

KLS Vishwanathrao Deshpande Institute of Technology

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

University / Model Question Paper Scheme & Solution

Faculty Name	:	Prof P. Laxin. Dias, Prof. Rohini Kallur
Course Name	:	Principles of communication systems
Course Code	:	BECL402
Year of Question Paper	:	June / July 2025
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Faculty Member


HoD


Dean (Acad.)

Dept. of Electronic & Communication Engg
KLS V.D.I.T., HALIYAL (U.K.)

	c. Interpret with a neat circuit diagram, the working principle of frequency modulation of a crystal oscillator with a Voltage Variable Capacitor (VVC).	8	L2	CO2
OR				
Q.6	a. Define Modulation. Identify any five differences between Frequency Modulation and Amplitude Modulation.	6	L2	CO2
	b. Why Pre-emphasis and de-emphasis are required? Explain how they are implemented?	6	L2	CO2
	c. Draw the block diagram of a super heterodyne receiver and explain the function of each.	8	L2	CO2
Module – 4				
Q.7	a. State and prove sampling theorem. Write a program for sampling and reconstruction of low pass signals and display the signals and its spectrum.	10	L3	CO3
	b. Infer the working of TDM system with a neat block diagram.	5	L2	CO3
	c. Explain briefly the block diagram of PPM generator.	5	L2	CO3
OR				
Q.8	a. Identify and explain the basic elements of a PCM system with neat diagrams. For the data stream [0 1 1 0 1 0 0 1], draw the following line code waveforms: (i) Unipolar NRZ (ii) Polar NRZ (iii) Unipolar RZ (iv) Bipolar RZ (v) Manchester code	10	L3	CO3
	b. Infer the advantages of digital signals over analog signals.	5	L2	CO3
	c. Explain briefly the midtread and midrise Quantizers with relevant figures.	5	L2	CO3
Module – 5				
Q.9	a. What is Intersymbol Interference (ISI)? With a neat block diagram outline the baseband binary data transmission system and write the necessary equations?	8	L2	CO4
	b. Define SNR. Summarize the different types of external and internal noise.	7	L2	CO4
	c. Illustrate the concept of Noise in cascaded stages with a diagram. Write Friis formula and mention its terms.	5	L2	CO4
OR				
Q.10	a. What is Baseband digital transmission? Explain the following concepts briefly: (i) Nyquist criterion for distortionless transmission. (ii) Baseband M-ary PAM transmission.	8	L2	CO4
	b. Define Noise. Classify the different types of semiconductor noise.	7	L2	CO4
	c. What is Noise Factor and Noise Figure? An RF amplifier has an S/N ratio of 8 at the input and an S/N ratio of 6 at the output. Calculate the Noise factor and Noise figure.	5	L2	CO4

Module - 1

1 (A) Probability: Probability of event A is denoted by $P(A)$
 Probability is a measure of how likely an event is to occur.

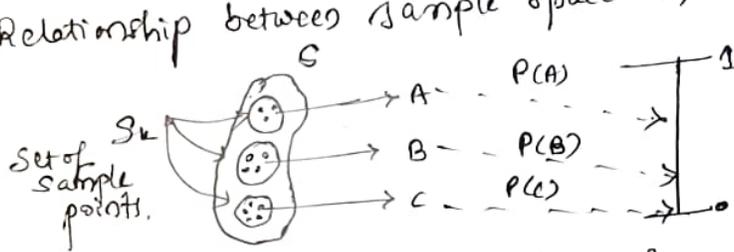
$$P(A) = \frac{\text{Number of favourable outcomes}}{\text{Total number of possible outcomes}}$$

Let a random experiment is repeated n times, if the event occurs n_A times, probability of event A i.e. $P(A)$ is defined as,

$$P(A) = \lim_{n \rightarrow \infty} \left(\frac{n_A}{n} \right)$$

The ratio n_A/n represents the fraction of occurrence of event A.
 Relationship between sample space (S), Events & probability

L2, cos



Defn + 2
 Diagram + 2
 Explaining + 2
 6m

Ex: $S = \{H, T\}$ $E = \{H, T\}$
 Sample space Event
 $E = \{H\} \subseteq S$
 Probability $P(E) = \frac{n(E)}{n(S)}$

$n(E)$ ← no of outcomes in the event
 $n(S)$ ← Total number of outcomes

1 (B) Moments: Moments are numerical measures that describe the shape and characteristics of random variable's probability distribution.

For random variable X , r th raw moment (about origin)

$$\mu_r' = E[X^r]$$

r th central moment (about mean)

$$\mu_r = E[(X - \mu)^r]$$

Defn + 2
 + formula + 2
 + explaining + 2
 6m

- 1st moment → Mean (μ)
- 2nd central moment → Variance (σ^2)
- 3rd central moment → Skewness
- 4th central moment → Kurtosis.

L2, cos

characteristic function $\phi_X(t) = E[e^{itx}]$

For Gaussian (Normal) random variable,

$$\phi_X(t) = \exp\left(i\mu t - \frac{1}{2}\sigma^2 t^2\right)$$

 Mean → μ Linear term
 Variance → σ^2 Quadratic term

Amud

(1c) Gaussian process: - It is a random process, in which finite set of samples has a joint Gaussian (normal) distribution.

For Gaussian random variable x , mean μ & variance σ^2 , the probability density function,

$$f_x(x) = \frac{1}{\sqrt{2\pi}\sigma} \exp \left\{ -\frac{(x-\mu)^2}{2\sigma^2} \right\} \quad L2, (05)$$

- Curve is symmetric about mean μ .
- Maximum value at $x = \mu$
- Spread the curve depends on variance σ^2
- Total area under the curve equals to 1.

Defn 2
- 1 formula + 3
- 1 explanation + 3

6m

for random process $x(t)$, for any time instants t_1, t_2, \dots, t_n
 $[x(t_1), x(t_2), \dots, x(t_n)]$

mean function $m_x(t) = E[x(t)]$
 $R_x(t_1, t_2) = E[x(t_1)x(t_2)]$

Properties: ① complete characterization by first & second moments.
 ② Any linear combination is Gaussian

If $x(t)$ is Gaussian,
 $y = \sum a_k x(t_k)$

- ③ marginal & joint distribution are Gaussian
- ④ The process is wide sense stationary, i.e. stationary conditions are simplified.

(02)

(2a) Random process: Random process is a collection of random variables indexed by time or space. It is denoted as $x(t)$ for fixed t ,

$x(t)$ is a random variable
 Expected value or mean function of a random process $x(t)$

is, $m_x(t) = E[x(t)]$
 It represents the average value of the process at time 't'

Covariance function: Measures how the values of the process at two different times are related.

$$C_x(t_1, t_2) = E[(x(t_1) - m_x(t_1))(x(t_2) - m_x(t_2))]$$

It indicates degree of dependence between samples of process at t_1 and t_2

$$C_x(t_1, t_2) = C_x(\tau) \quad \tau = t_2 - t_1$$

Defn 2
+ formula + 2
+ explanation + 2

6m

2

2b) Autocorrelation function, Properties of autocorrelation function
 the autocorrelation function of the random variable 'x' is defined as the expectation of the product of two random variables $x(k)$ & $x(l)$, obtained by observing the random variable x at times 'k' and 'l' respectively,

It is denoted by,

L2, C05

$$R_x(k, l) \text{ or } R_x(\tau)$$

ie - Auto correlation function is given by,

$$R_x(k, l) = E[x(k) \cdot x(l)] \\ = R_x(k-l)$$

Defn 2
 Formula + 2
 + Property + 2
 6m

Properties of autocorrelation function,

$R_x(\tau)$ be the autocorrelation function of random process 'x' then,

(i) $R_x(\tau) = R_x(k-l)$: It is a function of time difference $(k-l)$

(ii) $R_x(0) = E(x^2)$, when $k=l$

(iii) $R_x(\tau)$ is maximum value of $\tau=0$,
 ie $R_x(0) > R_x(\tau)$ for any value of τ

(iv) $R_x(\tau)$ is even function of (τ)
 $R_x(\tau) = R_x(-\tau)$

2c) PDF and CDF of random experiment, for three coins are tossed & condition to get random variable is getting head.

Tossing three fair coins,

$S = \{HHH, HHT, HTH, HTT, THH, THT, TTH, TTT\}$

L3, C05

Total outcome = 8

$X =$ number of heads to obtain
 $X = \{0, 1, 2, 3\}$

P.D.F	No of heads	$P(X=x)$
0	TTT	$\frac{1}{8}$
1	HHT, HTH, HTT	$\frac{3}{8}$
2	HHT, HTH, HTT	$\frac{3}{8}$
3	HHH	$\frac{1}{8}$

$f_x(x) = P(X=x) = \begin{cases} \frac{1}{8} & x=0 \\ \frac{3}{8} & x=1 \\ \frac{3}{8} & x=2 \\ \frac{1}{8} & x=3 \\ 0 & \text{otherwise} \end{cases}$

Problem
 Statement 2
 - Formula + 3
 + Brn + 3
 8m

CDF: $F_x(x) = P(X \leq x)$

$F_x(x) = \begin{cases} 0 & x < 0 \\ \frac{1}{8} & 0 \leq x < 1 \\ \frac{4}{8} & 1 \leq x < 2 \\ \frac{7}{8} & 2 \leq x < 3 \\ 1 & x \geq 3 \end{cases}$

Module - 2

3. Amplitude Modulation, Expressing for amplitude modulation in time domain, waveform.

Amplitude modulation is the process of altering the amplitude of carrier signal in accordance with the instantaneous value of message signal by keeping frequency and phase of carrier signal constant.

$$s(t) = A_c [1 + k_a m(t)] \cos 2\pi f_c t \quad \text{--- (1)}$$

Expressing for AM signal

message signal,

$$m(t) = A_m \cos(2\pi f_m t) \quad \text{--- (2)}$$

Carrier signal,

$$c(t) = A_c \cos(2\pi f_c t) \quad \text{--- (3)}$$

(Substitute $m(t)$, Eq. (2) in (1))

$$s(t) = A_c [1 + k_a A_m \cos(2\pi f_m t)] \cos 2\pi f_c t$$

$$s(t) = A_c [1 + \mu \cos(2\pi f_m t)] \cos(2\pi f_c t)$$

$\mu = k_a A_m = \text{Modulation Index,}$

$$s(t) = [A_c + \mu A_m \cos(2\pi f_m t)] \cos 2\pi f_c t$$

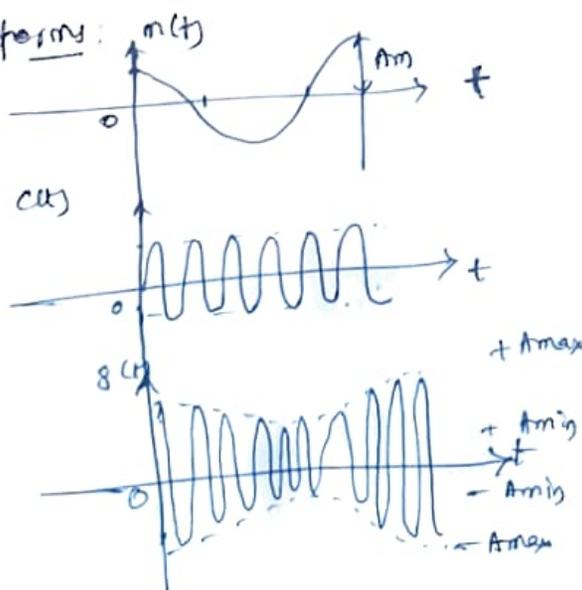
$$= A_c \cos 2\pi f_c t + \mu A_c \cos 2\pi f_m \cos 2\pi f_c t$$

$$\cos A \cos B = \frac{1}{2} [\cos(A-B) + \cos(A+B)]$$

$$\therefore s(t) = A_c \cos(2\pi f_c t) + \frac{\mu A_c}{2} \cos 2\pi (f_c - f_m)t + \frac{\mu A_c}{2} \cos 2\pi (f_c + f_m)t$$

$$\therefore s(t) = \underbrace{A_c \cos(2\pi f_c t)}_{\text{carrier signal}} + \frac{\mu A_c}{2} \cos(2\pi (f_c - f_m)t)_{\text{USB}} + \frac{\mu A_c}{2} \cos(2\pi (f_c + f_m)t)_{\text{LSB}}$$

Waveforms:



L2, C01

$$\begin{aligned} & \text{Def}^n && 2 \\ & + \text{Diagram} && + 3 \\ & + \text{Deriving} && + 3 \\ & && \hline & && 8m \end{aligned}$$

36

$f_m = 5 \text{ kHz}$

$f_c = 980 \text{ kHz}$

USB = ?

LSB = ?

BW = ?

L3, C01

DATE	1
+ Page No	+ 2
+ Sol ⁿ	+ 2
	<hr/> 5

Solⁿ

Upper Side Band: $f_{USB} = 980 + 5 = 985 \text{ kHz}$

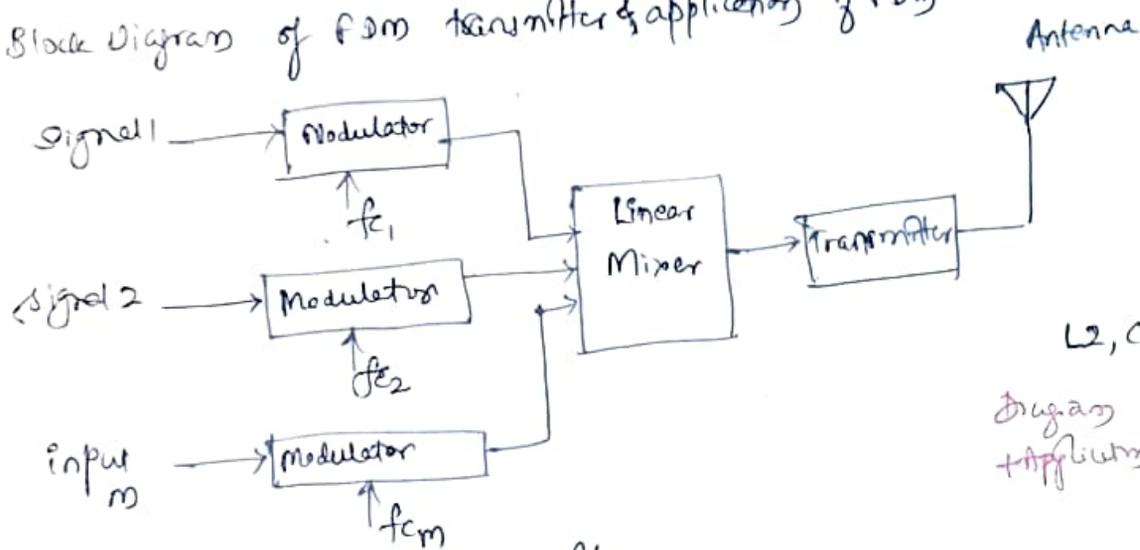
$f_{LSB} = 980 - 5 = 975 \text{ kHz}$

Bandwidth = $f_{USB} - f_{LSB}$
 $= 985 - 975 = 10 \text{ kHz}$

$BW = 2(5) \text{ kHz} = 10 \text{ kHz}$

37

Block Diagram of FDM transmitter & application of FDM



L2, C01

Diagram	3
+ Application	+ 1
	<hr/> 4

fig (1) Transmitter

Application of FDM

- Radio Broadcasting → AM, FM radio stations
- Television Broadcasting → TV channel
- Telephone systems
- Satellite communication
- Cable modem & broadband systems
- Microwave communication

~~2~~

OK

Q4) Code to generate amplitude modulation waveform & display its spectrum

Program: MATLAB

% Parameters:

$f_c = 1000$; % Carrier frequency
 $f_m = 50$; % Modulating frequency
 $A_m = 1$; % Modulating signal
 $A_c = 2$; % Carrier signal

L3, col

program

Code
 + waveforms + 2
 8 m

% Time vectors

$f_s = 10 \times f_c$; % Sampling freq.
 $t = 0 : 1/f_s : 1 - (1/f_s)$; % Time vector

% generate carrier & modulating signal

$carrier = A_c \times \cos(2 \times \pi \times f_c \times t)$;
 $modulating = A_m \times \cos(2 \times \pi \times f_m \times t)$;

% Amplitude Modulation

$modulated_signal = (1 + (A_m/A_c)) \times modulating) \times carrier$;

% Plotting original signals

$subplot(3, 2, 1)$;
 $plot(t, carrier)$;
 $title('Carrier signal')$;
 $xlabel('Time (s)')$;
 $ylabel('Amplitude')$;

$subplot(3, 2, 2)$;
 $plot(t, modulating)$;
 $title('modulating signal')$;
 $xlabel('Time (s)')$;
 $ylabel('Amplitude')$;

% modulated signal in time domain

$subplot(3, 2, [3, 4])$;
 $plot(t, modulated_signal)$;
 $title('Am modulated signal')$;
 $xlabel('Time (s)')$;
 $ylabel('Amplitude')$;

Q

∴ FFT of modulated signal

$$L = \text{length}(t);$$

$$f = fs * (0 : (L/2)) / L;$$

modulated_signal_fft = fft(modulated_signal);

$$P2 = abs(modulated_signal_fft / L);$$

$$P1 = P2 * (1 : L/2 + 1);$$

∴ plotting modulated signal spectrum

subplot(3, 2, 5);

plot(f, P1);

title('10m modulated signal spectrum');

xlabel('frequency (Hz)');

ylabel('magnitude');

L2, Col

4b

DSB and SSB waveforms

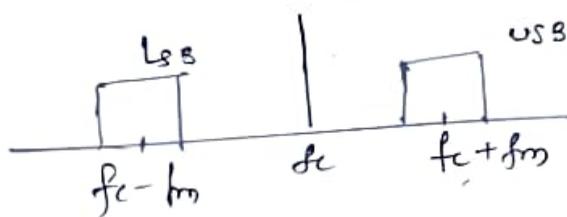
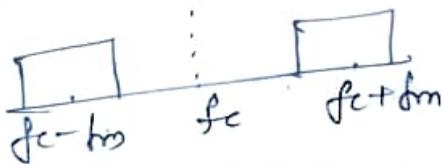
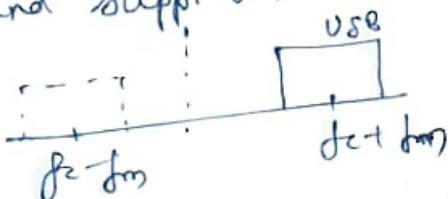


Diagram
+ formula
+ explanation $\frac{2}{5m}$

In process of amplitude modulation modulated wave consists of carrier wave and two side bands. Modulated wave has information only in sidebands. The transmission of signal which consists of carrier along with two sidebands can be termed as double side band full carrier or DSBFC. If the carrier is suppressed then it is DSBSC.

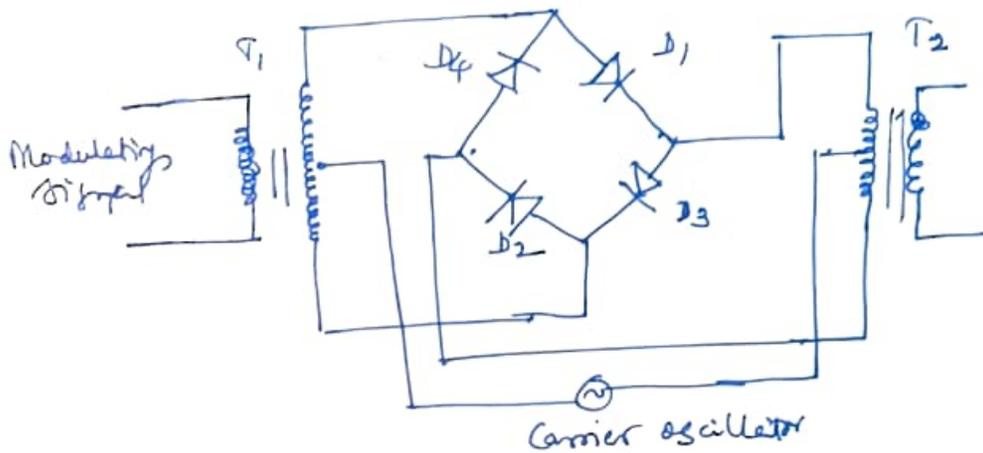


In SSB modulation, only one side band upper or lower and suppressed carrier is transmitted.



4c

(4c) Lattice Type Balanced Modulator



L2, C01

Diagram + explanatory $\frac{3}{4}$ / $\frac{7m}{7m}$

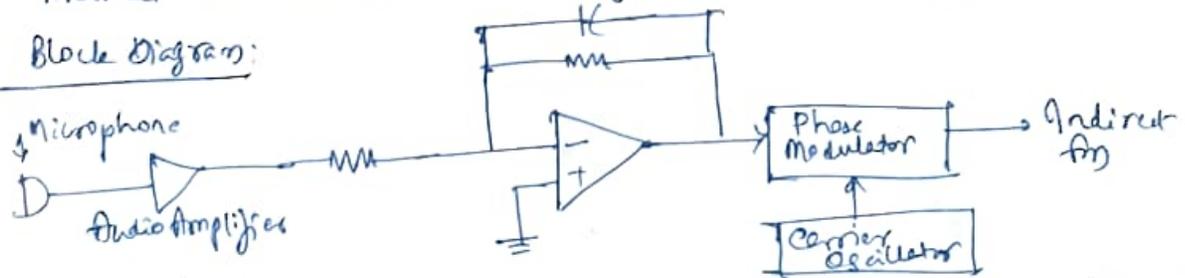
Lattice type balanced modulator is called diode ring or lattice modulator

It consists of input transformer T_1 & output transformer T_2 and four diodes connected in bridge circuit. The carrier signal is applied to the center taps of the input and output transformers and the modulating signal is applied to the input transformer T_1 . The output appears across the secondary of the output transformer T_2 . Carrier signal is used as a source of forward and reverse bias for the diodes. The carrier turns the diodes act as switches that connect the modulating signal at the secondary of T_1 to the primary of T_2 .

Module-3

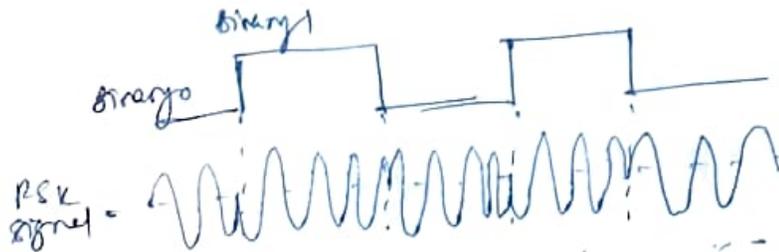
5(a) Method used to convert PM signal into a FM signal

Block Diagram:



L2, C03

Diagram + explanatory $\frac{3}{3}$ / $\frac{6m}{6m}$



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To make PM compatible with FM, the deviation produced by frequency variations in the modulating signal must be compensated for. This can be done by passing the intelligence signal through a low pass network.

This low pass network filter called a frequency correcting network pre-distorter or $1/f$ filter, causes the higher modulating frequencies to be attenuated. The pre-distorter compensates for the excess freq. deviation caused by high modulating frequencies.

The result is an o/p that is same as FM signal. The FM produced by phase modulator is called indirect FM.

(5b)

$$S/N = 2.8$$

$$f_m = 1.5 \text{ kHz}$$

$$\Delta f = \text{deviation} = 4 \text{ kHz}$$

Noise induced frequency deviation Δf_n

$$\Delta f_n = \frac{\Delta f}{\sqrt{S/N_{in}}} = \frac{4 \text{ kHz}}{\sqrt{2.8}} = \frac{4}{1.673} \text{ kHz} \approx 2.39 \text{ kHz}$$

L3, C02

Date	1
+ formula	2
+ 65/9	3
	6m

Modulation Index β :

$$\beta = \frac{\Delta f}{f_m} = \frac{4 \text{ kHz}}{1.5 \text{ kHz}} \approx 2.667$$

Output S/N

$$\begin{aligned} S/N_{out} &= \frac{3}{2} \beta^2 S/N_{in} \\ &= \frac{3}{2} (2.667)^2 \times 2.8 \\ &= 1.5 \times 2.111 \times 2.8 \\ &\approx 29.9 \end{aligned}$$

∴ (A) Noise induced frequency deviation $\Delta f_n \approx 2.39 \text{ kHz}$

(B) Improved o/p S/N

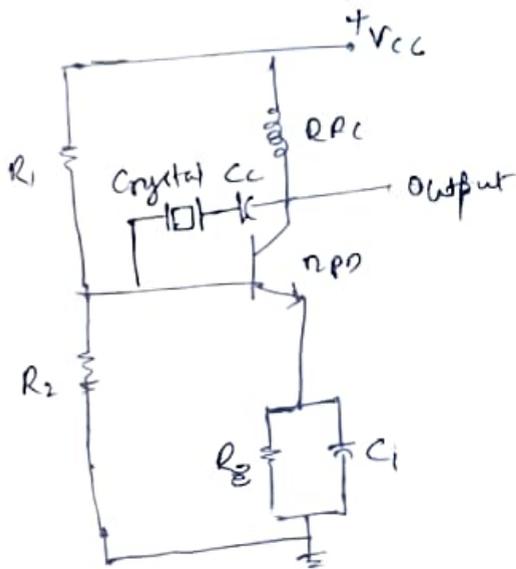
$$S/N_{out} \approx 29.9$$

50 Frequency modulation using crystal oscillator:

The oscillator works by applying an alternating voltage to a crystal, causing it to vibrate at its natural frequency.

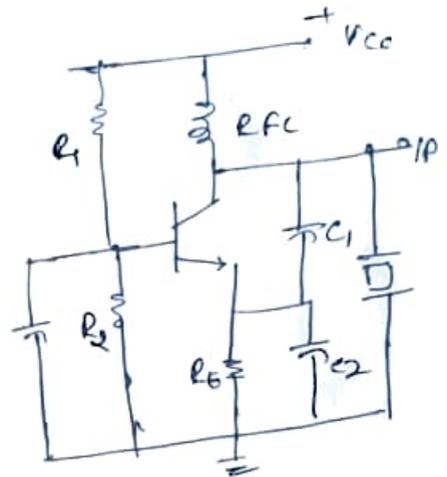
Crystal oscillators are designed to operate in series resonant mode (low impedance) or parallel resonant mode (high impedance)

Diagram +5
-1 cap = 8m



Oscillator with crystal operating in Series Resonance

$$f_r = \frac{1}{2\pi \sqrt{L_s C_s}}$$



Oscillator with crystal operating in Parallel resonance

$$f_p = \frac{1}{2\pi \sqrt{L_s \frac{C_p C_s}{C_p + C_s}}}$$

Q. Define modulation. Identify any five differences between Frequency modulation and Amplitude Modulation. [06 Marks] L2 CO2

Ans: Modulation:

Modulation is the process of encoding information onto a carrier signal, so it can be transmitted over long distances. — (2M)

Differences between FM and AM — (4M)

Feature	Amplitude modulation	Frequency Modulation
Variable Property	The amplitude of the carrier wave changes	The frequency of the carrier wave changes
Noise immunity	Highly susceptible to noise and electrical interference	Highly resistant to noise
Sound Quality	Lower Quality	High fidelity
Bandwidth	uses less bandwidth	uses more bandwidth
Range	can travel very long distances	Limited to line of sight range

Q.6 why pre emphasis and de emphasis are required? Explain how they are implemented? L2 CO2 [06 Marks]

Soln: In most communication systems especially, FM, speech transmission and analog links,

→ high frequency components of the signal have

Low amplitude and are more affected by noise and noise power generally increases with frequency. So we require pre emphasis and de emphasis.

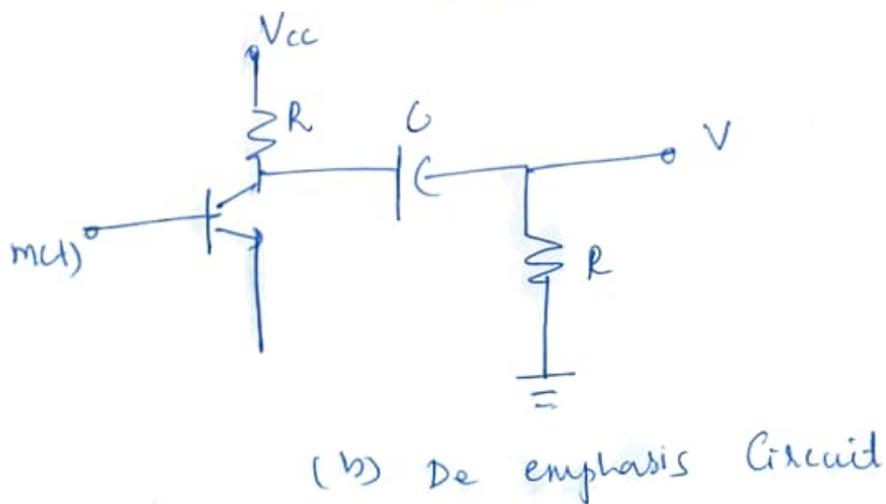
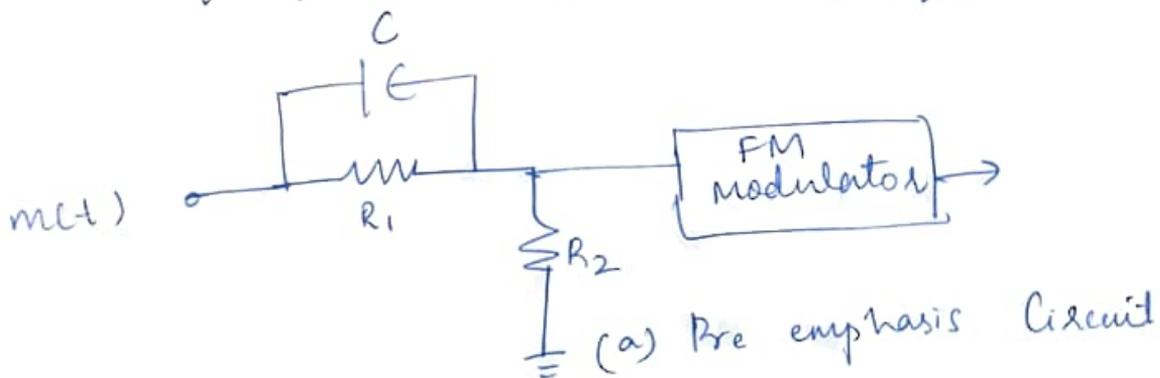
Pre emphasis → It is the process of amplifying high frequency components of the message signal before transmission.

- Purpose →
- 1) Improves SNR at high freq.
 - 2) Reduces the effect of channel noise
 - 3) enhances speech intelligibility

De emphasis: → It is the process of attenuating high freq components at the receiver to restore the original signal spectrum.

It can be implemented using high pass RC networks

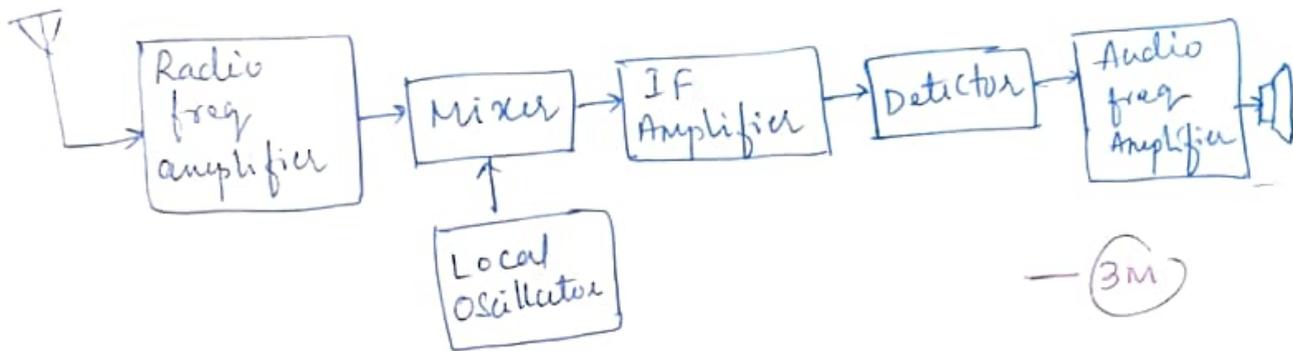
Transfer function: $H_{pre}(f) = 1 + j2\pi fRC$



E) Draw the block diagram of a super heterodyne receiver and explain the function of each.

(08 marks) L₂ CO2

Soln: Super heterodyne receiver:



Functions of Each block:

- 1) Antenna - Receives electromagnetic waves from the air and converts them into weak radio frequency signals.
- 2) RF amplifier - Selects the desired channel and amplifies the weak signal while suppressing unwanted noise and image frequencies.
- 3) Local oscillator - Generates a high frequency sine wave that changes in frequency along with the RF amplifier to tune the receiver.
- 4) Mixer: Combines the RF signal with the local oscillator signal to produce new frequencies, specifically the difference frequency, known as intermediate frequency.
- 5) IF amplifier: Provides majority of the receiver's amplification and selectivity.

- 6) Detector - Extracts the original audio or baseband signal from the modulated if signal.
- 7) Audio Amplifier - Amplifies the low power demodulated audio signal to a level high enough to drive the loud speaker
- 8) Speaker - Converts the electrical audio signal into audible sound waves.

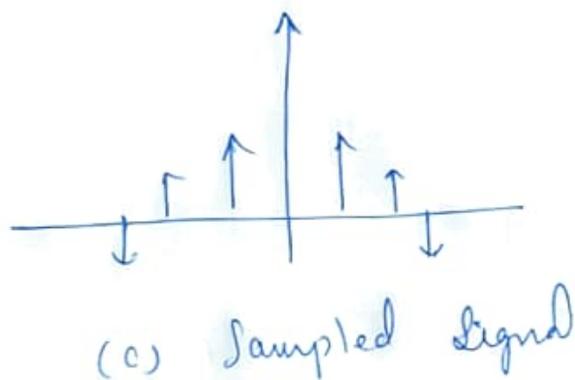
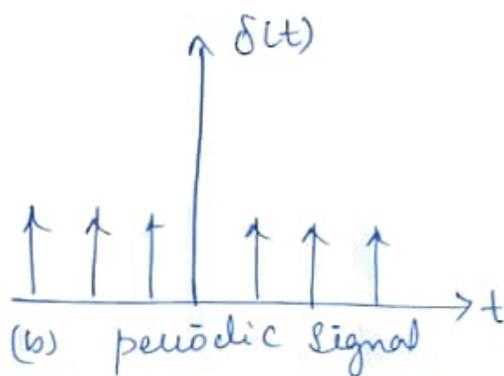
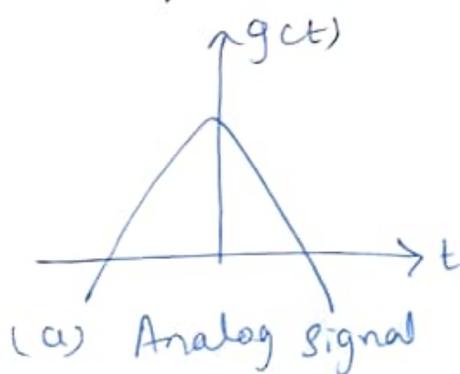
Module - 4

7) a) State and prove Sampling theorem. Write a program for sampling and reconstruction of low pass signals and display the signals and its spectrum.

Soln: Sampling theorem states that, any continuous time signal can be completely represented in its samples and recovered back if the sampling frequency is greater than or equal to twice the highest frequency component of baseband signal.

[10 Marks] L3 CO3

$$f_s \geq 2W \quad \text{or} \quad f_s \geq 2f_m$$



$$g(t) \longrightarrow \textcircled{\times} \longrightarrow g_{\delta}(t) = g(t) \cdot s_{\delta}(t)$$

↑
 $s_{\delta}(t)$

Let $g_{\delta}(t)$ denote, the signal obtained by individually weighting the elements of a periodic sequence spaced T_s seconds.

$$g_{\delta}(t) = g(t) * s_{\delta}(t) \quad \text{--- (1)}$$

$$s_{\delta}(t) = \sum_{n=-\infty}^{\infty} \delta(t - nT_s) \quad \text{--- (2)}$$

$$g_{\delta}(t) = g(t) \sum_{n=-\infty}^{\infty} \delta(t - nT_s)$$

$$g(t) * \delta(t - nT_s) = g(nT_s) \delta(t - nT_s) \quad \text{--- (3)}$$

for freq domain,

$$g_{\delta}(t) = g(t) * s_{\delta}(t)$$

$$G_{\delta}(f) = G(f) * S_{\delta}(f)$$

$$\therefore G_{\delta}(f) = G(f) * b_s \sum_{n=-\infty}^{\infty} \delta(f - n f_s)$$

$$\therefore G_{\delta}(f) = b_s G(f)$$

$$G_{\delta}(f) = \frac{1}{T_s} G(f)$$

$$\boxed{b_s = 2\omega}$$

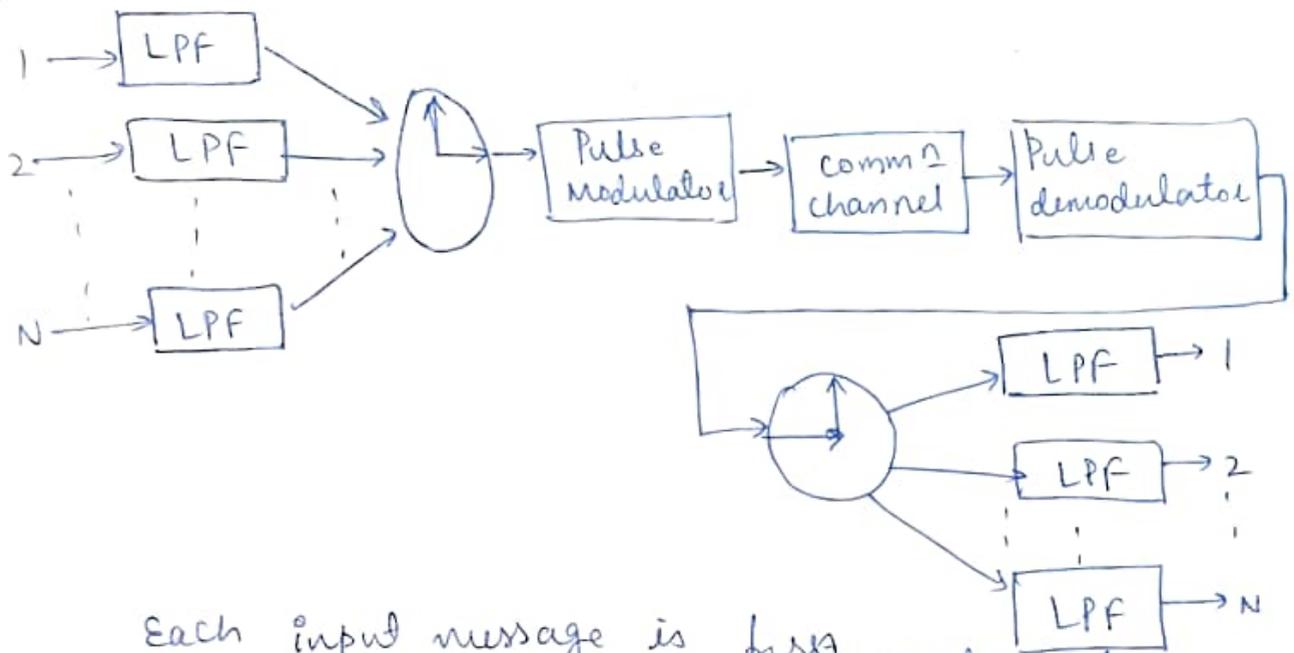
~~2~~

Program

```
fs = 1000;  
t = 0: 1/fs : 1 - 1/fs;  
f1 = 50;  
f2 = 120;  
Signal = 0.7 * sin(2 * pi * f1 * t) + sin(2 * pi * f2 * t);  
subplot(2,1,1);  
plot(t, Signal);  
title('Time domain signal');  
xlabel('Time(s)');  
ylabel('Amplitude');  
n = length(Signal);  
f = (0:n-1) * (fs/n);  
Spectrum = fft(Signal);  
subplot(2,1,2);  
plot(f, abs(Spectrum)/n);  
title('Frequency Spectrum');  
xlabel('Frequency (Hz)');  
ylabel('Magnitude');  
xlim([0, fs/2]);
```

7) b) Explain the working of TDM system with a neat block diagram. [5 Marks] L2 C03

Soln:

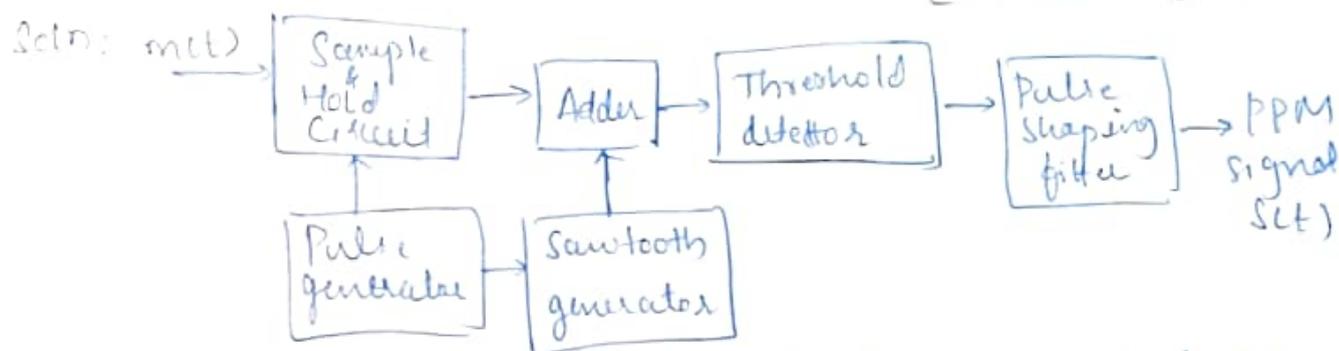


Each input message is first restricted in a bandwidth by LPF to remove the frequencies that are non essential to an adequate signal representation.

- The low pass filter o/p are then applied to commutator, which can be implemented using electronic switching circuitry.
- Following the commutation process, the multiplexed signal is applied to a pulse modulator, the purpose of which is to transfer the multiplexed signal into a form suitable for transmission over a channel.
- At the receiving end, the received signal is first applied to a pulse demodulator which performs the reverse operation of pulse modulation.
- The narrow samples produced at the pulse demodulator are distributed to appropriate LPF.

Q

7) (c) Explain briefly the block diagram of PPM generator. [05 Marks] L2 C03



The message signal $m(t)$ is first converted into a PAM signal by means of a sample and hold circuit, generates a staircase waveform $u(t)$.

→ The combined signal $v(t)$ is applied to a threshold detector that produces a very narrow pulse each time $v(t)$ crosses a zero in the negative going direction.

→ Finally the PPM signal $s(t)$ is generated by using this sequence of impulses to excite a filter whose impulse response is defined by the standard pulse $g(t)$.

8) a) Identify and explain the basic elements of a PCM system with neat diagrams.

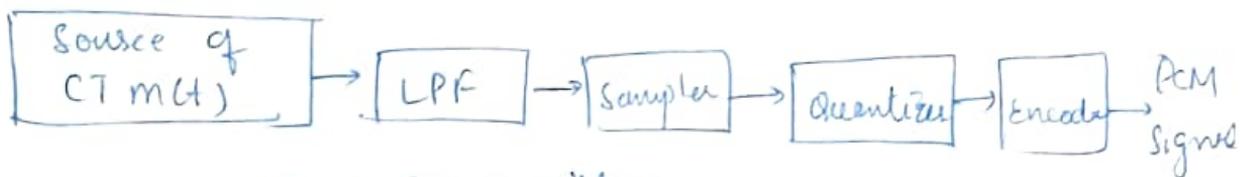
For the data stream [01101001], draw the following line code waveforms.

i) Unipolar NRZ ii) Polar NRZ iii) Unipolar RZ

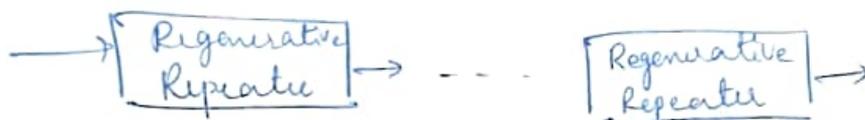
iv) Bipolar RZ v) Manchester code

[10 Marks] L3 C03

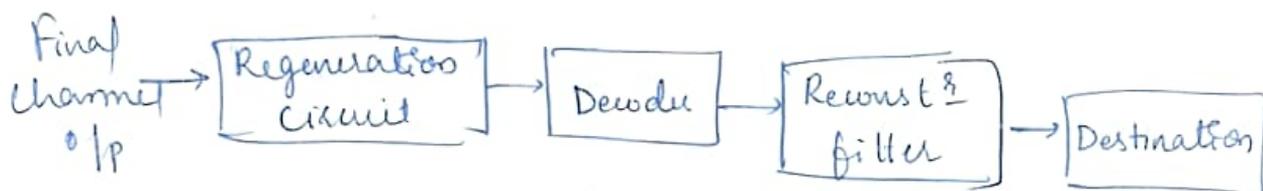
Soln:



(a) Transmitter



(b) Transmission path

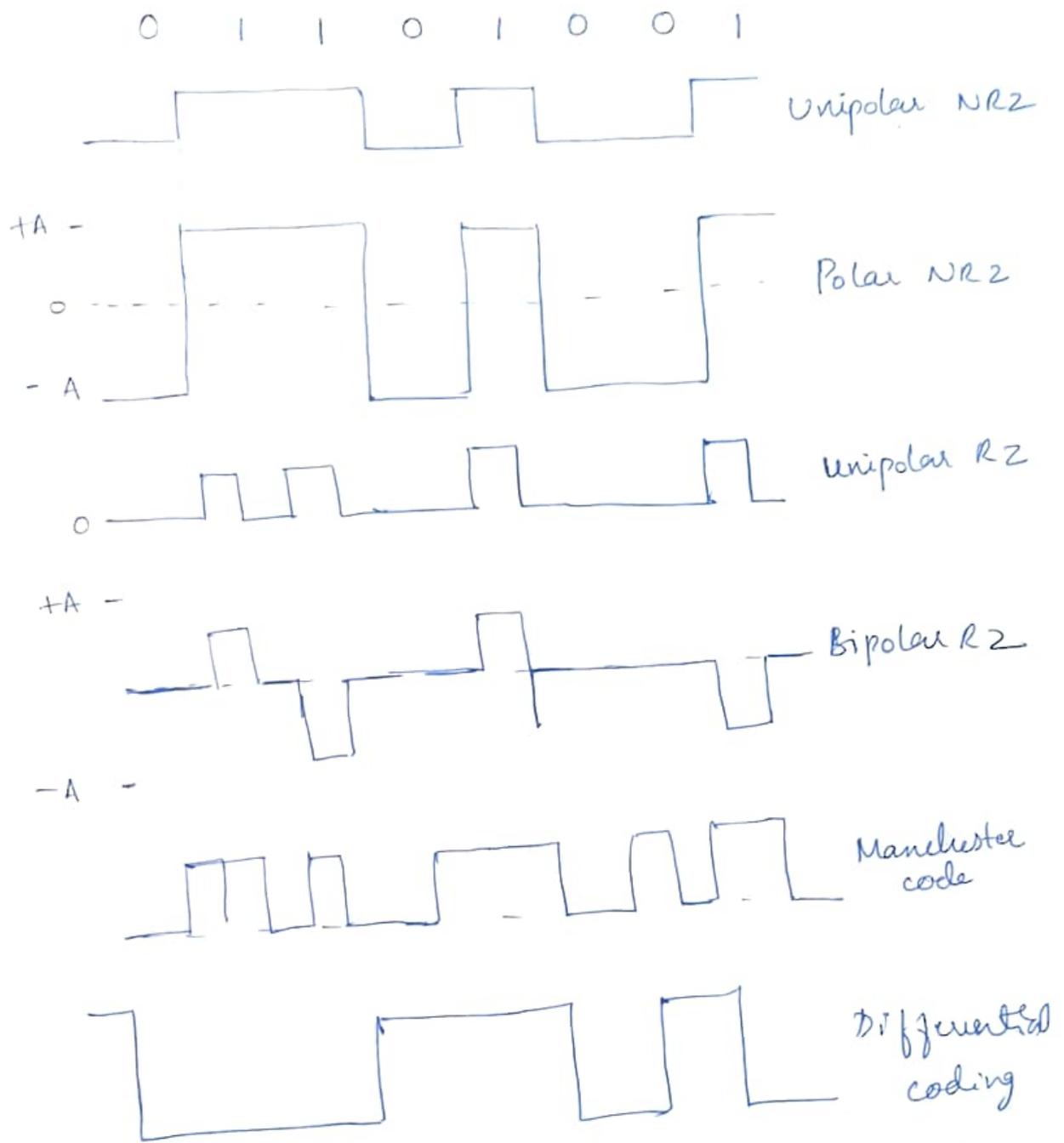


(c) Receiver

The block diagrams show the process of pulse code modulation (PCM).

- In sampling stage, message signal is sampled with a train of narrow rectangular pulses so as to closely approximate the instantaneous sampling.
- The sampled version is quantized and provides new representation of signal.
- The encoder combines the process and provides encoded values to each signal.
- Decoding is the first operation in the receiver to generate the received pulses.
- The final operation in the receiver is to recover the message signal wave by passing the decode o/p through a low pass reconstruction filter.
- In applications using PCM, multiplexing of signals happen through time division.

~~Q~~



8) b) Infer the advantages of digital signals over analog signals. [05 Marks] L2 C03

Soln: The advantages of digital signal over Analog signal are:

- 1) Digital signals are less sensitive to noise than analog signals.
- 2) It is easier to integrate different services.
- 3) The transmission scheme can be relatively independent of the source.

4) Circuitry for handling digital signals is easier to repeat and digital circuits are less sensitive to physical effects such as vibration and temperature

5) Digital signals are simpler to characterize and typically do not have the same amplitude range and variability as analog signals

8)c) Explain briefly the midtread and midrise Quantizers with relevant figures.

[5 marks] L₂ C03

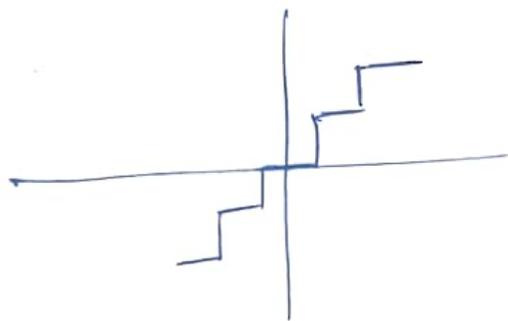
Soln: Mid Tread Quantizer -

It is characterized by having zero as one of its output reconstruction levels

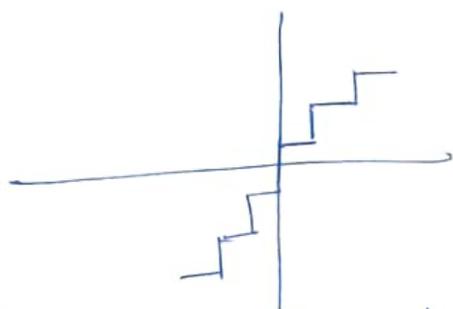
→ It has an odd number of quantization levels.

→ Small input values close to zero are mapped exactly to zero.

→ The staircase graphs tread lies on the origin



Mid rise Quantizer:



A mid rise quantizer does not have a zero o/p level. It is named 'mid rise' because the origin (0,0) lies in the middle of a rise of the staircase characteristic

→ Amplitudes close to zero are not mapped to zero instead they are mapped to the nearest positive or negative step ($+\Delta/2$ or $-\Delta/2$)

→ It has an even number of output levels

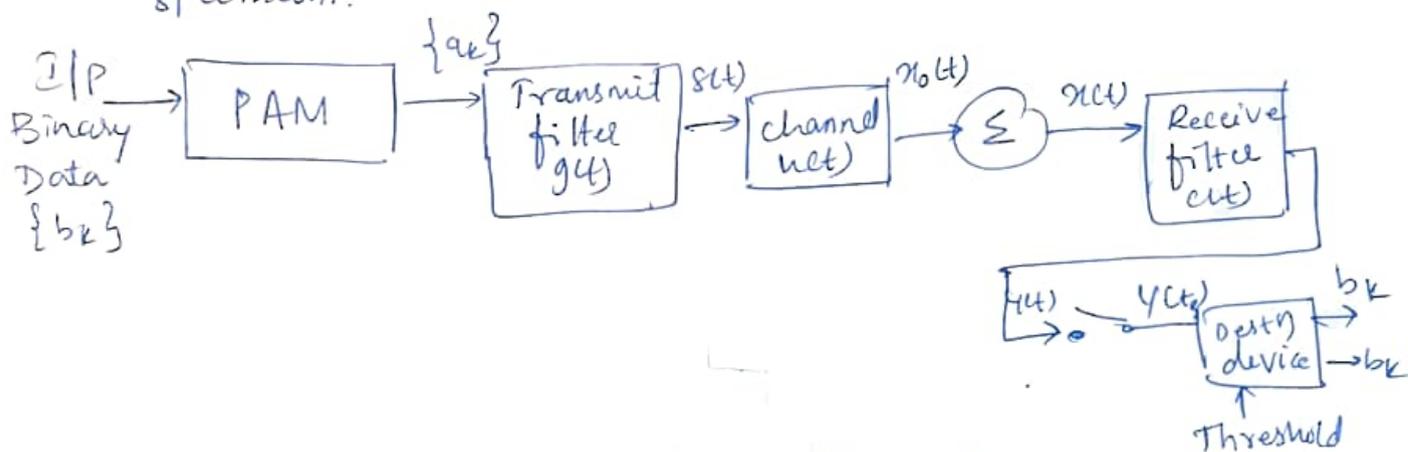
→ used for signal processing

Module-5

[08 marks] L2 co4

Q) a) What is intersymbol interference (ISI). with a neat block diagram outline the baseband binary data transmission system and write the necessary equations!

Soln: Inter Symbol Interference (ISI) is that which arises when the comm. channel is dispersive which means the channel has a frequency dependent amplitude spectrum.



Consider a baseband binary PAM s/m. The incoming binary sequence $\{b_k\}$ consists of symbols 1 and 0, each of duration T_b .

→ The PAM transforms this binary sequence into a new sequence of short pulses whose amplitude a_k is represented in the polar form

$$a_k = \begin{cases} +1 & \text{if symbol } b_k \text{ is } 1 \\ -1 & \text{if symbol } b_k \text{ is } 0 \end{cases}$$

The sequence of pulses so produced are applied to a transmit filter of response $g(t)$ producing transmitted signal $s(t)$

$$s(t) = \sum_k a_k g(t - kT_b)$$

The signal $s(t)$ is modified as a result of transmission through the channel of impulse response $h(t)$.

→ The noisy signal $x(t)$ is passed through receive filter of impulse response $c(t)$. The resulting filter output $y(t)$ is sampled with the transmitter, and the sampling instants are determined by clock signal.

→ Finally the sequence of samples are reconstructed by using decision device.

→ If threshold λ is exceeded, a decision in favour of 1 is made,

→ If threshold λ is not exceeded, a decision in favour of 0 is made.

1) b) Define SNR, Summarize the different types of external and internal noise [07 Marks] L2 CO4

Soln: Signal to noise ratio indicates relative strength of the signal and the noise in a communication system.

→ The stronger the signal, weaker the noise, the higher the SNR.

External noise:

External noise comes from sources over which we have little or no control

i) Industrial noise

ii) Atmospheric noise

iii) Extra-terrestrial noise

Industrial noise

Electrical disturbances that occur naturally in the earth's atmosphere as another source of noise. These occur from lightning, discharges occur between clouds and earth.

Extraterrestrial noise -

Source in space occur from solar and cosmic comes from

Internal noise -

Electrical components in a receiver such as resistors, diodes and transistors are major sources of internal noise

Thermal noise -

It is caused by thermal agitation, a random movement of free electrons in a conductor caused by heat.

Semiconductor noise

Electrical components such as diodes & transistors are major contributors of noise

Inter modulation noise

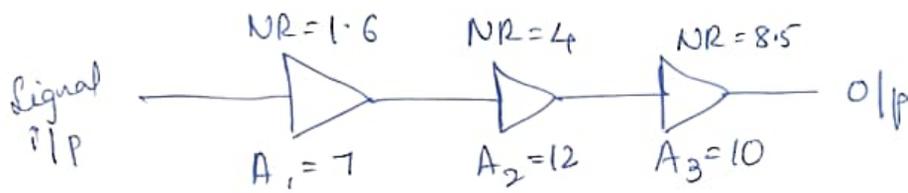
This results from the generation of new signals and harmonics caused by circuit non linearities.

9)c) Illustrate the concept of noise in cascaded stages with a diagram. write Friis formula and mention its terms. [05 Marks] L₂ CO₄

Soln: Noise has its greatest effect at the i/p to a receiver simply because that is the point at which

→ The noise performance of a receiver is invariably determined on the very first stage of the receiver usually an RF amplifier or mixer

→ Design of these circuits must ensure the use of very low noise components, taking into consideration current, resistance, bandwidth and gain figures in the circuit.



$$NR = 2.12, \quad NF = 3.26 \text{ dB}$$

The formula used to calculate the overall noise performance of a receiver or of multiple stages of RF amplification, called Friis's formula.

$$NR = NR_1 + \frac{NR_2 - 1}{A_1} + \frac{NR_3 - 1}{A_1 A_2} + \dots + \frac{NR_n - 1}{A_1 A_2 \dots A_{n-1}}$$

$$\therefore NR = 1.6 + \frac{4 - 1}{7} + \frac{8.5 - 1}{7 \times 12}$$

$$\boxed{NR = 2.12}$$

$$\begin{aligned} \text{Noise figure, } NF &= 10 \log NR \\ &= 10 \log 2.12 \end{aligned}$$

$$\boxed{NF = 3.26 \text{ dB}}$$

10) a) What is baseband digital transmission? Explain the following concepts briefly.

i) Nyquist criterion for distortionless transmission

ii) Baseband m -ary PAM transmission.

[08 marks] 12 CO4

Soln: Baseband digital transmission gives data about the transmission of binary signals.

i) Nyquist criterion for distortionless transmission

We typically find that, the transfer function of a channel and the transmitted pulse shape are specified, and the problem is to determine the transfer function of the transmit & receive filter so as to reconstruct original binary data sequence $\{b_k\}$.

→ The receiver does this by extracting and then decoding the corresponding sequence of co-efficients $\{a_k\}$ from $y(t)$.

→ we control the overall pulse $p(t)$, as shown by

$$p(iT_b - kT_b) = \begin{cases} 1 & i=k \\ 0 & i \neq k \end{cases}$$

$y(t_i)$ satisfies the eqn $y(t_i) = \sum a_i$ for all i , consider the sequence of samples $\{p(nT_b)\}$

where $n=0, \pm 1, \pm 2, \dots$

$$P_S(f) = R_b \sum_{n=-\infty}^{\infty} p(f - nR_b)$$

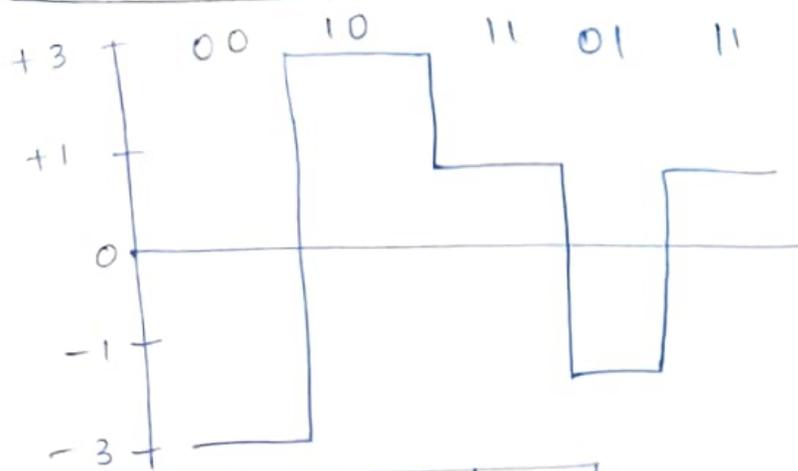
$$P_S(f) = \int_{-\infty}^{\infty} \sum_{m=-\infty}^{\infty} [p(mT_b) \delta(t - mT_b) \exp(-j2\pi ft)] dt$$

~~A~~

$$P_s(f) = \int_{-\infty}^{\infty} P_c(t) \delta(t) \exp(-j2\pi f t) dt$$

$$= P_c(f)$$

ii) Base band M-ary PAM Transmission



Dibit	Amplitude
00	-3
01	-1
10	+1
11	+3

In a baseband M-ary PAM system, the pulse amplitude modulator produces one of M possible amplitude levels with NRZ as shown above.

→ In the above case of a quaternary (M=4) system and the binary data sequence 0010110111.

→ In M-ary system, the information source emits a sequence of symbols from an alphabet that consists of M symbols.

→ The binary PAM s/m produces info^t as the rate of $1/T_b$, bits per second.

$$\therefore T = T_b \log_2 M$$

~~A~~

10) b) Define noise, classify different types of Semicondu.
- noise noise [07 marks] L2 CO4

Soln: Noise is defined as the random, spontaneous and unwanted fluctuation in electrical current or Voltage generated within semiconductor devices, often caused by thermal motion or discrete charge carriers.

Semiconductor noise:

- 1) Thermal noise - caused by the random thermal motion of electrons within any resistive material
- 2) Shot Noise - Generated due to the random, discrete flow of charge carriers across a potential barrier
- 3) Flicker noise - Appears at low frequencies, caused by surface traps and defects in materials
- 4) Burst noise - Sudden step-like transitions between discrete current levels often caused by heavy metal impurities

10) c) What is Noise factor and Noise figure. An AF amplifier has an S/N Ratio of 8 at the i/p and an S/N Ratio of 6 at the o/p. Calculate the Noise factor and Noise figure. [05 marks]
L2 CO4

Soln: a) Noise factor (NF) = $\frac{(S/N) \text{ Power at the i/p}}{(S/N) \text{ Power at the o/p}}$
 $= \frac{8}{6} = 1.33$

✶

(b) Noise figure, $F_{dB} = 10 \log F$
 $= 10 \log 1.33$
 $= 1.249$

(c) Noise temperature, $T_e = (F-1)T$
 $T_e = (1.33-1)290$
 $T_e = 95.7 \text{ K}$



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