Saket

MADE EASY

India's Best Institute for IES, GATE & PSUs

ESE 2024 : Mains Test Series

UPSC ENGINEERING SERVICES EXAMINATION

Electronics & Telecommunication Engineering

Test-4 : Electronic Devices & Circuits + Advanced Communication [All topics] Analog & Digital Communication Systems-1 [Part Syllabus] Signals and Systems-2 + Microprocessors and Microcontroller [Part Syllabus]

Name :

Roll No

Test Centres

Delhi ☑ Bhopal ☐ Jaipur ☐ Pune ☐

Kolkata ☐ Hyderabad ☐

Student's Signature

Instructions for Candidates

1. Do furnish the appropriate details in the answer sheet (viz. Name & Roll No).
2. There are Eight questions divided in TWO sections.
3. Candidate has to attempt FIVE questions in all in English only.
4. Question no. 1 and 5 are compulsory and out of the remaining THREE are to be attempted choosing at least ONE question from each section.
5. Use only black/blue pen.
6. The space limit for every part of the question is specified in this Question Cum Answer Booklet. Candidate should write the answer in the space provided.
7. Any page or portion of the page left blank in the Question Cum Answer Booklet must be clearly struck off.
8. There are few rough work sheets at the end of this booklet. Strike off these pages after completion of the examination.

FOR OFFICE USE

Question No.	Marks Obtained
Section-A	
Q.1	43
Q.2	
Q.3	37
Q.4	
Section-B	
Q.5	25
Q.6	
Q.7	29
Q.8	48
Total Marks Obtained	182

Good.

Signature of Evaluator ……………………

Cross Checked by ……………………

1. Avoid calculation error
2. Brush up the concepts for betterment

IMPORTANT INSTRUCTIONS

CANDIDATES SHOULD READ THE UNDERMENTIONED INSTRUCTIONS CAREFULLY. VIOLATION OF ANY OF THE INSTRUCTIONS MAY LEAD TO PENALTY.

DONT'S

1. Do not write your name or registration number anywhere inside this Question-cum-Answer Booklet (QCAB).
2. Do not write anything other than the actual answers to the questions anywhere inside your QCAB.
3. Do not tear off any leaves from your QCAB, if you find any page missing do not fail to notify the supervisor/invigilator.
4. Do not leave behind your QCAB on your table unattended, it should be handed over to the invigilator after conclusion of the exam.

DO'S

1. Read the Instructions on the cover page and strictly follow them.
2. Write your registration number and other particulars, in the space provided on the cover of QCAB.
3. Write legibly and neatly.
4. For rough notes or calculation, the last two blank pages of this booklet should be used. The rough notes should be crossed through afterwards.
5. If you wish to cancel any work, draw your pen through it or write "Cancelled" across it, otherwise it may be evaluated.
6. Handover your QCAB personally to the invigilator before leaving the examination hall.

Section A : Electronic Devices & Circuits + Advanced Communication Topics

Q.1 (a) The energy band gap of silicon (Si) depends on the temperature as follows:

$$E_g = 1.17\text{ eV} - 4.73\times10^{-4}\frac{T^2}{T+636}$$

If the intrinsic carrier concentration of Si at T = 300 K is 1.05 × 10^{10} cm^{-3}, what is the intrinsic carrier concentration of Si at temperature T = 77 K? (Assume at 300 K, KT = 0.026 eV, E_g(300 K) = 1.12 eV)

[12 marks]

Sol:- Given, $n_i = 1.05\times10^{10}/cm^3$

$$n_i = \sqrt{N_C N_V}\, e^{\frac{-E_g}{2KT}} \quad \text{— (i)}$$

If at T = 300 K, $n_i = 1.05\times10^{10}/cm^3$

put in eqn (i) we get,

$$(1.05\times10^{10})^2 = N_C N_V\, e^{\frac{-E_g}{2K(T)}}$$

$$\therefore N_C = 2\left[\frac{2\pi \bar{K} T m_n^*}{h^2}\right]^{3/2}$$

$$N_V = 2\left[\frac{2\pi \bar{K} T m_p^*}{h^2}\right]^{3/2}$$

$n_i^2 = A_0 T^3 e^{\frac{-E_g}{KT}}$ eqn (i) modifies as —

$$(1.05\times10^{10})^2 = A_0(300)^3 e^{\frac{-(1.12)}{0.026}}$$

$$\frac{(1.05\times10^{10})^2}{5.288\times10^{-12}} = A_0$$

$$\boxed{A_0 = 2.085\times10^{31}}$$

at T = 77 K.

$$E_g = 1.17 - 4.73\times10^{-4}\frac{[77]^2}{77+636}$$

$$\Rightarrow 1.166\,eV$$

$$np^2 = 2.085\times10^{31}T^3 e^{-\frac{1.166}{kT}}$$

$$ni^2 = 2.085\times10^{31} e^{-\frac{1.166\times10^3}{6.638}} (77)^3$$

$$\left[\because kT = \frac{T}{11600} \Rightarrow \frac{77}{11600}\right]$$

$$6.638\times10^{-3}$$

$$ni = 2.219\times10^{-20}/cm^3$$

Good

11

Q.1 (b) Consider a silicon one-sided abrupt junction with $N_A = 2 \times 10^{19}$ cm^{-3} and $N_D = 8 \times 10^{15}$ cm^{-3}. Calculate the ratio of junction capacitance, $\frac{C_j(V_R = 0\,V)}{C_j(V_R = -4V)}$ at $T = 300$ K, where V_R is the applied voltage across the junction.
(Assume, $V_T = 0.0259$ V, $\epsilon_s = 11.9\,\epsilon_0$, $n_i = 9.65 \times 10^9$ cm^{-3})

[12 marks]

Sol:

$$Cj = \frac{\varepsilon_0 A}{\omega}$$

$$\omega = \sqrt{\frac{2\epsilon}{q}\left(\frac{1}{N_A}+\frac{1}{N_D}\right)[V_{bi}+V_{br}]}$$

$$V_{bi} = V_T \ln\left(\frac{N_A N_D}{ni^2}\right)$$

$$\Rightarrow 0.0259 \ln\left[\frac{2\times10^{19}\times8\times10^{15}}{(9.65\times10^9)^2}\right]$$

$$\Rightarrow 0.0259 \ln\left[0.1718\times10^{16}\right]$$

$$\boxed{V_{bi} \Rightarrow 0.908\,V}$$

$$Cj = \frac{\varepsilon A}{\sqrt{\frac{2\epsilon}{q}\left[\frac{1}{N_A}+\frac{1}{N_D}\right][V_{bi}+V_{br}]}}$$

$$C_j = \frac{\varepsilon A}{\sqrt{\frac{2\epsilon}{q}\left[\frac{N_A+N_D}{N_AN_D}\right]\left[V_{bi}+V_{br}\right]}}$$

$$\Rightarrow \frac{\cancel{\varepsilon}A\sqrt{q(N_AN_D)}}{\sqrt{2\cancel{\epsilon}\left[N_A+N_D\right]\left[V_{bi}+V_{br}\right]}}$$

$$C_j \Rightarrow \frac{A\sqrt{q\epsilon(N_AN_D)}}{\sqrt{2(N_A+N_D)\left[V_{bi}+V_{br}\right]}}$$

$$C_j = \frac{A\sqrt{1.6\times10^{-19}\times11.9\times8.854\times10^{-14}\times16\times10^{34}}}{\sqrt{2(2.0008\times10^{19})\left[V_{bi}+V_{br}\right]}}$$

$$\Rightarrow \frac{A(164.234)}{\sqrt{V_{bi}+V_{br}}\;\left[6.33\times10^{9}\right]}$$

$$C_j \Rightarrow \frac{2.594\times10^{-8}A}{\sqrt{V_{bi}+V_{br}}}$$

$$C_{j_1} \propto \frac{1}{\sqrt{V_{bi}+0}}$$

⑪

$$C_{j_1} = \frac{1}{\sqrt{0.908}} \Rightarrow 1.049\ F$$

$$C_{j2} = \frac{1}{\sqrt{0.908+4}} \Rightarrow 0.4513$$

$$\frac{C_{j_1}}{C_{j2}} \Rightarrow \frac{1.049}{0.4513} \Rightarrow \underline{\underline{2.324}},$$

Q.1 (c) Two step index fibers exhibit the following parameters:

(i) A multimode fiber with a core refractive index of 1.5, a relative refractive index difference of 3% and an operating wavelength of 0.82 μm.

(ii) An 8 μm core diameter single mode fiber with an core refractive index same as (i), a relative index difference of 0.3% and an operating wavelength of 1.55 μm.

Estimate the critical radius of curvature at which large bending losses occur in both cases.

[8 + 4 marks]

c) i)

Sol: Given :- $n_1 = 1.5$

$\Delta = 3\%$

$\lambda = 0.82\,\mu m$ ~~$n_1 2\Delta =$~~

$NA = n_1\sqrt{2\Delta}$

$\Rightarrow 1.5\sqrt{\frac{2\times 3}{100}}$

$\Rightarrow \frac{1.5\sqrt{6}}{10}$

$\boxed{NA \Rightarrow 0.367}$

for multi mode fiber

$$R = \frac{3n_1^2\lambda}{4\pi[n_1^2 - n_2^2]^{3/2}}$$

$$\Rightarrow \frac{3(1.5)^2(0.82\times10^{-6})}{4\pi[(1.5)^2 - n_2^2]^{3/2}}$$

$\therefore n_1^2 - n_2^2 = NA^2$

$n_2^2 = n_1^2 - NA^2$

$\Rightarrow n_2 = 1.45$ ✓

8

$$\Rightarrow \frac{5.535\times10^{-6}}{4\pi[(1.5)^2 - (1.45)^2]^{3/2}}$$

$\boxed{R \Rightarrow 7.78\times10^{-6}\,m}$ ✓

ii) $2a = 8\,\mu m$, $n_1 = 1.5$, $\Delta = 0.3\%$ $\lambda = 1.55\,\mu m$

$$R_c \Rightarrow \frac{20\lambda}{[n_1 - n_2]^{3/2}}\left[2.748 - 0.996\left(\frac{\lambda}{\lambda_c}\right)\right]^{-3}$$ ✓

$NA^2 = n_1^2 - n_2^2$

$\boxed{n_2 = 1.49}$

$\therefore NA = n_1\sqrt{2\Delta}$

$\Rightarrow 1.5\sqrt{\frac{2\times0.3}{100}}$

$\frac{1.5\sqrt{0.6}}{10} \Rightarrow 0.116$

$\lambda_c = \frac{2\pi a \, NA}{2.405}$ [for single mode fiber]

$\lambda_c = \frac{\pi[8\times10^{-6}][0.116]}{2.405}$

$\boxed{\lambda_c \Rightarrow 1.212\times10^{-6}}$

②

$R = \frac{20(1.55\times10^{-6})}{[1.5-1.49]^{3/2}}\left[2.478 - 0.996[1.278]\right]$

$\Rightarrow 0.031[0.5713]$

$\Rightarrow 0.0177\,m$

calculation error

Q.1 (d) A base station transmitter has a power output of 10 watts operating at a frequency of 250 MHz. The transmitter is connected by 20 m of an RF coaxial cable, which has a loss of –3 dB/100 m specification, to an antenna that has a gain of 9 dBi. The receiving antenna is 25 km away and has a gain of 4 dBi. There is negligible loss in the receiver feeder line, but the receiver is mismatched; the receiving antenna and feeder cable are designed for a 50 Ω impedance, but the receiver input has 75 Ω impedance, resulting into a mismatch loss of about 0.2 dB. Calculate the power delivered to the receiver, assuming free space propagation.

[12 marks]

Soln - Given:

$P_o \Rightarrow 10\,W$, $f = 250\,MHz$

$L = 20\,m$ $\quad G_t = 9\,dB$, $G_r = 4\,dBi$

$$P_r = \frac{P_t G_t G_r}{P_L}$$

$$P_L = 32.45 + 20\log_{10}^{R(km)} + 20\log_{10}^{f(MHz)}$$

$$\Rightarrow 32.45 + 20\log_{10}^{(25)} + 20\log_{10}^{(250)}$$

$$\Rightarrow 108.36\,dB$$

⑦

$P_t \Rightarrow 10\log_{10}^{10} \Rightarrow 10\,dB$ 40

$[P_r]_{dB} \Rightarrow [P_t]_{dB} + G_t + G_r - P_L \Rightarrow P_t - [Loss]$

$\Rightarrow 10 - [-9 - 4 + 0.2 + 3\times5]$

40

$\Rightarrow 10 - [-13 + 15 + 0.2]$

$\Rightarrow 7.8\,dB.$

$[P_r] \Rightarrow$ ~~6.0250~~

Q.1 (e) (i) A photoconductor with dimensions $L = 6$ mm, $W = 2$ mm and $D = 1$ mm is placed under uniform radiation. The absorption of light increases the current by 2.83 mA. A voltage of 10 V is applied across the device. As the radiation is suddenly cutoff, the current falls, initially at a rate of 23.6 A/s. The electron and hole mobilities are 3600 cm^2/V-s and 1700 cm^2/V-s respectively. Find:

1. the equilibrium density of electron-hole pairs generated under radiation.
2. the minority carrier lifetime.
3. the excess density of electrons and holes remaining 1 ms after the radiation is cut off.

(ii) A field transistor has $N_A = 10^{17}\ \text{cm}^{-3}$, $\dfrac{Q_f}{q} = 10^{11}\ \text{cm}^{-2}$ and an n^+ polysilicon local interconnect as the gate electrode. If the requirement for sufficient isolation between device and well is $V_{th} > 20$ V, calculate the minimum field oxide thickness. (Assume $\phi_{ms} = -0.98$ V, $\in_s = 11.9 \in_0$, $\in_{ox} = 3.9 \in_0$, $n_i = 9.65 \times 10^9\ \text{cm}^{-3}$, $V_T = 26$ mV)

[6 + 6 marks]

Soln:- ~~Given: L = 6 mm, W = 2 mm, D = 1 mm~~

~~rate = 23.6 A/s~~

1)(e) ii) Given $N_A = 10^{17}$, $\dfrac{Q_f}{q} = 10^{11}$

$V_{th} > 20$ V

we know that, $V_T = \left[\dfrac{Q_{SDmax} - Q'_{ss}}{C_{ox}}\right] + 2\phi_F + \phi_{ms}$

$$\phi_f = V_T \ln\left[\frac{N_A}{n_i}\right]$$

$$\Rightarrow \cancel{26\times10^{-3}}\ 0.026\ \ln\left[\frac{10^{17}\times10^{-9}}{9.65}\right]$$

$$\Rightarrow 0.42V$$

$$x_{dT} \Rightarrow \sqrt{\frac{2\epsilon}{q}\left[\frac{2\phi_F}{N_A}\right]}$$

$$\Rightarrow \sqrt{\frac{2\times11.9\times8.854\times10^{14}\times2\times0.42}{1.6\times10^{-19}\times10^{17}}}$$

$$\Rightarrow \sqrt{110.63\times10^{-12}} \Rightarrow 1.05\times10^{-5}\,cm$$

$$Q_{SD\,max} \Rightarrow -qN_D x_{dT}$$

$$\Rightarrow -1.6\times10^{-19}\times10^{17}\times1.05\times10^{-5}$$

$$\Rightarrow -1.68\times10^{-7}\ C/m^2$$

4

$$C_{ox} = \frac{\varepsilon_{ox}}{t_{ox}} \Rightarrow \frac{3.9\times8.854\times10^{-14}}{t_{ox}}.$$

Put in eqn —

$$\frac{-1.68\times10^{-7}-10^{11}\times1.6\times10^{-19}}{C_{ox}} + 2\times0.42-0.98 > 20$$

$$\frac{-1.84\times10^{-7}}{C_{ox}} + 0.14 > 20$$

$$\frac{-1.84\times10^{-7}}{C_{ox}} > 20.14$$

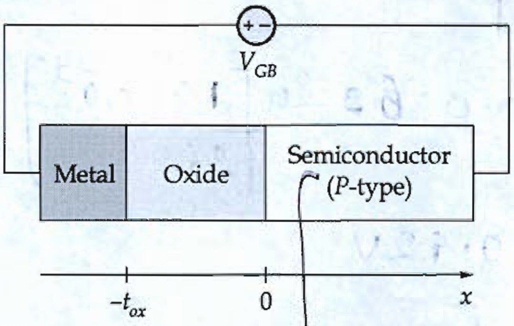
$$C_{ox} < \frac{1.84\times10^{-7}}{20.14}$$

$$\frac{\varepsilon_{ox}}{t_{ox}} < 9.136\times10^{-9}$$

$$\boxed{t_{ox} = 3.78\times10^{-5}\,cm}$$

Calculation error

Q.2 (a) Consider a MOS structure shown below:



The oxide thickness, $t_{ox} = 50$ nm and the doping level in the substrate is $N_a = 10^{16}$ cm^{-3}. Assume, intrinsic carrier concentration of semiconductor, $n_i = 10^{10}/\text{cm}^3$; thermal voltage, $V_T = 26$ mV, $\in_{oxide} = 3.45 \times 10^{-13}$ F/cm, $\in_{si} = 1.05 \times 10^{-12}$ F/cm.

Calculate the hole concentration, P at the oxide-semiconductor interface (i.e., $x = 0$) under the following conditions:

(i) At flatband.

(ii) At threshold

(iii) At a condition in which the potential build up from the quasi-neutral body of semiconductor to $x = 0$ is 0.5 V.

(iv) At a condition when the capacitance per unit area of the MOS structure is 50 nF/cm^2.

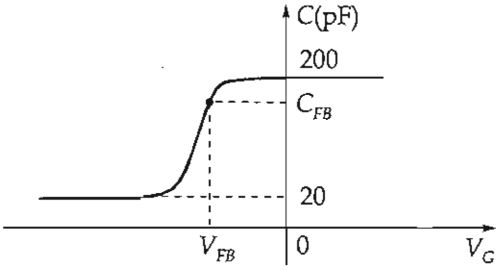
[20 marks]

Q.2 (b) **(i)** Explain in detail noise in photodetector.

(ii) The quantum efficiency of a particular silicon APD operating at a wavelength of 0.8 μm is 90%. The incident optical power is 0.5 μW. The output current is 13 μA. Determine the multiplication factor of the photodiode.

[10 + 10 marks]

Q.2 (c) The high frequency C-V characteristic curve of a MOS capacitor is shown in the figure below. The area of the device is 2×10^{-3} cm^2. The metal-semiconductor work function difference is $\phi_{ms} = -0.5$ V and $V_{FB} = -0.8$ V. The oxide is SiO_2 and the semiconductor is silicon with doping concentration 2×10^{16} cm^{-3}. Assume $\varepsilon_{si} = 1.06 \times 10^{-12}$ F/cm, $\varepsilon_{ox} = 3.45 \times 10^{-13}$ F/cm, $n_i = 1.5 \times 10^{10}$ cm^{-3} and $kT = 0.026$ eV.



(i) Is the semiconductor n or p-type?

(ii) What is the oxide thickness?

(iii) What is the equivalent trapped oxide charge carrier density?

(iv) Determine the flat-band capacitance C_{FB}.

[20 marks]

Q.3 (a) Consider a GaAs pn diode at T = 300 K with $N_a = N_d = 10^{17}$ cm^{-3} and with a cross sectional area of 10^{-3} cm^2. The minority carrier mobilities are μ_n = 3000 cm^2/V-sec and μ_p = 200 cm^2/V-sec. The life times are $\tau_{p0} = \tau_{n0} = \tau_0 = 10^{-8}$ sec. As a approximation, assume the electron-hole generation and recombination rates are constant across space charge region. Calculate the total diode current at a reverse bias voltage of 5 V and at a forward bias voltage of 0.5 V.

(Assume, $V_t = 0.0259$ V, $n_i = 1.8 \times 10^6$ cm^{-3}, $\in_G = 13.1\in_0$)

[20 marks]

Sol^n – diode current :-

$$I = I_S\left[e^{\frac{V_B}{\eta V_T}} - 1\right]$$

$$I_S = A q n_i^2\left[\frac{D_p}{L_p N_D} + \frac{D_n}{L_n N_A}\right]$$

Given $\mu_n = 3000\ cm^2/V\text{-}sec$ $\quad \tau_p = \tau_n = 10^{-8}$

$\mu_p = 200\ cm^2/V\text{-}sec$ $\quad V_T = 0.0259V$

$n_i = 1.8 \times 10^{6}/cm^3$

$\frac{D_p}{\mu_p} = V_T$ [from einstein eq^n]

$D_p = 0.0259 \times 200 \Rightarrow 5.18\ cm^2/sec$

$D_n \Rightarrow 0.0259 \times 3000 \Rightarrow 77.7\ cm^2/sec$

$L_n = \sqrt{D_n \tau_n}$

$\Rightarrow \sqrt{77.7 \times 10^{-8}} \Rightarrow 8.814 \times 10^{-4}$ cm

$L_P = \sqrt{D_P \tau_P}$

$\Rightarrow \sqrt{5.18 \times 10^{-8}} \Rightarrow 2.276 \times 10^{-4}$ cm

$$I_S \Rightarrow 10^{-3} \times 1.6 \times 10^{-19} \times (1.8 \times 10^{6})^{2} \left[\frac{5.18}{2.276 \times 10^{-4} \times 10^{17}} + \frac{77.7}{8.814 \times 10^{-4} \times 10^{17}} \right]$$

$$\Rightarrow 5.184 \times 10^{-10} \left[2.276 \times 10^{-13} + 8.155 \times 10^{-13} \right]$$

$$\boxed{I_S \Rightarrow 5.407 \times 10^{-22} \text{ A.}}$$

12

When forward biased . V = 0.5 V

$$I = 5.407 \times 10^{-22} \left[e^{\frac{0.5}{1 \times 0.0259}} - 1 \right]$$

$$\boxed{I = 1.309 \times 10^{-13} \text{ A}}$$

When reverse biased.

$$I \Rightarrow 5.407 \times 10^{-22} \left[e^{\frac{-5}{0.0259}} - 1 \right]$$

$$\approx -5.407 \times 10^{-22} \text{ A}$$

Incomplete solution

Refer solution

Q.3 (b) (i) Determine the change in the electron density of E-layer when the critical frequency changes from 4.5 MHz to 1.5 MHz for ionospheric communication between mid day and sun set periods.

(ii) In a RSA cryptosystem, a participant *A* uses two prime numbers $p = 13$ and $q = 17$ to generate public and private keys. If the public key of A is 35, then find the private key of *A*.

[10 + 10 marks]

Sol'- 3) b) i) $f_C = 9\sqrt{N_{max}}$.

when $f_C = 4.5\times10^6$

$f_{C_1} = 9\sqrt{N_{max_1}}$

Squaring both sides —

$(f_{C_1})^2 = 81\ N_1$

$(4.5\times10^6)^2 = 81\ N_1$

$\boxed{N_1 = 2.5\times10^{11}\ /\text{[illegible]}}$

$f_{c2} = 9\sqrt{N_{max2}}$

Sauaring both sides –

$(1.5\times10^{6})^{2} = 81\,[N_2]$

$\boxed{N_2 = 2.77\times10^{10}/\cancel{m^3}}$

9

So, change in electrondensity

⇒ $N_1 - N_2$

⇒ 2.223×10^{11} ~~/cm³~~ electron

---

3) b) ii) In RSA algorithm

given $p = 13$ $q = 17$.

Public key of $A = 35$.

Private key of $A = ?$

2

we known ~~that~~ $de \% z = 1$.

d → public key

e → private key

$(d\times e) \bmod z = 1$

So, $\dfrac{35e}{(13-1)(17-1)} = 1$

$\dfrac{35e}{192} = 1$

$\boxed{e \approx 5}$

Q.3 (c) (i) Give the performance comparison between IPv4 and IPv6 in detail.

(ii) 1. Determine the minimum cluster size for a cellular system designed with an acceptable value of signal to co-channel interference ratio $\frac{C}{I} = 18$ dB. Assume the path loss exponent as 4 and co-channel interference at the mobile unit from six equidistant co-channel cells in the first tier.

2. If the acceptable $\frac{C}{I}$ is enhanced to 20 dB, will the cluster size determined in (i) be adequate? If not, then what should be the cluster size?

[10 + 10 marks]

Sol:-

IPV4	IPV6
• It is of 32 bit	• It is of 128 bit
• It has only one header of 4 bits	• It has two header one is main header and another is extension header and it is of 8 bit.
• It does not have any security protocol	• It has its own security protocol IPsec.
• It support multicasting broadcasting, unicasting.	• It does not have any broadcast support.
• It have space issue limited to only 2^{35} bits	• It have long space of 2^{128} bits
• IPV4 has fragmatetation bits.	• It does not have any fragmentation bits.

- Its add is of 8 bit add divided in to four columns.
- It has default adding ~~128::/0~~

6

- Its address divided in 16 bits add divided in to 8 columns
- It also have some default and loop backadd ::120 x 42

Sol:- 3) c) ii) given $\frac{C}{I} = 18\,dB$

Path loss exponent $n = 4$

cochannel Interference at the mobil unit = 6.

we known that -

$$\frac{C}{I} = \frac{(\sqrt{3N})^n}{6}$$

~~$\frac{C}{I} = 18$~~

$$\frac{C}{I} = \frac{Q^4}{6}$$

$$18 \Rightarrow 10\log_{10}(4I)$$

$$\boxed{\frac{C}{I} = 63.095}$$

$$Q^4 = 378.57$$

$$\boxed{Q = 4.41}$$

5

$$\therefore \frac{C}{I} = 1.5N^2$$

$$\frac{63.095}{1.5} = N^2 \Rightarrow \boxed{N \simeq 6.48}$$

$$\boxed{N \approx 7}$$

2) If the $\left(\frac{C}{I}\right) \rightsquigarrow$ 20dB

$$\frac{C}{I} = 100 = 1.5N^2$$

$$N \approx 8.16.$$

If $\frac{C}{I}$ = 20dB then cluster size of the previous one will not be adequate and we have to increase our cluster size upto 8.16.

3

reuse factor:

$$\frac{C}{I} = \frac{Q^4}{6}$$

$$(100 \times 6)^{1/4} = Q$$

$$Q \simeq 4.949$$

$$Q \simeq 5$$

Reuse factor is also increased.

Incomplete solution

Q.4 (a) **(i)** For the system shown in figure (a), the receiver noise figure is 12 dB, the cable loss is 5 dB, the LNA gain is 50 dB, and its noise temperature 150 K. The antenna noise temperature is 35 K. Calculate the noise temperature referred to the input. Also, repeat the calculation when the system of figure (a) is arranged as shown in figure (b).

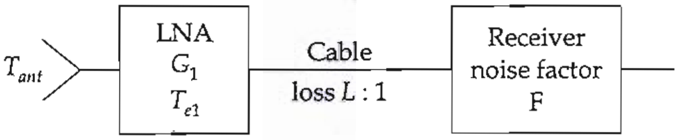


figure (a)

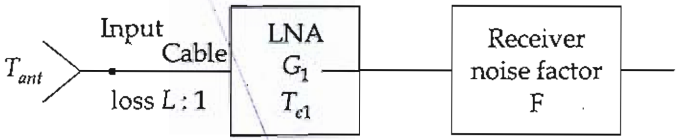


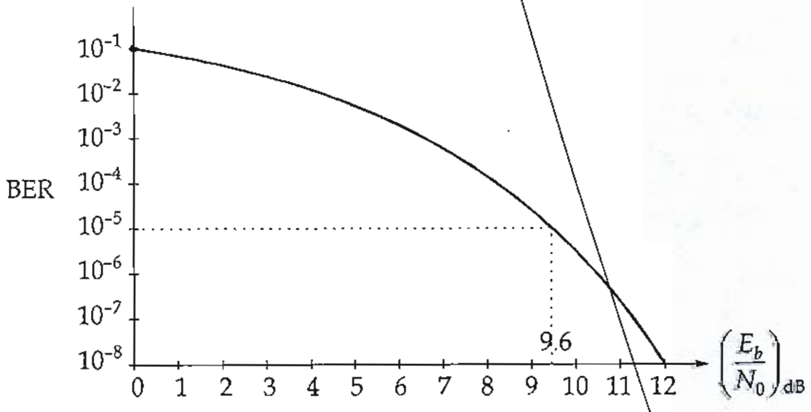
figure (b)

(ii) A QPSK signal is transmitted by satellite. Raised cosine filtering is used, for which the roll off factor is 0.2 and a bit error rate (BER) of 10^{-5} is required. For the satellite downlink, the losses amount to 200 dB, the receiving earth station $\frac{G}{T}$ ratio is 32 dB K^{-1}, and the transponder bandwidth is 36 MHz.

Calculate:

1. the bit rate which can be accommodated, and
2. the EIRP required.

BER versus $\left(\frac{E_b}{N_0}\right)$ plot for baseband signalling for QPSK modulated waveform is shown below:



[10 + 10 marks]

Q.4 (b) A silicon pnp bipolar transistor at $T = 300$ K has uniform dopings of $N_E = 10^{18}$ cm^{-3}, $N_B = 10^{16}$ cm^{-3}, and $N_C = 10^{15}$ cm^{-3}. The metallurgical base width is 1.2 μm. Let $n_i = 1.5 \times 10^{10}$ cm^{-3}, $D_B = 10$ cm^2/s and $\tau_{B0} = 5 \times 10^{-7}$ s. Assume that the minority carrier hole concentration in the base can be approximated by a linear distribution. Let $V_{EB} = 0.625$ V.

(i) Determine hole diffusion current density in the base for $V_{BC} = 10$ V.

(ii) Estimate the Early voltage for $V_{BC} = 5$ V. Use the results from part (i).

[20 marks]

Q.4 (c) **(i)** Consider that a geographical service area of a cellular system is 4200 km^2. A total of 1001 radio channels are available for handling traffic. Suppose the area of a cell is 12 km^2.

1. How many times would the cluster of size 7 have to be replicated in order to cover the entire service area? Calculate the number of channels per cell and the system capacity.
2. If the cluster size is decreased from 7 to 4, then does it result into increase in system capacity? Comment on the results obtained.

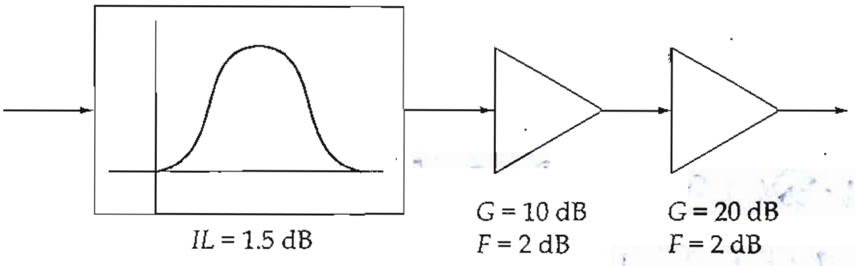
(ii) Give the performance comparison of UDP and TCP.

[10 + 10 marks]

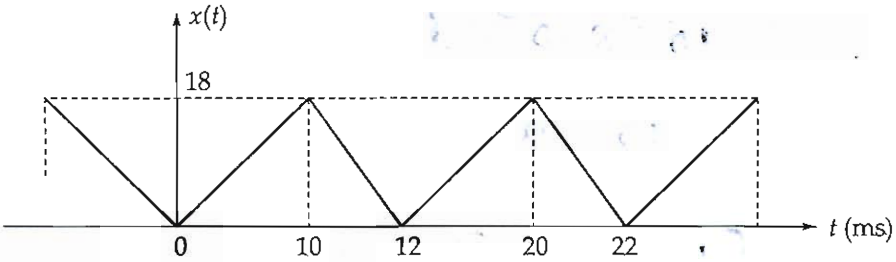
Section B : Analog & Digital Communication Systems-1 + Signals and Systems-2 + Microprocessors and Microcontroller-2

Q.5 (a) (i) Consider the following wireless local area network (WLAN) receiver front-end as shown in figure where the bandwidth of the bandpass filter is 100 MHz centered at 2.4 GHz. Assume the system is at room temperature.

1. Find the noise figure of the overall system.
2. What is the resulting signal-to-noise ratio at the output, if the input power level is –90 dBm?
3. Can the components be rearranged to give a better noise figure?



(ii) A message signal shown below phase modulates a carrier signal $A_c \cos \omega_c t$, where $f_c = 1$ MHz. If a maximum frequency deviation of 75 kHz is needed, determine the value of the phase constant (K_P) to be used by the modulator. With this value, find the range of variation of modulated signal frequency.



[6 + 6 marks]

Sol{:- 5) a) i) B.W ⇒ 100 MHz $f_{c\,\text{center}} \pm 2.4$ GHz

1) Noise figure

$$F = F_1 + \frac{(F_2-1)}{g_1} + \frac{(F_3-1)}{g_1 g_2}$$

2

$$\Rightarrow \cancel{10^{0.15} + \frac{(10^{0.2}-1)10^{0.15}}{10\times} + \frac{[10^{0.2}-1]10^{0.1}}{1000}}$$

$$\Rightarrow 10^{0.25} + \frac{(10^{0.2}-1)\times 10^{0.15}}{10} + \frac{[10^{0.2}-1]10^{0.15}}{1000} \rightarrow 10$$

$$\boxed{F \Rightarrow \cancel{1.49}}$$

2) $\left(\frac{S}{N}\right)_0 = ?$

p'

$N = KTB$

$NF = \frac{(S/N)_i}{(S/N)_0}$

Refer sollution

$(S/N)_0 = \frac{(S/N)_i}{NF}$

$N_i \Rightarrow 1.38 \times 10^{-23} \times 300 \times 10^{8}$

$\Rightarrow \underline{\underline{4.14 \times 10^{-13}}}$

$S_i = -90 = 10\log_{10}\left(\frac{P}{10^{-3}}\right)$

$10^{-9} \times 10^{-3} = P$

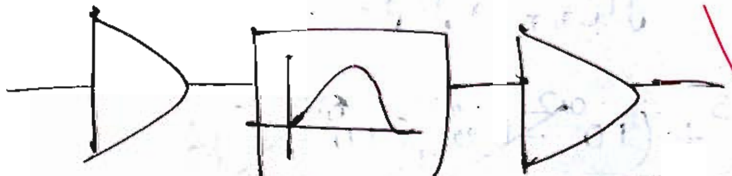
$S_i = 10^{-12} W$

$\left(\frac{S}{N}\right)_0 = \frac{\left[\frac{10^{-12}}{4.14 \times 10^{-13}}\right]}{1.49}$

$\Rightarrow 1.62$

$\Rightarrow \underline{\underline{2.095 dB}}$

3)



$\Rightarrow 10^{0.2} + \frac{10^{1.5}}{10} + \frac{(10^{0.2} - 1) \times 10^{1.5}}{10} \Rightarrow \underline{6.596}$

$10^{0.2} + \frac{10^{0.15}}{\cancel{10}} \xrightarrow{} 100 + \frac{(10^{0.2}-1)\,10^{0.15}}{1000} \Rightarrow \underline{1.726}$

---

ii) $f_c = 1MHz$ $\Delta f_{max} \Rightarrow \underline{75kHz}$.

$K_p \Rightarrow ?$

we know that,

$$\Delta f = \frac{K_p}{2\pi}\frac{d}{dt}[m(t)]$$

$$75\times10^3 = \frac{K_p}{2\pi}\frac{d}{dt}(m(t))_{max}.$$

$$\frac{75\times10^3\times2\pi}{1800 \xrightarrow{} 9\times10^3} = K_p$$

$K_p \Rightarrow \underline{261.79\ rad/Hz}$

Range of freq

$$f_{i_{max}} = f_c + \Delta f.$$

$$f_{i_{min}} = f_c - \Delta f.$$

$f_{i_{max}} = 10^6 + 75\times10^3.$

$\Rightarrow 1075kHz$

$f_{min} \Rightarrow 10^6 - 75\times10^3$

$\Rightarrow \underline{925kHz}$

②

Q.5 (b) (i) **1.** A WSS random process $X(t)$ with auto correlation function

$R_{XX}(\tau) = Ae^{-\alpha|\tau|}$

where A and α are real positive constants is applied to the input of an LTI system with impulse response,

$h(t) = e^{-\beta t}u(t)$

where b is a real positive constant. Find the auto correlation of the output $Y(t)$ of the system.

2. Let $X(t)$ and $Y(t)$ be both zero-mean and WSS random processes. Consider the random process $Z(t)$ defined by

$Z(t) = X(t) + Y(t)$

(a) Determine the auto correlation function and the power spectral density of $Z(t)$ if $X(t)$ and $Y(t)$ are jointly WSS.

(b) If $X(t)$ and $Y(t)$ are orthogonal, then show that the mean square of $Z(t)$ is equal to the sum of the mean squares of $X(t)$ and $Y(t)$. .

(ii) If the probability density function $f_X(x)$ of a random variable X is given by

$f_X(x) = (1 - x^2)$ for $0 \le x \le 1$

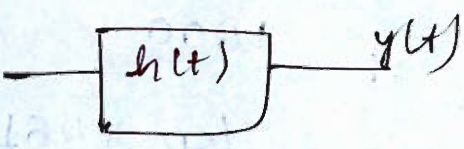
Find the standard deviation of this random variable.

[8 + 4 marks]

Soln – b) i)

$R_{XX}(\tau) = Ae^{-\alpha|\tau|}$

$h(t) = \bar{e}^{\beta t}u(t)$



find $R_{YY}(\tau) = ?$

$R_{XX}(\tau) \underset{IFT}{\overset{FT}{\rightleftarrows}} PSD.$

$(PSD)_{O/P} = (PSD)_{I/P}\,[H(f)]^2$

$R_{XX}(\tau) \xrightarrow{FT} \dfrac{2\alpha A}{\alpha^2+\omega^2}$

$h(t) \longrightarrow \dfrac{1}{j\omega+\beta}$

$h(f) \rightarrow \dfrac{1}{\beta+j2\pi f}$

$$(PSD)_{o/p} \Rightarrow \left[\frac{2\alpha A}{\alpha^2+\omega^2}\right]\left[\frac{1}{4\pi^2 f^2+\beta^2}\right]$$

$R_{xx}(\tau) \longrightarrow ?$

$PSD \xrightarrow{IFT} R_{yy}(\tau)$

②

$$\Rightarrow \frac{1}{2\pi}\int_{-\infty}^{\infty} \frac{2\alpha A}{\alpha^2+\omega^2}\left[\frac{1}{\omega^2+\beta^2}\right] d\omega$$

✓

$\Rightarrow$

2) a) $Z(t) = \underbrace{X(t)+Y(t)}_{\text{zero mean WSS Random function}}$

①

$R_{\cancel{xy}}(zt) \Rightarrow E[X(t)+Y(t)][X(t+\tau)+Y(t+\tau)]$

$\Rightarrow E[X(t)X(t+\tau) + Y(t)X(t+\tau) + X(t)Y(t+\tau)$
$+ Y(\tau) + Y(t+\tau)]$ ✓

$$\Rightarrow \boxed{R_{\cancel{zz}}[Z(t)] \Rightarrow R_{xy}(\tau) + R_{yy}(\tau)} + R_{xy}(\tau) + R_{yx}(\tau)$$

~~+cov~~

$[PSD] = ?$

$R_{zz}(Z(t)) \xrightarrow{IFT} (PSD)Z(t)$.

②

b) If $X(t)$ & $Y(t)$ are orthogonal then ✓

then $E[XY] = 0$ $cov(x,y) = 0$

So, ~~$Z(t) = X(t)+Y(t)$~~ $\Rightarrow E[X^2(t)] + E[X(t)]^{0} + E[Y^2(t)] + E[Y(t)]^{0}$

$$\boxed{E[Z^2(t)] \Rightarrow E[X^2(t)] + E[Y^2(t)]}$$

pp) SD of this function:

$\sigma = \sqrt{msq - mean^2}$

So, mean $\int_0^1 x(1-x^2)dx$

$\Rightarrow \int_0^1 (x - x^3)dx = \left[\frac{x^2}{2} - \frac{x^4}{4}\right]_0^1$

mean $= \frac{1}{2} - \frac{1}{4} \Rightarrow \frac{4-2}{8} = \frac{2}{8}$

mean $= \frac{1}{4}$

$msq = \int_0^1 x^2(1-x^2)dx$

$\Rightarrow \int_0^1 (x^2 - x^4)dx \Rightarrow \left[\frac{x^3}{3} - \frac{x^5}{5}\right]_0^1$

$\Rightarrow \frac{1}{8} - \frac{1}{5} \Rightarrow \frac{5-3}{15}$

$\Rightarrow \frac{2}{15}$

④

$\sigma = \sqrt{\frac{2}{15} - \frac{1}{16}}$

$\Rightarrow \underline{0.266}$

Q.5 (c) Consider the following Discrete Time Sequences:

$x_1(n) = \{\underset{\uparrow}{1}, a, b, 2\}$ and $x_2(n) = \{\underset{\uparrow}{c}, 2, d, 4\}$

(i) If the linear convolution of the sequence is $\{\underset{\uparrow}{1}, 3, 7, 13, 14, 14, 8\}$ then find, the values of a, b, c and d.

(ii) Find circular periodic convolution of the sequences $x_1(n)$ and $x_2(n)$ in terms of a, b, c and d.

(iii) Also find circular periodic convolution of the sequence $x_1(n)$ and $x_2(n)$ for the values of a, b, c and d calculated in (i).

[12 marks]

Soln – i) linear convalution:

	c	2	d	4
1	c	2	d	4
a	ac	2a	ad	4a
b	bc	2b	bd	4b
2	2c	4	2d	8

$\{c,\ 2+ac,\ 2a+d+bc,\ 4+ad+2b+2c,\ 4a+bd+4,\ 4b+2d,\ 8\}$

Compare with $\Rightarrow \{\underset{\uparrow}{1}, 3, 7, 13, 14, 14, 8\}$

$\boxed{c=1}$

$ac + 2 = 3$

$ac = 1$

$\boxed{a=1}$

$2a + d + bc = 7$

$2 + d + b = 7$

$\boxed{d+b=5}$

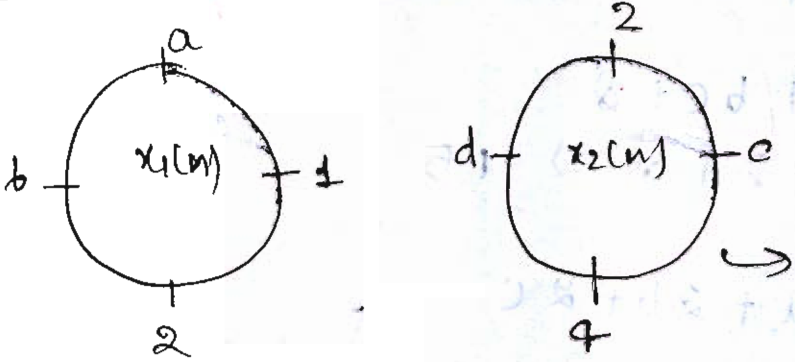
$4b + 2d = 14$ $d = 3$ $b = 2$

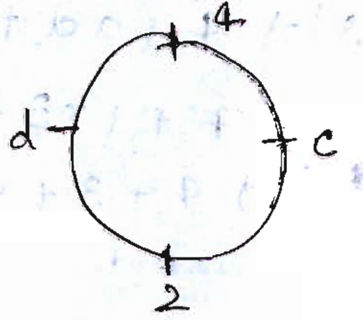
$d + b = 5$

$a = 1, b = 2, c = 1, d = 3$

4

ii) circular covalution



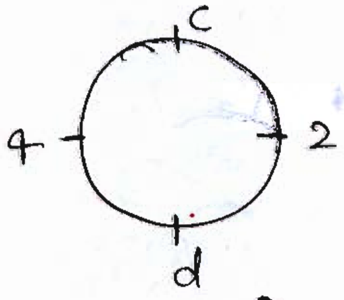


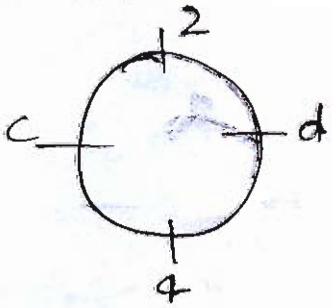
$x(0) \Rightarrow c + 4a + bd + 4$

$x(1) \Rightarrow 2 + ac + 4b + 2d$

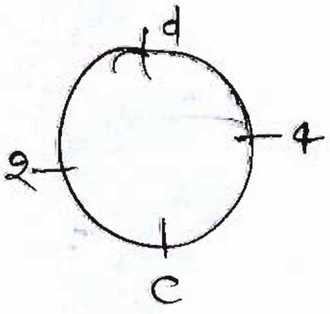
$x(2) \Rightarrow d + 2a + bc + 8$

$x(3) \Rightarrow 4 + ad + 2b + 2c$





4



ood

iii) $x(0) = c + 4a + bd + 4$

$\Rightarrow 1 + 4 + 6 + 4 \Rightarrow 15$

$x(1) = 2 + ac + 4b + 2d$

$\Rightarrow 2 + 1 + 8 + 6 \Rightarrow 17$

$x(2) = d + 2a + bc + 8$

$\Rightarrow 3 + 2 + 2 + 8 \Rightarrow 15$

$x(3) \Rightarrow 4 + ad + 2b + 2c$

$\Rightarrow 4 + 1 \times 3 + 2 \times 2 + 2 \times 1$ $\{15, 17, 15, 13\}$

$\Rightarrow 4 + 3 + 4 + 2 \Rightarrow 13$

4

Good

Q.5 (d) Describe the program status word register present in the 8051 microcontroller.

[12 marks]

Q.5 (e) A 12 MHz carrier is frequency modulated using a modulating signal $m(t) = A_m \sin 4\pi \times 10^3 t$. The resultant FM signal has frequency deviation of 8 kHz.

(i) Derive the expression for capture range of a PLL used for demodulation of this signal.

(ii) What should be the capture range of a PLL used for demodulation of this signal?

[10 + 2 marks]

Sol:- capture range for PLL is -

$\Rightarrow 2\sqrt{\Delta f f_m}$ $\qquad f_m = 2\times10^3$ Hz

$\Rightarrow 2\sqrt{8\times10^3\times2\times10^3}$

$\Rightarrow 2\sqrt{16\times10^6}$

$\Rightarrow 2\times4\times10^3$

$\Rightarrow \underline{8\times10^3 \text{ Hz}}$

✓

2

Q.6 (a) The probability density function of two independent random variables X and Y are given by

$f_X(x) = ae^{-ax}u(x)$ and $f_Y(y) = be^{-by}u(y)$

where a, b are positive real constants and $u(\cdot)$ represents the unit step function. Determine the probability density function of the random variable Z for each of the following cases: (Assume $z > 0$)

(i) $Z = X - Y$ **(ii)** $Z = \frac{X}{Y}$ **(iii)** $Z = \min(X, Y)$ **(iv)** $Z = \max(X, Y)$

[20 marks]

(b) Given a second-order transfer function,

$$H(z) = \frac{0.56(1 - z^{-2})}{1 + 1.5z^{-1} + 0.4z^{-2}}$$

Perform the filter realization and write the difference equations using the following realizations:

(i) Direct form I and direct form II.

(ii) Cascade form via the first-order sections.

(iii) Parallel form via the first-order sections.

[8 + 6 + 6 marks]

Q.6 (c) (i) Draw and describe the block diagram for processor to memory communication and processor to I/O communication.

(ii) Write some differences between Microcontroller and Microprocessor.

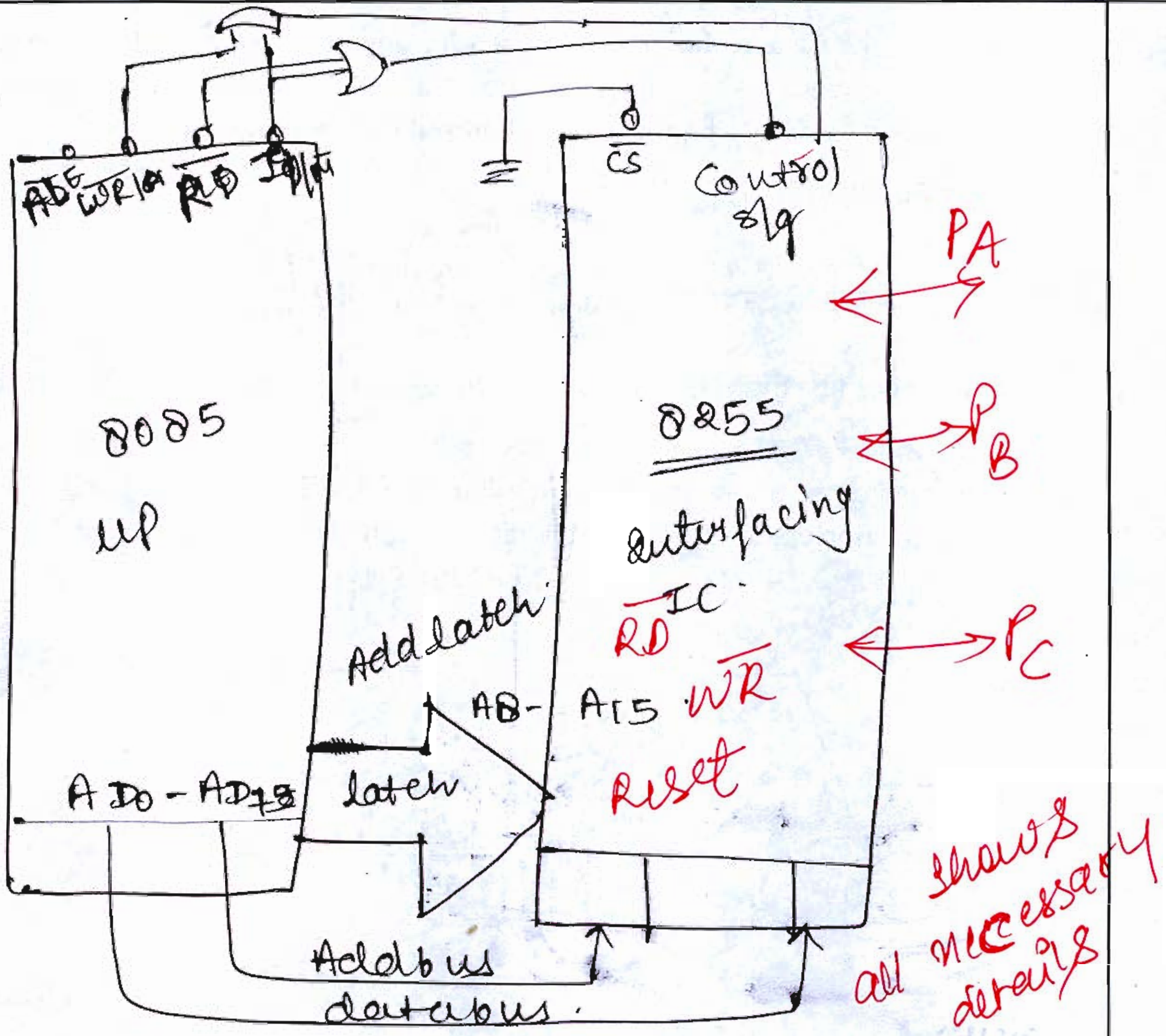
[15 + 5 marks]

Q.7 (a) With the help of schematic diagram, explain the interfacing of 8255 with 8085 processor.

[20 marks]

Soln 8255 (Programmable peripheral Interface IC)

- It is of 24 pin IC divided in to 3 port A, B & C
- Port A & B are of 8 bit and port C divided in to two 4 bit ports.
- Port C have PCu (upper of 4 bit) and PCL (lower of 4 bit).
- It works in 3 modes
  - ↳ Input / output mode
  - ↳ Bidirectional mode
  - ↳ Storobbed mode or handshaking mode



shows all necessary details

→ ALE: It is used to latch the address

It works as a switch when 0 the add is latched and when 1 the data is latched.

WR: low (active low) write slg

RD: Active low read slg.

IO/M̄: It is memory I/O slg.

15

AD0-AD7:- lower multiplexed lines

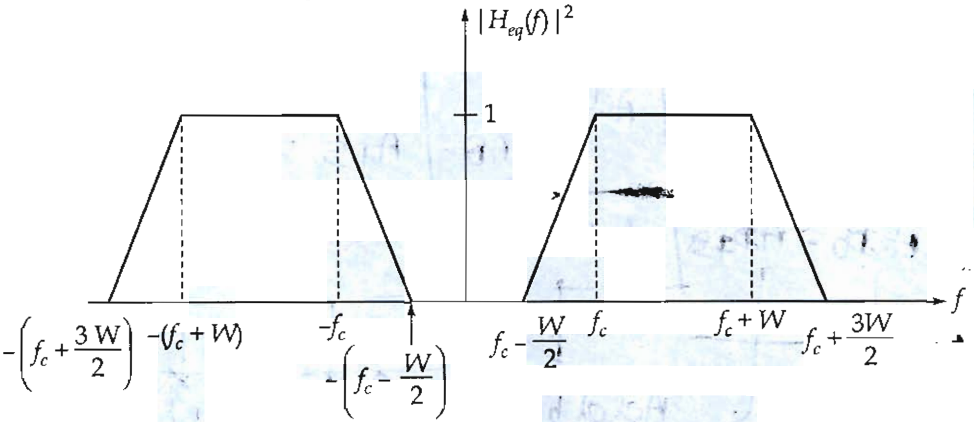
A8-A15: higher add lines.

Q.7 (b) (i) Consider the system shown below used for generation of amplitude modulated signal. The average value of $m(t)$ is zero and maximum value of $|m(t)|$ is A_m. The square-law device with input $x(t)$ and output $y(t)$ is defined by

$$y(t) = 6.5x(t) + 12x^2(t)$$

What should be the value of A_m, required to produce AM signal with modulation index of 0.85?

(ii) In a receiver meant for the demodulation of SSB AM signals, the band-pass filter has the characteristics $H_{eq}(f)$ as shown in the figure below. Find FOM of the system.



[5 + 15 marks]

7) b) i) given

$\text{avg}(m(t)) = 0$

$\max(m(t)) = A_m$

$\mu = 0.85 \quad A_m = ?$

$y(t) = 6.5[m(t) + \cos\omega_c t] + 12[m(t) + \cos\omega_c t]^2$

$\Rightarrow 6.5m(t) + 6.5\cos\omega_c t + 12[m^2(t) + \cos^2\omega_c t + 2m(t)\cos\omega_c t]$

$\Rightarrow 6.5m(t) + 6.5\cos\omega_c t + 12m^2(t) + 12\cos^2\omega_c t + 24m(t)\cos\omega_c t$

$\Rightarrow$ O/P of BPF $y_{AM}(t) \rightarrow 6.5\cos\omega_c t + 24m(t)\cos\omega_c t$

$\Rightarrow 6.5\left[1+\frac{24}{6.5}m(t)\right]\cos\omega_c t$

Compare with $S_{AM}(t) \Rightarrow A_c[1+k_a m(t)]\cos\omega_c t$

$\mu \Rightarrow k_a m(t)\big|_{max}$

$0.85 = \frac{24}{6.5} A_m$

$\boxed{A_m \Rightarrow 0.23}$ ✓

⑤

---

i) FOM $\Rightarrow \frac{(S|N)_o}{(S|N)_i}$

$(SSB\ AM)_{sig}$

⑤

$S_{AM}(t) \Rightarrow A_c[1+k_a m(t)]\cos\omega_c t$

$\Rightarrow A_c[1+k_a A_m\cos\omega_m t]\cos\omega_c t$

$\Rightarrow A_c\cos\omega_c t + k_a A_c A_m \cos\omega_c t \cos\omega_m t$

$\Rightarrow A_c\cos\omega_c t + \frac{k_a A_c A_m}{2}\cos(\omega_c+\omega_m)t$

$+ \frac{k_a A_c A_m}{2}\cos(\omega_c+\omega_m)t$

Consider upper side band

$A_c\cos\omega_c t + \frac{k_a A_c A_m}{2}\cos(\omega_c+\omega_m)t$

$S_i = \frac{A_c^2}{2} + \frac{k_a^2 A_c^2 P_m}{4}$

$\Rightarrow \frac{A_c^2}{2}\left[1+\frac{k_a^2 P_m}{2}\right]$

$\left(\frac{S}{N_i}\right) \Rightarrow \frac{A_c^2[2+k_a^2 P_m]}{4N_o\omega}$ ✓

$N_i^{\circ} \Rightarrow N_o \omega_o$ & $\omega_o = \frac{3\omega}{2} + \frac{\omega}{2}$

$\Rightarrow \underline{2\omega}$

<u>for o/p</u>

$S_{AM}(t) = A_c \cos\omega_c t + \frac{k_a A_c A_m}{2} \cos(\omega_c + \omega_m)t$ +n(t)

$+ n_i(t)\cos\omega_c t - n_q(t)\sin\omega_c t$

$\therefore$ left $n_q(t) = 0$

Refer solution for better understanding

$\Rightarrow [A_c + n_i^{\circ}(t)]\cos\omega_c t + \frac{k_a A_c A_m}{2}\cos(\omega_c + \omega_m)t$

$\Rightarrow [A_c + n_i(t)]\cos\omega_c t + \frac{k_a A_c A_m}{2}[\cos\omega_c t \cos\omega_m t - \sin\omega_c t \sin\omega_m t$

$\Rightarrow \left[A_c + n_i(t) + \frac{k_a A_c A_m}{2}\cos\omega_m t\right]\cos\omega_c t$

$\pm \frac{k_a A_c A_m}{2}\sin\omega_m t \sin\omega_c t$

$\Rightarrow$ envelop detector o/p

$\sqrt{\left(A_c + n_i(t) + \frac{k_a A_c A_m}{2}\cos\omega_m t\right)^2 + \frac{k_a^2 A_c^2 A_m^2 \sin^2\omega_m t}{4}}$

$\Rightarrow \sqrt{(A_c^2 + n_i(t))^2 + \frac{k_a^2 A_c^2 A_m^2}{4}}$

$\Rightarrow \left| A_c + n_i(t) + \frac{k_a A_c A_m}{2} \right|$

$\Rightarrow A_c^2 + \frac{k_a^2 A_c^2 P_m}{4} = S_o$

$N_o \Rightarrow 2 N_o \omega$

$\left(\frac{S}{N}\right)_o \Rightarrow \frac{\frac{A_c^2}{4}[4 + k_a^2 P_m]}{2 N_o \omega}$

~~FOM~~ ~~4~~ $A_c^2 + k_a^2$

FOM $\Rightarrow \frac{A_c^2 [4 + k_a^2 P_m]}{8 N_o \omega}$

$\frac{A_c^2 [2 + k_a^2 P_m]}{4 N_o \omega}$

$\boxed{\text{FOM} \Rightarrow \frac{4 + k_a^2 P_m}{4 + 2 k_a^2 P_m}}$

(i) The message signal $m(t)$ has a bandwidth of 15 kHz, a power of 18 W. It is desirable to transmit this message to a destination via a channel with 85 dB attenuation and additive white noise with power spectral density, $S_n(f) = \frac{N_0}{2} = 10^{-13}$ W/Hz and achieve a SNR at the receiver output of at least 55 dB. What is the required transmitter power and channel bandwidth if the following modulation schemes are employed?

1. DSB AM
2. SSB AM
3. Conventional AM with modulation index equal to 0.65.

(ii) For a superheterodyne receiver having no RF amplifier, the loaded Q of the antenna coupling circuit is 120. If the super heterodyne receiver is to be improved for HF reception so that its image rejection at 30 MHz is as good as at 1500 kHz.

Assuming IF of 455 kHz, determine:

1. loaded Q of an RF amplifier to be used for achieving the improved performance.
2. new IF for achieving the improved performance in the absence of RF amplifier.

[12 + 8 marks]

~~5~~ i) $m(t) \Rightarrow f_m = 15$ kHz   attenuation

Power → 10 W   = 85 dB

$S_n(f) = \frac{N_0}{2} = 10^{-13}$ W/Hz

$\left(\frac{S}{N}\right)_0 \Rightarrow 55$ dB

1) DSB AM   we know that FOM|DSB-SC = 1

$$FOM = 1 = \frac{(S/N)_0}{(S/N)_i}$$

②

$$\left(\frac{S}{N}\right)_0 = \left(\frac{S}{N}\right)_i$$

$$\left(\frac{S}{N}\right)_i = 10^{5.5}$$

$$\left(\frac{S}{N}\right)_i \Rightarrow 316227.766$$

~~SDSB(SC(t))~~

$$S_i = \frac{P_t}{P_L}.$$

$S_i = \dfrac{18}{10^{85/20}} \Rightarrow$

~~$\boxed{S_i = 5.692 \times 10^{-8}}$~~ $S_i = 1.012 \times 10^{-3}\,\omega$

$\dfrac{S_i}{N_p} = 10^{5.5}$.

$N_i \Rightarrow$ ~~$\dfrac{5.692 \times 10^{-8}}{10^{5.5}}$~~ $N_i = 3.2 \times 10^{-9}\,\omega$

Refer solution

$N_i = 3.2 \times 10^{-9}$

$2N_0\omega \Rightarrow 3.2 \times 10^{-9}$ $\left(N_0 = 2 \times 10^{-13}\right)$

$2\omega \Rightarrow$ ~~$\dfrac{1.8 \times 10^{-13}}{20 \times 10^{-13}}$~~.

incomplete

~~$\boxed{W = 0.9}$~~

$\omega = 8$ kHz

ii) for SSB-AM

①.

$FOM = 1$

$\left(\dfrac{S}{N}\right)_i = \left(\dfrac{S}{N}\right)_0$

$\left(\dfrac{S}{N}\right)_i = 10^{5.5}$

incomplete

$S_i = \dfrac{18}{10^{85/20}} \Rightarrow 1.012 \times 10^{-3}\,\omega$

$N_i = 3.2 \times 10^{-9}\,\omega$

$\boxed{\omega = 16 \text{ kHz}}$

$N_0\omega \Rightarrow 3.2 \times 10^{-9}\,\omega$

for AM $\quad$ FOM $\Rightarrow \dfrac{\mu^2}{\mu^2+2}$

$$FOM \Rightarrow \frac{(S/N)_o}{(S/N)_i} \Rightarrow \frac{0.65^2}{2+0.65^2}$$

$$\left(\frac{S}{N}\right)_o \Rightarrow 0.174\left(\frac{S}{N}\right)_i$$

Incomprehe

$$101 7400.95 = \left(\frac{S}{N}\right)_i$$

①

~~$N_i^\circ = 1.012\times10^{-3}$~~

$$N_i^\circ \Rightarrow 5.5695\times10^{-10}$$

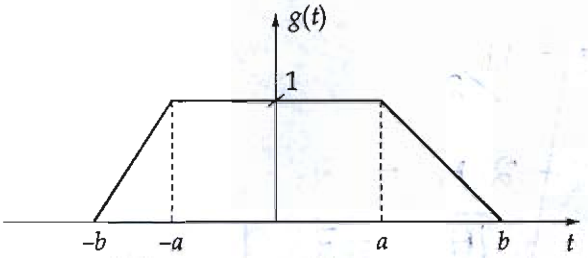
$$\omega \Rightarrow \frac{5.569\times10^{-10}}{2\times2\times10^{13}}$$

$$\boxed{\omega \Rightarrow 1.39\,\text{kHz}}$$

(i) Find the inverse z-transform of

$$X(z) = \frac{z^3 - 10z^2 - 4z + 4}{2z^2 - 2z - 4}; \text{ with ROC } |z| < 1$$

(ii) 1. Using time shifting and time differentiation properties; find the Fourier transform $G(j\omega)$ of the trapezoidal signal shown below:



What is the conditon under which this procedure is valid?

2. Calculate the value of $G(2j)$, if $a = \frac{b}{2} = 1$.

[10 + 7 + 3 marks]

$$Q(i)\ a)\ X(z) = \frac{z^3 - 10z^2 - 4z + 4}{2z^2 - 2z - 4}$$

$$2z^2 - 2z - 4 \overline{)\ \cancel{z^3} - 10z^2 - 4z + 4\ } \left(\frac{z}{2} - \frac{9}{2} \right.$$

$$\cancel{z^3} - z^2 - 2z$$
$$- \quad + \quad +$$

$$-9\cancel{z^2} - 2z + 4$$
$$\cancel{-9z^2} + 9z + 18$$
$$+ \quad - \quad -$$

$$-11z - 14$$

$$\Rightarrow \frac{z}{2} - \frac{9}{2} - \frac{(11z + 14)}{2z^2 - 2z - 4}$$

$$\Rightarrow \frac{z}{2} - \frac{9}{2} \underbrace{- \frac{(11/2\, z + 7)}{z^2 - z - 2}}_{X_3(z)}$$

$$X_3(z) = \frac{\frac{11}{2} z + 7}{(z-2)(z+1)} \Rightarrow \frac{z\left(\frac{11}{2} z + 7\right)}{z(z-2)(z+1)}$$

$$\frac{X_3(z)}{z} = \frac{\frac{11}{2} z + 7}{z(z-2)(z+1)} \Rightarrow \frac{A}{z} + \frac{B}{z-2} + \frac{C}{z+1}$$

$\frac{11}{2}z + 7 = (z-2)(z+1)A + z(z+1)B + z(z-2)C$

$\frac{11}{2}z + 7 = (z^2 - 2z + z - 2)A + (z^2+z)B + (z^2-2z)C$

$A + B + C = 0$

$-A + B - 2C = 11/2$

~~$-2A$~~ $-2A = 7$

$\boxed{A = \frac{-7}{2}}$

$B + C = \frac{7}{2}$

$B - 2C = \frac{11}{2} + A$

$B - 2C = \frac{11}{2} - \frac{7}{2}$

$\boxed{B - 2C = 2}$

$\boxed{B = 3, \quad C = \frac{1}{2}}$

$\Rightarrow \frac{-7\,z}{2\,z} + \frac{8z}{z-2} + \frac{z(0.5)}{z+1}$

$\Rightarrow \frac{-7}{2}\delta(n) + 8(2)^n u(n) + 0.5$

$\Rightarrow \frac{\frac{11}{2}z + 7}{(z-2)(z+1)} \Rightarrow \frac{A}{z-2} + \frac{B}{z+1}$

$\frac{11}{2}z + 7 = Az + A + Bz - 2B$ ✓

$A + B = \frac{11}{2}$ $\qquad A = 6$

$A - 2B = 7$ $\qquad B = \frac{-1}{2}$

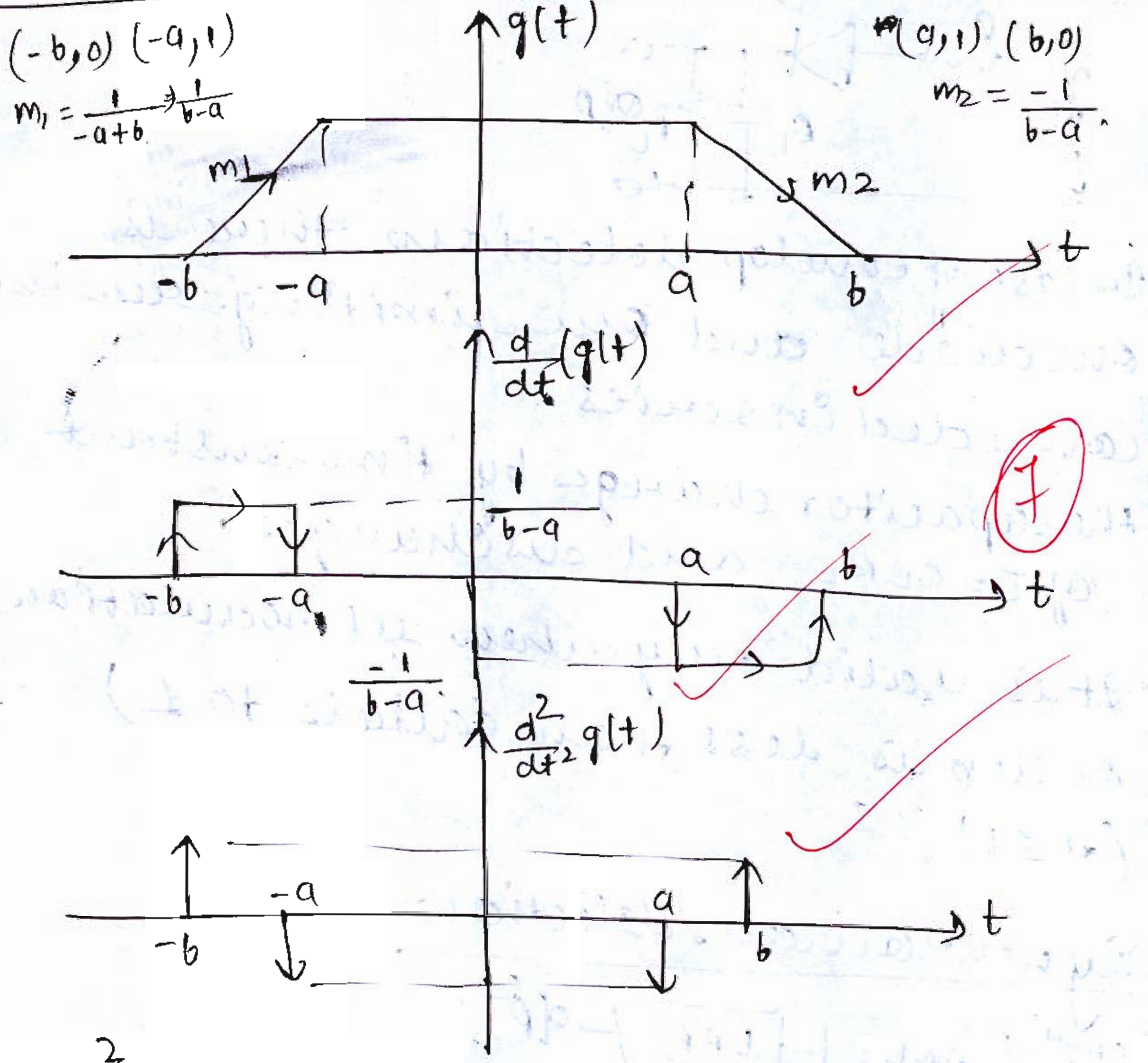
$\Rightarrow \frac{6}{z-2} - \frac{1}{2(z+1)} \Rightarrow x_3(n) \Rightarrow 6(2)^{n-1}u(n-1) - 0.5(-1)^{n-1}u(n-1)$ ✓

$x(n) = x_1(n) + x_2(n) + x_3(n)$

0

$\Rightarrow \frac{2}{2} - \frac{9}{2} - \left[6(2)^{n-1} u(n-1) + 0.5(-1)^{n-1} u(n-1)\right]$

$x(n) \Rightarrow 0.5\delta(n+1) - \frac{9}{2}\delta(n) - 6(2)^{n-1} u(n-1) + 0.5(-1)^{n-1} u(n-1)$



7

$$\frac{d^2}{dt^2} g(t) = \frac{1}{(b-a)}\delta(t+b) - \frac{1}{b-a}\delta(t+a) - \frac{1}{b-a}\delta(t-a) + \frac{1}{b-a}\delta(t-b)$$

$\Rightarrow x(t-t_0) \xrightarrow{FT} e^{-j\omega t_0} X(\omega)$

$\frac{d}{dt} x(t) \longrightarrow (j\omega) X(\omega)$

$\Rightarrow \frac{1}{b-a}\left[e^{j\omega b} - e^{j\omega a} - e^{-j\omega a} + e^{-j\omega b}\right]$

$\Rightarrow \frac{-\omega^2 2}{b-a}\left[\cos\omega b - \cos\omega a\right]$

$\Rightarrow \frac{-2\omega^2}{b-a}\left[\cos\omega b - \cos\omega a\right]$

(e) $\omega = 2 \quad a = 1, b = 2$

$F(\omega) \Rightarrow \frac{-2\times 4}{1}\left[\cos 4 - \cos 2\right]$

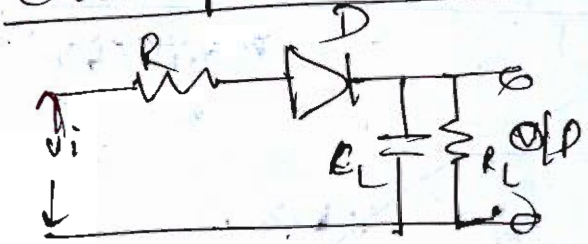
$\Rightarrow -8\left[\cos 4 - \cos 2\right]$

$\Rightarrow \underline{-0.0146}$

Q.8 (b) Explain the Envelope detection and synchronous detection methods for demodulation of AM signal. Show that in an envelope detector, to avoid diagonal clipping, $RC \leq \frac{1}{\omega_m}\frac{\sqrt{1-\mu^2}}{\mu}$. Also, explain the Quadrature null effect in synchronous detector.

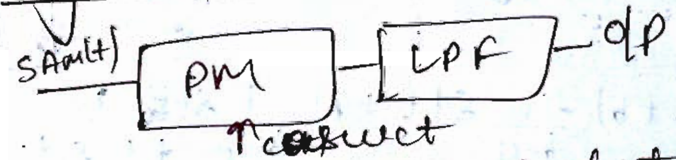
[20 marks]

Sol/- envelop detection

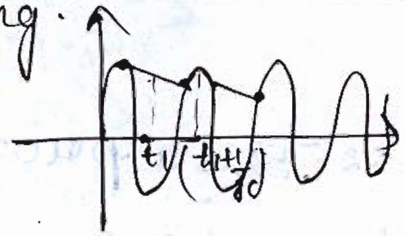


- In case of envelop detection there is one diode and one limiting resistance connected in series.
- the capacitor charges by time constant of $\tau = C_L R_L$ and discharges.
- It is valid only when μ (modulation Index is less than equals to 1) ($\mu \leq 1$)

Synchronous detection



In this synchronous detection μ (modulation Index can be greater than will also used for any value of μ it is valid it is also called coherent detection for avoiding diagonal clippling.



$S_{AM}(t) \Rightarrow A_c \cos[2\pi f_c t[1+k_a m(t)]]$

$\Rightarrow A_c[1+\mu m(t)]\cos\omega_c t$.

$\Rightarrow |A_c[1+\mu \cos\omega_m t]|$

at $t = t_1$ envelop o/p $\Rightarrow S_1(t) \Rightarrow A_c[1+\mu \cos\omega_m t_1]$

$S_2(t) = A_c[1+\mu\cos\omega_m(t_1+\frac{1}{f_c})]$

$s_2(t) \Rightarrow e^{-t/R_LC_L} A_c[1+\mu \cos\omega_m(t_1+\frac{1}{f_c})]$

$$\left[1-\frac{1}{R_LC_Lf_c}\right]\cancel{A_c}\left[1+\mu\cos\omega_m\left(t_1+\frac{1}{f_c}\right)\right] \le \cancel{A_c}\left[1+\mu\cos\omega_m\left(t_1+\frac{1}{f_c}\right)\right]$$

$$\left(1-\frac{1}{R_LC_Lf_c}\right)\left[1+\mu\cos\omega_m t\right] \le \left[1+\mu\cos\left(\omega_m t_1+\frac{\omega_m}{f_c}\right)\right]$$

$$\left(1-\frac{1}{R_LC_Lf_c}\right)\left(1+\mu\cos\omega_m t\right] \le \left[1+\mu\cos\omega_m t\cos\frac{\omega_m}{f_c} - \mu\sin\omega_m t\sin\frac{\omega_m}{f_c}\right.$$

for very small θ $\cos\theta \approx 1$
$\sin\theta \approx \theta$

$$\left(1-\frac{1}{R_LC_Lf_c}\right)\left[\cancel{1}+\mu\cos\omega_m t\right] \le \left[\cancel{1}+\frac{\mu\omega_m \cos\omega_m t}{f_c} - \mu\sin\omega_m t\sin\frac{\omega_m}{f_c}\right]$$

15

$$\mu\cos\omega_m t - \frac{1\cos\omega_m t}{R_LC_Lf_c} \le \frac{\mu\cos\omega_m t}{f_c} - \mu\sin\omega_m t\sin\frac{\omega_m}{f_c}$$

for max value of the envelop.

$\sqrt{A^2+B^2}$ ⇒ ~~A~~ $\cos\omega_c t + B\sin\omega_c t$.

Qns?

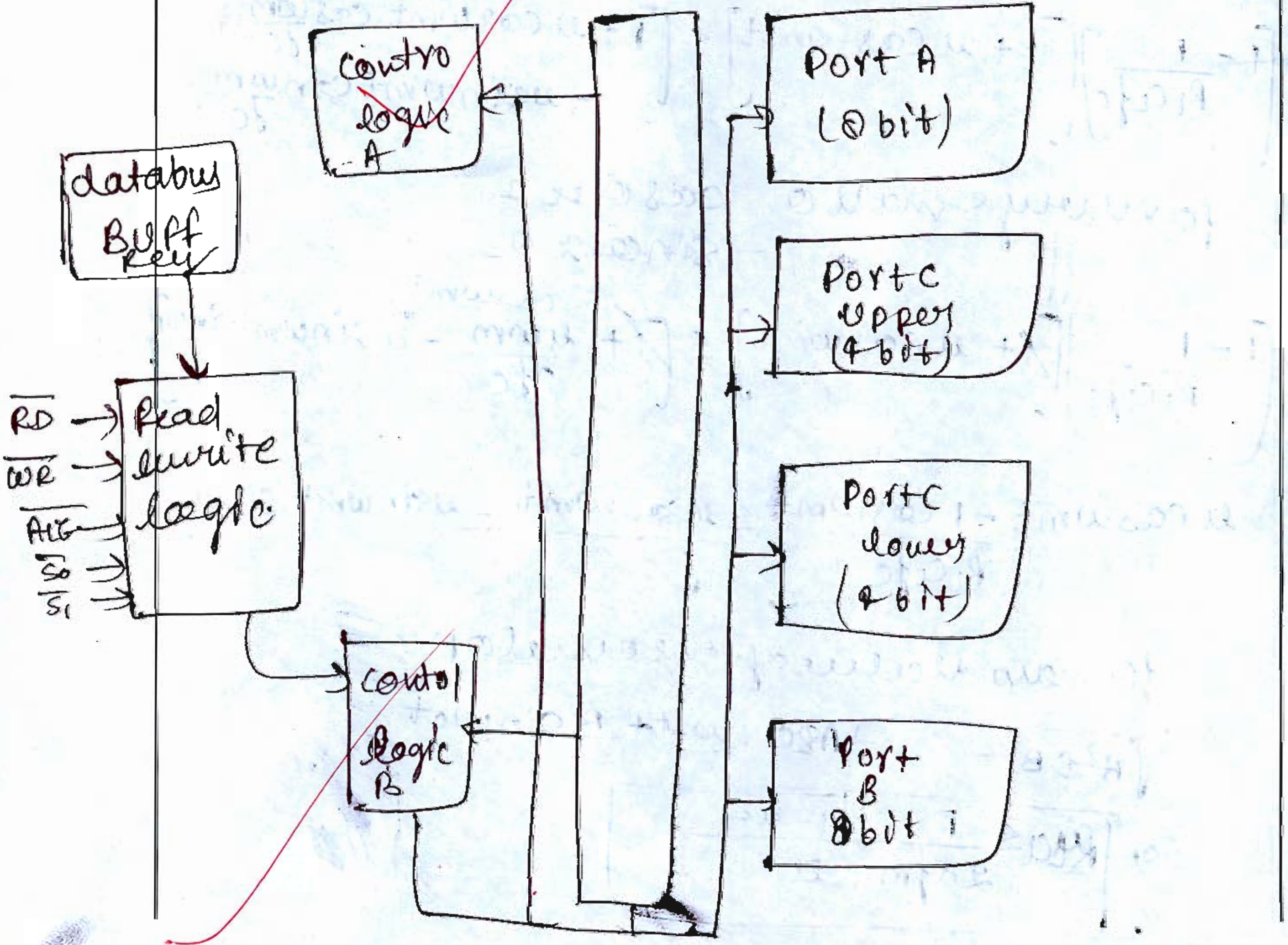
So, $\boxed{R_LC_L \le \frac{1}{2\pi f_m}\frac{\sqrt{1-\mu^2}}{\mu}}$

Q.8 (c) Briefly describe the 8255 A programmable peripheral interface and also draw the block diagram of 8255 A. **[20 marks]**

Sol:- 8255 is a programmable peripheral Interface IC

- It has 3 ports and each port consist of an 8 bit Port A, B & C.
- port A, B, C & and each port can work either as I/o p further port C can be divided in 4 ports ech.

mode 0 → I/o mode
mode 1 → bidirectional mode
mode 2 → strobbed mode or handshaking mode.



mode 0: I/P/O/P mode In this Port A & Port B can work either as I/P & O/P port C can work as handshaking sig O/P port can be latched ~~but~~ I/P cannot also be lached.

mode 1: In this mode either of any A, B, C can work as I/P I/P and O/P device O/P can be lached but I/P cannot be latched.

18

~~bidirectional~~.

mode 2: handshaking mode in this port B can work as I/P and port A as O/P and port C can work as handshaking sig they have error detection capabilities.

7	6	5	4	3	2	1	0
BSR mode	D6	D5	D4	D3	D2	D1	D0

dont' care

PC0 → PC7

mode sel

7	6	5	4	3	2	1	0
latch	mode port	of A	Port A	Port C uppr	mode of Port B	Port B	Port C lower

control word reg

0000

Space for Rough Work

Space for Rough Work