11	a)	Explain how PPM can be generated from PWM signals.	L2	CO5	5 M
	b)	Describe Time Division Multiplexing.	L2	CO5	5 M

PVP 23

Code: 23EC3403

II B.Tech - II Semester – Regular Examinations - MAY 2025

ANALOG COMMUNICATIONS
(ELECTRONICS & COMMUNICATION ENGINEERING)

Duration: 3 hours — Max. Marks: 70

Note: 1. This question paper contains two Parts A and B.
2. Part-A contains 10 short answer questions. Each Question carries 2 Marks.
3. Part-B contains 5 essay questions with an internal choice from each unit. Each Question carries 10 marks.
4. All parts of Question paper must be answered in one place.

BL – Blooms Level — CO – Course Outcome

PART – A

		BL	CO
1.a)	Draw the block diagram of communication system.	L1	CO1
1.b)	What is meant by modulation?	L1	CO1
1.c)	With the help of neat diagram explain VSB signal.	L1	CO2
1.d)	Write the time domain representation of SSB signal.	L1	CO2
1.e)	Define angle modulation.	L1	CO3
1.f)	State the advantage of FM Radio broadcasting.	L1	CO3
1.g)	Define Figure of Merit of Receiver.	L1	CO4
1.h)	What is FM threshold effect?	L1	CO4
1.i)	Describe Nyquist rate & Nyquist interval.	L1	CO5
1.j)	Compare PAM and PWM.	L1	CO5

PART – B

			BL	CO	Max. Marks
UNIT-I					
2	a)	With necessary expressions, explain single-tone AM.	L2	CO1	5 M
	b)	With the help of circuit diagram explain the operation of square-law diode modulator for AM.	L2	CO1	5 M
OR					
3	a)	With the help of neat diagram explain AM Envelop detector.	L2	CO1	5 M
	b)	Write short notes on AM switching modulator with necessary equations.	L2	CO1	5 M
UNIT-II					
4	a)	Explain generation of DSB-SC signal with the help of balanced modulator.	L2	CO2	5 M
	b)	Derive an expression for SSB-SC modulated wave.	L3	CO2	5 M
OR					
5	a)	With the help of neat diagram explain VSB modulated signal.	L2	CO2	5 M
	b)	Compare different types of AM techniques.	L2	CO2	5 M
UNIT-III					
6	a)	Explain the generation of FM using direct method.	L2	CO3	5 M

	b)	Write a short notes on Super-heterodyne FM receiver.	L1	CO3	5 M
OR					
7	a)	For an FM modulator with a modulating signal $m(t) = V_m \sin(300\times10^3\ t)$, the carrier Signal $V_c(t)=8\sin(6.5\times10^6\ t)$ and the modulator index = 2. Find out the significant side band frequencies and its bandwidth.	L4	CO3	5 M
	b)	Compare frequency and Amplitude modulation.	L2	CO3	5 M
UNIT-IV					
8	a)	Write short note on Pre-Emphasis and De-Emphasis circuits.	L1	CO4	5 M
	b)	Discuss about FM receiver model.	L3	CO4	5 M
OR					
9	a)	Compare the noise performance in frequency modulated system and amplitude modulated systems.	L2	CO4	5 M
	b)	Obtain the expression for output SNR of AM system.	L3	CO4	5 M
UNIT-V					
10	a)	State and prove sampling theorem.	L2	CO5	5 M
	b)	Explain generation of PAM with mathematical analysis.	L2	CO5	5 M
OR					

II B.Tech – II Semester – Regular Exams – May 2025

3, Analog Communications

Scheme of Evaluation   Max marks:

1 (a) Block diagram – 2M

(b) Def & Explanation – 2M

(c) Spectral diagram – 2M

(d) Time domain Eq of SSB – 2M

(e) Def of angle mod – 2M

(f) Advantages – 2M

(g) Formula – 2M.

(h) Threshold Effect Explanation – 2M.

(i) Nyquist rate – 1M, Nyquist interval – 1M

(j) Two Comparisons – 2M

2 (a) Mathematical analysis – 3M.

Spectral diagram – 2M

(b) Block diagram – 2M

Derivation & Explanation – 3M

3 (a) Block diagram – 1M, waveforms – 2M.

Explanation – 2M

(b) Block diagram, Eq – 2M, Derivation & Explanation 3M

4 (a) Block diagram of Balanced modulator – 2M

Explanation – 3M

(b) SSB Explanation – 2M

Mathematical Eq – 3M.

Explanation, spectral analysis - 3M

6 (a) Block diagram of direct FM - 2M

Explanation - 3M

(b) Superheterodyne Rx, diagram - 2M

Explanation - 3M

7 (a) Sidebands - 3M, Bandwidth - 2M

(b) Comparison between AM and FM - 5M

8 (a) Pre Emphasis & De Emphasis Block diagram - 2M

Explanation - 3M

(b) FM Rx model diagram - 2M, Equation - 3M

9 (a) Comparison - 5M

(b) Block diagram - 2M, Equations = 3M

10 (a) Statement - 2M

Derivation - 3M

(b) PAM Block diagram - 2M.

Mathematical Eq^n - 3M

11 (a) PPM Block & ckt diagram - 2M

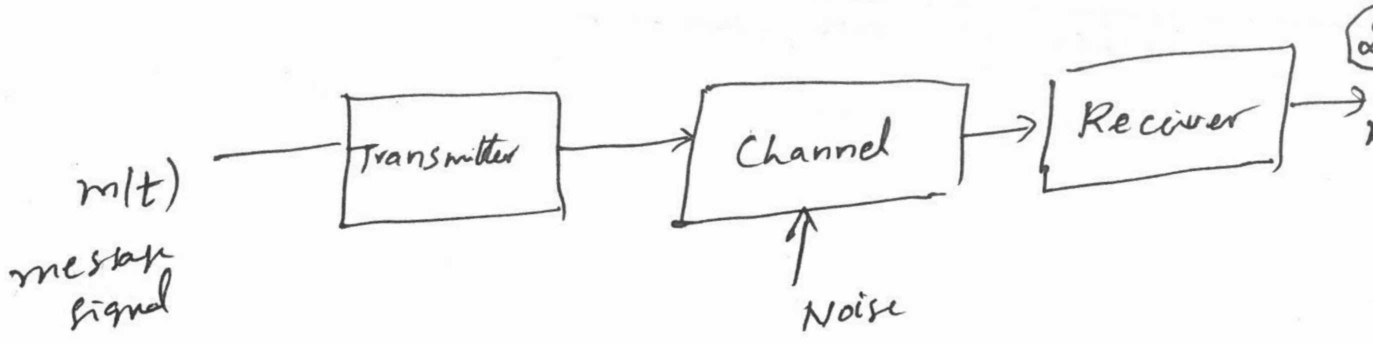
Explanation - 3M

(b) TDM Block diagram - 2M

Explanation - 3M

PART – A

1 a) Block diagram of Communication System



1(b) Modulation:

(2M)

Modulation is the process of frequency translation which imparts, the source information on to a bandpass signal with a carrier frequency f_c by the introduction of amplitude or frequency or phase variations in accordance with modulating signal. amplitude of carrier varies – AM, Frequency of carrier varies – FM, Phase of carrier varies – PM

Bandpass signal → Modulated signal

Baseband signal → Modulating signal or message signal

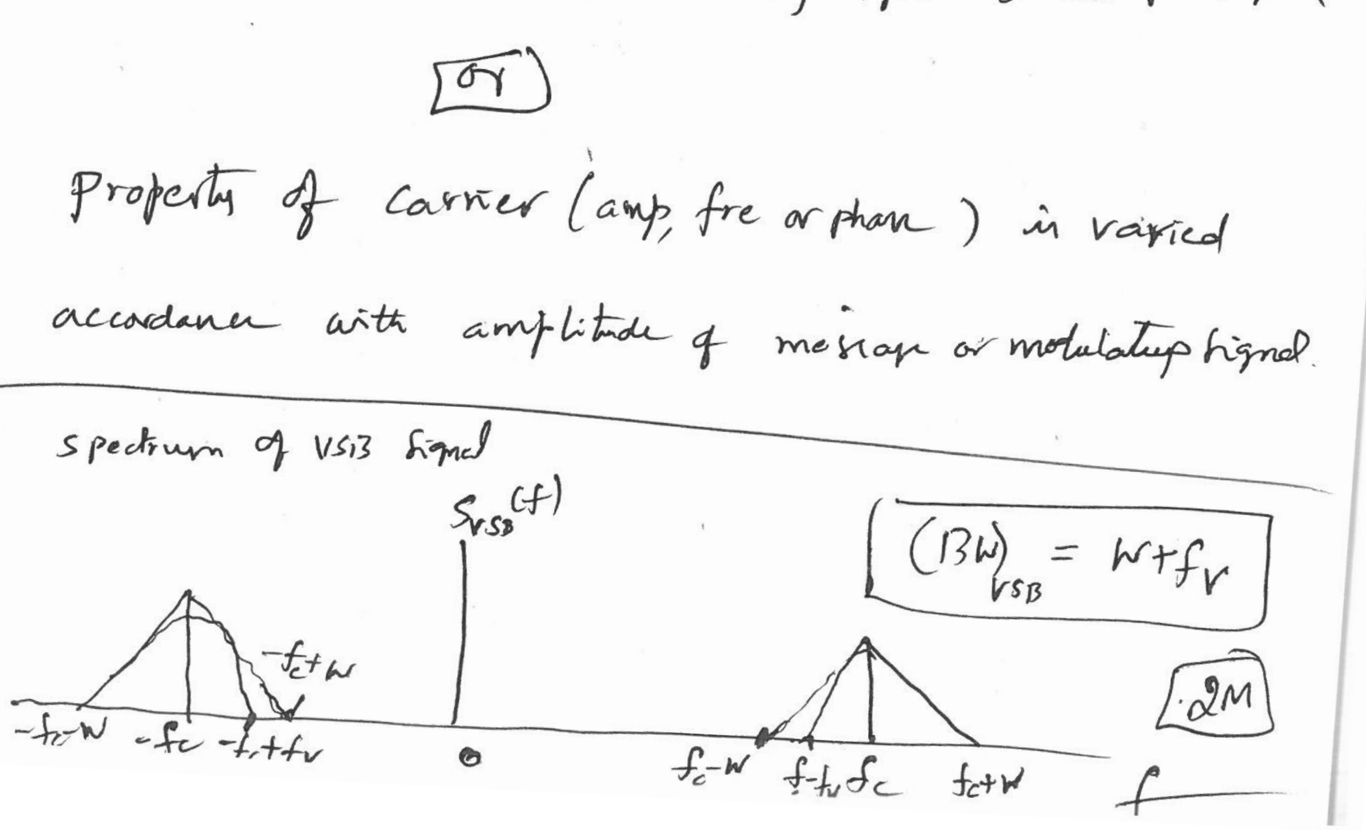
(or)

⇒ Property of carrier (amp, fre or phase) is varied in accordance with amplitude of message or modulating signal.

1(c) spectrum of VSB signal

$$(BW)_{VSB} = W + f_v$$

(2M)

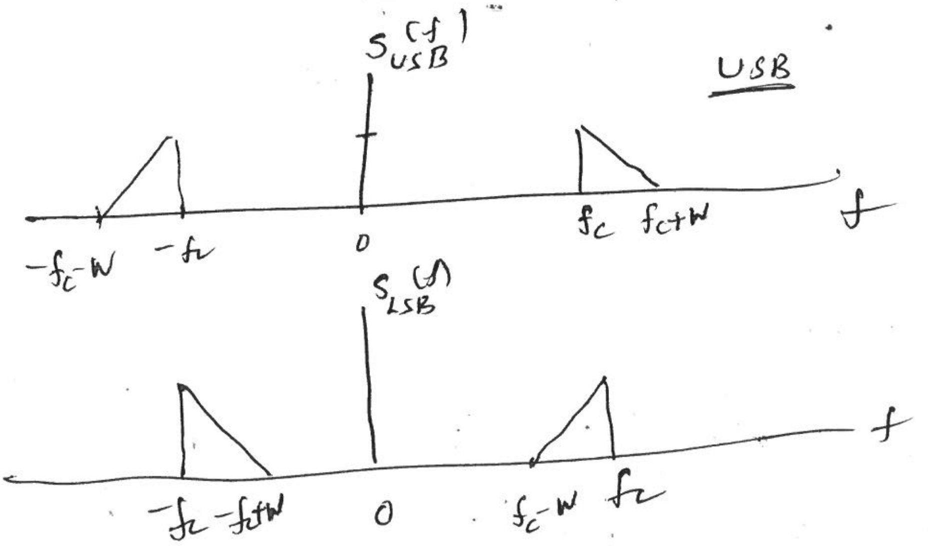


VSB – Transmitting one full sideband and
Vestige of other sideband

Adv — BW Efficient, used in TV broadcasting

---

1 (d)



2M

$$S_{SSB}(t) = \frac{A_c}{2} m(t) \cos 2\pi f_c t \mp \frac{A_c}{2} \hat{m}(t) \sin 2\pi f_c t$$

$\hat{m}(t)$ – Hilbert transform of $m(t)$

2M

---

1 (e) Angle of carrier (Frequency or phase) is varied in proportion to the instantaneous amplitude of modulating signal. Amplitude of carrier is constant.

$$S(t) = A_c \cos(2\pi f_c t + \phi(t))$$

In FM, $\phi(t)$ is proportional to Integral of message signal.

$$S_{FM}(t) = A_c \cos\left(2\pi f_c t + 2\pi k_f \int_0^t m(t)\,dt\right)$$

In PM, $\phi(t)$ is proportional to message signal itself

1 (f) 1. Stereo Broadcasting possible with FM [2M]

2. Less channel interference (Since IF BW of FM is 200KHz

3. Better noise immunity

4. Superior Sound Quality

---

1 (g) Figure of merit of Receiver [2M]

FOM = Output Signal to Noise ratio of Receiver / Channel Signal to Noise ratio over message Bandwidth

$$FOM = \frac{(SNR)_o}{(SNR)_c}$$

---

1 (h) FM Threshold Effect [2M]

If SNR at the input of Receiver drops below certain critical Level, then output SNR falls rapidly. This Critical point is called Threshold. Below Threshold you can hear cracking, popping sounds.

To Eliminate Threshold effect, we use preEmphasis and deEmphasis ckts and amplitude limiter ckts.

Threshold point in case of FM is 10 to 12dB of input SNR. If Input SNR is above 12dB we can have Superior Sound performance in FM.

1(i) Let Modulating signal has highest frequency component W (f_m), sampling rate is f_s. **2M**

(Notation W or f_m)

If $f_s = 2W\ (2f_m)$ then Sampling rate is called **Nyquist rate**

Nyquist interval $= \frac{1}{2W}$

1(j) **2M**

PAM	PWM
1. Amplitude of pulse train is varied in accordance with message signal	Width of pulse train is varied in accordance with message signal
	
– poor noise performance	Better noise performance
– Requires less Bandwidth	Requires more Bandwidth
– Simple demodulation process	Complex demodulation process

Part – B

2 (a) Singh tone AM

Time domain representation of standard AM is

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

In case of single tone modulation, $m(t) = A_m \cos 2\pi f_m t$

$$c(t) = A_c \cos 2\pi f_c t$$

Substitute (2) in (1)

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

Modulation index $\mu = |k_a m(t)|_{max} = k_a A_m$

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

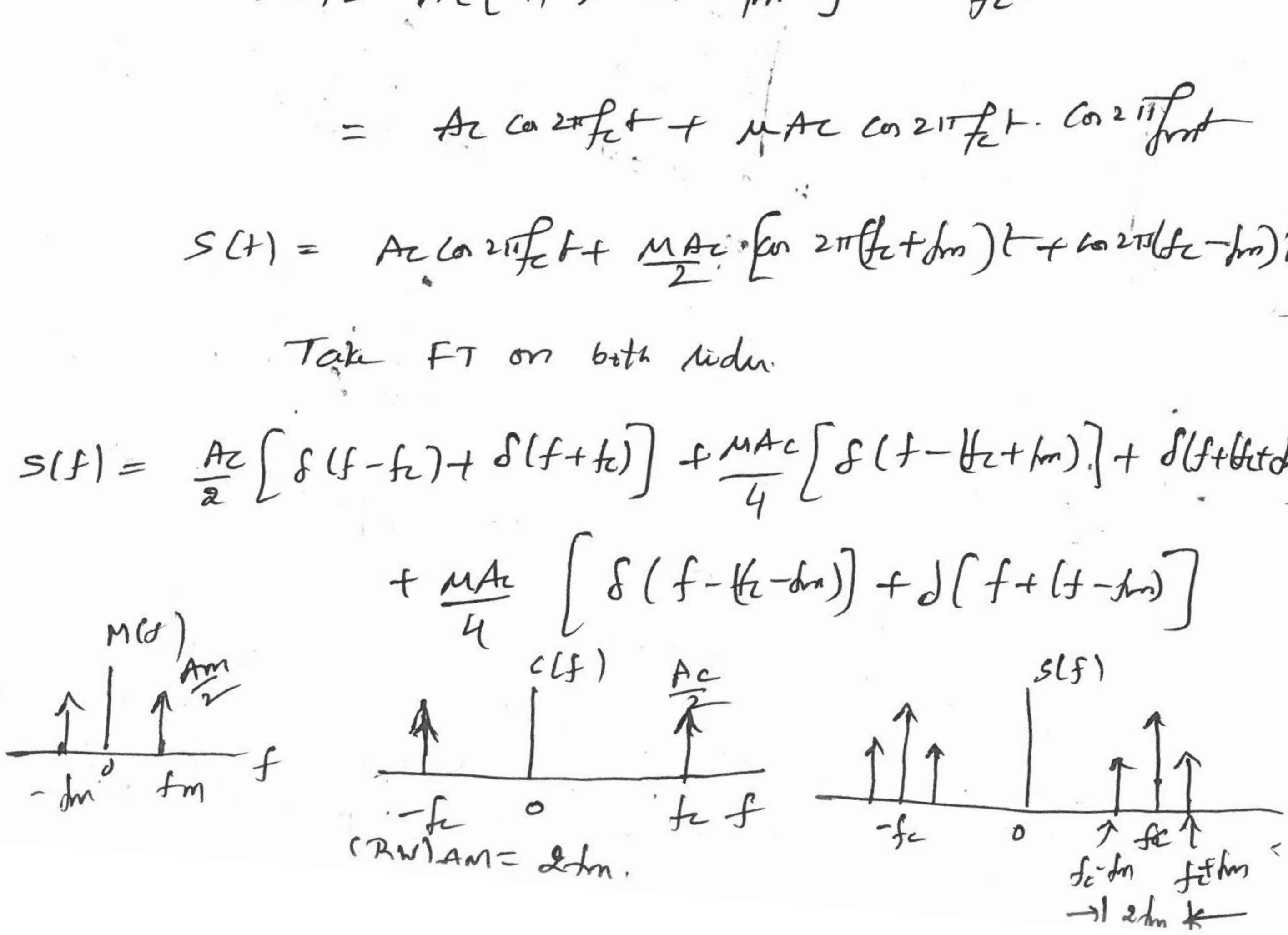
$$= A_c \cos 2\pi f_c t + \mu A_c \cos 2\pi f_c t \cdot \cos 2\pi f_m t$$

$$s(t) = A_c \cos 2\pi f_c t + \frac{\mu A_c}{2}\left[\cos 2\pi (f_c + f_m) t + \cos 2\pi (f_c - f_m) t\right]$$

Take FT on both sides

$$S(f) = \frac{A_c}{2}\left[\delta(f - f_c) + \delta(f + f_c)\right] + \frac{\mu A_c}{4}\left[\delta(f - (f_c + f_m)) + \delta(f + (f_c + f_m))\right]$$

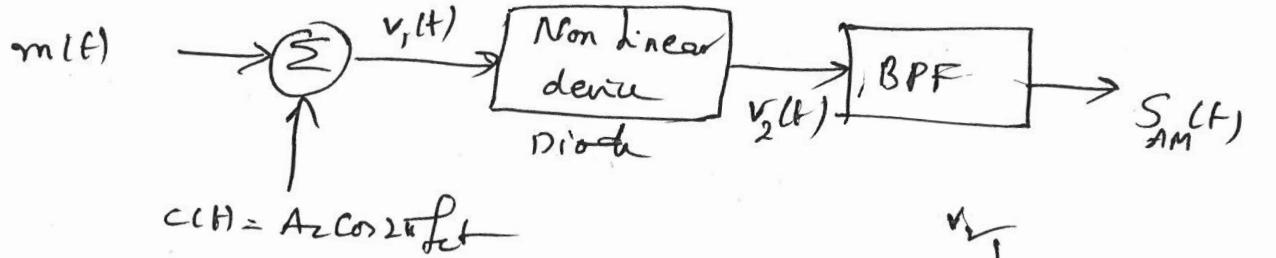
$$+ \frac{\mu A_c}{4}\left[\delta(f - (f_c - f_m)) + \delta(f + (f_c - f_m))\right]$$

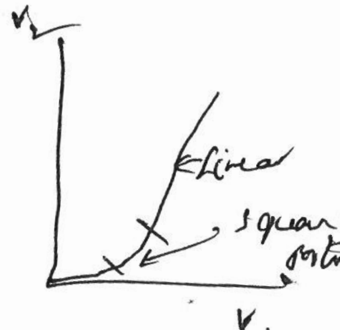


(BW) AM = 2fm.

modulator.

5M





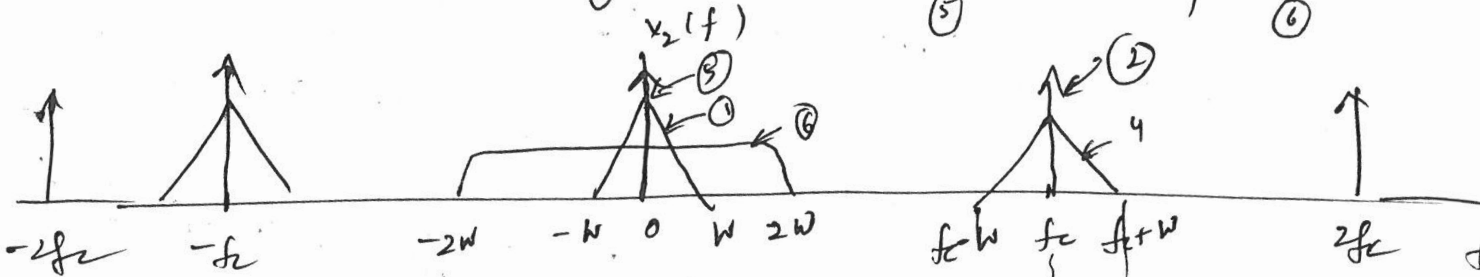
$$v_1(t) = m(t) + A_c \cos 2\pi f_c t$$

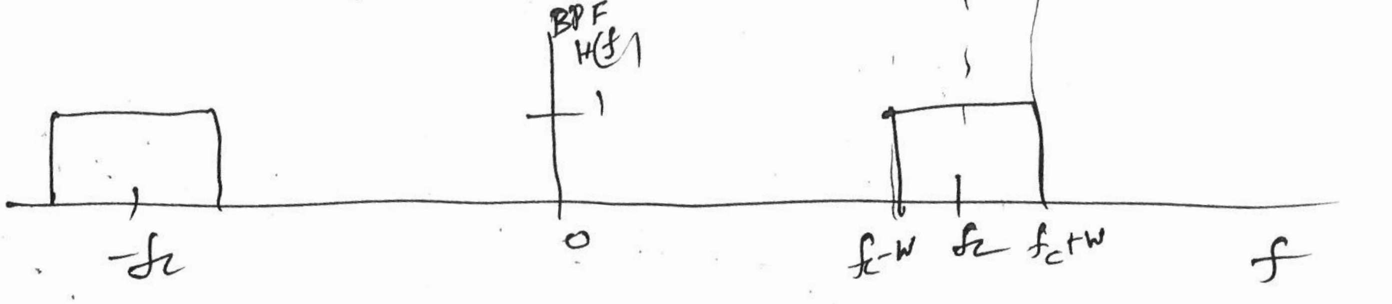
$$v_2(t) = a_1 v_1(t) + a_2 v_1^2(t)$$

$$v_2(t) = a_1 (m(t) + A_c \cos 2\pi f_c t) + a_2 (m(t) + A_c \cos 2\pi f_c t)^2$$

Take FT on both sides

$$V_2(f) = \underset{①}{a_1 M(f)} + \frac{a_1 A_c}{2}\underset{②}{[\delta(f-f_c) + \delta(f+f_c)]} + a_2 \underset{③}{[M(f) * M(f)]}$$
$$+ \frac{2a_2 A_c}{2}\underset{④}{[M(f-f_c) + M(f+f_c)]} + \underset{⑤}{\frac{a_2 A_c^2}{2}\delta(f)} + \frac{a_2 A_c^2}{4}\underset{⑥}{[\delta(f-2f_c) + \delta(f+2f_c)]}$$





o/p of BPF is ② and ④ components only. other components gets rejected

$$S_{AM}(t) = a_1 A_c \cos 2\pi f_c t + 2a_2 A_c m(t) \cos 2\pi f_c t$$
$$= a_1 A_c \left[1 + \frac{2a_2}{a_1} m(t)\right] \cos 2\pi f_c t$$

$K_a = \frac{2a_2}{a_1}$

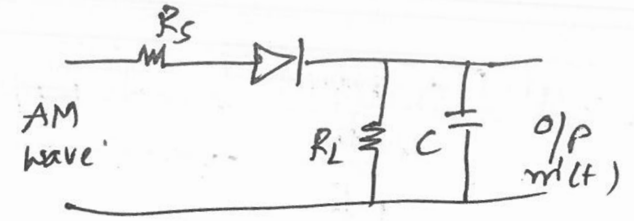
To Reconstruct m(t) properly

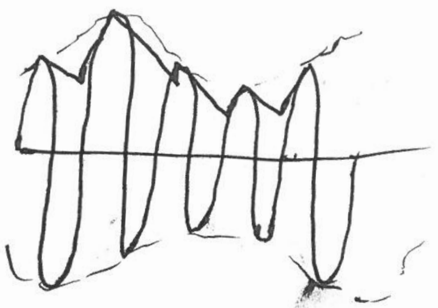
$f_c - W > 2W$

$f_c > 3W$

3(a) Envelope detector

5M



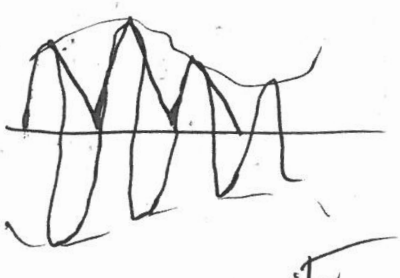


on +ve cycle of input signal diode in forward biased and capacitor charges to peak value of input signal. - When i/p falls below the voltage across capacitor, diode becomes reverse biased, capacitor discharges slowly through load Resistor R_L

Time Constant R_LC must be selected such that

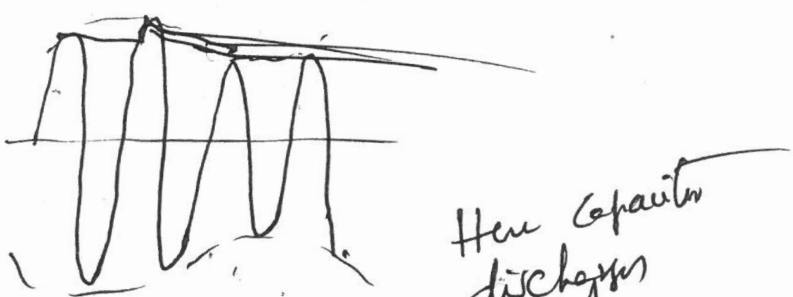
$$\frac{1}{f_c} << R_L C << \frac{1}{f_m}$$

Case I: When $R_L C << \frac{1}{f_c}$



Here capacitor discharges Rapidly

Case II. $R_L C >> \frac{1}{f_m}$

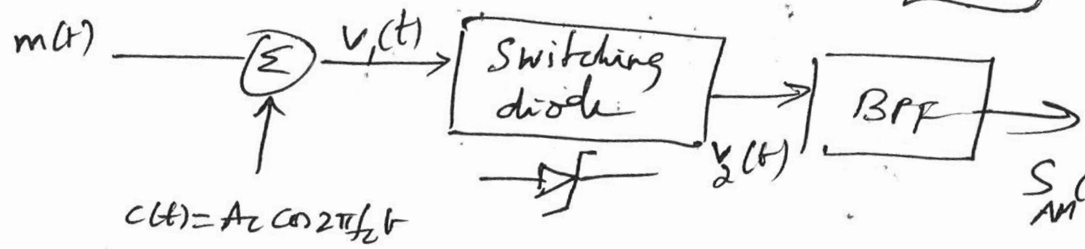


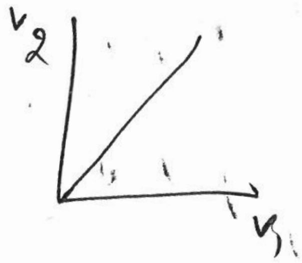
Here capacitor discharges slowly

This problem is Called

Diagonal clipping

(5M)

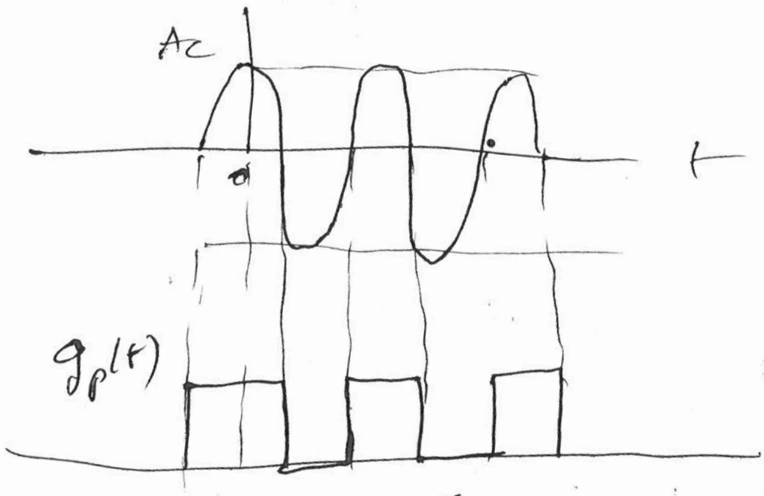




$v_1(t) = m(t) + A_c \cos 2\pi f_c t$

$v_2(t) = v_1(t) \; g_p(t)$

$g_p(t)$ is rectangular pulse train with period T, duty cycle =

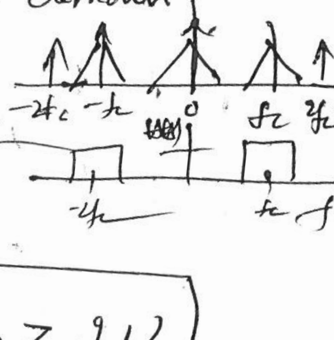


using TFS $\quad x(t) = a_0 + \sum_{k=1}^{\infty} a_k \cos k\omega_0 t + \sum_{k=1}^{\infty} b_k \sin k\omega_0 t$

$g_p(t) = \frac{1}{2} + \frac{2}{\pi} \cos 2\pi f_c t + \text{------}$

$v_2(t) = v_1(t) \cdot g_p(t) = \left(m(t) + A_c \cos 2\pi f_c t \right) \cdot \left[\frac{1}{2} + \frac{2}{\pi} \cos 2\pi f_c t + \dots \right.$

By solving and representing in frequency domain



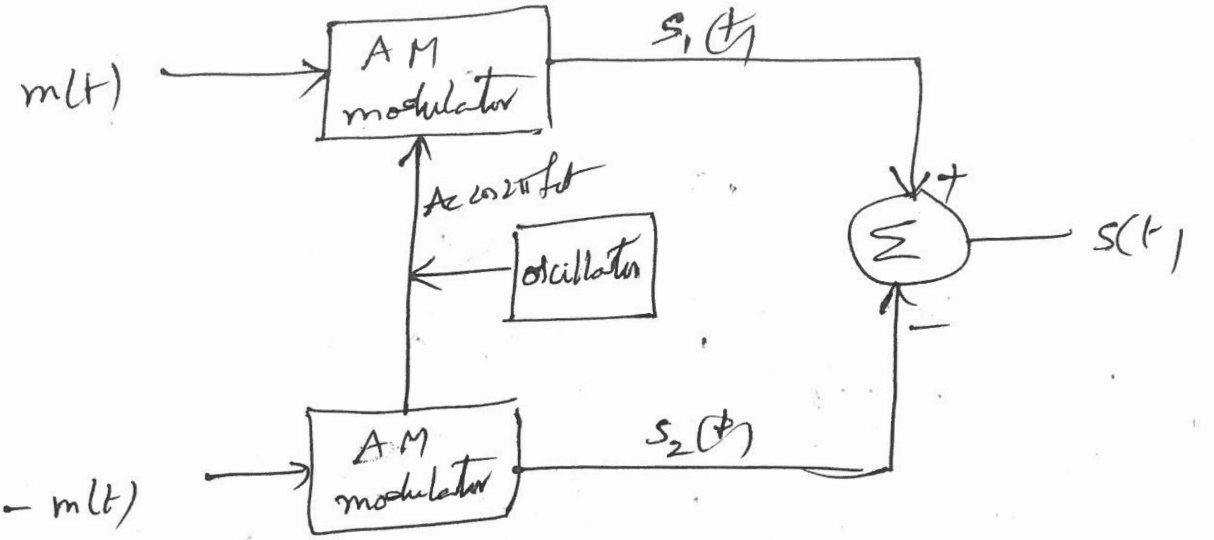
$S_{AM}(t) = \frac{A_c}{2} \left[1 + \frac{4}{A_c \pi} m(t) \right] \cos 2\pi f_c t$

$$K_a = \frac{4}{A_c \pi}$$

$$f_c > 2W$$

UNIT-II

4(a) Balanced Modulator (5M)



$$s_1(t) = A_c(1 + k_a m(t)) \cos 2\pi f_c t$$

$$s_2(t) = A_c(1 - k_a m(t)) \cos 2\pi f_c t$$

$$s(t) = s_1(t) - s_2(t)$$

$$= A_c \cos 2\pi f_c t + A_c k_a m(t) \cos 2\pi f_c t - A_c \cos 2\pi f_c t + A_c k_a m(t) \cos 2\pi f_c t$$

DSBSC wave

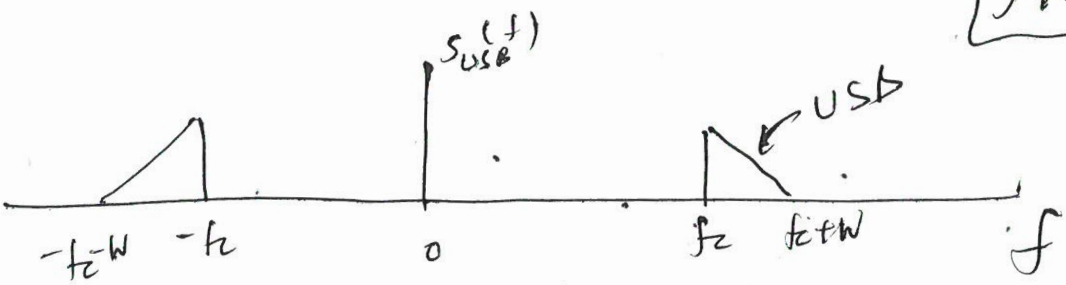
$$s(t) = 2 A_c k_a m(t) \cos 2\pi f_c t$$

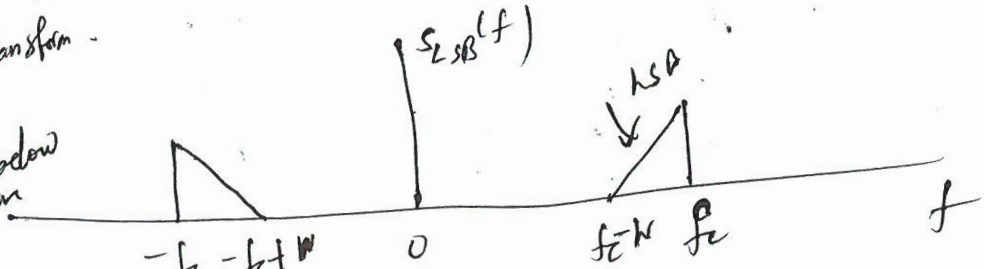
Except the scaling factor $2k_a$, Balanced modulator o/p is product of message signal m(t) and carrier signal $c(t) = A_c \cos 2\pi f_c t$

DSBSC wave, $s(t) = m(t) \cdot A_c \cos 2\pi f_c t$

4 (b) Single Sideband modulation (SSB)

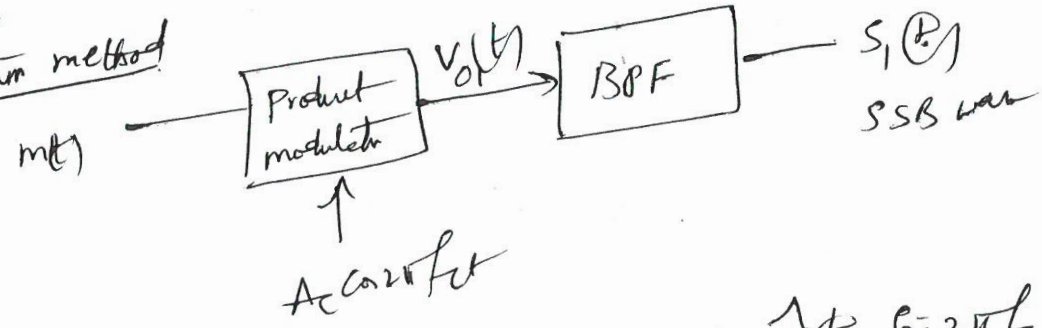
5 M





Hilbert transform. It is lengthy question. Any below answer can be given marks

Frequency discrimination method

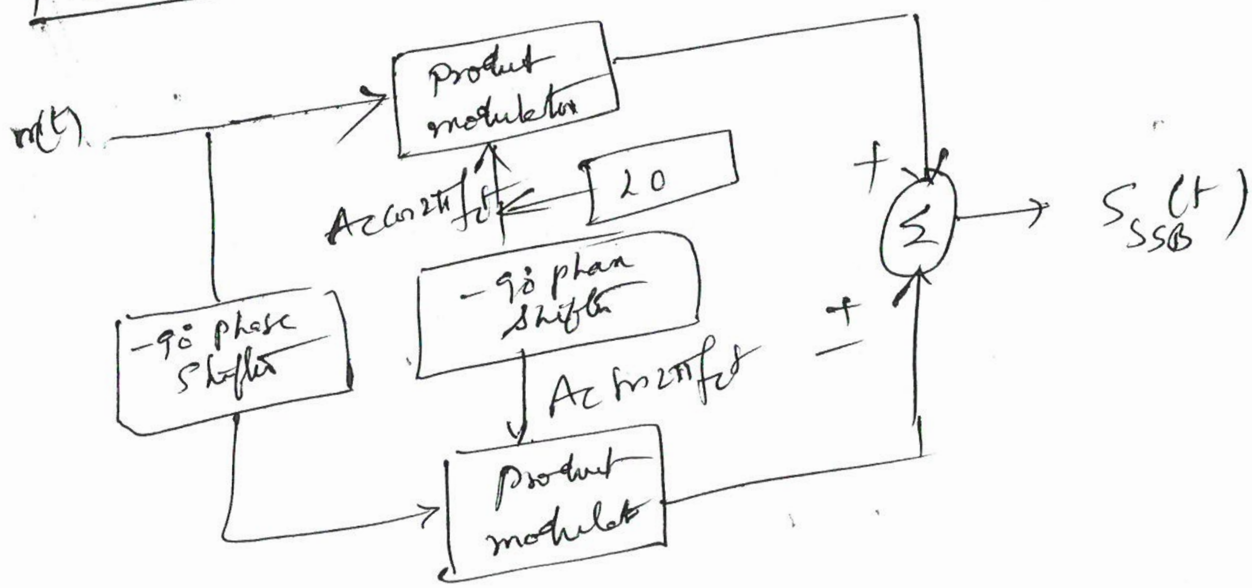


$$S_{LSB}(t) = \frac{A_c}{2} m(t) \cos 2\pi f_c t + \frac{A_c}{2} \hat{m}(t) \sin 2\pi f_c t$$

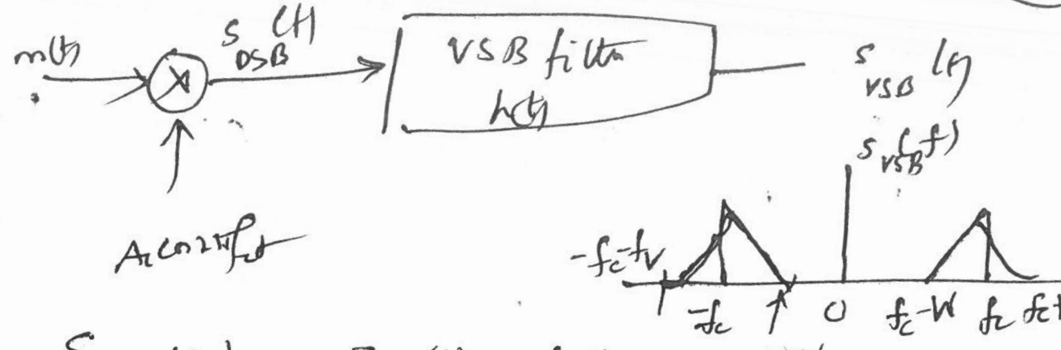
$$S_{USB}(t) = \frac{A_c}{2} m(t) \cos 2\pi f_c t - \frac{A_c}{2} \hat{m}(t) \sin 2\pi f_c t$$

$$S_{SSB}(t) = \frac{A_c}{2} m(t) \cos 2\pi f_c t \mp \frac{A_c}{2} \hat{m}(t) \sin 2\pi f_c t$$

Phase discrimination method



5(a) VSB Generation [5M]



$$S_{VSB}(t) = S_{DSB}(t) * h(t)$$

h(t) is Impulse response of VSB filter

$$S_{DSB}(t) = m(t) \cdot A_c \cos 2\pi f_c t \quad \text{---} \; (1)$$

$$S_{VSB}(t) = A_c\, m(t) \cos 2\pi f_c t * h(t)$$

$$= A_c \int_{-\infty}^{\infty} h(\tau)\, m(t-\tau) \cos 2\pi f_c (t-\tau)\, d\tau$$

$$S_{VSB}(t) = \frac{A_c}{2} \cdot 2 \int_{-\infty}^{\infty} h(\tau)\, m(t-\tau) \cdot \cos 2\pi f_c t \cdot \cos 2\pi f_c \tau \, d\tau$$

$$+ \frac{A_c}{2} \cdot 2 \int_{-\infty}^{\infty} h(\tau)\, m(t-\tau) \cdot \sin 2\pi f_c t \cdot \sin 2\pi f_c \tau \cdot d\tau$$

For USB

$$S_{VSB}(t) = \frac{A_c}{2} m_I(t) \cos 2\pi f_c t + \frac{A_c}{2} m_Q(t) \cdot \sin 2\pi f_c t$$

$$m_I(t) = 2 \int_{-\infty}^{\infty} h(\tau)\, m(t-\tau) \cdot \cos 2\pi f_c \tau \, d\tau$$

$$m_Q(t) = 2 \int_{-\infty}^{\infty} h(\tau)\, m(t-\tau) \sin 2\pi f_c \tau \, d\tau$$

$$S_{VSB}(t) = \frac{A_c}{2} m_I(t) \cos 2\pi f_c t \underset{+\,\text{USB}}{\overset{-\,\text{LSB}}{\mp}} \frac{A_c}{2} m_Q(t) \sin 2\pi f_c t$$

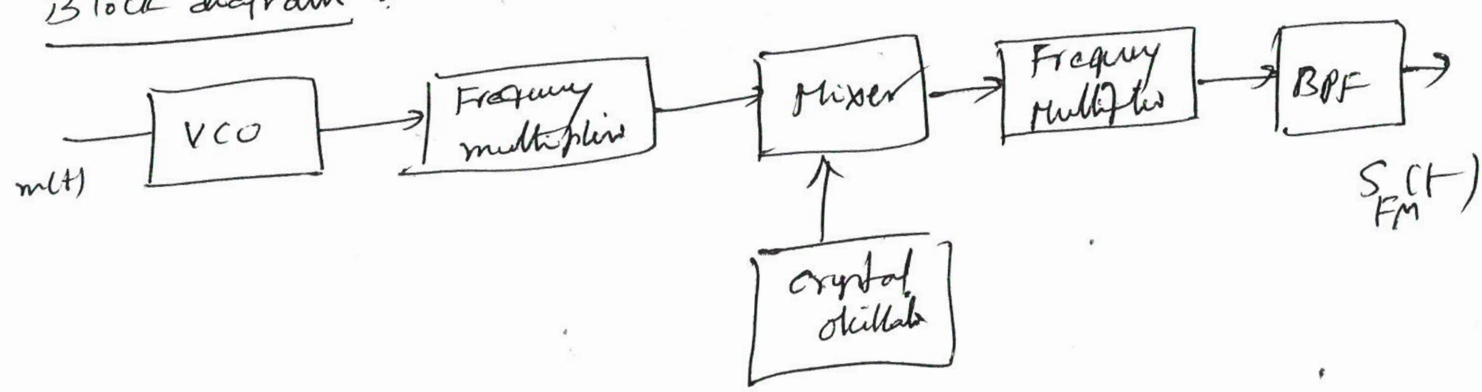
5(b) Comparison b/w AM, DSB, SSB and VSB — 5M

Parameter	AM	DSB	SSB	VSB
Bandwidth	2W	2W	W	$W + f_V$
Transmitted power	$P_C + P_{USB} + P_{LSB}$	$P_{USB} + P_{LSB}$	P_{LSB} (or) P_{USB}	$P_{LSB} + P_V$
Complexity (TX and RX)	Simple	Moderate	High	Moderate
Sideband	Both LSB and USB	Both LSB and USB	LSB or USB	One sideband + partial other sideband
Noise performance	Poor	Good	Good	Moderate
Application	AM Radio Broadcasting	Basic Comm s/w Two system	Voice Communication, point to point	TV video
Carrier presence	Present	Suppressed	Suppressed	present

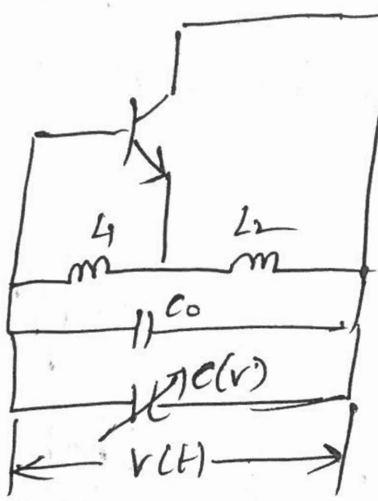
UNIT–III

6(a) — 5M

Block diagram :



In direct method of FM, instantaneous frequency of carrier wave is varied directly in accordance with message signal by means of VCO. Example of VCO is Hartley oscillator



$$C(t) = C_0 + C_m \cos 2\pi f_m t$$

C_0 — Total capacitance in the absence of modulation

C_m — max change in total capacitance

$$f_i(t) = f_0 \left[1 + \frac{C_m}{C_0} \cos 2\pi f_m t \right]^{-1/2}$$

$$f_0 = \frac{1}{2\pi \sqrt{(L_1 + L_2) C_0}}$$

$$f_i(t) = f_0 \left[1 - \frac{C_m}{2C_0} \cos 2\pi f_m t \right]$$

$$-\frac{C_m}{2C_0} = \frac{\Delta f}{f_0}$$

$$f_i(t) = f_0 \left[1 + \frac{\Delta f}{f_0} \cos 2\pi f_m t \right]$$

Instantaneous frequency of FM wave

$$\boxed{f_i(t) = f_0 + \Delta f \cdot \cos 2\pi f_m t}$$

b) FM Superheterodyne Receiver

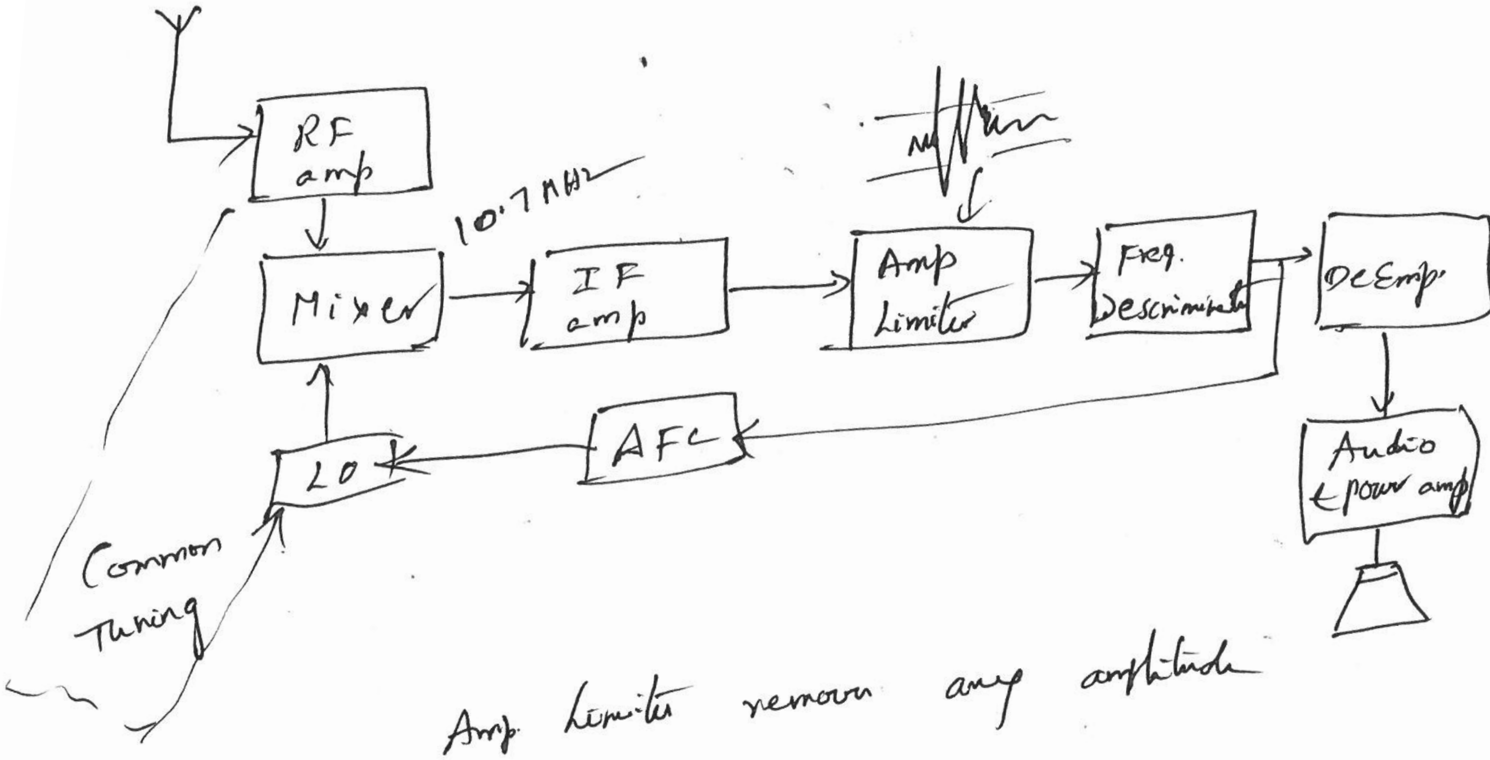
[5M]

operating range 88 MHZ – 108 MHZ

IF Bandwidth = 200KHZ

$(\Delta f)_{max} = 75$ KHZ

Intermediate frequency = 10.7 MHZ



Amp Limiter removes any amplitude fluctuation in Received FM Signal.

Frequency descriminator is FM demodulator which Converts FM Signal into message signal

DeEmphasis Ckt is reduce the message signal which is artifically boosted at the transmitter section

7 (a) Modulating signal $m(t) = V_m \sin(300 \times 10^3 t)$ — (1)

Carrier Signal, $V_c(t) = 8 \sin(6.5 \times 10^6 t)$ — (2)

Modulation Index, $\beta = 2$

From Eq (1) $2\pi f_m = 300 \times 10^3$

$$f_m = \frac{300 \times 10^3}{2\pi} = 47.7\,KHZ \simeq 48\,KHz$$

From Eq (2) $2\pi f_c = 6.5 \times 10^6$

$$f_c = \frac{6.5 \times 10^6}{2\pi} = 1.03\,MHZ \simeq 1\,MHZ$$

Since $\beta = 2$, FM is WBFM.

WB FM signal $S_{FM}(t) = A_c \sum_{n=-\infty}^{\infty} J_n(\beta) \cos(2\pi(f_c + n f_m)t)$

Take FT on both sides

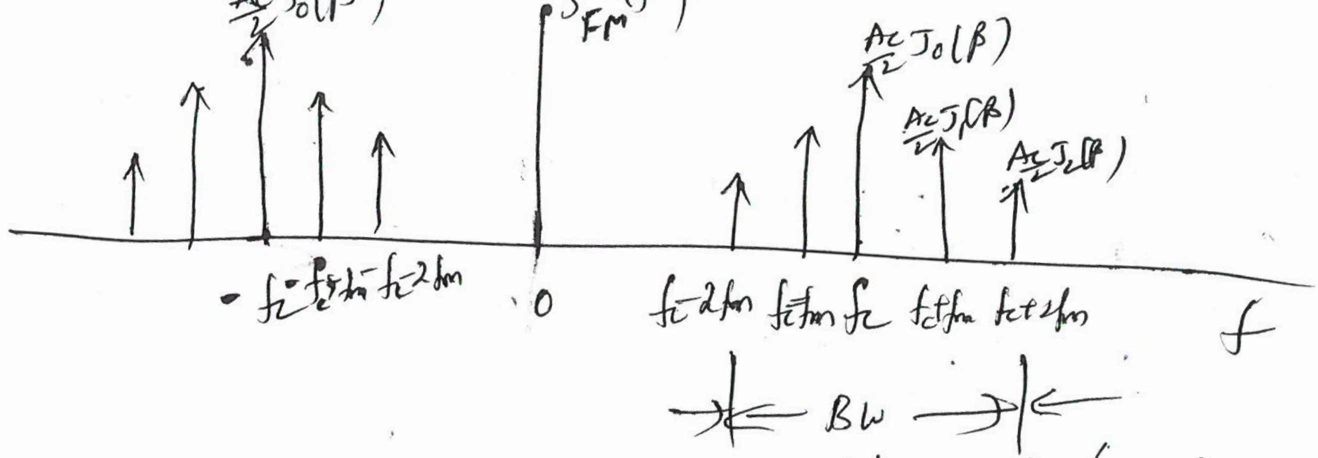
$$S_{FM}(f) = \frac{A_c}{2} \sum_{n=-\infty}^{\infty} J_n(\beta) \left[\delta(f - (f_c + n f_m)) + \delta(f + (f_c + n f_m)) \right]$$

For WBFM, $J_n(\beta) \simeq 0$ for $n > \beta$. We have to consider only $J_0(\beta)$, $J_1(\beta)$ and $J_2(\beta)$.

$$J_3(\beta) = J_4(\beta) = \cdots = 0$$

$$S_{FM}(f) = \frac{A_c}{2} J_0(\beta) \left[\delta(f - f_c) + \delta(f + f_c) \right] + \frac{A_c}{2} J_1(\beta) \left[\delta(f - (f_c + f_m)) + \delta(f + (f_c + f_m)) \right]$$

$$+ \frac{A_c}{2} J_2(\beta) \left[\delta(f - (f_c + 2f_m)) + \delta(f + (f_c + 2f_m)) \right]$$



$= 4f_m = 2\beta f_m \; (\beta = 2)$

From the graph, ie spectrum $BW = 2\beta f_m$

But Cälson generlized the BW formula as

$$(BW)_{FM} \simeq 2(\beta + 1) f_m$$

Substitute $\beta = 2$, $f_m = 48$ KHZ

$$(BW)_{FM} = 2(2+1)\cdot 48 = 288 \text{ KHZ}$$

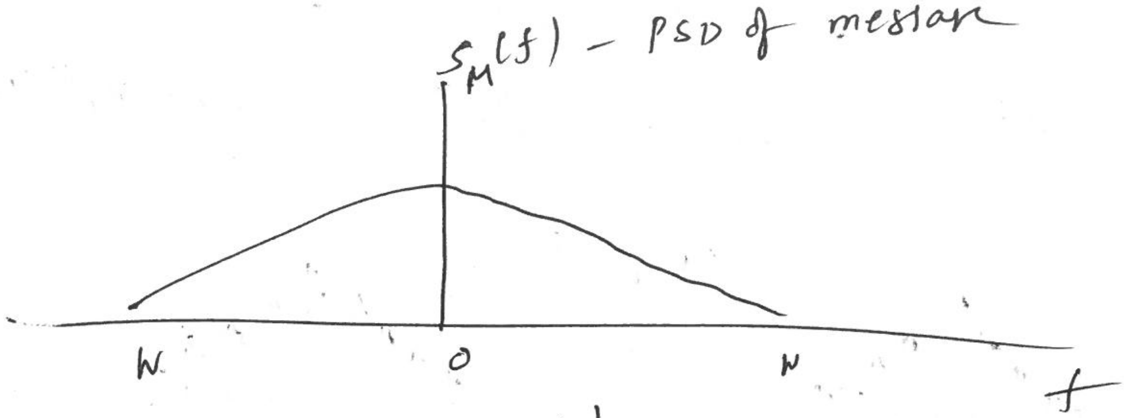
5

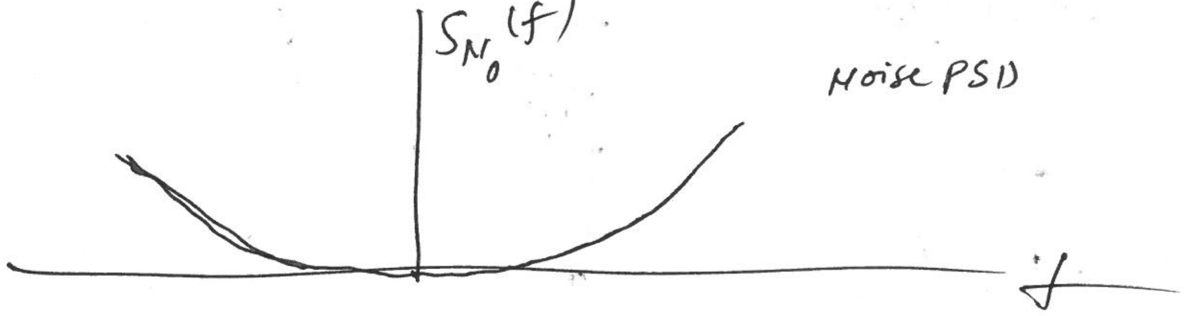
7 (b)

	AM		FM
1.	Amplitude of carrier is varied according to message signal	1.	Frequency of carrier is varied according to message signal
2.	$(BW)_{AM} = 2f_m$ (narrow)	2.	$(BW)_{WBFM} = 2(\beta+1) f_m$ (wide)
3.	Poor signal quality	3.	Superior signal quality
4.	Less power Efficient	4.	More power Efficient
5.	Less resistance to Interference from other Channels	5.	Greater resistance to Interference
6.	operating range – 535–1605 KHZ	6.	Operating range 88–108 MHz, IF = 10.7 MHz

UNIT – IV

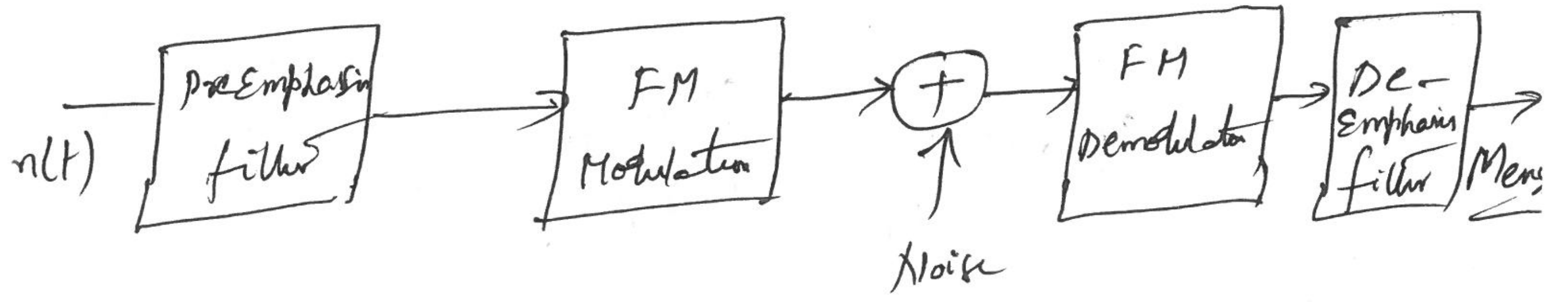
8 (a) **PreEmphasis and DeEmphasis** (5M)



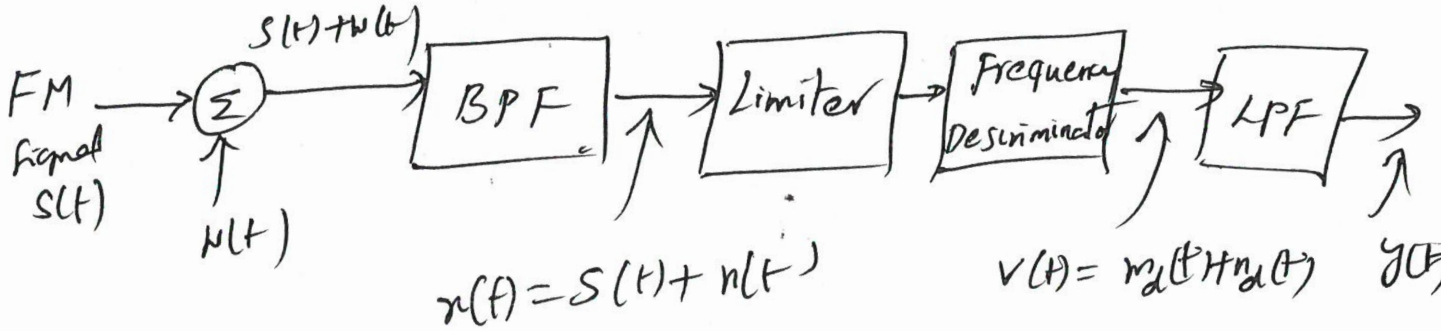


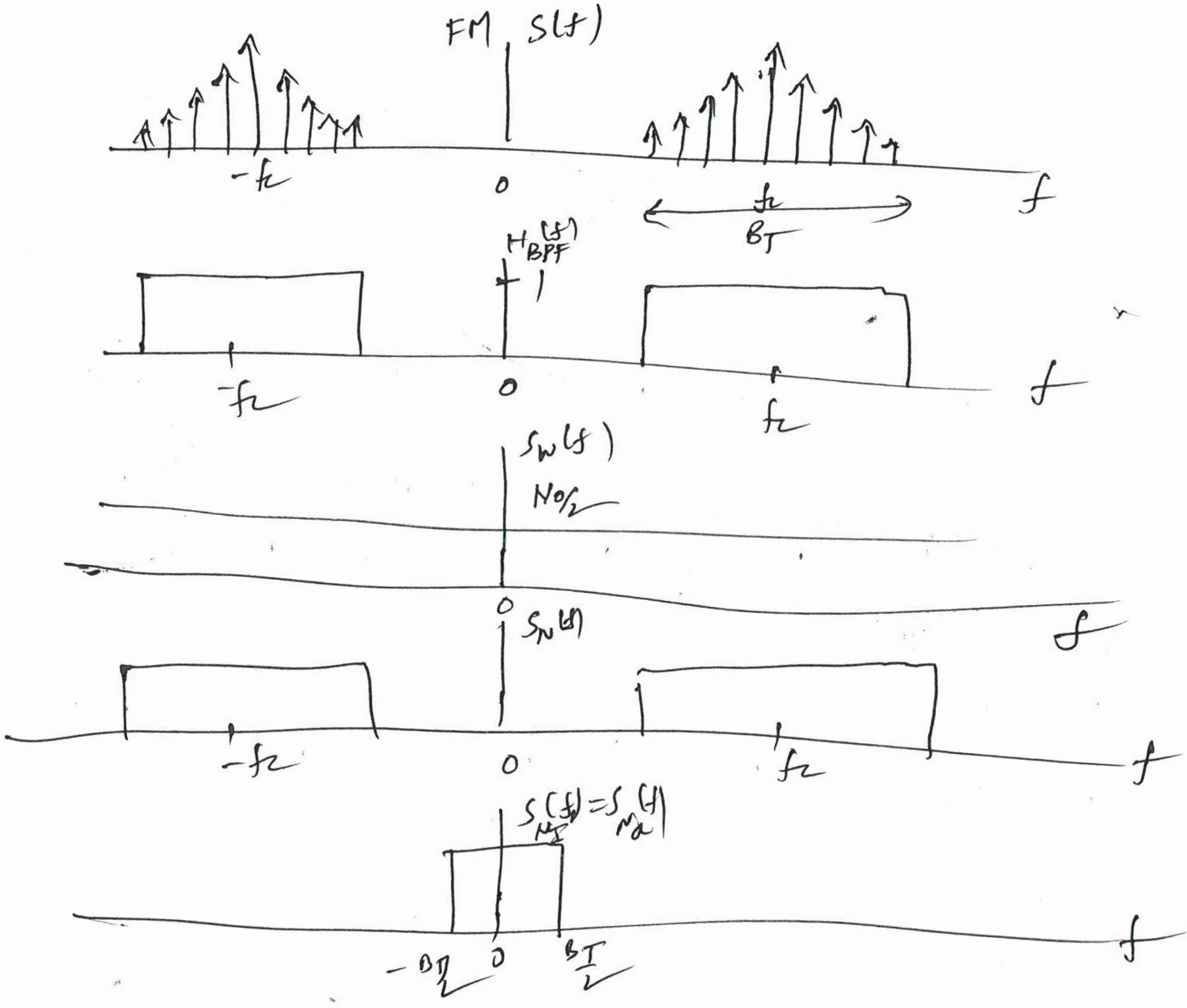
PreEmphasis: Artificially boosting high frequency Components of message signal to increase o/p SNR. preEmphasis used in Tx

DeEmphasis: It is the process of decreasing high frequency Components of message signal to get back to original signal. DeEmphasis used in Receiver



8 (b) FM Receiver model [5M]





$$(FOM)_{FM} = \frac{(SNR)_O}{(SNR)_C} = \frac{3}{2}\beta^2$$

9 (a)

$$\text{FOM of Receiver} = \frac{(SNR)_o}{(SNR)_c}$$

In case of DSBSC, $(SNR)_o = \frac{A_c^2 P}{2N_0W}$ P - avg power m(t)

$(SNR)_c = \frac{A_c^2 P}{2N_0W}$

$$(FOM)_{DSB} = \frac{A_c^2 P}{2N_0W} \cdot \frac{2N_0W}{A_c^2 P} = 1$$

SSB

$$(FOM)_{SSB} = \frac{A_c^2 P}{4N_0W} \cdot \frac{4N_0W}{A_c^2 P} = 1$$

AM

$$[FOM]_{AM} < 1$$

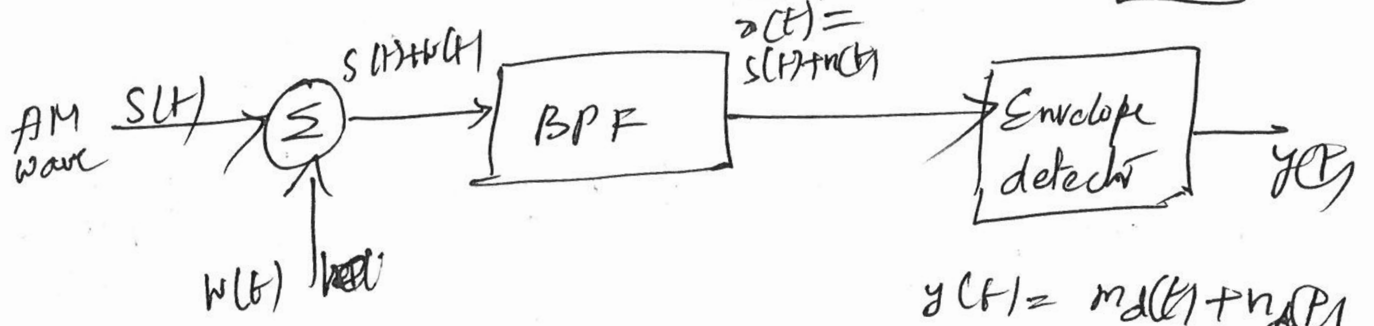
FM $(FOM)_{FM} = \frac{3}{2}\beta^2$.

For Large value of β, FOM of FM is much superior wrt AM, DSB, SSB, etc.
Noise performance is superior in case of FM over AM DSB, SSB & VSB

9 (b)

AM Receiver model

[5M]



$y(t) = m_d(t) + n_d(t)$

Channel SNR:

$$(SNR)_c = \frac{\overline{s^2(t)}}{N_0 W}$$

$$= \frac{A_c^2}{2N_0W}(1 + k_a^2 P) \quad \text{--- (1)}$$

Output SNR:

$$(SNR)_0 = \frac{\overline{m_d^2(t)}}{\overline{n_d^2(t)}}$$

$$(SNR)_0 = \frac{A_c^2 k_a^2 P}{2N_0W} \quad \text{--- (2)}$$

$$\text{Figure of merit } (FOM)_{AM} = \frac{(SNR)_0}{(SNR)_c}$$

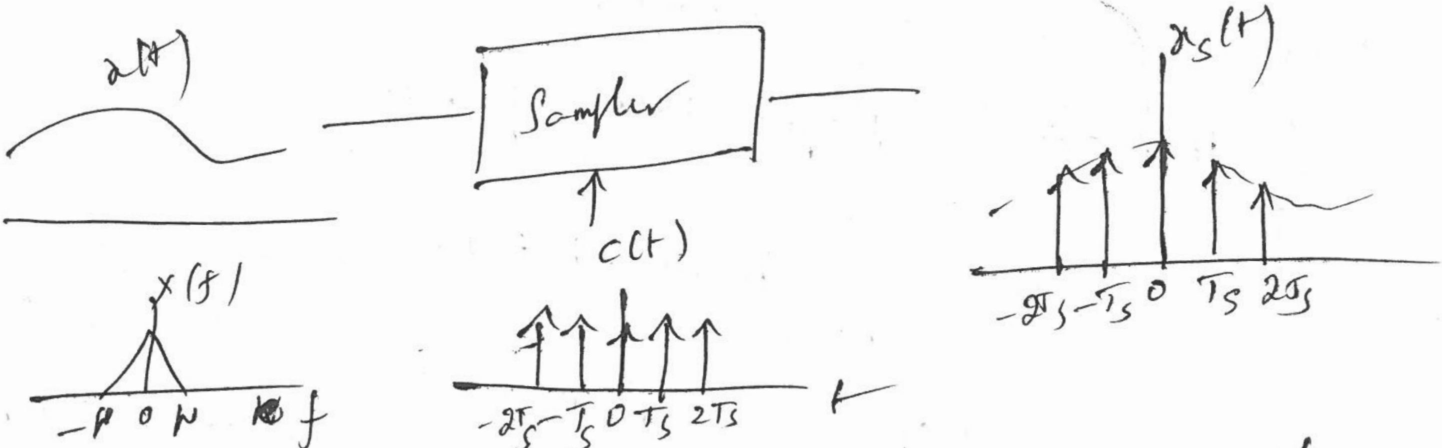
From Eq (1) & (2) $(FOM)_{AM} = \frac{A_c^2 k_a^2 P}{2N_0W} \cdot \frac{2N_0W}{A_c^2(1+k_a^2P)} = \frac{k_a^2 P}{1+k_a^2 P}$

$$\boxed{(FOM)_{AM} < 1}$$

UNIT-V

10 (a) Sampling theorem

Sampling theorem: $f_s > 2f_m$



$$c(t) = \sum_{n=-\infty}^{\infty} \delta(t - nT_s) \qquad x_s(t) = x(t)\cdot\sum_{n=-\infty}^{\infty}\delta(t-nT_s)$$

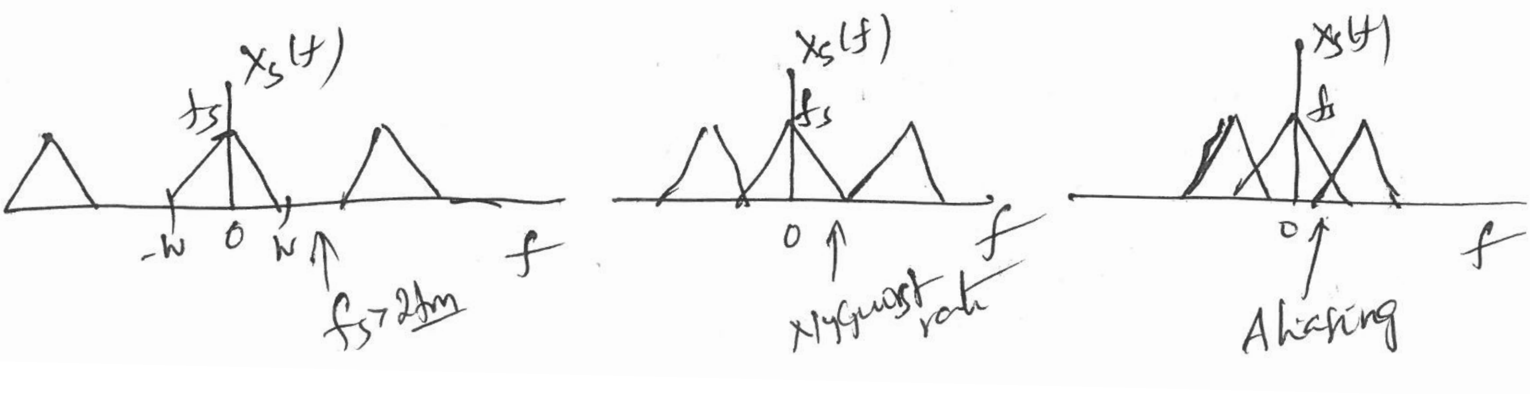
To represent this in frequency domain, Take FT

$x_s(t) = x(t)\cdot c(t)$, Take FT on both sides

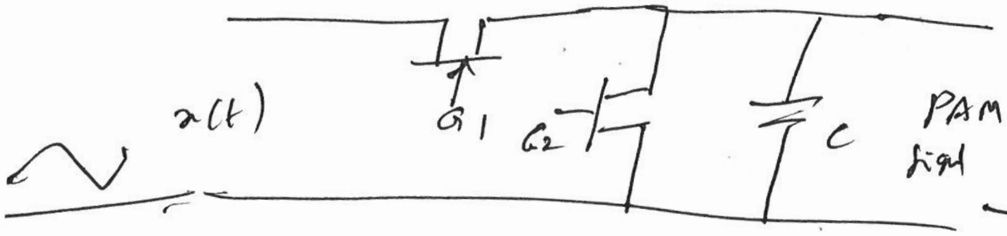
$$X_s(f) = X(f) * C(f) = X(f) * f_s \sum_{n=-\infty}^{\infty} \delta(f - nf_s)$$

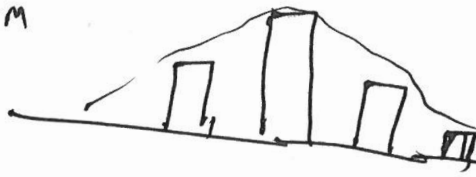
$$\boxed{X_s(f) = f_s \sum_{n=-\infty}^{\infty} X(f - nf_s)}$$

$f_s > 2f_m$ $\qquad$ $f_s = 2f_m$ $\qquad$ $f_s < 2f_m$



10(b) Generation of PAM. 5M





Sample and hold ckt

Switches G_1 and G_2 can be closed and opened to generate PAM signal

Mathematical Representation of PAM

$$s(t) = \sum_{n=-\infty}^{\infty} m(nT_s) \cdot h(t - nT_s)$$

T_s - Sampling period

Standard rectangular pulse $h(t)$:

$$h(t) = 1, \quad 0 < t < T$$
$$= \tfrac{1}{2} \quad t = 0, t = T$$
$$= 0 \quad \text{otherwise}$$

$m(nT_s)$ - sampled value of $m(t)$ at $t = nT_s$

Take FT, $S(f) = f_s \sum_{k=-\infty}^{\infty} M(f - kf_s) \cdot H(f)$

Naturally sampled PAM

τ - width of pulse

$$s(t) = \frac{\tau A}{T_s} \sum_{n=-\infty}^{\infty} m(t) \, \text{sinc}(f_n \tau) \, e^{j2\pi f_s t}$$

$$S(f) = \frac{\tau A}{T_s} \sum_{n=-\infty}^{\infty} \text{sinc}(n f_s \tau) \cdot X(f - nf_s)$$

Ideally sampled PAM

$$s(t) = \sum_{n=-\infty}^{\infty} m(nT_s) \, \delta(t - nT_s)$$

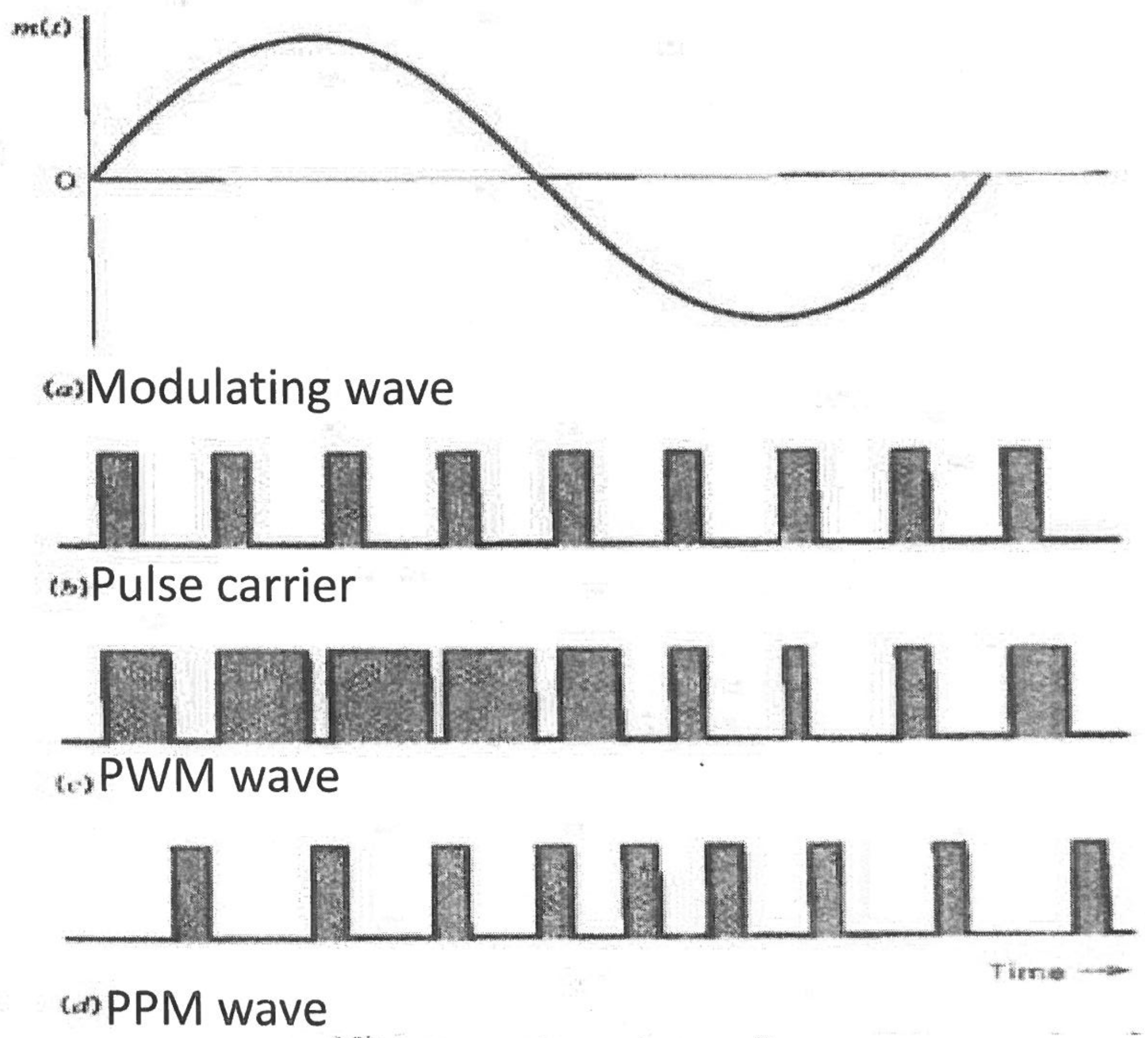
$$S(f) = f_s \sum_{n=-\infty}^{\infty} X(f - nf_s)$$

11 @

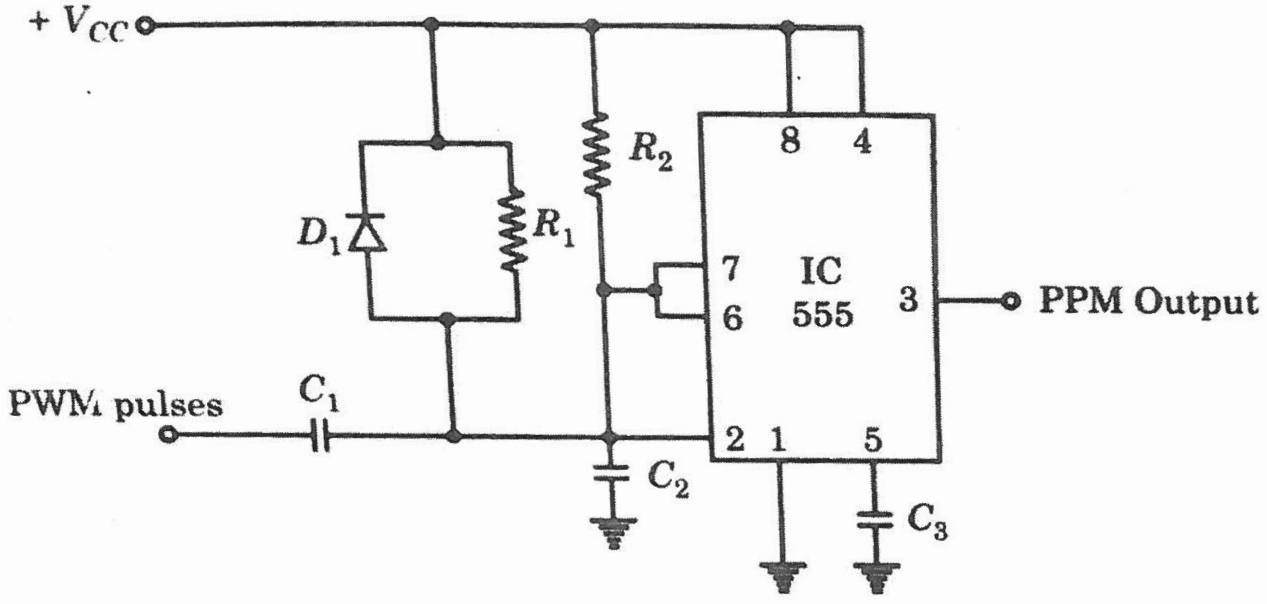
Pulse Position Modulation (PPM)

Definition:

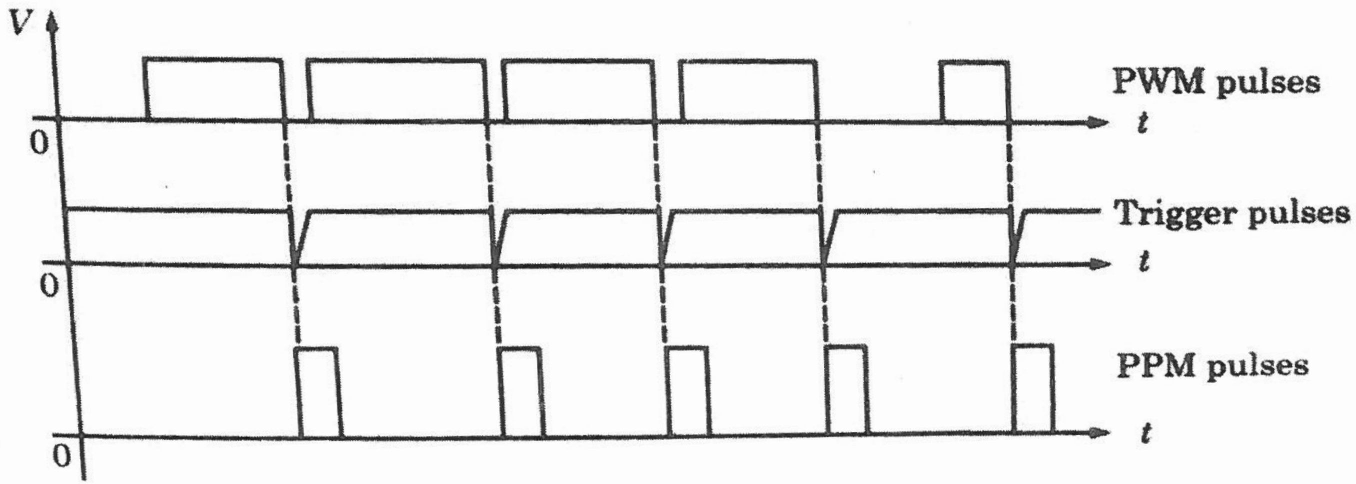
In PPM, the position of the pulse relative to its un-modulated time occurrence is varied in accordance with the message signal.



PPM Generation



(a) PPM generator



(b) Waveforms of PPM generator

PPM Generation

- PPM generator consists of differentiator and monostable multivibrator.
- The differentiator generates positive and negative spikes corresponding to leading and trailing edges of the PWM waveform.
- Diode D1 is used to bypass the positive spikes
- The negative spikes are used to trigger the multivibrator.
- The monostable multivibrator then generates the pulses of same width and amplitude with reference to the trigger to give PPM waveform as shown in figure.

11 (b)

5M

In TDM, we can transmit multiple signals over single channel, by dividing time into several slots.

TDM Contd.,

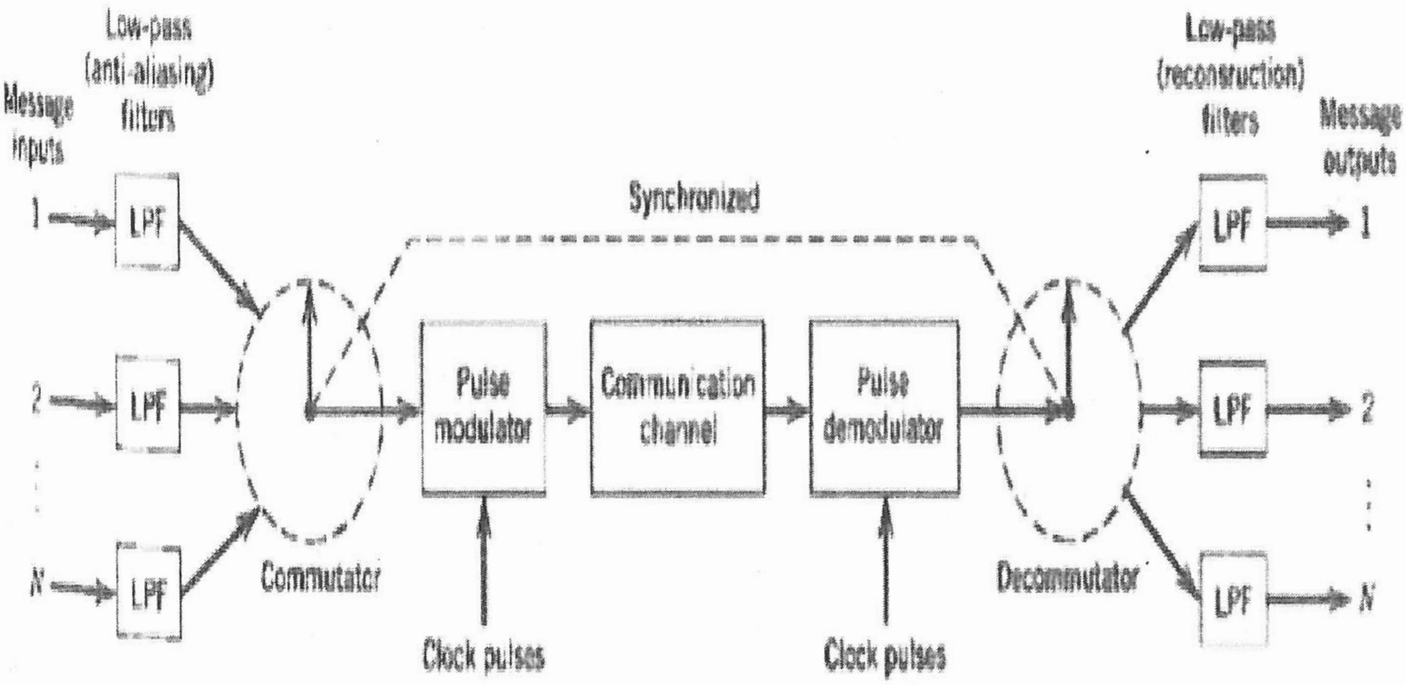


Figure: Block diagram of TDM system

Commutator and decommutator rotate with same speed, and both are synchronized so that we can reconstruct the message without distortion.