} = A_c \cos(2\pi f_c t) - A_c\,\beta \sin(2\pi f_c t)\sin(2\pi f_m t)$

$S(t)_{NBFM} = A_c[\cos(2\pi f_c t)] - A_c\,\beta \sin(2\pi f_m t)\,[\sin(2\pi f_c t)]$

Envelope of S(t) = $|S(t)|_{NBFM} = \pm\sqrt{A_c^2 + A_c^2\beta^2 \sin^2(2\pi f_m t)}$

$$= \pm A_c\sqrt{1+\beta^2\sin^2(2\pi f_m t)}$$

$$|S(t)|_{MAX} = A_c\sqrt{1+\beta^2}$$

$$|S(t)|_{MIN} = -A_c\sqrt{1+\beta^2}$$

$$\therefore\ \frac{|S(t)|_{MAX}}{|S(t)|_{MIN}} = \frac{+A_c\sqrt{1+\beta^2}}{-A_c\sqrt{1+\beta^2}} = -1$$

(ii) $S(t)_{NBFM} = A_c \cos(2\pi f_c t) - A_c\,\beta \sin(2\pi f_c t)\sin(2\pi f_m t)$

$$= A_c\cos(2\pi f_c t) - \frac{A_c\beta}{2}\cos[2\pi(f_c - f_m)t] + \frac{A_c\beta}{2}\cos[2\pi(f_c + f_m)t]$$

$P_{avg} = P_t = P_c + P_{USB} + P_{LSB}$

$$= \frac{A_c^2}{2} + \frac{A_c^2\beta^2}{8} + \frac{A_c^2\beta^2}{8}$$

$$= \frac{A_c^2}{2} + \frac{A_c^2\beta^2}{4}$$

$$P_{avg} = P_t = \frac{A_c^2}{2}\left[1+\frac{\beta^2}{2}\right](\text{watts})$$

(iii) The time domain of the FM signal is

$S(t) = A_c\cos\left[2\pi f_c t + 2\pi k_f \int m(t)dt\right]$

In the case of single tone modulation

$S(t) = A_c\cos[2\pi f_c t + \beta\sin 2\pi f_m t]$

$= A_c\cos 2\pi f_c t\cos(\beta\sin 2\pi f_m t) - A_c\sin 2\pi f_c t\sin[\beta\sin 2\pi f_m t]$

For NBFM $\beta << 1$

Using $\cos\theta \approx 1$

$\sin\theta \approx \theta$

$S(t) = A_c\cos 2\pi f_c t - A_c\beta\sin 2\pi f_m t\sin 2\pi f_c t$

Using the relationship

$A\cos 2\pi f_c t + B\sin 2\pi f_c t = \sqrt{A^2+B^2}\cos[2\pi f_c t + \phi]$

$A = A_c$ $\qquad B = -A_c\beta\sin 2\pi f_m t$

$S(t) = \sqrt{A_c^2 + A_c^2\beta^2\sin 2\pi f_m t}\ \cos[2\pi f_c t + \phi]$

$\phi = \tan^{-1}\left[\frac{B}{A}\right] = \tan^{-1}[\beta\sin 2\pi f_m t]$

$$S(t) = \sqrt{A_c^2 + A_c^2\beta^2 \sin^2 2\pi f_m t}\ \cos\left[2\pi f_c t + \tan^{-1}(\beta \sin 2\pi f_m t)\right]$$

Angular argument $= 2\pi f_c t + \tan^{-1}[\beta \sin 2\pi\, f_m t]$

Power series of

$$\tan^{-1}(x) = x - \frac{x^3}{3} + ...$$

$$x = \beta \sin 2\pi\, f_m t$$

Angular argument $= 2\pi f_c t + \beta \sin 2\pi f_m t - \frac{\beta^3}{3}\sin^3 2\pi f_m t$

By replacing $\sin^3(2\pi f_m t)$ with the help of

$\sin(3A) = 3\sin A - 4\sin^3(A)$

We can rewrite $\theta(t)$ as

$$\theta(t) = 2\pi f_c t + \sin(2\pi f_m t)\left[\beta - \frac{3\beta^3}{12}\right] + \frac{\beta^3}{12}\sin(6\pi f_m t)$$

$$\theta(t) = 2\pi f_c t + \left[\frac{4\beta - \beta^3}{4}\right]\sin(2\pi f_m t) + \frac{\beta^3}{12}\sin[2\pi(3f_m)t]$$

Harmonic Distortion is the ratio of the sum of the powers of all harmonic components to the power of fundamental frequency.

(OR) $\frac{\sqrt{V_3^2}}{V_1}$

V_3 is RMS Value of third harmonic

V_1 is RMS value of 1st harmonic

Harmonic Distortion (H.D) $= \sqrt{\left(\frac{\beta^3}{12\sqrt{2}}\right)^2} \Bigg/ \frac{4\beta - \beta^3}{4\sqrt{2}}$

$\Rightarrow$ at $\beta = 0.3$

$$\frac{(0.3)^3}{12\sqrt{2}} \times \frac{4\sqrt{2}}{\left(1.2 - (0.3)^3\right)}$$

$$\Rightarrow \frac{(0.3)^3}{3(1.173)} = 0.00765\ \ (\text{OR})\ 0.765\%$$

Exclusive Online Live Classes for ESE | GATE | PSUs - 2023

Batches for English

Morning & Evening (Last Batch)

13th November, 2021

Regular Batches

BATCH DATES

18th December, 2021	20th January 2022	26th February 2022
13th March 2022	27th March 2022	11th April 2022
25th April 2022	08th May 2022	22nd May 2022
11th June 2022		

Batches for Hindi + English (Hinglish)

College Goers Batch (Evening Batch)

13th November, 2021 | 18th December, 2021

COURSE DETAILS

- For ESE+GATE+PSUs Students
  >> Online Live Classes - Technical Subjects Only
  >> Recorded Classes - General Studies Subjects & ESE Addl. Subjects. on ACE Online (Deep Learn)
- Recorded version of the online live class will be made available through out the course (with 3 times view)
- Doubt clearing sessions and tests to be conducted regularly
- Free study material (hard copy)
- Morning Batch: 6 am - 8 am
- Evening Batch: 8 pm - 10 pm
- Regular Batches: 4 - 6 Hours on Weekdays, 6 - 7 Hours on Sundays and Public Holidays
- Access the lectures from any where

FEATURES

Experienced Faculty | Daily Doubt Clearance | Replica of Classroom | Structured Course | Backup Classes

DISCOUNTS

25% OFF	20% OFF	15% OFF
for ACE old students	for IIT/NIT students	for IIIT/Govt. College students

Scan QR Code to Enroll

04. (b) A unity feedback system has a loop transfer function

$$L(s)=\frac{4(s+a)}{s(s+1)(s+3)}$$

(i) Draw the root locus as 'a' varies from '0' to 100. (10 M)

(ii) Using the root locus, estimate the percentage overshoot and settling time (with a 2% criterion) of the system at a = 2 and a = 4. (5 M)

(iii) Determine the actual overshoot and settling time at a = 2 and a = 4. (5 M)

Sol: $$L(s)=\frac{4(s+a)}{s(s+1)(s+3)}$$

(i) 'a' varies from 0 to 100

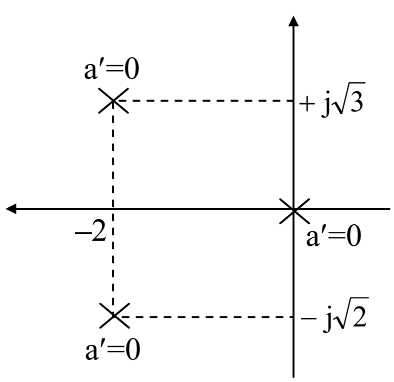
$$\text{CE}: 1+G(s)=0$$

$$\text{CE}: s(s+1)(s+3)+4s+4a=0$$

$$\text{CE}: s^3+4s^2+7s+4a=0$$

$$\text{CE}: 1+\frac{4a}{s(s^2+4s+7)}=0$$

$$G(s)=\frac{4a}{s(s^2+4s+7)}=\frac{a^1}{s(s^2+4s+7)}\left[a^1=4a\right]$$



$$\Rightarrow \text{Asymptotes: } \theta=\frac{(2q+1)180^\circ}{(p-z)}=60^\circ,180^\circ,300^\circ$$

$$\Rightarrow \text{Centroid: } \sigma=\frac{-2-2}{3}=-1.33$$

⇒ No break points exist.

Intersection point with imaginary axis:-

CE: $s^3 + 4s^2 + 7s + a' = 0$

$$\begin{array}{c|ll} s^3 & 1 & 7 \\ s^2 & 4 & a^1 \\ s^1 & \left(\dfrac{28-a'}{4}\right) > 0(s) \Rightarrow (28-a') > 0 \Rightarrow a' < 28 & \\ s^0 & a^1 > 0\ (s) & \end{array}$$

$0 < a' < 28$

$0 < 4a < 28$

$0 < a < 7$ Stable

Marginal stable:

$(28-a') = 0 \Rightarrow a' = 28$

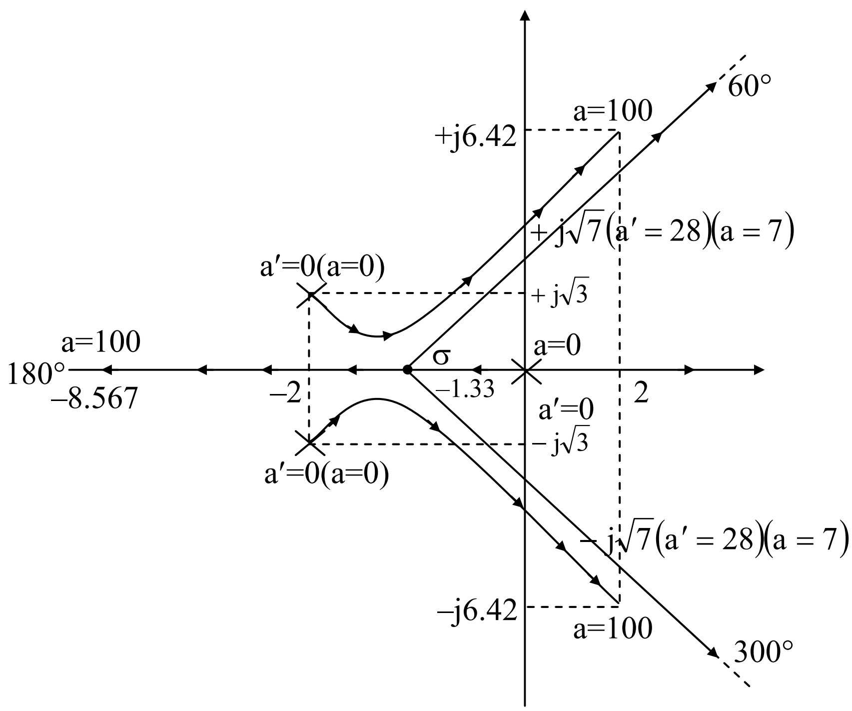
$4a = 28$

$a = 7$ marginal stable

$IP \Rightarrow 4s^2 + a' = 0$

$4s^2 + 28 = 0 \Rightarrow s = \pm j\sqrt{7}$

When $a = 100 \Rightarrow s = -8.567,\ 2.298 \pm j6.42$



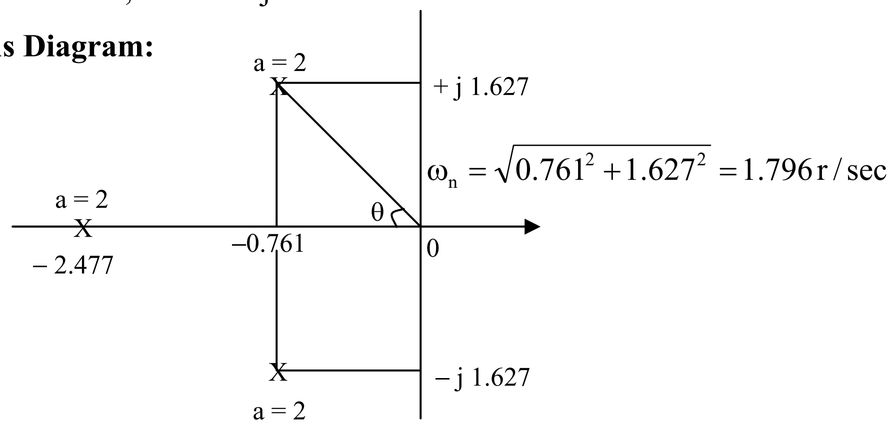
(ii) a = 2

CE: $s^3 + 4s^2 + 7s + 4 \times 2 = 0$

$s^3 + 4s^2 + 7s + 8 = 0$

Roots $\Rightarrow$ s = – 2.477, –0.761 ± j1.627

Root Locus Diagram:



$$\Rightarrow \xi = \cos\theta = \frac{0.76}{1.796} = 0.4237$$

$$\%M_p = e^{-\pi\xi/\sqrt{1-\xi^2}}$$

$$= e^{-\pi\times 0.423/\sqrt{1-0.423^2}} \times 100\% = 23\%$$

$$t_s(\pm 2\%) = \frac{4}{\xi\omega_n} = \frac{4}{0.761} = 5.25\,sec$$

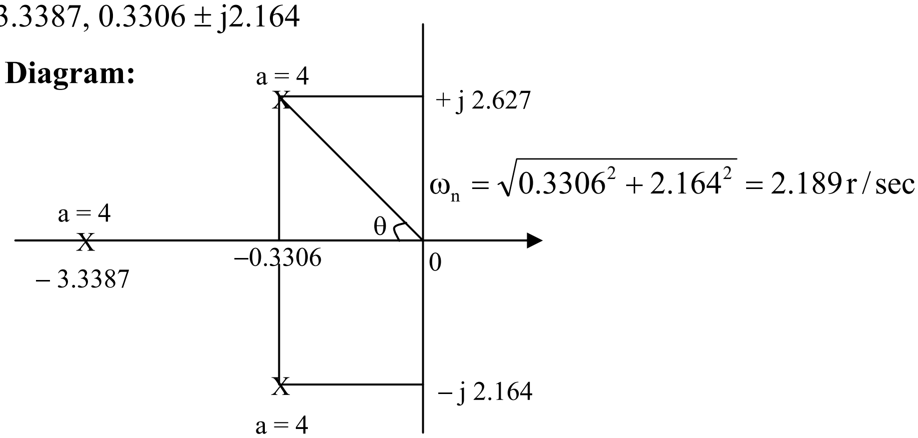
$\Rightarrow$ a = 4

CE $s^3 + 4s^2 + 7s + 4 \times 4 = 0$

CE $s^3 + 4s^2 + 7s + 16 = 0$

Roots s = – 3.3387, 0.3306 ± j2.164

Root Locus Diagram:



$$\Rightarrow \xi = \cos\theta = \frac{0.3306}{2.189} = 0.151$$

$$\%m_p = e^{-\pi\xi/\sqrt{1-\xi^2}} \times 100\%$$

$$= e^{-\pi\times 0.151/\sqrt{1-0.151^2}} \times 100\% = 61.88\%$$

$$\Rightarrow\ t_s(\pm 2\%) = \frac{4}{\xi\omega_n} = \frac{4}{0.3306} = 12\,\text{sec}$$

(iii) $a = 2,\quad \text{Actual over shoot} \Rightarrow M_p = e^{\frac{-\pi\xi}{\sqrt{1-\xi^2}}}$

$\Rightarrow M_P = 0.23$

$$\Rightarrow\ t_s(\pm 2\%) = \frac{4}{\xi\omega_n} = \frac{4}{0.761} = 5.25\,\text{sec}$$

$a = 4,\quad \text{Actual over shoot} \Rightarrow M_p = e^{\frac{-\pi\xi}{\sqrt{1-\xi^2}}}$

$\Rightarrow M_P = 0.6188$

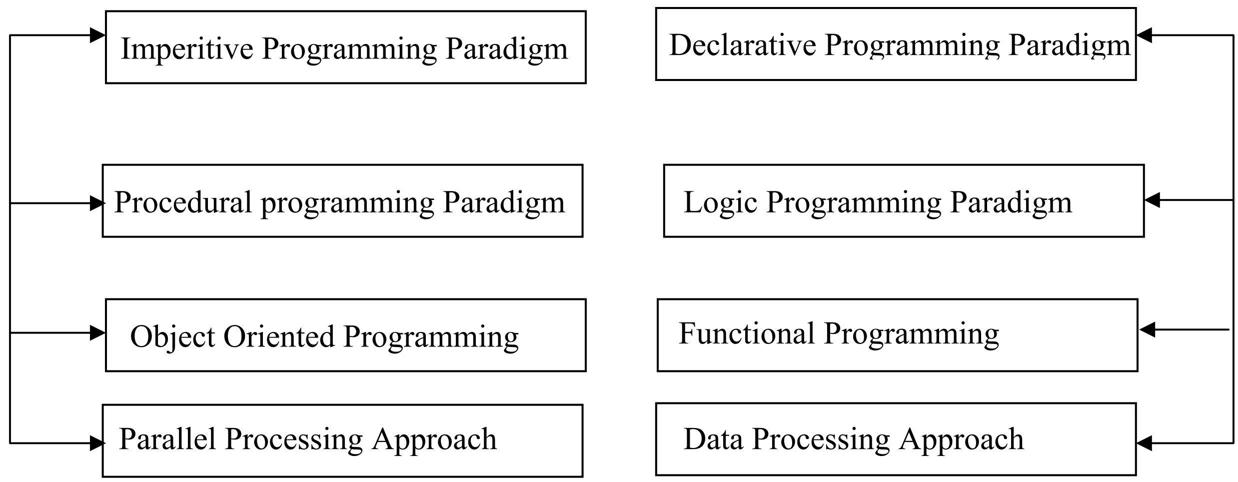
$$\Rightarrow\ t_s(\pm 2\%) = \frac{4}{\xi\omega_n} = \frac{4}{0.3306} = 12\,\text{sec}$$

04. (c) (i) Explain programming paradigms with examples. **(10 M)**

(ii) Write a pseudocode/program to sort given number. **(10 M)**

Sol:

(i) **Paradigm** can also be termed as method to solve some problem or do some task. Programming paradigm is an approach to solve problem using some programming language or also we can say it is a method to solve a problem using tools and techniques that are available to us following some approach. There are lots for programming language that are known but all of them need to follow some strategy when they are implemented and this methodology/strategy is paradigms. Apart from varieties of programming language there are lots of paradigms to fulfill each and every demand. They are discussed below:



1. **Imperative programming paradigm:**

   It is one of the oldest programming paradigm. It features close relation to machine architecture. It is based on Von Neumann architecture. It works by changing the program state through assignment statements. It performs step by step task by changing state. The main focus is on how to achieve the goal. The paradigm consists of several statements and after execution of all the result is stored.

   Ex: **C, FORTAN, BASIC.**

   Imperative programming is divided into three broad categories: Procedural, OOP and parallel processing. These paradigms are as follows:

- **Procedural programming paradigm-**

  This paradigm emphasizes on procedure in terms of under lying machine model. There is no difference in between procedural and imperative approach. It has the ability to reuse the code and it was boon at that time when it was in use because of its reusability.

  Ex: **C, C++, JAVA, ColdFusion, Pascal.**

  Object Oriented Programming

  The program is written as a collection of classes and object which are meant for communication. The smallest and basic entity is object and all kind of computation is performed on the objects only. More emphasis is on data rather procedure. It can handle almost all kind of real life problems which are today in scenario.

  Ex: **Simula**, **Java, C++, Objective-C, Visual Basic .NET, Python, Ruby**, **Smalltalk**

- **Parallel processing approach**

  Parallel processing is the processing of program instructions by dividing them among multiple processors. A parallel processing system posses many numbers of processor with the objective of running a program in less time by dividing them. This approach seems to be like divide and conquer. Examples are NESL (one of the oldest one) and C/C++ also supports because of some library function.

2. Declarative programming paradigm:

It is divided as Logic, Functional, Database. In computer science the declarative programming is a style of building programs that expresses logic of computation without talking about its control flow. It often considers programs as theories of some logic. It may simplify writing parallel programs. The focus is on what needs to be done rather how it should be done basically emphasize on what code code is actually doing. It just declares the result we want rather how it has be produced. This is the only difference between imperative (how to do) and declarative (what to do) programming paradigms. Getting into deeper we would see logic, functional and database.

- **Logic programming paradigms**

  It can be termed as abstract model of computation. It would solve logical problems like puzzles, series etc. In logic programming we have a knowledge base which we know before and along with the question and knowledge base which is given to machine, it produces result. In normal programming languages, such concept of knowledge base is not available but while using the concept of artificial intelligence, machine learning we have some models like Perception model which is using the same mechanism.

  In logical programming the main emphasize is on knowledge base and the problem. The execution of the program is very much like proof of mathematical statement, e.g., Prolog

- **Functional programming paradigms**

  The functional programming paradigms has its roots in mathematics and it is language independent. The key principal of this paradigms is the execution of series of mathematical functions. The central model for the abstraction is the function which are meant for some specific computation and not the data structure. Data are loosely coupled to functions.The function hide their implementation. Function can be replaced with their values without changing the meaning of the program.

Ex: **JavaScript, Perl, Haskwell, Scala, Erlang, Lisp, ML, Clojure**

- **Database/Data driven programming approach-**

  This programming methodology is based on data and its movement. Program statements are defined by data rather than hard-coding a series of steps. A database program is the heart of a business information system and provides file creation, data entry, update, query and reporting functions. There are several programming languages that are developed mostly for database application. For example **SQL.** It is applied to streams of structured data, for filtering, transforming, aggregating (such as computing statistics), or calling other programs. So it has its own wide application.

(ii)

```
# include <stdio.h>
void sort_numbers_ascending(int number[], int count)
{
        int temp, i, j, k;
        for (j = 0; j < count; ++j)
        {
         for (k = j + 1; k < count; ++k)
         {
          if (number[j] > number[k])
          {
                temp = number[j];
                number[j] = number[k];
                number[k] = temp;
   }
  }
}
```

```
    printf("Numbers in ascending order:\n");
    for (i = 0; i < count; ++i)
    printf("%d\n", number[i]);
}
void main()
{
  int i, count, number[20];
  printf("How many numbers you are gonna enter:");
  scanf("%d", &count);
  printf("\nEnter the numbers one by one:");
   for (i = 0; i < count; ++i)
   scanf("%d", &number[i]);
   sort_numbers_ascending(number, count);
}
```

Output:

How many numbers you are gonna enter:5

Enter the numbers one by one:

1

32

15

2

18

Numbers in ascending order:

1

2

15

18

32

SECTION - B

05. (a) (i) Let X be a random variable and let Y = $(X - \mu_X)/\sigma_X$. What is the mean and variance of the random variable Y? (5 M)

(ii) Compute the mean of $e^{j\omega t}$ where ω is a random variable. (5 M)

Sol:

(i) Let MEAN of RVX = μ_x

$$Y = \frac{X-\mu_x}{\sigma_x}$$

$$E[Y] = E\left[\frac{X-\mu_x}{\sigma_x}\right] = \frac{1}{\sigma_x}[E[X]-\mu_x]$$

$$\therefore\ E[Y] = \frac{1}{\sigma_x}[\mu_x - \mu_x] = \text{ZERO}$$

$$\sigma_Y^2 = E[Y^2] - E[Y]^2$$

$$\sigma_Y^2 = E[Y^2] = E\left[\frac{(x-\mu_x)^2}{\sigma_x^2}\right] = \frac{E(x-\mu_x)^2}{\sigma_x^2}$$

$$\therefore\ \sigma_Y^2 = \frac{1}{\sigma_X^2} X \sigma_X^2 = 1$$

(ii) Given $e^{j\omega t}$ in which random variable is ω

$$e^{j\omega t} = 1 + j\omega t + \frac{(j\omega t)^2}{2!} + \frac{(j\omega t)^2}{2!} + \text{- - - -} + \frac{(j\omega t)^n}{n!}$$

$$e^{j\omega t} = 1 + jt\omega - \frac{\omega^2 t^2}{2} - \frac{j\omega^3 t^3}{6} + \text{- - - -} + \frac{(j\omega t)^n}{n!}$$

$$E[e^{j\omega t}] = E\left[1 + jt\omega - \frac{\omega^2 t^2}{2} - \frac{j\omega^3 t^3}{6} + \text{- - - -} + \frac{(j\omega t)^n}{n!}\right]$$

$$\therefore\ E[e^{j\omega t}] = 1 + jtE[\omega] - \frac{t^2}{2}E[\omega^2] - j\frac{t^3}{6}E[\omega^3] \text{ - - - -}$$

05. (b) Describe the importance of photolithography in the fabrication of the integrated Circuits. How is the junction depth determined after the diffusion of n-type dopants in a p-type substrate with a background concentration of $10^{15}/cm^3$? (10 M)

Sol: Importance of photolithography

1) Lithography transforms complex circuit diagram into pattern which are define on the wafer in a succession of exposure of processing steps.
2) It is a process used in micro-fabrication to transfer geometric patterns to a films or substrate.
3) High exposure sensitivity : 2 or more orders of magnitude higher than that of electron beam lithography.
4) It can be used as physical sputtering etch and chemical assisted etch.

Junction depth

$$C(x, t) = Cs\ \text{erf}\left\{\frac{xg}{2\sqrt{Dt}}\right\}$$

05. (c) Explain the following terms with example: (10 M)

(i) Attribute

(ii) Domain

(iii) Entity

(iv) Relationship

Sol: The ER model defines the conceptual view of a database. It works around real-world entities and the associations among them. At view level, the ER model is considered a good option for designing databases.

(i) Attributes

Entities are represented by means of their properties, called **attributes**. All attributes have values. For example, a student entity may have name, class, and age as attributes.

There exists a domain or range of values that can be assigned to attributes. For example, a student's name cannot be a numeric value. It has to be alphabetic. A student's age cannot be negative, etc.

Types of Attributes

- **Simple attribute** - Simple attributes are atomic values, which cannot be divided further.
  For example, a student's phone number is an atomic value of 10 digits.
- **Composite attribute** - Composite attributes are made of more than one simple attribute.
  For example, a student's complete name may have first_name and last_name.
- **Derived attribute** - Derived attributes are the attributes that do not exist in the physical database, but their values are derived from other attributes present in the database.
  For example, average_salary in a department should not be saved directly in the database, instead it can be derived. For another example, age can be derived from data_of_birth.
- **Single-value attribute** - Single-value attributes contain single value.
  For example- Social_Security_Number.
- **Multi-value attribute** - Multi-value attributes may contain more than one values.
  For example, a person can have more than one phone number, email_address, etc.

These attribute types can come together in a way like -

- simple single-valued attributes
- simple multi-valued attributes
- composite single-valued attributes
- composite multi-valued attributes

(ii) Domain

Each column of a relational table is defined on a domain. A domain is a set of values. A datatype, which is also defined for each column, consists of a domain of values and a set of operations on those values. The sets S_1, S_2, and S_3 are sets of values. In the context of a database, they are domains of columns.

When assigned to a column of a table, a domain defines the set of the only values, and only the values, which are valid in row-level instances of that column. For example, the domain of a customer status column is the set of all valid customer status codes.

Sometimes domains include all the values permitted by the datatype of the column they are assigned to. At other times, domains contain only some of those values.

There are three domains, D_1, D_2 and D_3. The first two domains are not ordered, shown by using braces; the third one is ordered, shown by using brackets. These domains are the sets S_1, S_2, and S_3, but understood as functioning as domains for the columns of database tables. Later on, we will assign them to $T_X.C_1$, $T_X.C_2$, and $T_X.C_3$, the columns of table T_X.

$D_1 = \{C_1, C_2, C_3\}$

$D_2 = \{A, B, C\}$

$D_3 = \{\text{Platinum, Gold, Silver}\}$

(iii) Entity

An entity can be a real-world object, either animate or inanimate, that can be easily identifiable. For example, in a school database, students, teachers, classes, and courses offered can be considered as entities. All these entities have some attributes or properties that give them their identity.

An entity set is a collection of similar types of entities. An entity set may contain entities with attribute sharing similar values. For example, a Students set may contain all the students of a school; likewise a Teachers set may contain all the teachers of a school from all faculties. Entity sets need not be disjoint.

(iv) Relationship

The association among entities is called a relationship. For example, an employee **works_at** a department, a student **enrolls** in a course. Here, Works_at and Enrolls are called relationships.

Relationship Set

A set of relationships of similar type is called a relationship set. Like entities, a relationship too can have attributes. These attributes are called **descriptive attributes**.

Degree of Relationship

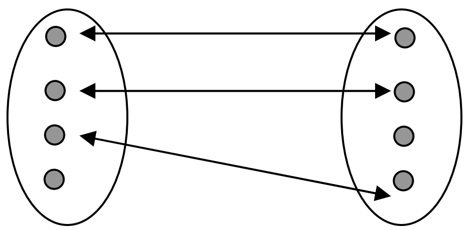
The number of participating entities in a relationship defines the degree of the relationship.

- Binary = degree 2
- Ternary = degree 3
- n-ary = degree-n

Mapping Cardinalities

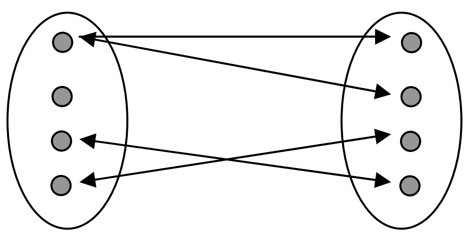
Cardinality defines the number of entities in one entity set, which can be associated with the number of entities of other set via relationship set.

- **One-to-one** - One entity from entity set A can be associated with at most one entity of entity set B and vice versa.



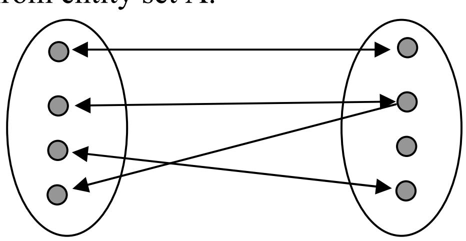
A B

- **One-to-many** - One entity from entity set A can be associated with more than one entities of entity set B however an entity from entity set B, can be associated with at most one entity.



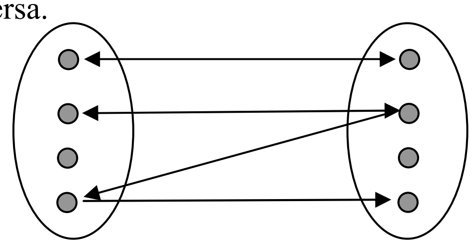
A B

- **Many-to-one** − More than one entities from entity set A can be associated with at most one entity of entity set B, however an entity from entity set B can be associated with more than one entity from entity set A.



A B

- **Many-to-many** − One entity from A can be associated with more than one entity from B and vice versa.



A B

05. (d) A reflector antenna used for a cellular base station backhaul ratio link operates at 38 GHz with a gain of 39 dB, a radiation efficiency of 90%, and a diameter of 30 cm. Find the aperture efficiency of this antenna. (10 M)

Sol: $f = 38\text{ GHz},\ \lambda = \dfrac{3\times10^{8}}{38\times10^{9}} = \dfrac{3}{380}$ MHz

Gain = 39 dB = $10^{3.9}$

Radiation Efficiency = 90%

Diameter = 30 cms

Aperture Efficiency of Antenna = ?

$$\eta_{ap} = \frac{A_e}{A_p}$$

A_e = Effective Aperture

A_p = Physical Aperture

$$G = \frac{4\pi A_e \eta}{\lambda^2}$$

$$10^{3.9} = \frac{4\pi A_e \times (380)^2 \eta}{9}$$

$$\therefore A_e = \frac{0.03939}{0.9} = 0.04376$$

$$A_p = \pi r^2 = \frac{\pi D^2}{4} = \frac{\pi\times(0.3)^2}{4} = 0.070685$$

$$\eta_{ap} = \frac{A_e}{A_p} = \frac{0.04376}{0.070685} = 61.9\%$$

05. (e) Design a pipelined architecture to compute the value of the following summation by using 8-bit adders and 8-bit registers:

Sum = A + B + C + D + E + F + G + H

Assume that all the inputs are of 8-bits and the output 'Sum' is also restricted to 8-bits. Moreover, all the inputs and outputs are registered. Also compute its latency. (10 M)

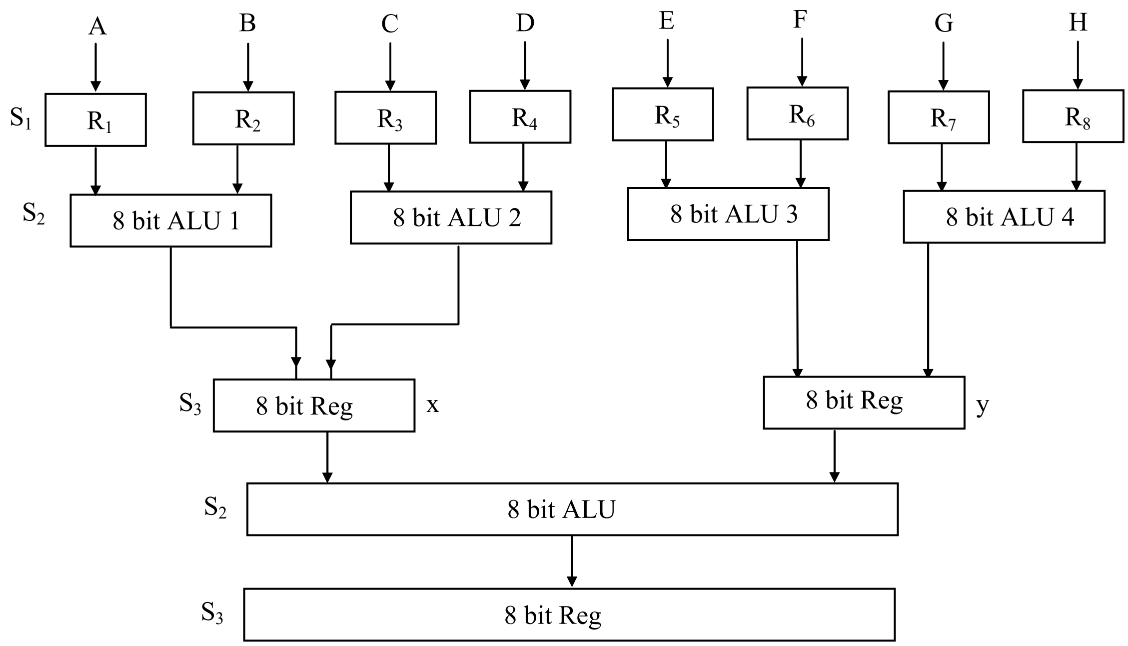
Sol: → Given expression is A + B + C + D + E + F + G + H

→ It is performed in Arithmetical pipelined CPU

→ Arithmetical pipelined CPU is designed with multiple ALU's.

→ Since number of input operands is 8; them number of ALUs is 4 with size of 8 bit each

→ Inputs are applied through 8 bit Regs and output is also stored in 8 bit Reg



Let CPU clock is f_{clk}, then segment delay time $(T_{seg}) = \frac{1}{f_{clk}}$ = 'T' state

R to R_8 Registers are considered as stage S_1, four 8 bit ALUs are considered as stage S_2. Both ALUs output is fed to 2. Register for storing partial Result stage 3.

→ Note: One more ALU is not required

→ The output registers (x and y) result are fed to one of the ALU's in stage 2 (S_2)

→ Final result is placed in stage S_3

Latency computation

Let T segment = $T_{Reg} = T_{ALU}$ = 1 clk

→ 3 clocks are sufficient to get partial result in x and y stages.

→ After 3 clocks 'x' holds A + B + C + D and y holds E + F + G + H.

→ Three more clocks are required to feed the partial results of (A + B +C + D) and (E + F + G + H) to input registers, ALU operation and for storing the final result.

→ Hence total number of clocks required is six.

→ Let the CPU is designed with 5th ALU then, after 3 clocks x and y gets the partial Result of (A + B + C + D) and (E + F + G + H).

→ Fourth clock is required to operate ALU5 and after completion of 5th clock the final result is saved in output register.

Note: Let CPU has 4 ALUs it requires 6 clocks and only 5 clocks are sufficient when cpu is designed with 5th ALU.

05. (f) Write down the procedure to compute orthogonal basis function for two given signals ($x_1(t)$ and $x_2(t)$). (10 M)

Sol: Consider the problem of approximating a real signal $x_1(t)$ in terms of another real signal $x_2(t)$ over the interval $(t_1. t_2)$

$$x_1(t) \simeq Cx_2(t)\ ;\ h \le t \le t_2$$

Error in this approximation is

$$e(t) = x_1(t) - Cx_2(t)\ ;\ t_1 \le t \le t_2$$

We need to minimise the error signal that is minimize its size, which is energy E_e over (t_1, t_2)

$$E_e = \int_{t_1}^{t_2} e^2(t)dt = \int_{t_1}^{t_2} [x_1(t) - Cx_2(t)]^2 dt$$

Here E_e is a function of parameter "C".

To minimize E_e, necessary condition is $\frac{dE_e}{dC} = 0$.

$$\frac{d}{dC}\left[\int_{t_1}^{t_2} x_1^2(t)dt\right] - \frac{d}{dC}\left[2C\int_{t_1}^{t_2} x_1(t)x_2(t)dt\right] + \frac{d}{dC}\left[C^2\int_{t_1}^{t_2} x_2^2(t)dt\right] = 0$$

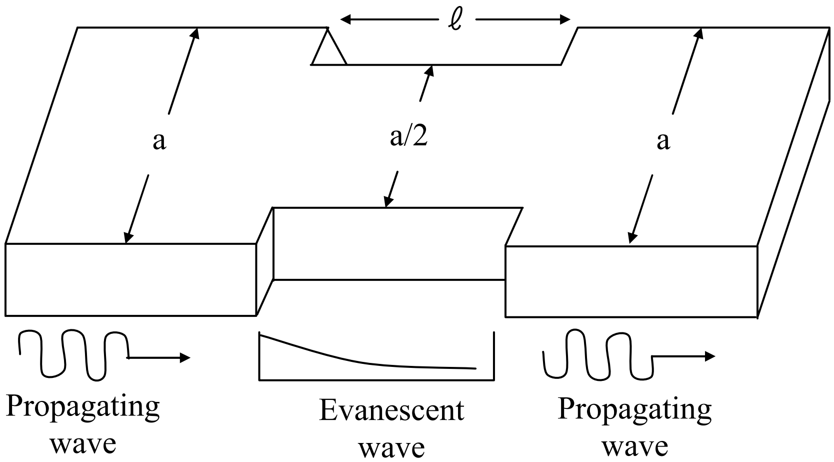
$$\Rightarrow -2\int_{t_1}^{t_2} x_1(t)x_2(t)dt + 2C\int_{t_1}^{t_2} x_2^2(t)dt = 0$$

$$C = \frac{\int_{t_1}^{t_2} x_1(t)x_2(t)dt}{\int_{t_1}^{t_2} x_2^2(t)dt}$$

If the component of $x_1(t)$ of the form $x_2(t)$ is zero (i.e., C = 0) the signals $x_1(t)$ & $x_2(t)$ are orthogonal over (t_1, t_2)

∴ The signals $x_1(t)$ & $x_2(t)$ are orthogonal over the interval (t_1, t_2) if $\int_{t_1}^{t_2} x_1(t)x_2(t)dt = 0$

06. (a) An attenuator can be made using a section of waveguide operating below cutoff as shown in the following figure. If a = 2.286 cm and operating frequency is 12 GHz, determine the required length of the below-cutoff section of a waveguide to achieve an attenuation of 100dB between the input and output guides. The effect of reflections at the step discontinuities can be neglected.



(20 M)

Sol: Given: a = 2.286 cm and f = 12GHz

$\alpha_T = 100$ dB

$$\alpha = 2\pi\sqrt{\mu_0\varepsilon_0}\sqrt{f_c^2 - f^2}$$

$$f_c / TE_{10} = \frac{1}{2\sqrt{\mu_0\varepsilon_0}}\frac{1}{\left(\frac{a}{2}\right)} = \frac{3\times10^8}{a} = \frac{3\times10^8}{2.286\times10^{-2}} = 1.312\times10^{10}\,\text{Hz}$$

$$f_c / TE_{10} = 13.12\times10^9\,\text{Hz} = 13.12\text{GHz}$$

$$\alpha = \frac{2\pi}{3\times10^8}\sqrt{(13.12\times10^9)^2 - (12\times10^9)^2}$$

$$= \frac{2\pi\times10^9}{3\times10^8}\sqrt{(13.12)^2 - (12)^2}$$

$$\alpha = \frac{2\pi\times10^9}{3\times10^8}\sqrt{28.1344}$$

$$\alpha = 111.09\,\text{Np/m}$$

1NP = 8.686dB

So, $\alpha = 101.09 \times 8.686 \text{dB/m}$

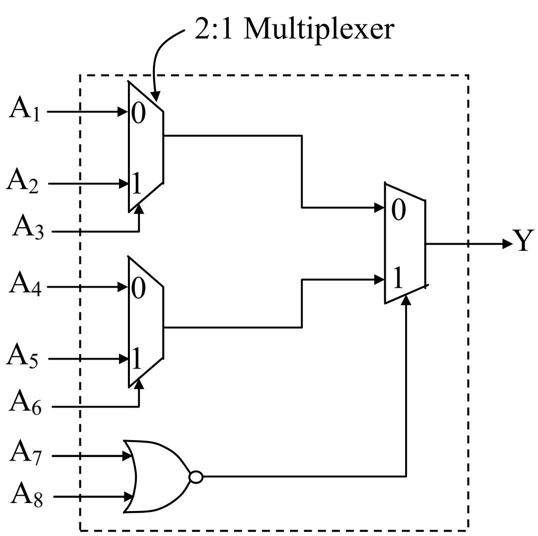
$\alpha = 964.9277 \text{dB/m}$

so $964.9277\text{dB} \rightarrow 1\text{m}$

$100\text{dB} \rightarrow \ell = ?$

$$\ell = \frac{100}{964.9277} = 0.10363\text{m} = 10.36\text{cm}$$

06. (b) Realize a full adder Sum = A ⊕ B ⊕ C in output by using only minimum number of multiplexer based logic blocks as shown below. The 'Sum' output is obtained by appropriately setting all the inputs of these logic blocks.



Logic Block

(20 M)

Sol: $S = A \oplus B \oplus C = m_1 + m_2 + m_4 + m_7$

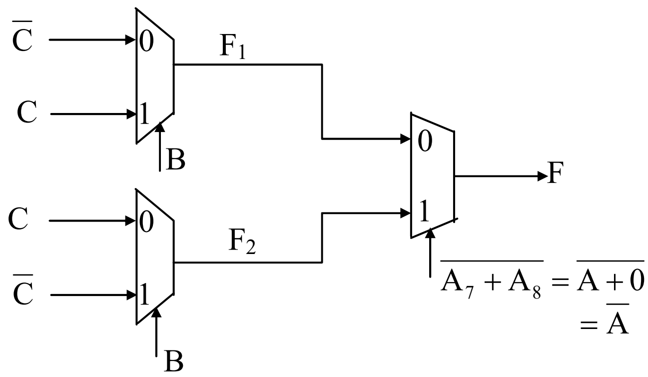
$S = \overline{A}\,\overline{B}C + \overline{A}B\overline{C} + A\overline{B}\,\overline{C} + ABC$

$S = \overline{A}\left[\overline{B}.C + B.\overline{C}\right] + A\left[\overline{B}.\overline{C} + B.C\right]$

Choose

$A_3 = A_6 = B$; $A_1 = \overline{C}$, $A_2 = C$; $A_7 = A$

$A_4 = C$, $A_5 = \overline{C}$; $A_8 = 0$



$$F = \overline{\left(\overline{A}\right)}.I_0 + \overline{A}.I_1$$

$$= A.F_1 + \overline{A}\ .\ F_2$$

where: $F_1 = \overline{B}.\overline{C} + B.C$

$$F_2 = \overline{B}.C + B.\overline{C}$$

$$F = A\left[\overline{B}.\overline{C} + B.C\right] + \overline{A}\left[\overline{B}.C + B.\overline{C}\right]$$

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

$F = A \oplus B \oplus C$

06. (c) Two multimode step index fibers have Numerical Aperture of 0.2 and 0.4 respectively. Both fibers have 1.48 as their refractive index of core. Calculate the insertion loss at a joint in each fiber caused due to 5^o angular misalignment of axes of fiber core. Medium between fibers is air. (20 M)

Sol: The angular coupling efficiency is given

$$\eta_{ang} = \frac{16(n_1/n)^2}{\left[1 + (n_1/n)^4\right]}\left[1 - \frac{n\theta}{\pi n_1 (2\Delta)^{\frac{1}{2}}}\right]$$

The numerical aperture is related to the relative refractive index difference following as

$$NA \cong n_1(2\Delta)^{1/2}$$

Hence:

$$\eta_{ang} \approx \frac{16(n_1/n)^2}{\left[1 + (n_1/n)^4\right]}\left[1 - \frac{n\theta}{\pi NA}\right]$$

For the NA = 0.2 fiber:

$$\eta_{ang} \cong \frac{16(1.48)^2}{[1+1.48]^4}\left[1-\frac{5\pi/180}{\pi 0.2}\right]$$

$$= 0.797$$

The insertion loss due to the angular misalignment may be obtained as

$$\text{Loss}_{ang} = -10 \log_{10} \eta_{ang} = -10 \log_{10} 0.797$$

For the NA = 0.4 fiber:

$$\eta_{ang} \cong 0.926\left[1-\frac{5\pi/180}{\pi 0.4}\right]$$

$$= 0.862$$

The insertion loss due to the angular misalignment is therefore:

$$\text{Loss}_{ang} = -10 \log_{10} 0.862$$

07. (a) The radial components of the radiated power density of an antenna is given by

$$W_{rad} = \hat{a}_r W_r = \hat{a}_r A_0 \frac{\sin\theta}{r^2} \text{ W/m}^2$$

where 'A_0' is the peak value of the power density, 'θ' is the usual spherical coordinate, and '$\hat{a}_r$' is the radial unit vector. Find the maximum directivity of the antenna. Write an expression for the directivity as a function of directional angles 'θ' and 'ϕ'. (10 + 10 M)

Sol: Given:

The radiated power density of an antenna is

$$\vec{W}_{rad} = W_r \hat{a}_r = A_0 \frac{\sin\theta}{r^2} \hat{a}_r \text{ W/m}^2$$

The radiation intensity is given by

$$U(\theta,\phi) \text{ or } U(\theta) = r^2 W_{rad} = r^2 A_0 \frac{\sin\theta}{r^2}$$

$$U(\theta,\phi) \text{ or } U(\theta) = A_o \sin\theta$$

Average power radiated from the antenna is

$$P_{rad} = \int_{\theta}\int_{\phi} U(\theta,\phi)\sin\theta d\theta d\phi$$

$$= \int_{\theta=0}^{\pi}\int_{\phi}^{2\pi} A_o \sin\theta \sin\theta d\theta d\phi$$

$$= A_o\left[\int_{\theta=0}^{\pi}\sin^2\theta d\theta\right]\left[\int_{\phi=0}^{2\pi} d\phi\right]$$

$$= A_0\left[\int_{\theta=0}^{\pi}\frac{1-\cos 2\theta}{2}d\theta\right](2\pi)$$

$$= A_o \times \frac{\pi}{2}\times 2\pi$$

$$P_{rad} = \pi^2 A_o \text{ Watt}$$

As radiation intensity is only a function of ‘θ’ and hence the directivity as a function of directional angle is represented by

$$D = 4\pi\frac{U(\theta)}{P_{rad}}$$

$$= 4\pi \times \frac{A_o \sin\theta}{\pi^2 A_o}$$

$$D = \left(\frac{4}{\pi}\right)\sin\theta$$

$$\therefore D(\theta) = 1.2732\sin\theta$$

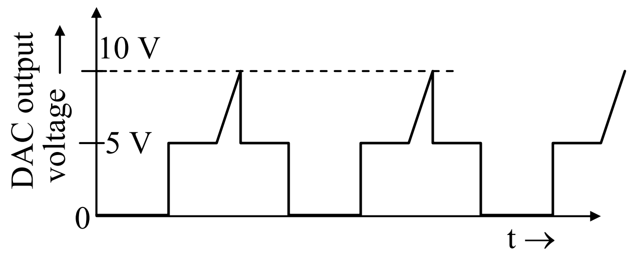
The maximum radiation is directed along $\theta = \frac{\pi}{2}$, thus $U_{max} = A_o$

Maximum directivity af antenna is given by ,

$$D = 4\pi\frac{U_{max}}{P_{rad}} = 4\pi \times \frac{A_o}{\pi^2 A_o} = \frac{4}{\pi}$$

$$\therefore D = 1.2732$$

07. (b) Write an 8085 program to generate the following waveform with the help of 8085 microprocessor kit and an 8-bit DAC connected to an output port 'A' of 8255. The output voltage range of DAC is 0 V to 10 V. The address of port 'A' and Control register of 8255 are 00H and 03H respectively.



(20 M)

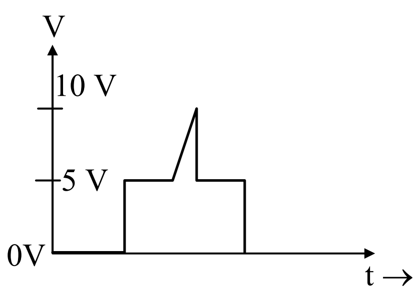
Sol: → Given that 8-bit DAC is connected to port A of 8255 that is interfaced to 8085.

→ DAC's output voltage range is 0V to 10V

→ PA address of 8255 is 00H

→ CWR address of 8255 is 03H

→ The waveform to be generated is as given below



→ IO mode 0 operation is to be used for 8255.

Control word for choosing IO mode 0 i.e., simple I/O is 1 0 0 0 0 0 0 0 i.e., 80H

→ By loading 80H into CWR register, PA will be programmed as output port in simple I/O mode

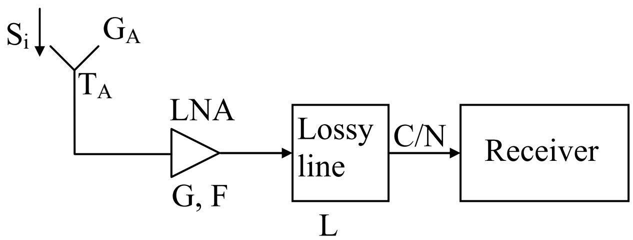
→

Digital input to DAC	Analog output of DAC
00H	0V
80H	5V
FFH	10V

→ **Program:**

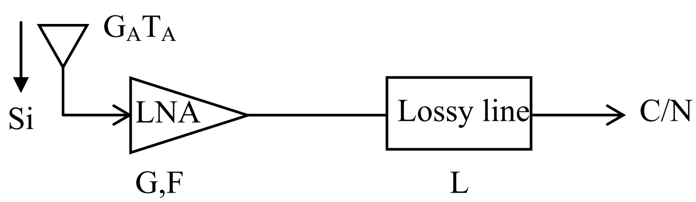
```
              MVI A, 80H  ;    80H is control word
              OUT   03H   ;    PA configured as output port in mode 0
NEXT:         XRA   A     ;    (A) = 00H (Digital equivalent of 0V)
              OUT   00H   ;    DAC output will be 0V
              CALL ZERO   ;    0V level maintained for some time
              MVI A, 80H  ;    (A) = 80H (Digital equivalent of 5V)
              OUT   00H   ;    DAC output will be 5V level
              CALL FIVE   ;    5V level maintained for some time
       RISE:  INR   A
              OUT   00H   ;    Sawtooth starts
              CPI   FFH
              JNZ   RISE  ;    Sawtooth continued till 10V reaches
              MVI A, 80H  ;    (A) = 80H (Digital equivalent of 5V)
              OUT   00H   ;    DAC output will be 5V
              CALL FIVE   ;    5V level maintained for some time
              JMP   NEXT  ;    For next cycle, same operation will be repeated
      ZERO:   MVI C, FFH  ;    ZERO subroutine
     AGAIN:   DCR C
              JNZ AGAIN
              RET
      FIVE:   MVI C, 88H  ;    FIVE subroutine
    REPEAT:   DCR C
              JNZ REPEAT
              RET
              HLT
```

07. (c) Consider the GPS receiver system given below. The guaranteed minimum L1(1575 MHz) carrier power received by an antenna on Earth having a gain of 0 dBi is S_i = – 160 dBW. A GPS receiver is usually specified as requiring a minimum carrier to noise ratio, relative to a 1 Hz BW, of C/N (Hz). If the receiver antenna actually has a gain G_A, and a noise temperature T_A, derive an expression for the maximum allowable amplifier noise figure, F, assuming an amplifier gain, G, and a connecting line loss, L. Evaluate this expression for C/N= 32 dB-Hz, G_A = 5 dB, T_A = 300 K, G = 10dB and L = 25 dB.



(20 M)

Sol:



S_i/dB = –160 dBW = 10 $\log_{10}\left(\frac{S_i}{1}\right)$

$S_i = 10^{-16}$ w

The signal power in the output of this GPS receiver will be $C = \frac{G_A.G.Si}{L}$

$N_0 \times$ (IHZ) = N

$\Rightarrow$ noise available at antenna output in a one sided BW B is kT_AB W

$T_{LNA} = (F_{LNA} - 1)$ 290 K

$T_{LOSS} = (F_{LOSS} - 1)$ 290 K

We have $F_{LOSS} = L$

From the formula for a cascade;

$$T_C = T_{LNA} + \frac{T_{LOSS}}{G} = \left[F_{LNA} - 1 + \frac{L-1}{G}\right]290K$$

Therefore, the effective input referenced noise of the LNA - Lossy line in BW B is

$$KT_CB = \left[F_{LNA} - 1 + \frac{L-1}{G}\right]k(290k)B$$

& total paise power in a BW B at I/P is

$KT_AB + KT_CB$

$$N = \left[T_A + \left(F_{LNA} - 1 + \frac{L-1}{G}\right)290\right]KB$$

B = 1 HZ & apply cascade gain GL^{-1}

$$N = GL^{-1}\left[T_A + \left(F_{LNA} - 1 + \frac{L-1}{G}\right)290\right]K$$

$$\therefore \frac{C}{N} = \frac{G_A Si}{K\left[T_A + \left(F_{LNA} - 1 + \frac{L-1}{G}\right)\times 290\right]} >, r \text{ this is min } \frac{C}{N} \text{ needed.}$$

From above inequality

$$F_{LNA} \le \frac{G_A Si}{Kr.290} - \frac{T_A}{290} + 1 - \left(\frac{L-1}{G}\right)$$

Evaluate expression with

$\frac{C}{N} = r = 32$ dB Hz $\rightarrow 1524.89$

G_A = SdB $\rightarrow 3.16$

T_A = 300 k

G = 10 dB $\rightarrow 10.0$

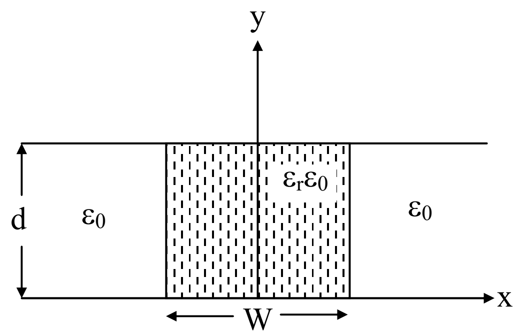
L = 25 dB $\rightarrow 316.23$

$$F_{LNA} \le \frac{3.16\times 10^{-16}}{(1584.09)(1.38\times 10^{-23})(290)} - \frac{300}{290} + 1 - \left(\frac{316.23-1}{10}\right)$$

$F_{LNA} \le 18.26 = 12.6$ dB

Hearty Congratulations to our
GATE - 2021 TOP RANKERS
AIR 1ST IN PRATIK PRAKASH SHINDE
AIR 1ST EE AAKASH DHILL
AIR 1ST ME SUYASH SHARMA
AIR 1ST PI GANESH ADIGAUR
AIR 1ST XE VARUN KAUSHIK
AIR 2nd ME JAY CHAVDA
AIR 2nd PI GOWTHAM GUDIMELLA
AIR 2nd EC M POOJASREE
AIR 2nd ES ANUSH VERMA
AIR 3rd ME MUNISH KUMAR
AIR 3rd ME NUKULA VISWA TEJA
AIR 3rd PI REHAN ANWAR DESAI
AIR 3rd EC MANOJ KUMAR
AIR 3rd CE SHASHIKANT KUMAR
AIR 3rd EE JAYMAL KHUNTI
AIR 4th PI ROHIT SONI
AIR 4th EC P AKHIL
AIR 4th IN DIVAKAR CH.
AIR 4th IN SAURABH JAISWAL
AIR 4th XE JATIN BHANDARI
AIR 4th ES HEMANTH TIWARI
AIR 5th ME ABHISHEKA
AIR 5th EC VAISHNAV KV
AIR 5th CE PRASHANT DWIVEDI
AIR 5th CS PANKAJ LAHKAR
AIR 5th CS S BHATTACHARJEE
AIR 5th PI SUBHANSHU TIWARI
AIR 6th ME ABHISHEK MEWAR
AIR 6th PI AKASH JAISWAL
AIR 6th EC PARAG SAROHA
AIR 6th IN HARSHIT GUPTA
AIR 6th IN RAJU SHARMA
AIR 6th CE TANMAY MAHAJAN
AIR 6th XE MANISH YADAV
AIR 7th ME VATSAL PANCHAL
AIR 7th PI SACHIN DUBOLIYA
AIR 7th PI ATULYA JYOTHI
AIR 8th ME RAJAT GUPTA
AIR 8th ME ROHIT S PATIL
AIR 8th EC ANKUR LAL MEENA
AIR 8th IN KUNAL SAURAV
AIR 8th CE PRANSHU JANGID
AIR 8th CE RAHUL PATI
AIR 8th EE UJJWAL KUMAR
AIR 8th EE HEMANT JINDAL
AIR 9th EC ABHISHEK SINGH
AIR 9th EC ALEESHA ROSE
AIR 9th EC SAI VAMSI DOSAPATI
AIR 9th IN RAMESH KUMAR
AIR 9th CS NIRANJAN NITIN DHOOT
AIR 9th XE RACHIT KUMAR
AIR 10th ME DEEPESH AGARWAL
AIR 10th PI VYOM SHARMA
AIR 10th IN PRAGYA KAUSHIK
AIR 10th CE GOVIND PRASAD B
AIR 10th XE D KUMAR PATIL
AIR 10th XE R SHIVAJI NALE
and many more...
Total 57 Ranks in Top 10
ME : 10
PI : 09
CE : 08
EE : 4
EC : 09
CS : 03
IN : 08
XE : 06

08. (a) Consider the partially filled parallel plate waveguide as shown below. Derive the solution (field and cutoff frequency) for the lowest order TE mode of this structure. Assume the metal plates are infinitely wide.



(20 M)

Sol: Field equations by modifying Maxwell's equations are given by

$$H_x = \frac{j}{K_c^2}\left(\omega\varepsilon\frac{\partial E_z}{\partial y} - \beta\frac{\partial H_z}{\partial x}\right)$$

$$H_y = \frac{-j}{K_c^2}\left(\omega\varepsilon\frac{\partial E_z}{\partial x} + \beta\frac{\partial H_z}{\partial y}\right)$$

$$E_x = \frac{-j}{K_c^2}\left(\beta\frac{\partial E_z}{\partial x} + \omega\mu\frac{\partial H_z}{\partial y}\right)$$

$$E_y = \frac{j}{K_c^2}\left(-\beta\frac{\partial E_z}{\partial y} + \omega\mu\frac{\partial H_z}{\partial x}\right)$$

where $K_c^2 = K^2 - \beta^2$ & $K = \omega\sqrt{\mu\varepsilon}$

TE wave:

Transverse electric (TE) wave also referred as H-wave are characterized by $E_z = 0$ & $H_z \neq 0$ and hence above equation becomes

$$H_x = \frac{-\beta j}{K_c^2}\frac{\partial H_z}{\partial x} \quad \text{........(1)}$$

$$H_y = \frac{-j\beta}{K_c^2}\frac{\partial H_z}{\partial y} \quad \text{.........(2)}$$

$$E_x = \frac{-j\omega\mu}{K_c^2}\frac{\partial H_z}{\partial y} \ ....(3)$$

$$E_y = \frac{j\omega\mu}{K_c^2}\frac{\partial H_z}{\partial x} \ ....(4)$$

By solving wave equation

$H_z(y) = A \cos K_d y$; for $0 < y < W$ ($K_c = K_d$)

$= B \cos K_a(d - y)$; for $W < y < d$ ($K_c = K_a$)

where:

K_d : Cut off wave number in the dielectric

K_c : Cut off wave number in the air dielectric

$$\beta = \sqrt{\varepsilon_r K_0^2 - K_d^2} = \sqrt{K_0^2 - K_a^2}$$

Also H_z has choosen to satisfy $E_x = 0$ at $y = 0, d$

From the above equation (3)

Since $E_x \cong \frac{\partial H_z}{\partial y}$

$$E_x(y) = \frac{-j\omega\mu}{K_c^2}\frac{\partial H_z}{\partial y} = \frac{j\omega\mu}{K_d} A \sin K_d y \ ; \text{for } 0 \le y < W$$

$$= \frac{-j\omega\mu}{K_a} B \sin K_a(d - y); \text{for } W < y < d$$

From the equation of $H_z(y)$ & $E_x(y)$ at $y = W$, gives

$A \cos K_d W + B \cos K_a (d - W) = 0$ and ....(5)

$$\frac{A}{K_d}\sin K_d W - \frac{B}{K_a}\sin K_a(d - W) = 0 \ ....(6)$$

By simplifying the above two equations (5) & (6)

$K_d \tan K_a(d - W) + K_a \tan K_d W = 0$

The above equation gives us final field equations.

Cut off frequency:

$$\bar{\beta} = \sqrt{\varepsilon_r K_0^2 - K_d^2}$$

at $\omega = \omega_c$ $\qquad \bar{\gamma} = 0 \text{ (or) } \bar{\beta} = 0$

$$\varepsilon_r K_0^2 = K_d^2$$

$$\sqrt{\varepsilon_r}\,\omega_c\sqrt{\mu_0\varepsilon_0} = \frac{n\pi}{d} \; ; n = 0,1,2,3,\ldots\ldots$$

$$\sqrt{\varepsilon_r}\,2\pi \quad f_c\sqrt{\mu_0\varepsilon_0} = \frac{n\pi}{d}$$

$$f_c = \frac{n}{2d\sqrt{\varepsilon_r}\sqrt{\mu_0\varepsilon_0}} \; ; \text{For dielectric filled}$$

$$f_c = \frac{n}{2d\sqrt{\mu_0\varepsilon_0}} \; ; \text{for air filled}$$

The lowest order possible mode for n = 1, is TE_1

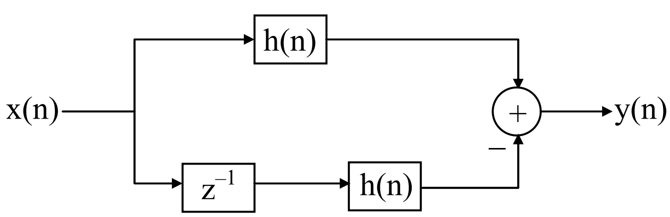
$$f_c(TE_1) = \frac{1}{2d\sqrt{\varepsilon_r}\sqrt{\mu_0\varepsilon_0}}$$

08. (b) (i) Find the response y(n) of the system shown below to the input

$x(n) = u(n + 4) - u(n - 9)$

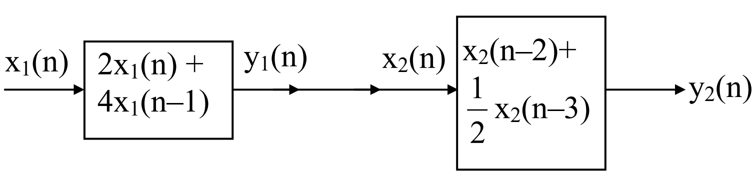
where

$h(n) = b^n u(n), -1 < b < 1$



(10 M)

(ii)



Determine input - output relationship between $x_1(n)$ and $y_2(n)$.

Comment, when the sequence is reversed. **(10 M)**

Sol:

(i) $y(n) = x(n)*h(n) - x(n)*h(n-1)$

$= x(n) * [h(n) - h(n-1)]$

$= x(n)*[b^n u(n) - b^{n-1}u(n-1)]$

$= \{u(n+4) - u(n-9)\}*\{b^n u(n) - b^{n-1}u(n-1)\}$

$\downarrow$ Take Z.T.

$Y(z) = X(z)H(z) - z^{-1}X(z)H(z)$

$= X(z)H(z)(1-z^{-1})$

$$= \frac{(1-z^{-1})}{(1-bz^{-1})}\cdot\frac{z^4-z^{-9}}{(1-z^{-1})}$$

$$Y(z) = \frac{z^4 - z^{-9}}{1-bz^{-1}}$$

$\downarrow$ I.Z.T

$y(n) = (b)^{n+4}u(n+4) - (b)^{n-9}u(n-9)$

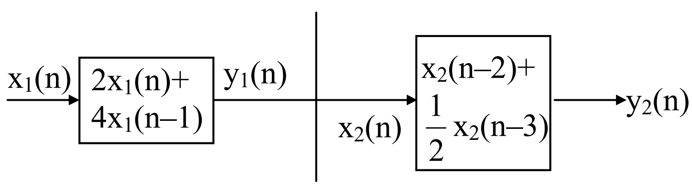
$x(n) = u(n+4) - u(n-9)$

$$X(z) = \frac{z^4 - z^{-9}}{1-z^{-1}}$$

we know $x(n-n_0) \xleftrightarrow{Z.T} z^{-n_0}X(z)$

$$u(n) \xleftrightarrow{Z.T} \frac{1}{1-z^{-1}}$$

(ii)



$y_1(n) = 2x_1(n) + 4x_1(n-1)$

$$\frac{Y_1(z)}{X_1(z)} = 2 + 4z^{-1}$$

$y_2(n) = x_2(n-2) + \frac{1}{2}x_2(n-3)$

$$\frac{Y_2(z)}{X_2(z)} = z^{-2} + \frac{1}{2}z^{-3}$$

But $Y_1(z) = X_2(z)$

$$\frac{X_2(z)}{X_1(z)} = 2 + 4z^{-1}$$

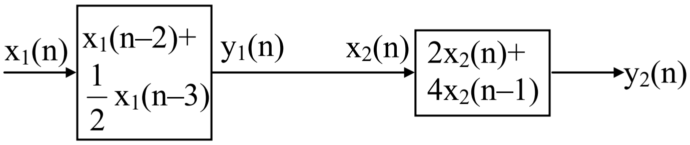
$x(n-n_0) \xleftrightarrow{Z.T} z^{-n_0}X(z)$

$$\frac{Y_2(z)}{X_2(z)}\cdot\frac{X_2(z)}{X_1(z)} = \left[z^{-2} + \frac{1}{2}z^{-3}\right]\left[2 + 4z^{-1}\right]$$

$$\frac{Y_2(z)}{X_1(z)} = 2z^{-2} + 4z^{-3} + z^{-3} + 2z^{-4} \;.......(A)$$

$Y_2(z) = (2z^{-2} + 5z^{-3} + 2z^{-4})\,X(z)$

$y_2(n) = 2x(n-1) + 5x_1(n-3) + 2\,x_4(n-4)$.



But $Y_1(z) = X_2(z)$

$$y_1(n) = x_1(n-2) + \frac{1}{2}x_4(n-3) \qquad y_2(n) = 2x_2(n) + 4x_2(n-1)$$

$$\frac{Y_1(z)}{X_1(z)} = z^{-2} + \frac{1}{2}z^{-3} \qquad \frac{Y_2(z)}{X_2(z)} = 2 + 4z^{-1} \text{ ....(2)}$$

$$\frac{X_2(z)}{X_1(z)} = z^{-2} + \frac{1}{2}z^{-3} \text{ ....(1)}$$

Multiply (1) & (2)

$$\frac{Y_2(z)}{X_1(z)} = \left(z^{-2} + \frac{1}{2}z^{-3}\right)\left(2 + 4z^{-1}\right) \text{........(B)}$$

As equations (A) & (B), even if we reverse the sequence, $y_2(n)$ & $x_1(n)$ holds the same relation as both the systems are L.T.I.

08. (c) A 10 kW transmitter amplitude modulates a carrier with a tone m(t) = sin (2000πt), using 50% modulation. Propagation losses between the transmitter and the receiver attenuate the signal by 90 dB. The receiver has a front-end noise N_0 = –113 dBW/Hz and includes a BPF B_T = 2ω = 10 kHz. What is the post-detection SNR, assuming the receiver uses an envelope detector? (20 M)

Sol: $f_m = 1000$ Hz

$\mu = 0.5$

Loss = 90 dB = 10^{-9}

$N_D = -113$ dBW/Hz = $10^{-11.3}$ W/Hz

BW of BPF = 10 kHz

The component coming at I/P of Envelope Detector is r(t) = s(t) + n(t)

$$r(t) = A_C[1 + K_a m(t)]\cos(2\pi f_c t) + n_I(t)\cos(2\pi f_c t) - n_q(t)\sin(2\pi f_c t)$$

$$r(t) = A_C[1 + K_a m(t) + n_I(t)]\cos(2\pi f_c t) + n_q(t)\sin(2\pi f_c t)$$

O/P of Envelope detector is |r(t)|

$$\therefore |r(t)| = \sqrt{[A_c[1 + K_a m(t)] + n_I(t)]^2 + n_q^2(t)}$$

$$|r(t)| = \sqrt{A_c^2(1 + K_a m(t))^2 + n_I^2(t) + 2A_c(1 + K_a m(t))n_I(t) + n_q^2(t)}$$

Considering $\sqrt{n_q^2(t)} << A_c$

i.e $|n_I(t)| << A_c$ and $|n_q(t)| << A$

the NOISE terms $n_I^2(t)$ and $n_q^2(t)$ terms are dropped.

Hence

$$|r(t)| = \sqrt{A_c^2(1 + K_a m(t))^2 + 2A_c(1 + K_a m(t))n_I(t)}$$

$$|r(t)| = A_c[1 + K_a m(t)] + n_I(t)$$

$\therefore$ O/P signal power neglecting DC terms is $\frac{A_c^2\mu^2}{2}$

Power of signal = $10^4 \times 10^{-9} = 10^{-5}$ W

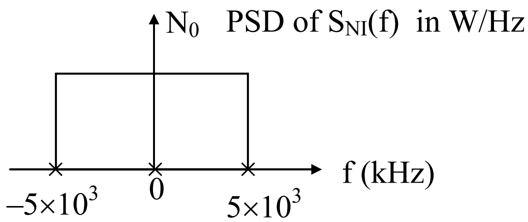
at Rx Input

$$10^{-5} = \frac{A_c^2}{2}\left[1 + \frac{\mu^2}{2}\right]$$

$$10^{-5} = \frac{A_c^2}{2}\left[1 + \frac{1}{8}\right]$$

$$\frac{A_c^2}{2} = \frac{8}{9} \times 10^{-5}$$

Signal power at O/P of Rx = $\frac{8}{9} \times 10^{-5} \times \frac{1}{4} = \frac{2}{9} \times 10^{-5} = 2.22\,\mu W$



Power of Noise component at O/P of filter = $N_0 \times (2f_m) = 10^{-11.3} \times (10 \times 10^3) = 5.01 \times 10^{-8}$ W

$$\left(\frac{S}{N}\right)_{O/P\ at\ ED} = \frac{2.22\times10^{-6}}{5.01\times10^{-8}} = 44.31 = 16.46\,dB$$


Hearty Congratulations to our
ESE - 2020 TOP RANKERS
AIR 1 CHARUDATTA S ME
AIR 1 SHASHANK GAUR EE
AIR 1 PRAKASH JHA E&T
AIR 1 GAURAV KUMAR CE
AIR 2 K S SHARADRAO ME
AIR 2 ABHISHEK SINGH EE
AIR 2 PARTH BATRA E&T
AIR 2 PRASHANT SINGH CE
AIR 3 SURAJ KUMAR S ME
AIR 3 VIKASH SHANKAR EE
AIR 3 RAHUL NAREDI E&T
AIR 3 KULDEEP JANGRA CE
AIR 4 SHUBHAM B ME
AIR 4 ANUPAM S EE
AIR 4 SHUBHAM E&T
AIR 4 ANISH BAGGA CE
AIR 5 KAMLESH PARWAR ME
AIR 5 MANOJ KUMAR E&T
AIR 5 PAVITRA GOYAL CE
AIR 6 MD ZUHAIB ME
AIR 6 VISHWA SIMHAA EE
AIR 6 SAURAV KUMAR S E&T
AIR 7 PRATEEK S ME
AIR 7 DINESH KUMAR S EE
AIR 7 RAGHAV PURWAR E&T
AIR 8 V SAIKRISHNA REDDY ME
AIR 8 GAGAN GHUNAWAT EE
AIR 8 RAM KRISHNA E&T
AIR 9 GANESH KUMAR A ME
AIR 9 AKSHAY KUMAR T EE
AIR 9 CHHAVI JAIN E&T
AIR 9 ARPIT JAIN CE
AIR 10 HEMABH TRIVEDI ME
AIR 10 RAJAT DIXIT EE
AIR 10 L KUMARI JAISWAL E&T
AIR 10 AMIT SHARMA CE
and many more...
TOTAL 36 RANKS IN TOP 10
ME 10
EE 09
E&T 10
CE 07