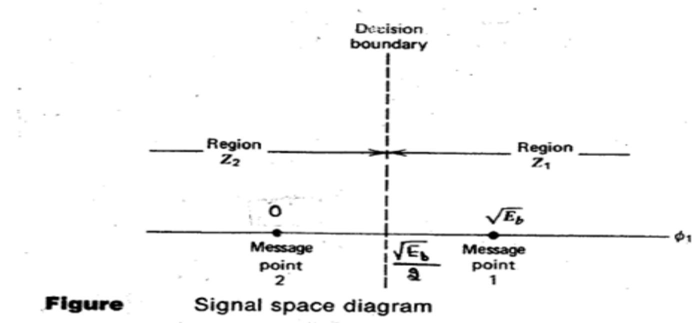
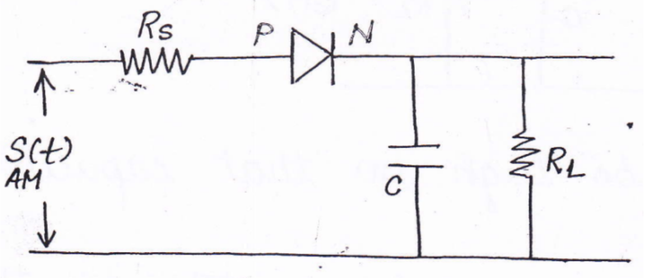
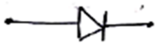
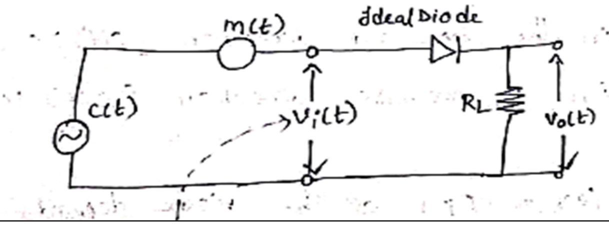
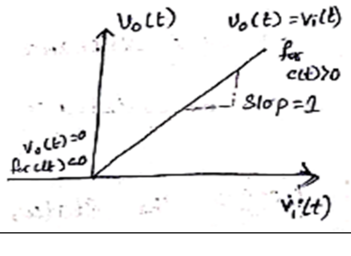
III/IV B.Tech (Regular) Degree Examination, February 2021
Department of ECE
Scheme of Evaluation
Subject code:- 18EC505(Analog and Digital Communications)

Time: Three Hours — **Maximum:**50 Marks

Answer Question No.1 compulsorily. (10X1 = 10 Marks)

Answer ONE question from each unit. (4X10=40 Marks)

1.	**Answer all questions**	
a)	Define Under modulation.	
Ans	Under modulation occurs when modulation index (μ<1)	1M
b)	Compare AM, DSB-SC and SSB-SC in terms of Bandwidth.	
Ans	Bandwidth of AM= 2fm Bandwidth of DSB-SC = 2fm Bandwidth of SSB-SC = fm	1M
c)	A broadcast AM transmitter radiates 50KW of carrier power. What will be the radiated power at 85% modulation?	
Ans	$P_t = P_c\left[1+\frac{m^2}{2}\right]$ $= 50\text{ kW}\left[1+\frac{(0.85)^2}{2}\right]$ $= 68.06\text{ kW}.$	1M
d)	State Carson's rule.	
Ans	According to Carson's rule, the bandwidth is equal to twice the sum of the maximum frequency deviation and the modulating frequency. $Bw=2(\delta+fm)$	1M
e)	Define Angle Modulation.	
Ans	Angle modulation is defined as the process by which the frequency or phase of the carrier wave is changed in accordance with the instantaneous value of the message signals.	1M
f)	What is pre-emphasis? Why is it used?	
Ans	The noise suppression ability of FM decreases with the increase in the frequencies. Thus increasing the relative strength or amplitude of the high frequency components of the message signal before modulation is termed as Pre-emphasis	1M
g)	Differentiate between coherent and non coherent detection.	
Ans	In coherent detection the local carrier generated at the receiver is phase locked with. the carrier at the transmitter. In non coherent detection the local carrier generated at the receiver is not phase locked with the carrier at the transmitter.	1M
h)	List the errors in delta modulation.	
Ans	• Slope overload Distortion • Granular Noise	1M
i)	What is meant by Companding?	
Ans	It is a non-uniform quantization process. It is nothing but Compression + Expansion. Compression will be done at the transmission and expansion will be done at the receiver.	1M
j)	Sketch the signal constellation diagram of BASK.	

Ans	 **Figure** Signal space diagram		1M
	UNIT-I		
2.	a)	List out the methods for generation of SSB-SC signal and explain any one of the method in detail.	
	Ans	**List the methods for generation of SSB-SC Signal:** - Frequency Discrimination Method - Phase Discrimination Method **Operation of any one method**	1M 2M 2M
	b)	Discuss the working of envelope detector with a neat circuit diagram..	
	Ans	**Envelop detector circuit diagram:**  **Working and operation of envelop detector**	2M 3M
	(OR)		
3.	a)	Explain the generation of AM wave using Switching modulator.	
	Ans	→ Device used for AM generation is Switching Modulator or Switching amplitude modulator → In this device an important element used ie, is a non-linear element (Diode) is used for its implementation.  → With the help of Switching property of a diode we can generate an AM wave. → this device is called Low power modulator circuits. → Here we consider an ideal diode.  	2M 3M

→ The Switching modulator consists of the following
(i) An ideal diode (2) A carrier Source c(t)
& modulating signal m(t)

→ In Switching modulator, the carrier signal and modulating signal are connected in series with each other. So, the input voltage to the diode is given by

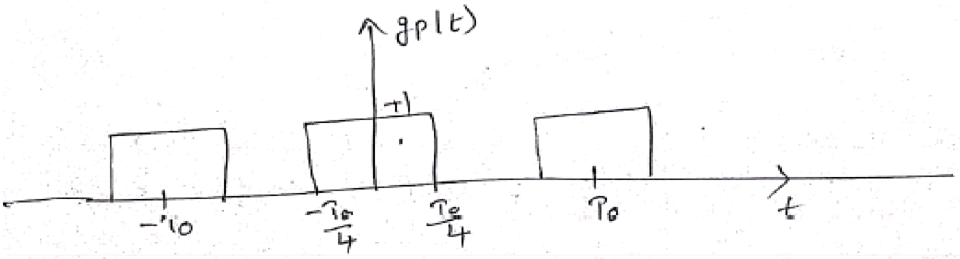
$$V_i(t) = c(t) + m(t)$$

$$V_i(t) = A_c \cos w_c t + m(t)$$

The diode has been assumed to be ideal, it means that it offers

→ zero resistance in the forward direction [c(t) > 0]

→ ∞ resistance in the reverse direction [c(t) < 0]



Substituting eq^n (3) in eq^n (2) we get

$$v_0(t) = [A_c \cos(2\pi f_c t) + m(t)]\left\{\frac{1}{2} + \frac{2}{\pi}\sum_{n=1}^{\infty}\frac{(-1)^{n-1}}{2n-1}\cos[2\pi f_c t(2n-1)]\right\}$$

when n=1 we get; odd harmonics are eliminated

$$= [A_c \cos(2\pi f_c t) + m(t)]\left\{\frac{1}{2} + \frac{2}{\pi}\cos(2\pi f_c t)\right\} + \underbrace{\text{odd harmonics}}_{\text{eliminated (unwanted)}}$$

$$v_0(t) = \frac{A_c}{2}\cos(2\pi f_c t) + \frac{2A_c}{\pi}\cos^2(2\pi f_c t) + \frac{m(t)}{2} + \frac{2}{\pi}m(t)\cos(2\pi f_c t)$$

$$\Rightarrow \underbrace{\frac{A_c}{2}\cos(2\pi f_c t) + \frac{2}{\pi}m(t)\cos(2\pi f_c t)}_{\text{AM wave}} + \underbrace{\frac{m(t)}{2}}_{\text{modulating signal}} + \underbrace{\frac{2A_c}{\pi}\cos^2(2\pi f_c t)}_{\text{Second harmonic of carrier}}$$

unwanted Terms Removed from $v_0(t)$ by means of BPF with center freq, fc & BW=2W

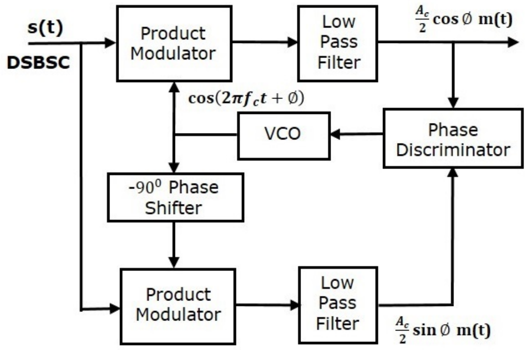
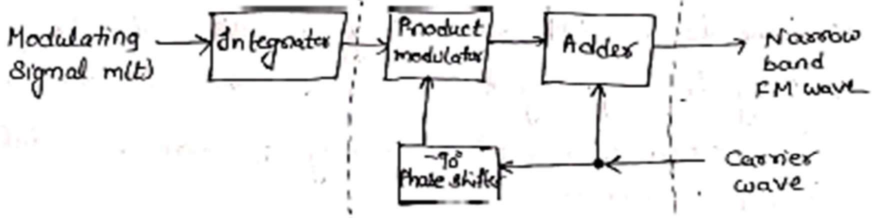
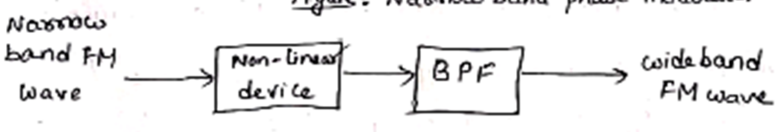
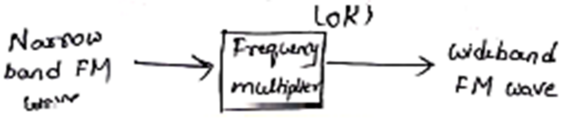
$$\therefore v_0(t) = \frac{A_c}{2}\cos(2\pi f_c t) + \frac{2}{\pi}m(t)\cos(2\pi f_c t)$$

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

$$\boxed{\text{where } K_a = \frac{4}{\pi A_c}}$$

The unwanted terms are removed from the load voltage by means of a Band Pass Filter (BPF)

b) Explain about COSTAS loop with a neat block diagram for demodulating DSB-SC wave.

	Ans	**COSTAS loop Block Diagram**  **Explanation of the demodulation process**	2M 3M
	UNIT II		
4.	a)	Discuss the FM generation using Indirect method.	
	Ans	Generation of FM waves:- There are two basic methods of generating frequency-modulated wave. The are (i) Indirect FM (ii) Direct FM. In the Indirect method of FM, the modulating signal first produces a narrow-band FM wave, and subsequently the frequency deviation is increased to the desired value using frequency multiplication techniques. In the Direct method of FM, the carrier frequency is directly varied according to the incoming message signal (modulating signal). (i) Indirect FM:- The figure below shows block schematic of generating a narrow-band FM wave.  Figure: Narrow band phase modulator  (or)  	1M 2M 2M

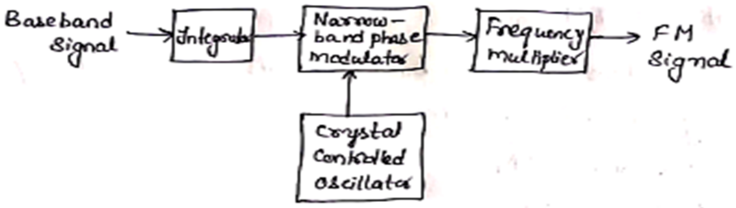


Fig:- Block diagram of the Indirect method of generating a wide-band FM Signal.

The figure shows block diagram of Indirect FM system.

→ In Indirect method, the message signal m(t) is 1st passed through an Integrator before applying it to the phase modulator as shown in figure.

→ The carrier signal is generated by using crystal oscillator because it provides very high frequency ~~selectivity~~. Stability.

→ The operation of Indirect method is divided into two parts as follows:

(i) Generate a NBFM wave using a Phase modulator.

(ii) Using the frequency multipliers & mixer to obtain the required values of frequency deviation & modulation index (ie, WBFM)

* In order to minimize distortion in the phase modulator, the maximum phase deviation or modulation index 'β' is kept small there by resulting in a NBFM signal.

Let $S_1(t)$ be the NBFM wave, then we have

$$S_1(t) = A_c \cos\left[2\pi f_1 t + 2\pi k_f \int_0^t m(t) \cdot dt\right] \text{ —— (1)}$$

where k_f = freq. sensitivity Hz/volt

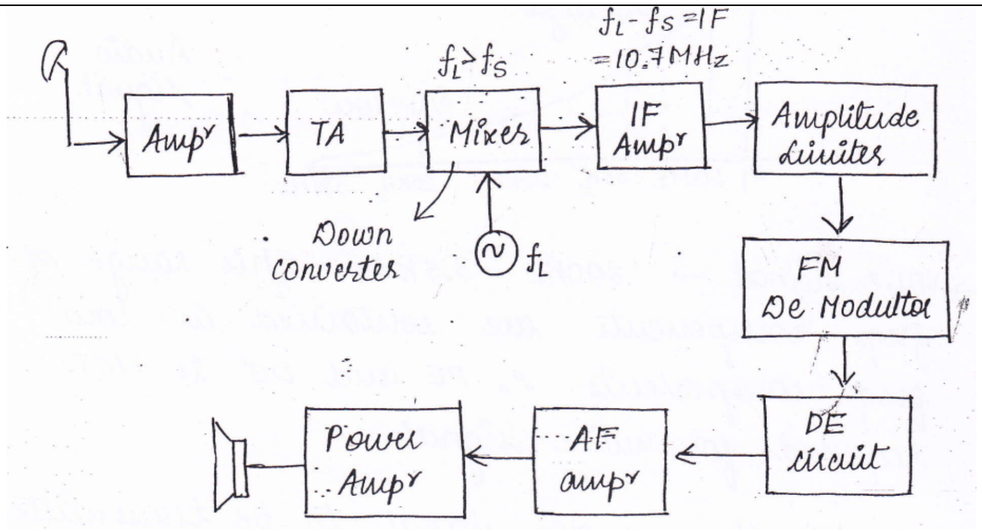
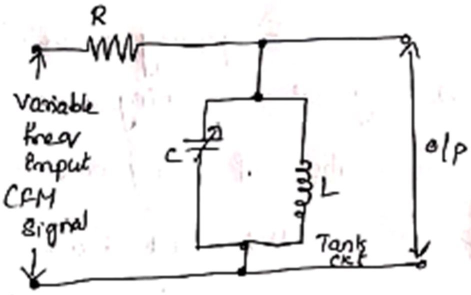
For a single-tone modulation signal defined by $m(t) = A_m \cos 2\pi f_m t$, then eq(1) becomes

$$S_1(t) = \cancel{A_c[\cos}\ A_c \cos\left[2\pi f_1 t + \beta_1 \sin 2\pi f_m t\right] \text{ —— (2)}$$

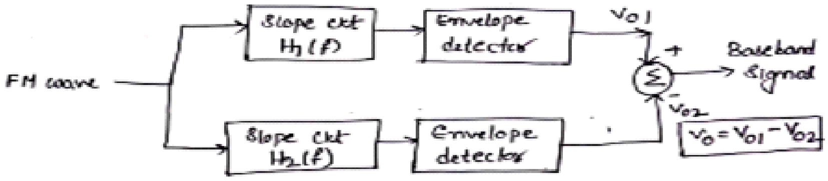
β_1 = modulation index (kept below 0.3 rad to minimize distortion)

The instantaneous frequency of eq(2) is $f_i(t) = f_1 + k_f m(t)$

	b)	Draw the block diagram of FM Superhetrodyne receiver and explain the function of each block.	
	Ans	Block diagram of FM Superhetrodyne receiver	2M 3M

		 Functionality of each block	
	(OR)		
5.	a)	Explain with appropriate sketches and relevant mathematical expressions about demodulation of a FM signal.	
	Ans	FM demodulator :- Frequency demodulation is the process of recovering the original modulating wave from the modulated wave. Demodulation of FM waves are classified into (1) Direct method (i) Frequency Discriminator (i) Zero-crossing detector. (2) Indirect method (i) Phase-locked loop. Frequency discriminator or Simple Slope detector :- Principle of slope detection:-  fig:- Tuned circuit Let us consider a Tuned circuit shown in figure. A frequency modulated (FM) signal of is applied to this tuned circuit. The centre frequency of FM signal is 'fc' & the frequency deviation is 'Δf'. The resonant frequency of the tuned circuit depends on the frequency deviation of I/p FM signal.	2M 3M

Balanced Frequency Discriminator or Balanced Slope detector or Round-Travis Detector:-



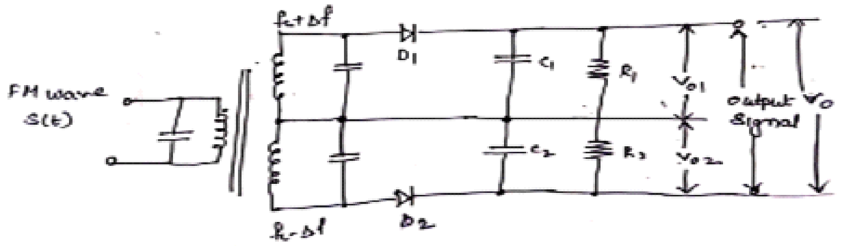


Fig: Circuit Diagram

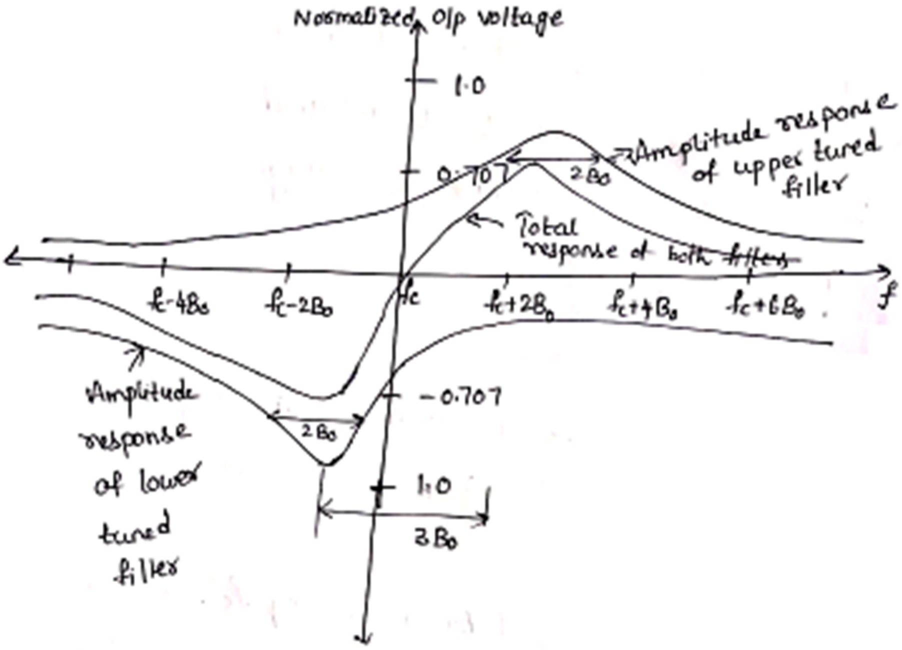


Fig:- Frequency Response.

The Balanced Slope detector consists of two slope detectors circuits. The i/p transformer has a center tapped secondary. Hence the i/p voltages to the two slope detectors are 180° out of phase.

There are 3 tuned circuits

(i) The primary is tuned to IF ie, f_c

(ii) The upper tuned circuit of the secondary (T_1) is tuned above f_c by Δf. ie, the resonant frequency is $f_c+\Delta f$.

(iii) The lower tuned circuit of the secondary (T_2) is tuned below f_c by Δf

→ R_1C_1 & R_2C_2 are the filter circuits

→ V_{01} & V_{02} are the o/p voltages of the two slope detector

→ The final o/p voltage V_0 is obtained by taking the difference of individual o/p voltages V_{01} & V_{02}

$$\boxed{\text{ie, } V_0 = V_{01} - V_{02}}$$

Operation of the circuit :-

we can understand the operation by dividing the i/p frequency into three ranges as follows.

i) $f_{in} = f_c$:-

when i/p freq is equal to carrier freq 'f_c' the reduced voltage in the T_1 winding of secondary is exactly equal to that induced in the winding T_2. Thus the i/p voltages to both the diodes D_1 & D_2 will be same.

∴ The dc o/p voltages V_{01} & V_{02} will also be identical but they have opposite polarities hence $V_0 = 0V$.

ii) $f_{in} > f_c$:-

when i/p frequency is greater than 'f_c' the induced voltage in 'T_1' winding is higher than that induced in 'T_2'. ∴ The i/p to D_1 is higher than D_2. So +ve o/p V_{01} (of D_1) is higher than the -ve o/p V_{02} (of D_2).

Thus the o/p voltage V_0 is positive. (The +ve o/p voltage increases as the i/p freq increases towards $f_c + \Delta f$).

(iii) $f_{in} < f_c$:-

when I/p frequency is less than 'f_c' the induced voltage in 'T_2' winding in higher than 'T_1', so I/p voltage to diode 'D_1' is higher than that of D_2.

Hence the -ve o/p 'V_{02}' is greater than V_{01}.

∴ the o/p voltage of balanced slope detector is -ve in this frequency range. (the -ve voltage increases as fin goes closer to '$f_c - \Delta f$')

$$\therefore \boxed{V_0 = \begin{matrix} 0 & , f_{in} = f_c \\ +ve & , f_{in} > f_c \\ -ve & , f_{in} < f_c \end{matrix}}$$

Advantages:-

1) The ckt is more efficient than simple slope detector.

2) It has better linearity than the simple slope detector.

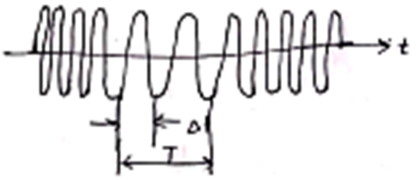
Disadvantages :-

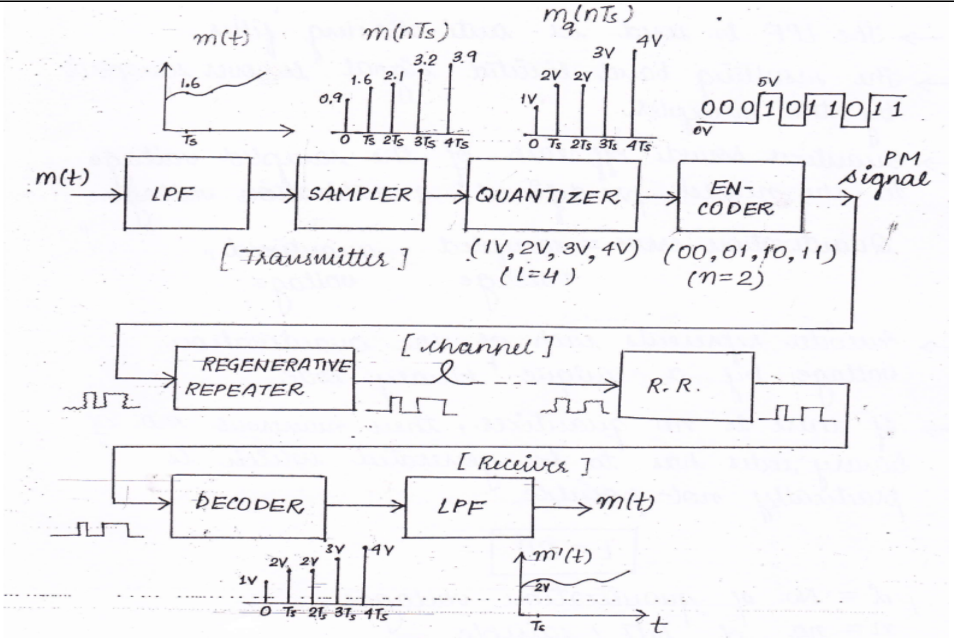
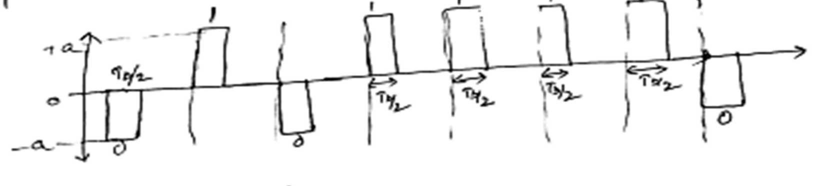
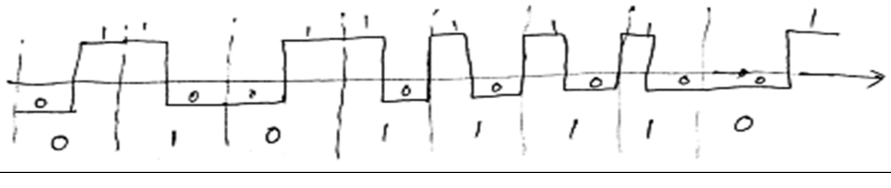
1) This ckt is difficult to tune since the three tuned ckts are to be tuned at different frequencies ie, f_c, $(f_c + \Delta f)$, $(f_c - \Delta f)$

2) Amplitude limiting is not provided.

Zero crossing detector

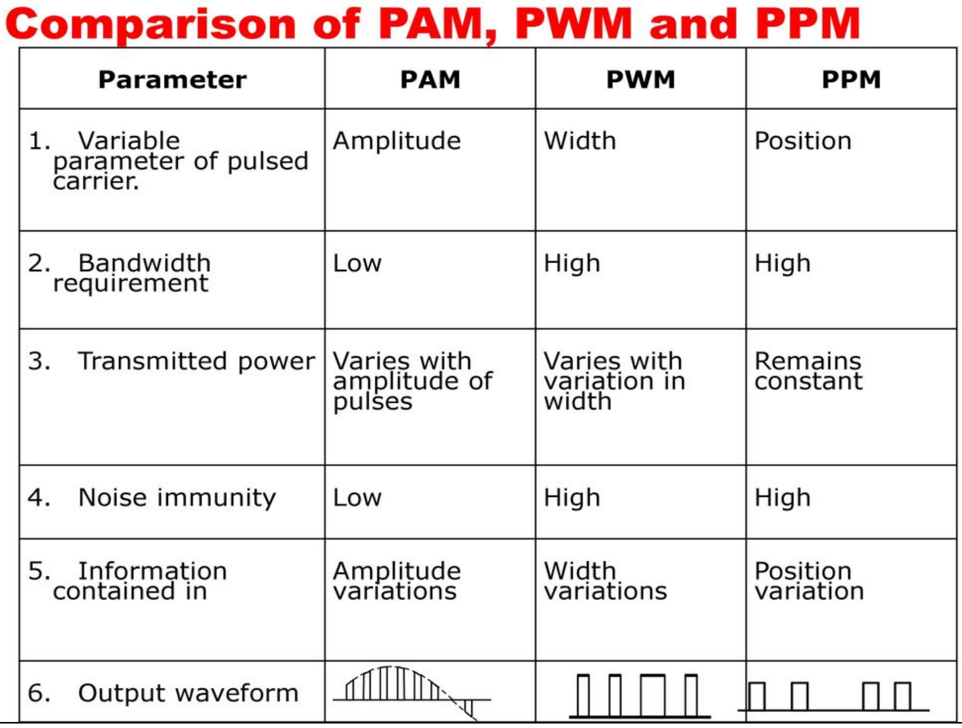
The zero crossing detector operates on the principle that the instantaneous frequency of an FM wave is approximately given by $\boxed{f_i \simeq \frac{1}{2\Delta t}}$ where Δt is the time difference b/w adjacent zero crossing of the FM wave as shown in fig (1).

		 Definitions of T & Δt for an FM wave → The time interval 'T' is chosen in accordance with the following two conditions. → The interval 'T' is ~~small~~ large compared to the reciprocal of the carrier frequency 'fc' of FM wave ie, (1/fc) → The interval 'T' is small compared to the reciprocal of the carrier frequency 'fc' of the FM wave ie, (1/fc). → Let 'n₀' denote the no of zero crossings inside the interval 'T'. Hence Δt is the time between the adjacent zero crossing points given by $\boxed{\Delta_t = \frac{T}{n_0}}$. → Instantaneous frequency is given by $f_i \approx \frac{1}{2\Delta t}$ $f_i \simeq \frac{1}{2\frac{T}{n_0}}$ $f_i \simeq \frac{n_0}{2T}$ → By the definition of instantaneous frequency we know that there is a linear relationship b/w msg signal m(t) & fi. Hence we can recover m(t) if n₀ is known. → the simplified block diagram based on this principle is shown in figure.  	
	b)	An FM signal is represented in time domain as s (t) = 10Cos ($2\pi10^6$ t + 5Sin $8\pi10^3$t). Calculate the frequency deviation, modulation index, power and band width.	
		s(t) = 10Cos ($2\pi10^6$ t + 5Sin $8\pi10^3$t). Calculation of **Frequency deviation,** **Modulation index** **Identification of NBFM or WBFM based on β** **Power** **Band width.**	 1M 1M 1M 1M 1M
	UNIT III		
6.		Explain in detail about transmitter and receiver of PCM.	
	Ans	**Block diagram of PCM**	

		 PCM Tx – analog to digital converter PCM Rx – digital to analog converter **Quantization and encoding process** **Explanation of remaining blocks**	4M 3M 3M
	(OR)		
7.	a)	Given the data stream of 01011110, sketch the transmitted sequence of pulses for each of the following line codes i) Unipolar NRZ ii)Polar NRZ iii) Unipolar RZ iv) Polar RZ v) Manchester code	
	Ans	7(a) 0 1 0 1 1 1 1 0. Ans (i) Unipolar NRZ  (ii) Polar NRZ  (iii) unipolar RZ  (iv) Polar RZ  (v) Manchester code 	1M 1M 1M 1M 1M

b) Compare PAM, PWM and PPM pulse modulation techniques.

Ans — 5M



Comparison of PAM, PWM and PPM

Parameter	PAM	PWM	PPM
1. Variable parameter of pulsed carrier.	Amplitude	Width	Position
2. Bandwidth requirement	Low	High	High
3. Transmitted power	Varies with amplitude of pulses	Varies with variation in width	Remains constant
4. Noise immunity	Low	High	High
5. Information contained in	Amplitude variations	Width variations	Position variation
6. Output waveform			

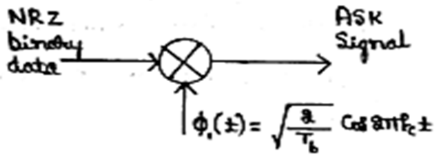
UNIT IV

8. Explain in detail about generation and detection of ASK

Ans — 1M
2M
2M

Amplitude Shift Keying (ASK) :- or ON-OFF Keying :-

Generation of ASK :-



* In binary ASK System Symbol 1 & 0 are represented as follows

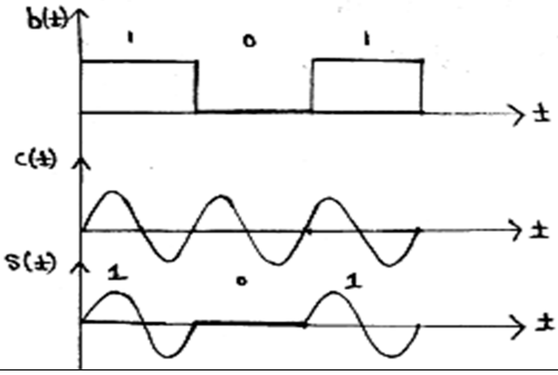
$$S(t) = \begin{cases} S_1(t) = \sqrt{\frac{2E_b}{T_b}} \cos 2\pi f_c t & 0 \leq t \leq T_b \text{ for Symbol 1} \\ S_2(t) = 0 & 0 \leq t \leq T_b \text{ for Symbol 0} \end{cases}$$

* Let us define a basic function $\phi_1(t)$ which has unit energy

$$\phi_1(t) = \sqrt{\frac{2}{T_b}} \cos 2\pi f_c t$$

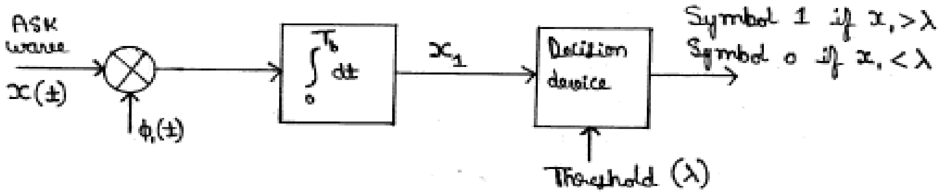
* Binary ASK can be written as :

$$S(t) = \begin{cases} S_1(t) = \sqrt{E_b}\, \phi_1(t) & 0 \leq t \leq T_b \text{ for Symbol 1} \\ S_2(t) = 0 & 0 \leq t \leq T_b \text{ for Symbol 0} \end{cases}$$



* In ASK System, binary Symbol 1 is represented by transmitting a carrier $c(t) = A_c \cos 2\pi f_c t$ for a bit duration 'T_b' Seconds, where as Symbol 0 is represented by Switching off the carrier for 'T_b' Seconds.

Coherent detection (demodulation) of ASK Signal :-



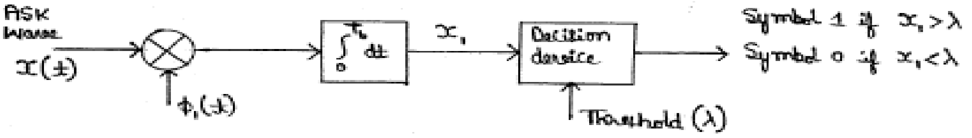
* The received Signal is cross correlated with local reference Signal $\phi_1(t)$. The o/p of the correlator 'x_1' is applied to the decision device.

* The decision device compares the o/p of correlator with preset threshold 'λ' i.e.

  If $x_1 > \lambda \rightarrow$ decides in favour of Symbol 1.

  If $x_1 < \lambda \rightarrow$ decides in favour of Symbol 0.

* In coherent detection the o/p of local oscillator is in perfect Synchronization with the carrier used in the transmitter.



* Let $x(t)$ be the received Signal

$$\boxed{x(t) = s(t) + w(t)} \longrightarrow ①$$

Where $w(t)$ is the additive white gaussian noise (AWGN) with Zero mean ($\mu = 0$) and variance (σ) of $\frac{N_0}{2}$.

$$\therefore \quad x(t) = \begin{cases} s_1(t) + w(t), & \text{for Symbol 1} \\ 0 + w(t), & \text{for Symbol 0} \end{cases}$$

* Let us assume that Symbol '0' is transmitted. Then o/p of the correlator is

$$x_1 = \int_0^{T_b} x(t) \cdot \phi_1(t) \cdot dt$$

$$= \int_0^{T_b} w(t)\, \phi_1(t) \cdot dt$$

$$\boxed{x_1 = W_1}$$

$$\therefore \quad E[x_1] = E[W_1] = 0 \quad \&$$

$$\text{var}[x_1] = \frac{N_0}{2}$$

$$\therefore \boxed{\begin{array}{c} \mu = 0 \\ \sigma^2 = \frac{N_0}{2} \end{array}}$$

Computing P_e of 1st Kind :-

Decision region : $\sqrt{\frac{E_b}{2}} < x_1 < \infty$

(Since x_1 has gaussian distribution, it is defined by)

$$f_{x_1}(x_1/0) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{\frac{-(x_1-\mu)^2}{2\sigma^2}} \cdot dx_1$$

Conditional PDF when Symbol '0' is transmitted is given by:

$$P_{x_1}(x_1|0) = \frac{1}{\sqrt{\cancel{2}\pi\frac{N_0}{\cancel{2}}}} \cdot e^{\frac{-(x_1-0)^2}{\cancel{2}\frac{N_0}{\cancel{2}}}}$$

$$\boxed{P_{x_1}(x_1|0) = \frac{1}{\sqrt{\pi N_0}}\; e^{\left(\frac{-x_1^2}{N_0}\right)} \cdot dx_1} \longrightarrow ②$$

∴ Probability of Symbol error, when Symbol '0' is transmitted

$$P_e(0) = \int_{\frac{\sqrt{E_b}}{2}}^{\infty} P_{x_1}(x_1|0) \cdot dx_1 \longrightarrow ③$$

Substituting eq ② in eq ③, we get

$$P_e(0) = \int_{\sqrt{E_b/2}}^{\infty} \frac{1}{\sqrt{\pi N_0}}\; e^{-\left[\frac{x_1}{\sqrt{N_0}}\right]^2} dx_1 \longrightarrow ④$$

Let $Z = \frac{x_1}{\sqrt{N_0}}$

$Z\sqrt{N_0} = x_1$

$\boxed{dx_1 = dZ\sqrt{N_0}}$

limits

When $x_1 = \frac{\sqrt{E_b}}{2}$	When $x_1 = \infty$
$Z\sqrt{N_0} = \frac{\sqrt{E_b}}{2}$ $Z = \frac{\sqrt{E_b}}{2} \cdot \frac{1}{\sqrt{N_0}}$ $Z = \sqrt{\frac{E_b}{N_0}} \times \frac{1}{2}$	$Z\sqrt{N_0} = \infty$ $Z = \frac{\infty}{\sqrt{N_0}}$ $Z = \infty$

$$P_e(0) = \int_{\sqrt{\frac{E_b}{N_0}} \times \frac{1}{2}}^{\infty} \frac{1}{\sqrt{\pi \cancel{N_0}}}\, e^{-Z^2} \cdot dZ \cancel{\sqrt{N_0}}$$

$$P_e(0) = \int_{\frac{1}{2}\sqrt{\frac{E_b}{2}}}^{\infty} \frac{1}{\sqrt{\pi}}\, e^{-Z^2}\, dZ \longrightarrow ⑤$$

WKT Complementary error function

$$\boxed{\operatorname{erfc}(u) = \frac{2}{\sqrt{\pi}} \int_{u}^{\infty} e^{-u^2} du} \longrightarrow ⑥$$

From eq ⑥, we can write eq ⑤ as

$$P_e(0) = \frac{1}{\sqrt{\pi}}\; \frac{2}{2} \int_{\frac{1}{2}\sqrt{\frac{E_b}{N_0}}}^{\infty} e^{-Z^2} dZ$$

$$\boxed{P_e(0) = \frac{1}{2}\operatorname{erfc}\left(\frac{1}{2}\sqrt{\frac{E_b}{N_0}}\right)}$$

Where $u = \frac{1}{2}\sqrt{\frac{E_b}{N_0}}$

* Similarly we can calculate probability of error for 2nd kind:

$$\boxed{P_e(1) = \frac{1}{2}\operatorname{erfc}\left(\frac{1}{2}\sqrt{\frac{E_b}{N_0}}\right)}$$

Let probability of Sending '0' is $p(0) = \frac{1}{2}$

Let probability of Sending '1' is $p(1) = \frac{1}{2}$

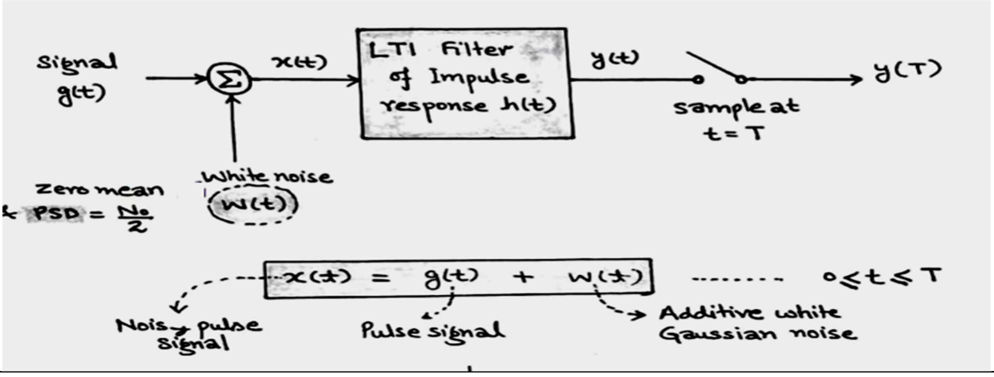
* Then average probability of error

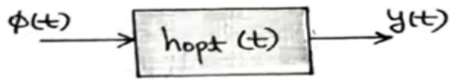
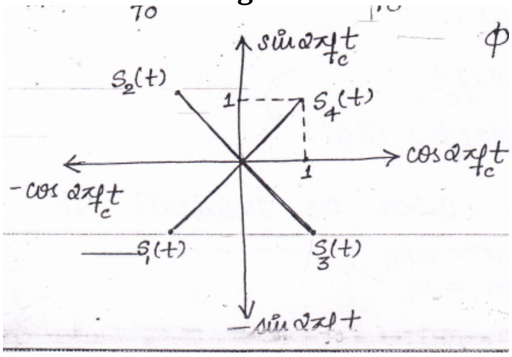
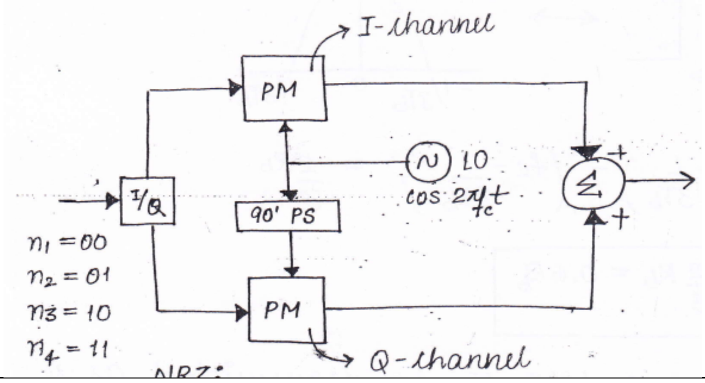
$$P_e = P(0)\,P_e(0) + P(1)\,P_e(1)$$

$$P_e = \frac{1}{2}\left[\frac{1}{2}\operatorname{erfc}\left(\frac{1}{2}\sqrt{\frac{E_b}{N_0}}\right)\right] + \frac{1}{2}\left[\frac{1}{2}\operatorname{erfc}\left(\frac{1}{2}\sqrt{\frac{E_b}{N_0}}\right)\right]$$

$$\boxed{P_e = \frac{1}{2}\operatorname{erfc}\left(\frac{1}{2}\sqrt{\frac{E_b}{N_0}}\right)}$$

(OR)

9.	a)	Define matched filter. Evaluate the impulse response of matched filter.	
		Definition of Matched Filter **Receiver Block Diagram** 	1M 2M 2M

		Evaluation of Impulse Response  $y(t) = h_{opt}(t) * \phi(t)$ For matched filter $h_{opt}(t) = \phi(T-t)$	
	b)	With neat sketch explain the working principle of QPSK.	
		QPSK Principle **Constellation Diagram**  **Block Diagram**  	2M 1M 2M