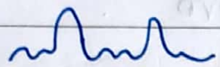
07/Jan/20

Communication Systems

Analog	Digital
	0, 1.
→ Continuous	Discrete.

Message → Tx → Channel → Rx → Out.

Tx: Transmitter
Channel: Medium
Rx: Receiver

Transmitter, Medium, Receiver → Communication System.

Types of Messages — Audio (sound) } Natural } Analog message
Video (picture) }
Text (data). — Digital message.

- Tele (means far)

Channel

- Wired (closed)
  - 2 wire line
  - Ex → Coaxial cable
  - Optical fibre
  - waveguide
- Wireless (open) (supports radio frequency signals only).
  - Air
  - space

09/Jan/20

Page No.:
Date:

- If it is confined within the boundary then the system is wired system
- If it is not confined within the boundary then the system is wireless system.

* Antenna is a device which converts electrical signal into radio frequency signal or vice-versa & it acts as an ~~interf~~ interface b/w transmitter & receiver.

* TYPES OF COMMUNICATION :-

1] Point to Point transmission :-

It is one-to-one connection and wired communication is preferable.

Ex :- telephone.

2] Point to Multipoint transmission :-

Also known as broadcast

Ex :- Television, radio, internet

* Modes of Communication :-

- Simplex
- Duplex.
- Half Duplex.

1) Simplex :-

One can only receive. We cannot retransmit it. All broadcast comes under this category.

2) Duplex :- ⇌

from both sides, they can receive and transmit.

3) Half - Duplex :- → ←

At a time, only one side can transmit and other side has to receive.

- Electromagnetic spectrum
  - Infrared
  - visible
  - Ultra violet
  - x-ray
  - γ-ray

$\boxed{f \cdot \lambda = c}$

Electromagnetic Bands

(radio signals)	LF	low frequency	300 KHz
(AM broad-casting)	MF	Mid frequency	3 MHz
(aviation industry, amateur radio)	HF	High frequency	30 MHz
(military app)	VHF	very high frequency	300 MHz
(TV, phones, phones, wi-fi)	UHF	ultra high frequency	3 GHz
(long distance terrestrial communication)	SHF	super high frequency	30 GHz
(radio astronomy, remote sensing)	EHF	extreme high frequency	300 GHz

1K = 10^3 Hz

1 MHz = 10^6 Hz = 1000 KHz

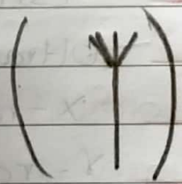
1 GHz = 10^9 Hz = 1000 MHz

Q] Applications of electromagnetic spectrum & bands.

amplitude ← A cos 2π f t
↓
frequency (most imp factor) in communication system

13/Jan/20 * **Modulation** :-
↳ To modify

Ranges of frequencies of different signals
- Speech – 20Hz to 20,000Hz
- Video – 0Hz to 5MHz
- Tel-line – 300 to 3400Hz.

Sign of antenna 

frequency of range of data/text is variable.

14/Jan/20

MODULATION.

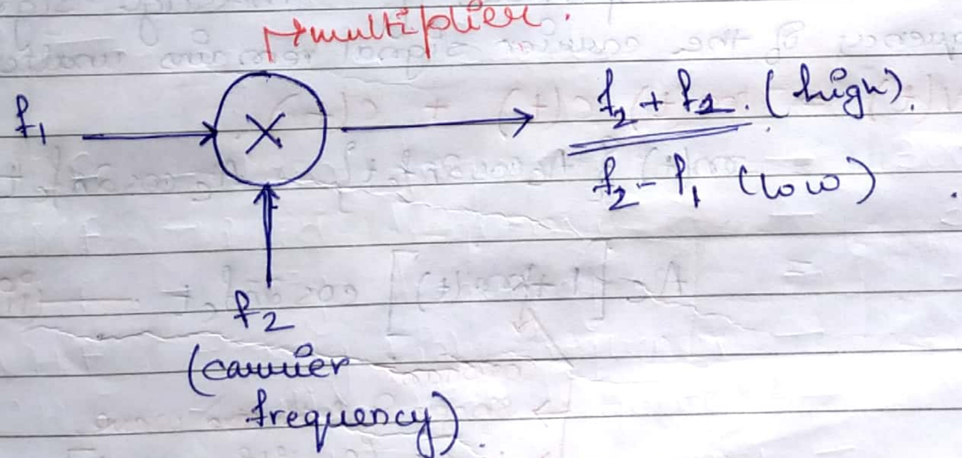
- Analog
  - Linear
    - A.M (Amplitude modulation)
      - DSB (double side band)
      - DSB/SC (double side band suppress carrier)
      - SSB (single side band)
      - VSB (vestigial side band)
  - Angular.
    - F.M (frequency modulation)
      - NB (narrow band)
      - WB (white band)
    - P.M (Phase modulation)
- Digital.
  - Transmission (⟶)
    - PCM (pulse code modulation)
      - DPCM (Differential)
    - DM (delta modu-lation)
      - ADM (A[illegible]
  - Radio (↯)

Radio

- ASK (amplitude shift keying)
  - [OOK] (on-off keying)
- FSK (frequency shift keying)
- PSK (pulse shift keying)
  - BPSK (Binary)
  - DPSK (Differential)
  - QPSK (Quaternary)
  - MPSK (Minimum)
  - 8PSK

* frequency Translation :-
Translating low frequency to high frequency.

f_1 (low) $\longrightarrow$ f_2 (high)



NOTE :- height of antenna $\boxed{h = \frac{\lambda}{2} = \frac{c}{2f}}$ $\rightarrow$ (i).

If $f \uparrow \rightarrow \lambda \downarrow \rightarrow h \downarrow \rightarrow$ practicability of antenna is possible.

Page No.:
Date:

15/Jan/20

* **Modulation :-** Modulation is a technique in which some of the property of the carrier signal is changed or modified w.r.t the message signal.

Message Signal :- $m(t) = A_m \cos 2\pi f_m t$.

Carrier Signal. $c(t) = A_c \cos(2\pi f_c t + \phi)$ ← phase

$= A_c \cos 2\pi f_c t$.

$\phi \rightarrow$ can be zero.

$A \rightarrow$ cannot be zero.

$f \rightarrow$ if it is zero $\rightarrow$ it becomes dc signal

- **Amplitude Modulation :-** Amplitude modulation is a technique in which ~~some of the property~~ of amplitude of carrier signal is changed w.r.t the amplitude of message signal. The frequency of the carrier signal remains unaltered.

o/p of amplitude modulation ← $v(t) = m(t)\,c(t) + c(t)$

$= m(t)\{A_c \cos 2\pi f_c t\} + A_c \cos 2\pi f_c t$.

$= A_c[1 + k\,m(t)] \cos 2\pi f_c t$ —— (ii)

k → constant
→ shape of A.M ~~the~~ wave
→ $k \leq 1$ [Condition no. 1]

[If k is greater than 1 then the wave gets distorted]

$= A_c[1 + k \cos 2\pi f_m t] \cos 2\pi f_c t$ —— (iii)

[for single frequency]

$\boxed{k = \frac{A_m}{A_c}}$ —— (iv)

$= A_c[1 + k(\cos 2\pi f_{m_1} t + \cos 2\pi f_{m_2} t + \dots)] \cos 2\pi f_c t$

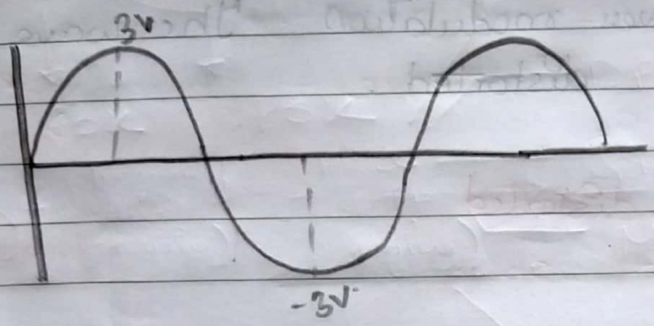
[for more than one frequency]

Condn no:- 2 $f_c \gg f_m$.

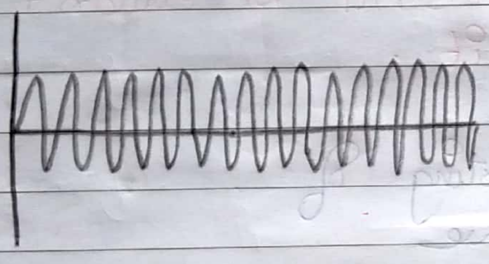
f_c → frequency of carrier signal, f_m → frequency of message signal

16/Jan/20

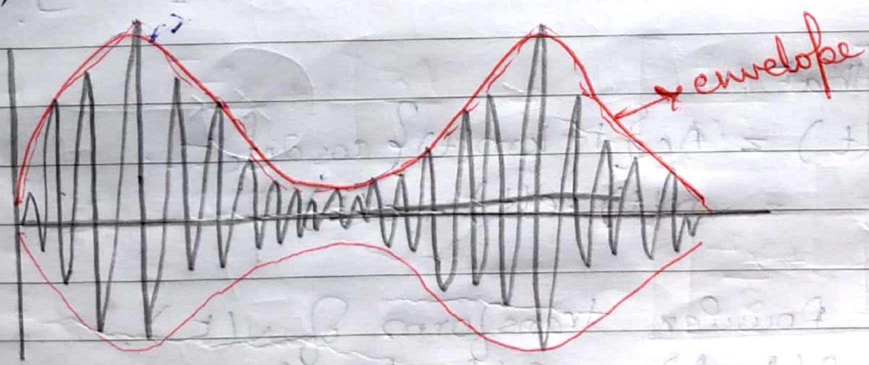
m(t)



c(t)

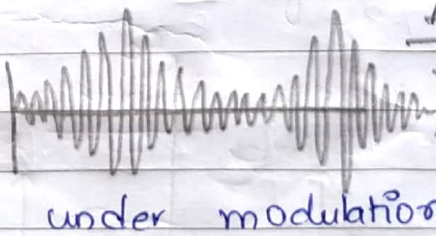


v(t)



$V_{max} = A_c + A_m$

$V_{min} = A_c - A_m$.



$\frac{A_m}{A_c} < 1$

$A_m < A_c$

- If $k < 1$.

  i.e., $A_m < A_c$.

That is, it becomes under modulation.

- If $k = 1$.

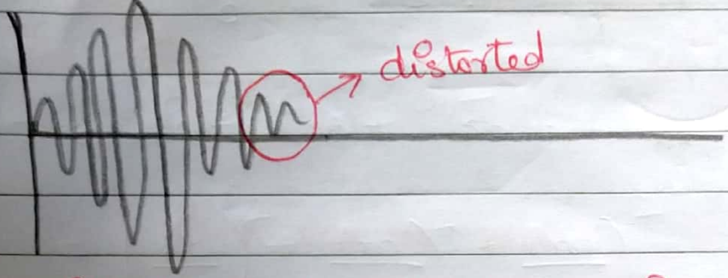
  i.e., $A_m = A_c$.

That is, it is a perfect modulation.

• If $k > 1$

$A_m > A_c$

That is, it is over-modulation. The wave form thus formed is distorted.



We will be able to transmit but couldn't be able to receive it.

AM wave is consisting of.

1. Carrier wave
2. Upper side band (USB)
3. ~~lowe~~ Lower side band [LSB].

We know that,

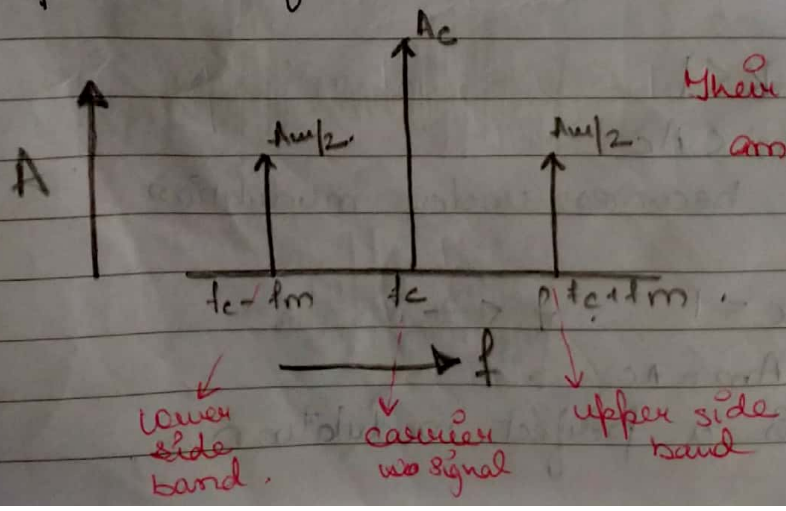
$$v(t) = A_c\{1 + km(t)\}\cos 2\pi f_c t$$

$$= m(t)\cdot c(t) + c(t)$$

$\boxed{\text{To prove :-}}$ $V(f) =$ fourier transform of $v(t)$.

$$= \delta(f + f_c) + \delta(f + f_c \pm f_m)$$

Spectrum of AM :-



Their strength & amplitude remains same.

Page No.:
Date:

- Carrier + Lower side band + upper side band = Double side Band (DSB)

[Walkie-Talkie / Half-duplex communication] • LSB + USB = Double side Band - Suppress Carrier (DSB-SC)

(All radio communication) • LSB | USB = Single side band (SSB)

(Television transmission) • USB + some portion of LSB = Vestigial side Band (VSB)

It will be better if we increase the power and bandwidth decreases.

Bandwidth → Message – should be as min as possible
Bandwidth → Transmission – should be as max as possible

$$\text{No. of messages that can be transmitted in a channel} = \frac{\text{channel bandwidth}}{\text{Message bandwidth}}$$

⇒ Bandwidth of AM is min to 10 KHz

Page No.:
Date:

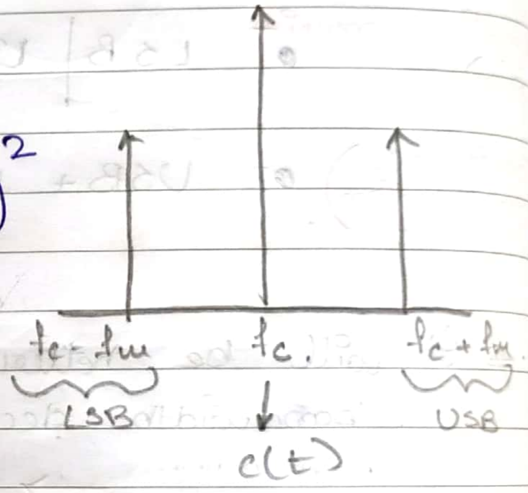
20/Jan/20

* POWER OF AM WAVE.

P_T = Power of carrier wave + Power of side bands

$= P_c + P_s$.

$P_T = P_c + P_{LSB} + P_{USB}$.



$$= \left(\frac{A_c}{\sqrt{2}}\right)^2 + \left(\frac{A_m}{2\sqrt{2}}\right)^2 + \left(\frac{A_m}{2\sqrt{2}}\right)^2$$

$$= \frac{A_c^2}{2} + \frac{A_m^2}{8} + \frac{A_m^2}{8}.$$

$$= \frac{A_c^2}{2} + \frac{A_m^2}{4}.$$

$$= \frac{A_c^2}{2}\left[1 + \frac{A_m^2}{2A_c^2}\right] = \frac{A_c^2}{2}\left[1 + \frac{k^2}{2}\right]$$

$$\boxed{P_T = P_c\left[1 + \frac{k^2}{2}\right]}$$

* Efficiency of AM Wave :-

$$\eta = \frac{\text{Power of side band}}{\text{Total power}}.$$

$$= \frac{P_c \frac{k^2}{2}}{P_c\left(1 + \frac{k^2}{2}\right)} = \frac{k^2/2}{\frac{2+k^2}{2}} = \frac{k^2}{2+k^2}.$$

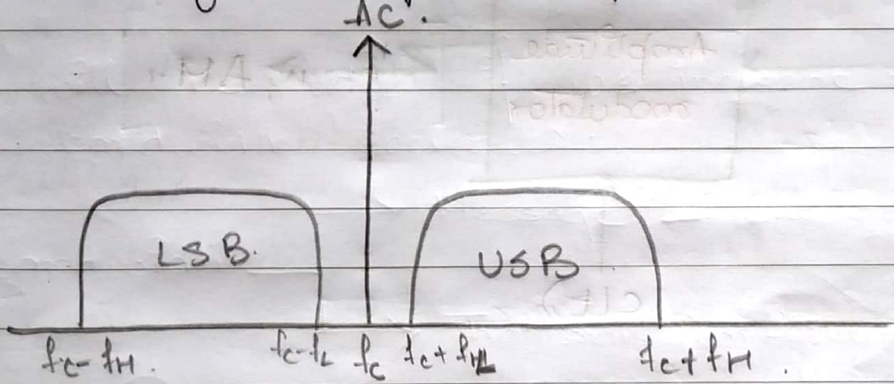
Page No.:
Date:

$$\boxed{\eta = \frac{k^2}{2+k^2}}$$

In terms of percent.

$$\boxed{\eta(\%) = \frac{k^2}{2+k^2} \times 100\%}$$

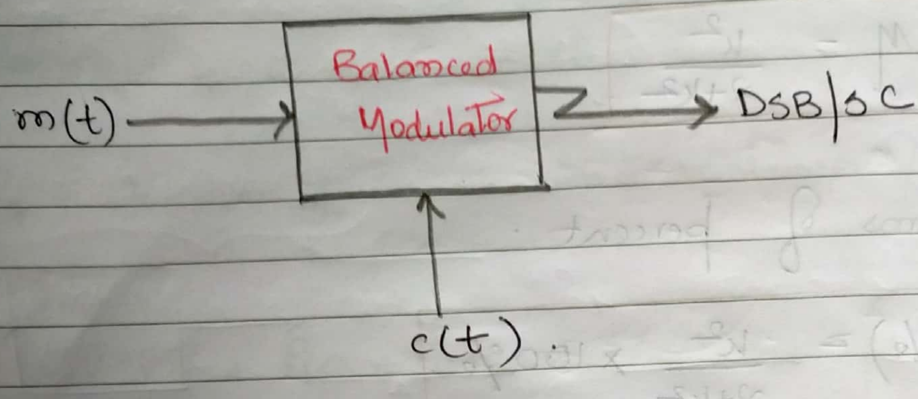
Spectrum of a composite AM wave.

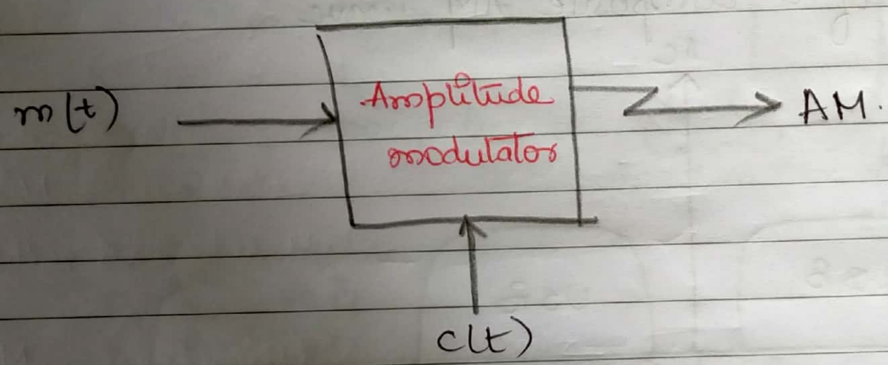


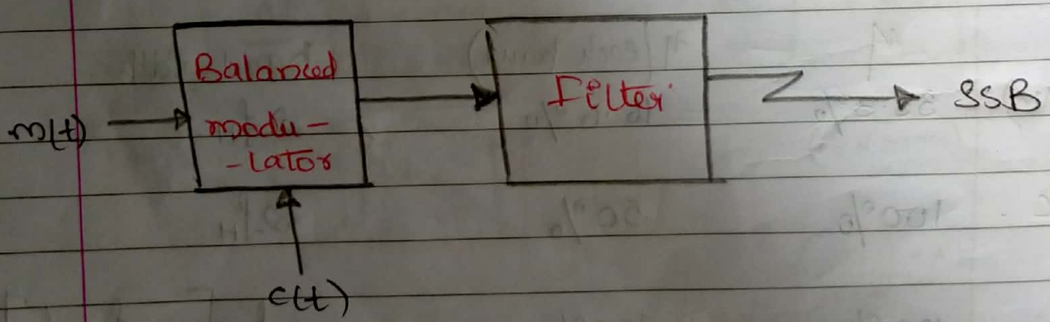
	η	η (each band)	bandwidth
• DSB (AM)	33.3% (when k = 1)	16.6%	$2f_H$
DSB - S C	100% $\left(\eta = \frac{P_c k^2/2}{P_c k^2/2}\right)$	50%	$2f_H$
SSB	100%	100%	f_H [or, $f_H - f_L$]
VSB	100%	≅ 80%	f_H < b/w < $2f_H$

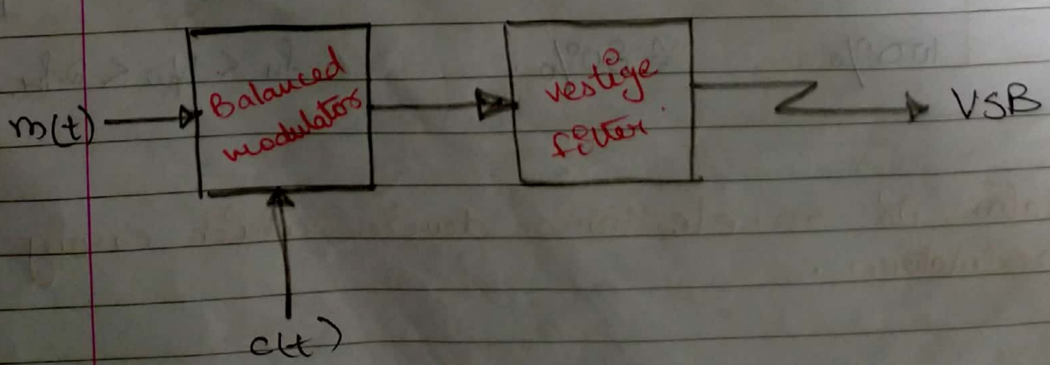
Modulator is an electronic device which carry modulation.

Scanned with CamScanner


m(t)
Balanced Modulator
DSB/SC
c(t)


m(t)
Amplitude modulator
AM
c(t)

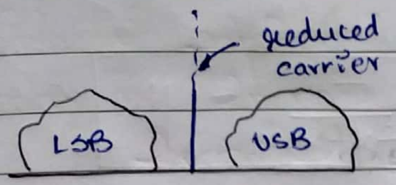

m(t)
Balanced modu-
-lator
Filter
SSB
c(t)


m(t)
Balanced modulator
vestige filter
VSB
c(t)

AM = DSB = DSB-FC

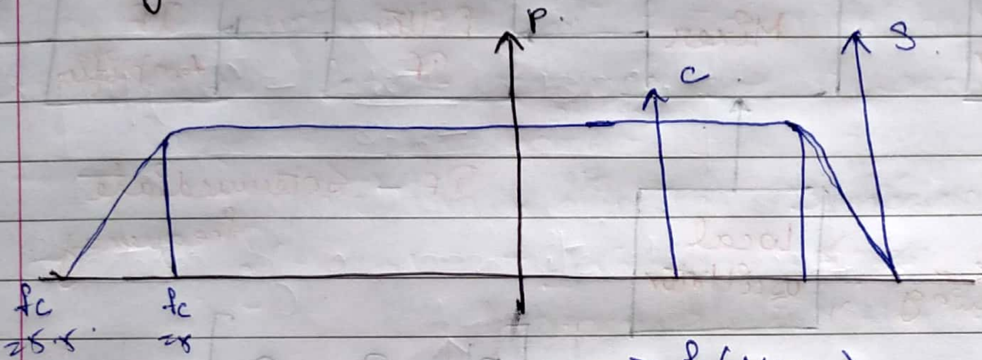
(Full carrier)

21/Jan/20



Bandwidth ⇒ frequency range of a signal.

Vestigial Side Band.



2 side band spectrum of TV transmission

(LF = 0Hz ; UF = 5MHz)

DSB = 11MHz.

SSB = not possible

(TV transmission has many info, thus bandwidth is large

ex:- different colours)

7MHz.

→ Picture by AM → VSB

Sound by FM

→ Picture at f_c (0).

Colour at 4.43MHz

Sound at 5.5 MHz

USB = 5MHz

USB Attn = 0.5MHz

LSB = 0.75 MHz

LSB Attn = 0.5MHz

6.75 MHz

gap = 0.25 MHz

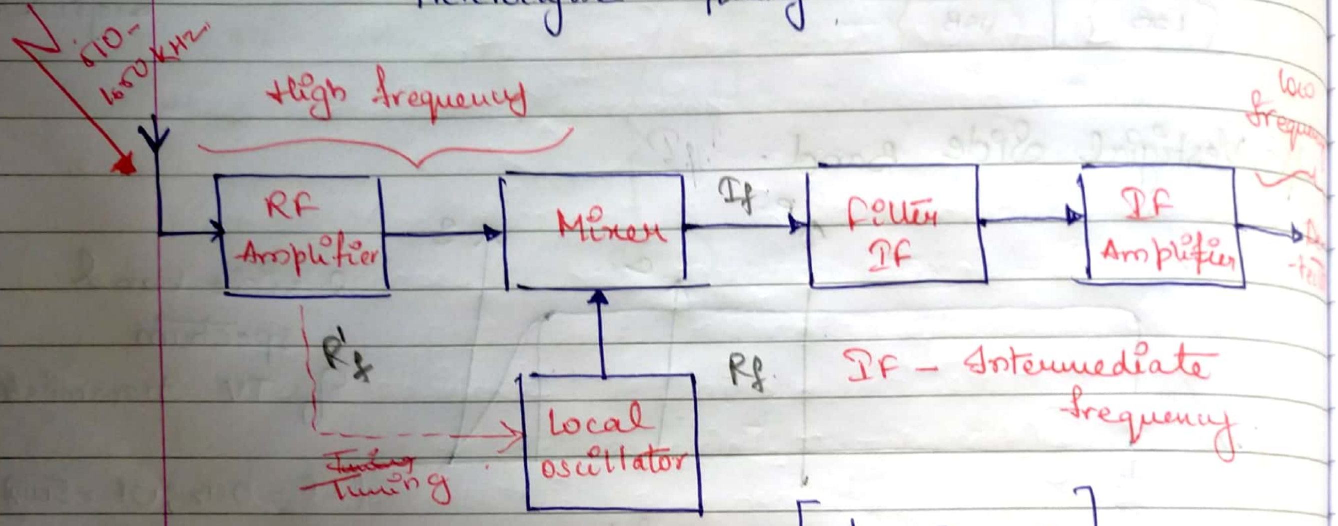
7MHz → Bandwidth

gap of 0.25 is given for different channels, so that there is no clashing of signals of different channels.

22/Jan/20

* Super Heterodyne Receiver :-

Heterodyne – Mixing.



IF – Intermediate frequency

$$\left[R'_f - R_f = I_f\right]$$

AM → 455 KHz.

FM → 88-108 MHz.

Max bandwidth is 10KHz.

AM features / characteristics :-

- Advantages :-

→ first class/type of modulation

→ Simple in circuit

→ Many types

→ Use in Audio & Video signals

→ Linear

→ low bandwidth (~ 10KHz audio)

→ Many channels [↑N = channel b/w ↓].

- **Disadvantages** :–

→ Easily affected by noise

→ Poor SNR

→ Long distance of transmission

→ Ionosphere reflection.

27/Jan/20

NOISE.

unwanted signal, random in nature.

- External
  - Space / environment
  - Man-made / machine
- Internal
  - Thermal [4kTRB] (register noise).
  - semiconductor / tube.

4kTRB → Bandwidth
↓ → register
→ temp.
Boltzmann's constant

$$SNR = \frac{\text{signal power}}{\text{noise power}}.$$

Page No.:
Date:

Frequency Modulation :- It is a technique in which frequency of carrier signal is changed w.r.t. the amplitude of the message signal.
The amplitude of carrier signal remains unaltered.

Phase Modulation :- It is a technique in which phase of the carrier signal is changed w.r.t. the amplitude of message signal.
The frequency remains unaltered.

$$\Rightarrow A_c \cos\{2\pi f_c t + k_p m(t)\}.$$

If $m(t)$ is sinusoidal.

$$\Rightarrow A_c \cos\{2\pi f_c t + \underbrace{k_p}_{\text{phase sensitivity of the device}} a_m \cos 2\pi f_m t\}$$

$$\Rightarrow A_c \cos\{2\pi f_c t + \underbrace{\beta_p}_{\text{constant.}} \cos 2\pi f_m t\}$$

$$\boxed{\beta_p = k_p a_m}$$

Eqn of FM

$$= A_c \cos\{2\pi f_c t + \phi\}$$

$$= A_c \cos\{2\pi f_c t + \int \phi'(t)dt\}$$

$$= A_c \cos\{2\pi f_c t + k_f \int \phi'(t)\, dt\}.$$

$$= A_c \cos\{2\pi f_c t + k_f \int m(t).dt\}$$

$$= A_c \cos\{2\pi f_c t + k_f \int a_m \cos 2\pi f_m t\}.$$

$$= A_c \cos\{2\pi f_c t + \frac{k_f a_m}{2\pi f_m} \sin 2\pi f_m t\}.$$

Page No.:
Date:

$$FM = A_c \cos\{2\pi f_c t + \beta \sin 2\pi f_m t\}.$$

Direct PM = Indirect FM
" FM = " PM.

28/Jan/20

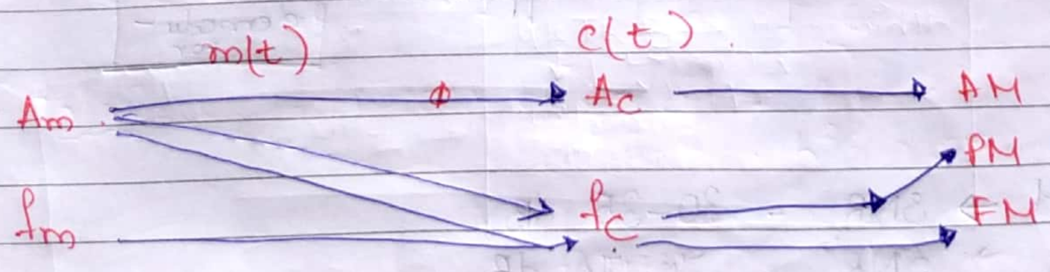
$m(t) \rightarrow$ Integrator. $\rightarrow$ Phase modulator $\rightarrow$ FM.

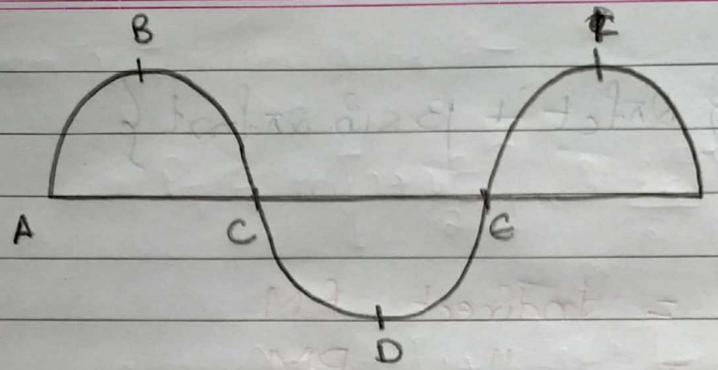
$m(t) \rightarrow$ Differentiator $\rightarrow$ frequency modulator $\rightarrow$ PM.

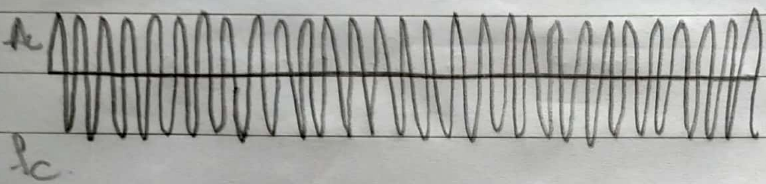
W.k.T

$$FM :- v(t) = A_c \cos\{2\pi f_c t + \beta \sin 2\pi f_m t\}.$$

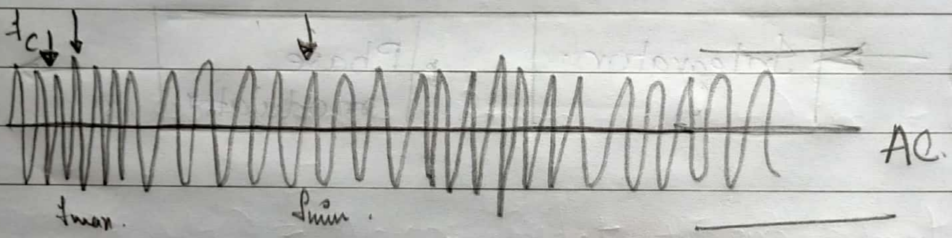
$$\beta = \frac{k_f A_m}{2\pi f_m} = \frac{\Delta f}{f_m} = \frac{\text{change in frequency}}{\text{Message frequency}}.$$





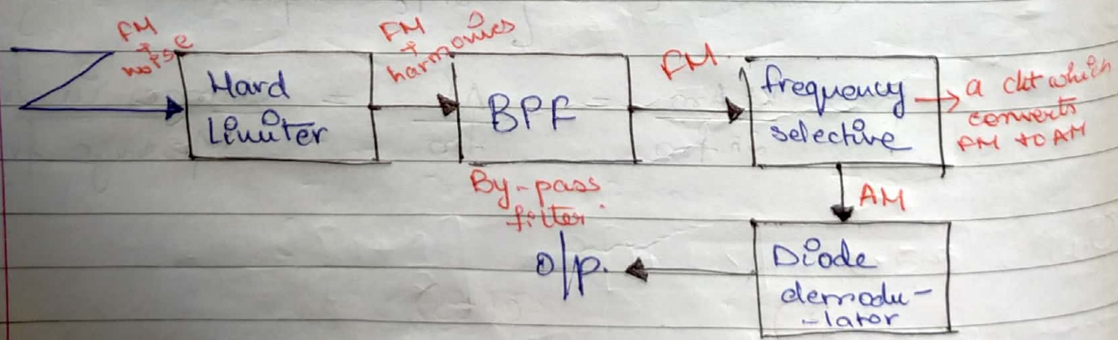


FM



Disadvantages of AM = Advantages of FM.

FM Receiver :-



AM → SNR = 30-35 dB.

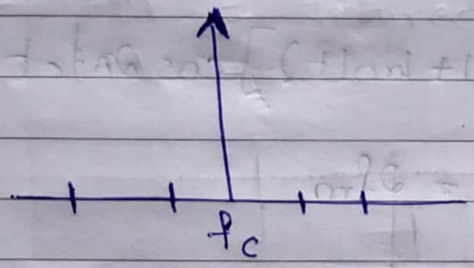
FM → SNR = 70-75 dB.

Page No.:
Date:

1 Jan 20

$\eta = f(\beta)$
$n = \beta + 1$ } Carson's Rule.

If $n = 2$; $\beta = 1$



At only $\beta = 5$ $f_c \simeq 0$.

At $\beta = 5$, we get the best sufficient result

$\beta = 5$; $n = 6$ $= 2 \times n \times f_m$.
Bandwidth $= 12 \times 15 = 180$ KHz
f_m.
[∵ voice signal varies from 0 to 20 & it rarely go above 15 kHz].

Bandwidth $= 2nf_m$.
$= 2(\beta + 1) f_m$ [∵ $\beta = \frac{\Delta f}{f_m}$]
$= 2(\Delta f + f_m)$.

* Power of FM Wave :-

$$\boxed{P_T = \frac{A_c^2}{2}}$$

Bandgap is space present b/w two channels. and also when so many signals are being transmitted.

The min distance b/w any two channels in FM is 0.2 MHz.

The frequency of FM lies b/w 88 – 110 MHz which lies in very high frequency region.

FM → only used for audio transmission [∵ coz it has high bandwidth]
AM → used for video & Aus transmission.

$P_T = P_c \sum_{n=1}^{\infty} J_n(\beta)^2 \rightarrow 1$

$P_T = P_c$

30/Jan/20.

Important Formulas :-

AM

- $P_T = P_c\left[1+\frac{k^2}{2}\right]$; $\frac{A_c^2}{2}\left[1+\frac{k^2}{2}\right]$

- $v(t) = A_c[1+km(t)]\cos 2\pi f_c t$.

- Bandwidth $= 2f_m$

FM

- Bandwidth $= 2nf_m = 2(\beta+1)f_m = 2[\Delta f + f_m]$

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

Q) An AM signal
$v(t) = 4\{1+3\cos 3140t\}\cos 6.24\times10^6 t$
find P_T, B/W

$A_c = 4$.
$k = 3$.

$P_T = \frac{16}{2}\left[1+\frac{9}{2}\right] = 8[1+4.5] = 8\times5.5 = 44.0\,W$

∵ $v(t) = A_c\cos[1+k\cos 2\pi f_m t]\cos 2\pi f_c t$.

Bandwidth $= 2f_m$.

$2\pi f_m = 3140$
$f_m = \frac{3140}{2\pi}$

Bandwidth $= 2\times\frac{3140}{2\pi} = \frac{3140}{\pi} = 999.4 \approx 1000\,Hz$

Q] FM eqn :- $5 \cos \{ 6.28 \times 10^6 t + 6 \sin 3140t \}$
find P_T, b/w, Δf.

$A_c = 5$; $\beta = 6$; $f_m = 500$.

$$P_T = \frac{A_c^2}{2}$$

$$P_T = \frac{25}{2} = 12.5 \text{ W}$$

$$\text{Bandwidth} = 2(\beta + 1) f_m = 2(6+1)\,500$$
$$= 2 \times 7 \times 500$$
$$= 7000 \text{ Hz}$$

$$7000 = 2[\Delta f + 500]$$
$$3500 = \Delta f + 500$$
$$\Delta f = 3000.$$

or, $\beta = \dfrac{\Delta f}{f_m}$

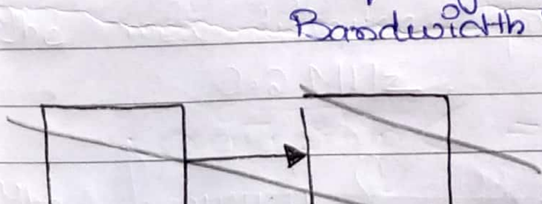
$$6 = \frac{\Delta f}{500}$$

$$\Delta f = 3000.$$

* FM Transmitter.

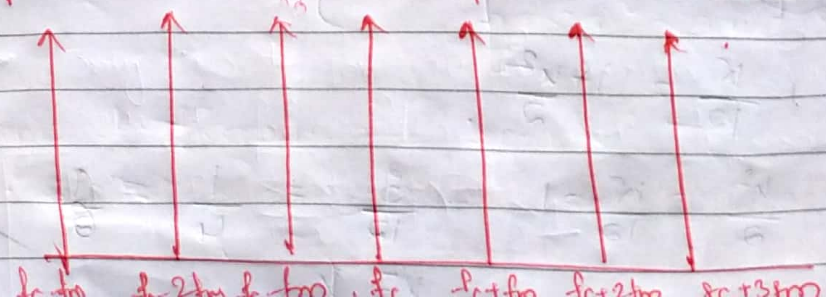
frequency :- 88 – 110 MHz

Bandwidth :- 0.2 MHz (200 kHz).

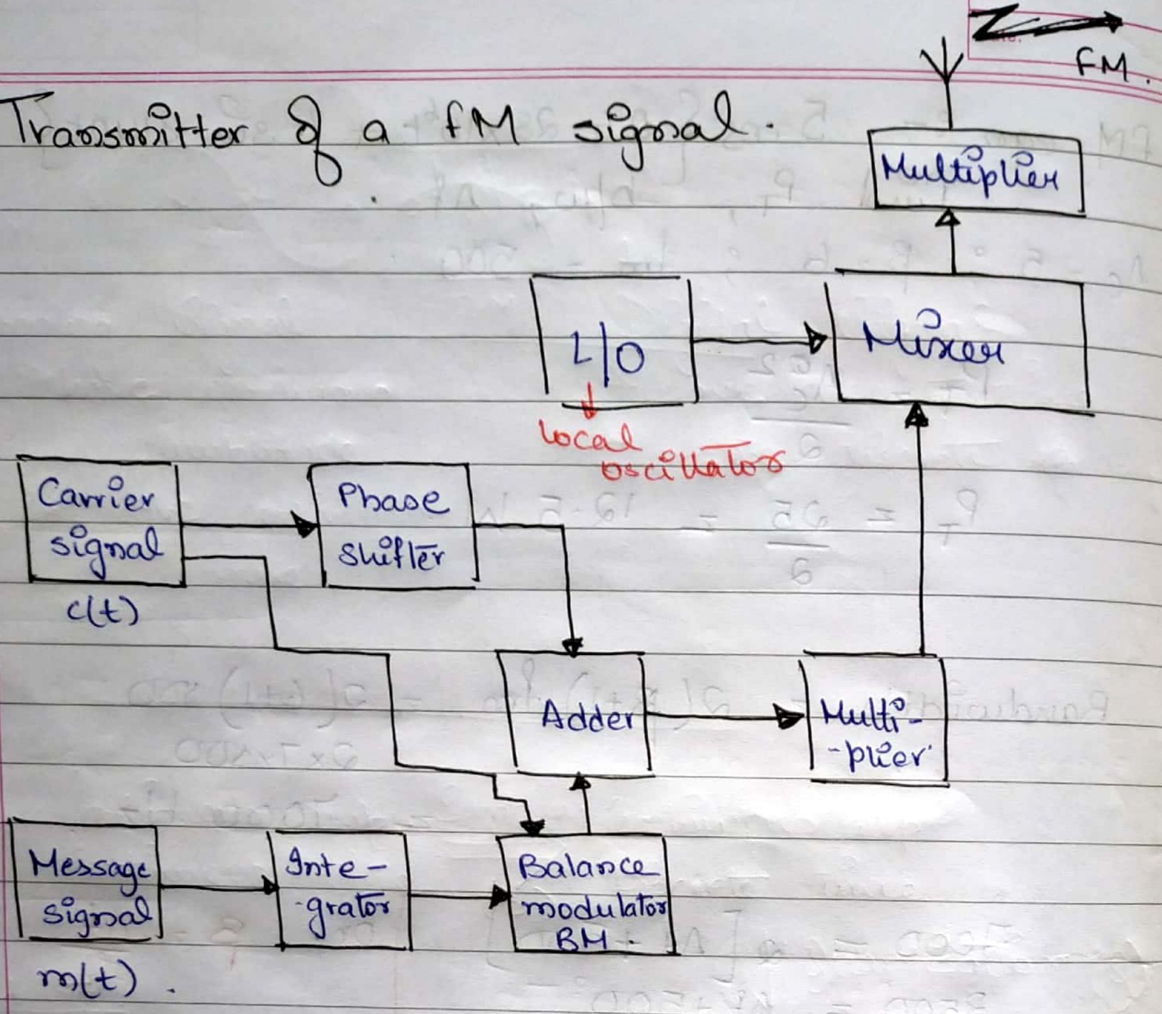


FM spectrum :- . w.r.t $n = \beta + 1$
If $\beta = 2$; $n = 3$

[By checking Bessel's table]



Transmitter of a FM signal.



03/feb/20

1) Power of a carrier signal = 12 W
" " AM wave = 15 W
find modulation index

2) Power of carrier signal = 12 W
modulation = 2
find power of FM wave

① $P_T = P_c\left[1+\frac{k^2}{2}\right]$

$15 = 12\left[1+\frac{k^2}{2}\right]$

$\frac{15}{12} = 1+\frac{k^2}{2}$

$\frac{k^2}{2} = \frac{15}{12}-1 = \frac{3}{12} = \frac{1}{4} = \frac{1}{8}$

$k^2 = \frac{1}{2}$

$k = \frac{1}{\sqrt{2}}$.

(2) $P_c = 12W$.

$k = 2$.

$A_c = \sqrt{2P_c}$

$= \sqrt{2 \times 12}$

$= \sqrt{24} = 4.89$.

$P_{FM} = \frac{24}{2} = 12W$.

3] Power of carrier wave = 10KW.

" " AM signal = ? [for modulation index (i) 0.66 (ii) 1.5]

(i) $P_T = 10\left[1 + \frac{(0.66)^2}{2}\right] = 12.178\ KW$

(ii) $P_T = 10\left[1 + \frac{(1.5)^2}{2}\right] = 21.25\ KW$

* DIGITAL COMMUNICATION :-

[Not depended on atmospheric condn]

→ long distance transmission (best advantage for digital comm.)

→ noise free

→ high SNR (≈90dB) [SNR - signal to noise ratio]

→ security

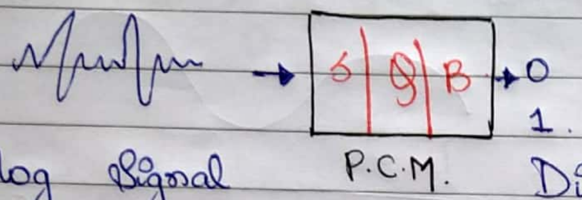
→ Integrated.

→ storage

→ many forms.

father of IT :- Claudde Ernest Shannon in 1948.

↳ to convert Analog transmission to digital transmission.



Analog Signal
- have continuous amplitude
- have continuous time

Digital Signal
- have discrete time
- have discrete ~~of~~ amplitude

Continuous amp. / Continuous time $\xRightarrow[(S)]{\text{Sampling}}$ Continuous amp / Discrete time

$\Downarrow$ Quantisation (Q)

Discrete amp / Discrete time $\xLeftarrow[\text{Binary coding (B)}]{}$ 0 | 1 $\xLeftarrow[\text{~~Line Coding~~}]{\text{voltage}}$ Lines coding $\Leftarrow$ Source coding

AM/FM/PM — modulator

Pulse Code Modulation (PCM) :- It is a process in which three things happen simultaneously i.e., Sampling + Quantisation + Binary coding

Sampling + Quantisation = Digitisation.

Line Coding :- Transmission of 0's & 1's in form of voltage across the line is called line coding.

Source Coding :- Storage of transmitted signal. Increases the efficiency of storage.

Note:- In analog, AM & FM is used frequently whereas in digital AM, FM & PM is used

QAM [Quadration Amplitude Modulation]:- Combination of AM & PM.

Note:- There are 6 types of line coding & 2 types of source coding

- Variable rate of transmission [In case of bandwidth]

4/Feb/20

* Sampling:- Sampling is done in a device called sampler.

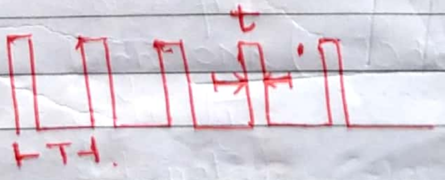
$m(t) \longrightarrow$ [Sampler] $\longrightarrow$ Sampled signal ($s(t)$) [discrete time, discont. amp]

[continuous time, continuous amp]

↑ pulse $m(t)$ [not a digital signal].

Sampling is a process which converts continuous time continuous amplitude signal into discrete time continuous amplitude signal.

Pulse signal:-



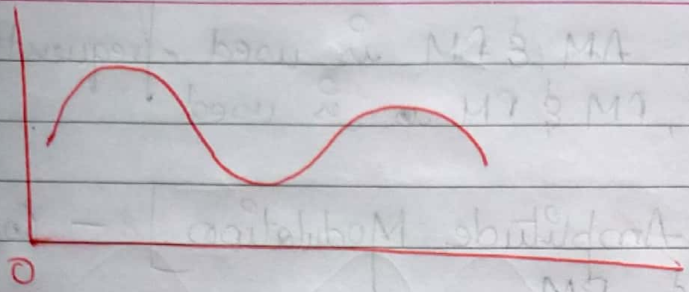
[dc signal + harmonics]

$$f = \frac{1}{T}$$

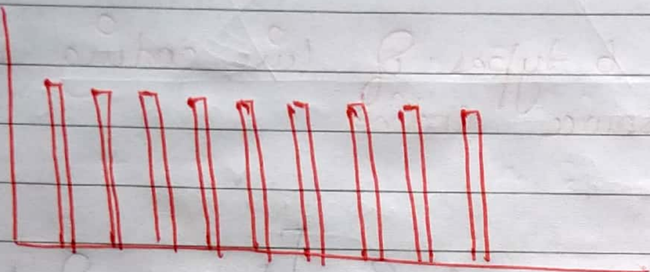
The pulse signal is sharp or broad. It all depends on the duty cycle.

duty cycle:- $\tau = \frac{t}{T} \times 100\%$.

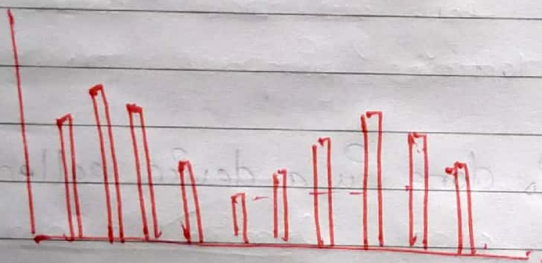
Message signal →



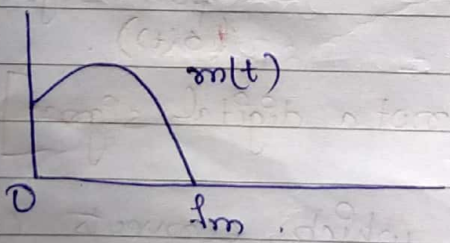
Pulse Signal →

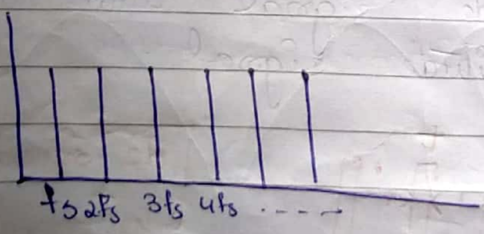


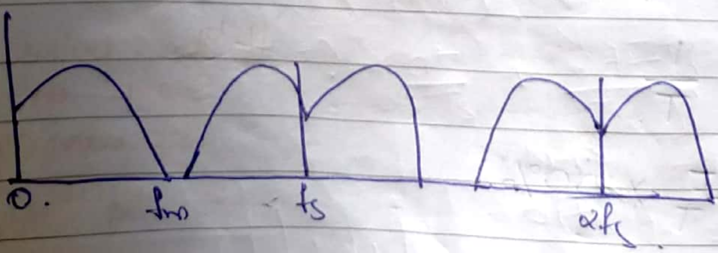
Sampled Signal →



Ex :-







Nyquist ~~rate~~ theorem :-

$t_s \le \frac{1}{2f_m}$ → max. frequency

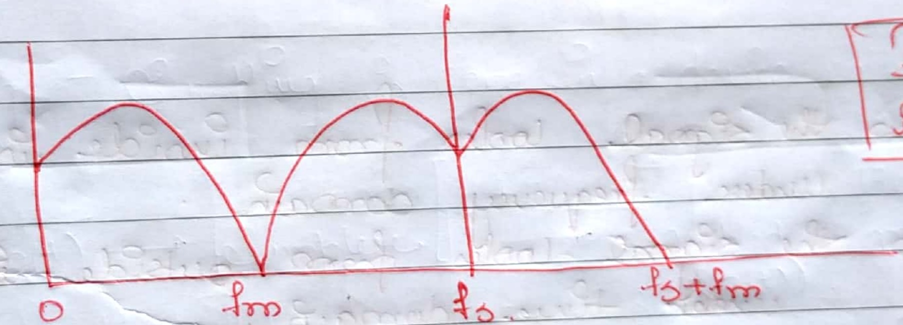
t_s ↓ sampling time

Or, $\frac{1}{f_s} \le \frac{1}{2f_m}$

Or, $\boxed{f_s \ge 2f_m}$ → Nyquist sampling rate.

By Nyquist sampling rate we can derive it into three condns.

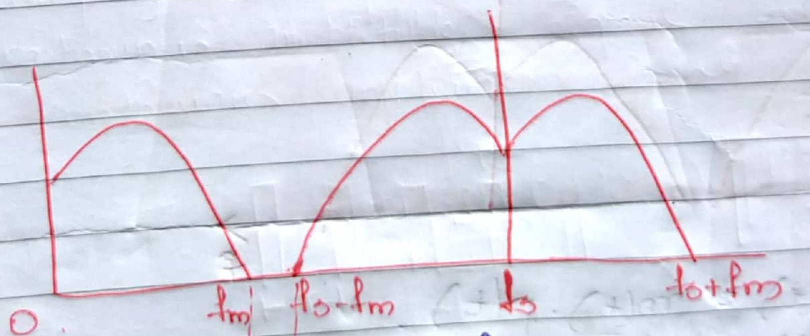
- $f_s = 2f_m$



Ideal filter is used here

$\therefore f_s - f_m = f_m$.

- $f_s > 2f_m$



practical condn

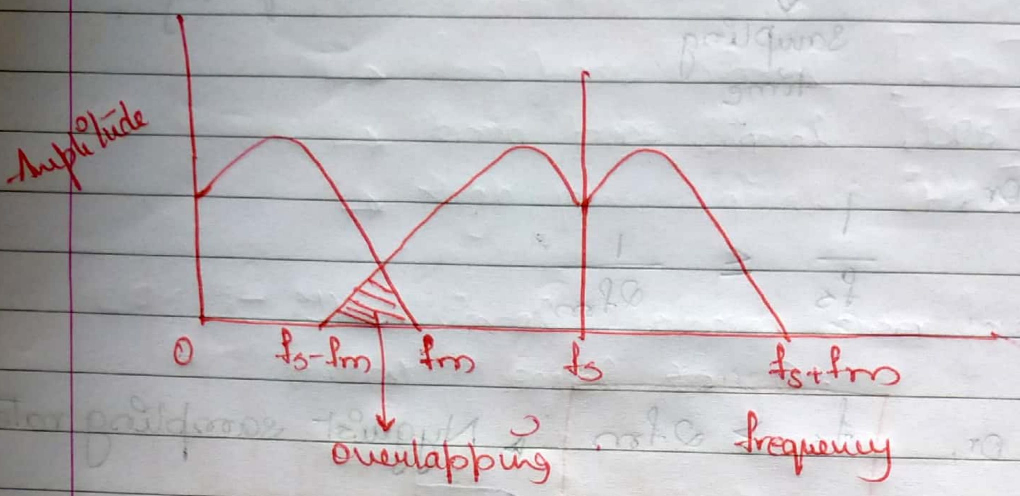
$\therefore f_s - f_m > f_m$.

bandgap (f_b)

$f_s - 2f_m = f_b$

or, $f_s = 2f_m + f_b$.

- $f_s < 2f_m$



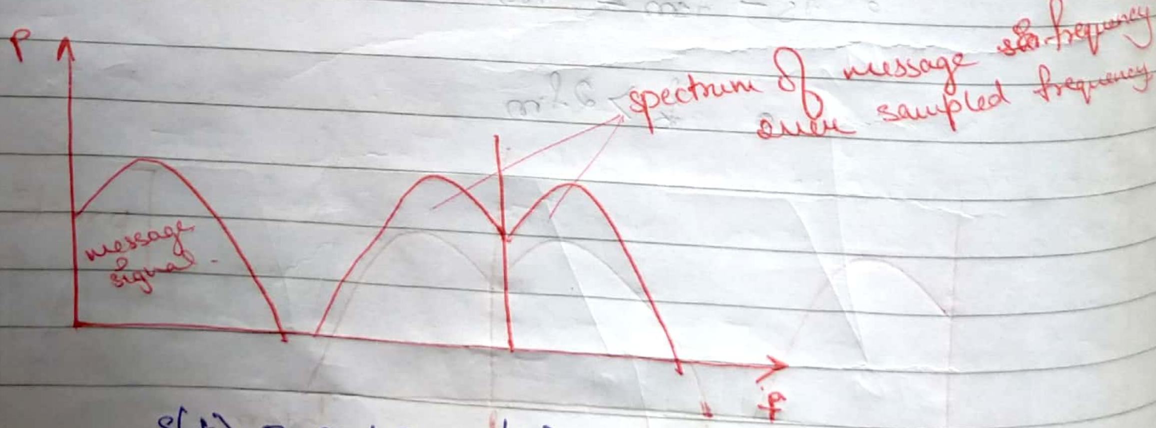
$f_s < 2f_m$
$f_s - f_m < f_m$

The overlapping is termed as aliasing. Here we cannot use any type of the filter. Due to which sampling cannot be done.

How the signal looks from inside is studied under frequency domain

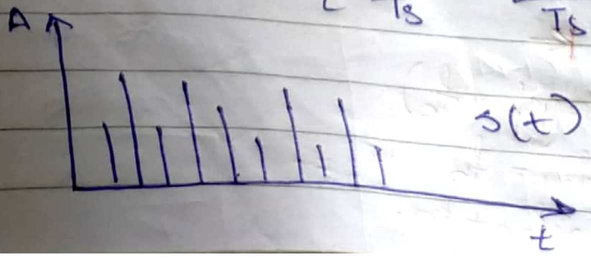
How the signal looks from outside is studied under time domain.

05/feb/20



$s(t) = m(t) \cdot p(t)$.

$s(t) = m(t) \left\{ \frac{dt}{T_s} + \frac{2dt}{T_s} \left\{ \cos 2\pi f_s t + \cos 4\pi f_s t + \cdots \right\} \right\}$.



Page No.:
Date:

Q] $m(t) = 5\cos 100\pi t + 3\cos \underline{150}\pi t$

~~fs~~ $f_s = ?$

$f_m = \frac{150}{2} = 75 \text{ Hz}$.

$\therefore f_s \geq 2f_m$.

$f_s \geq 150 \text{ Hz}$.

* We know that telephone line ranges from $\overset{f_L}{300}$ to $\overset{f_H}{3400}$ Hz.

$f_s \geq 2f_H \geq 6800 \text{ Hz}$.

or,

Since it is practical line.

$f_s = 2f_H + f_b$.

$= 6800 + 1200$.

$f_s = 8000 \text{ Hz}$ or 8 kHz.

Sampling frequency of telephone line $= 8 \text{ kHz}$.

or,

Nyquist b/w $= \frac{f_s}{2} = 4 \text{ kHz}$

Sampled pulse timing $= t_s = \frac{1}{f_s} = \frac{1}{8000} = 125 \mu s$.

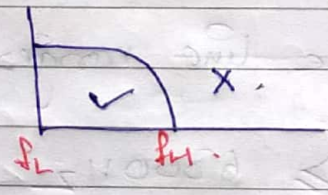
$\boxed{T\ \cancel{t} = 5\% \rightarrow \text{standard value}}$

* Types of Signal :

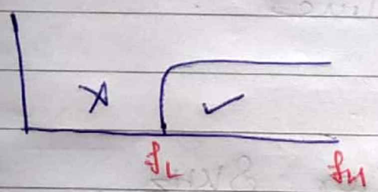
- Low pass Signal [LPS]
- Band pass Signal [BPS]
- High pass signal [HPS]

[$f_s \geq 2f_m$ is mo suitable for LP

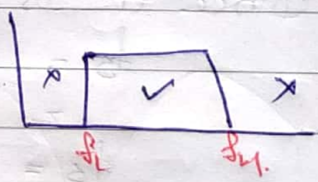
LPS :- The signal whose lower frequency is 0 or almost equal to 0.

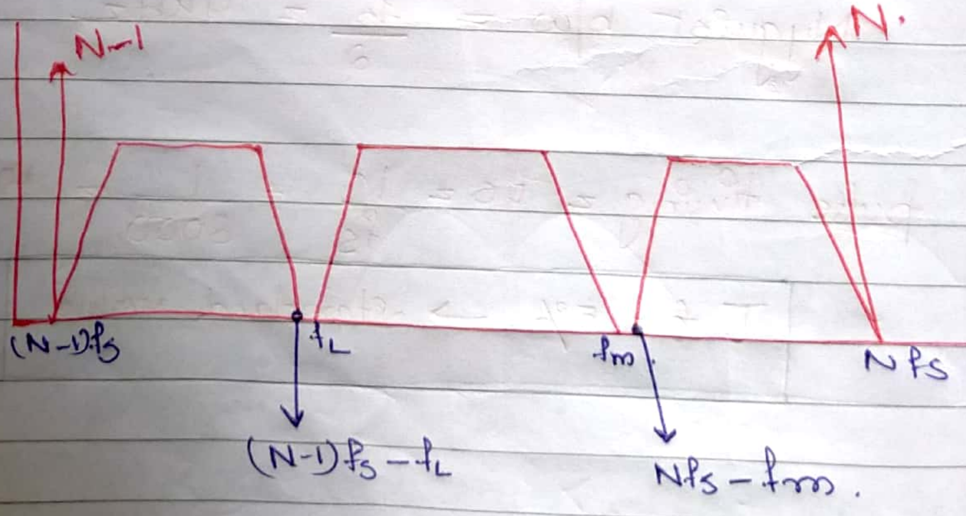


HPS :-



BPS :-





$Nf_s - f_m \geq f_m$

$Nf_s \geq 2f_m$

$$\boxed{f_s \geq \frac{2f_m}{N}}$$

$(N-1)f_s - f_L \leq f_L$

$(N-1)f_s \leq 2f_L$

$$\boxed{f_s \leq \frac{2f_L}{N-1}}$$

$$\boxed{\frac{2f_L}{N-1} \geq f_s \geq \frac{2f_m}{N}}$$

In case of LPS $\Rightarrow N=1$.

Page No.:
Date:

Feb/20

(b/sec) = R = N · fs → sampling frequency (/sec).
↓ Rate of transmission
↓ No. of levels (bits)

N ↑ → M ↑ → S ↓ → Quality ↑

SNR in digital is SQR ≅ 6N dB.
signal to quantisation ratio

- Telephone line
  W.o.k.T
  fs = 8KHz
  M = 256 ; N = 8.
  R = 64 kb/s. → also called DSO line
  [Digital signal 0]

12/feb/20

* Pulse Code Modulation [PCM] :-

Pulse code modulation is a modulation technique in which an analog signal is converted into a streams of 0's & 1's.

The whole process of PCM involves sampling, quantisation & binary coding.

* Line Coding.

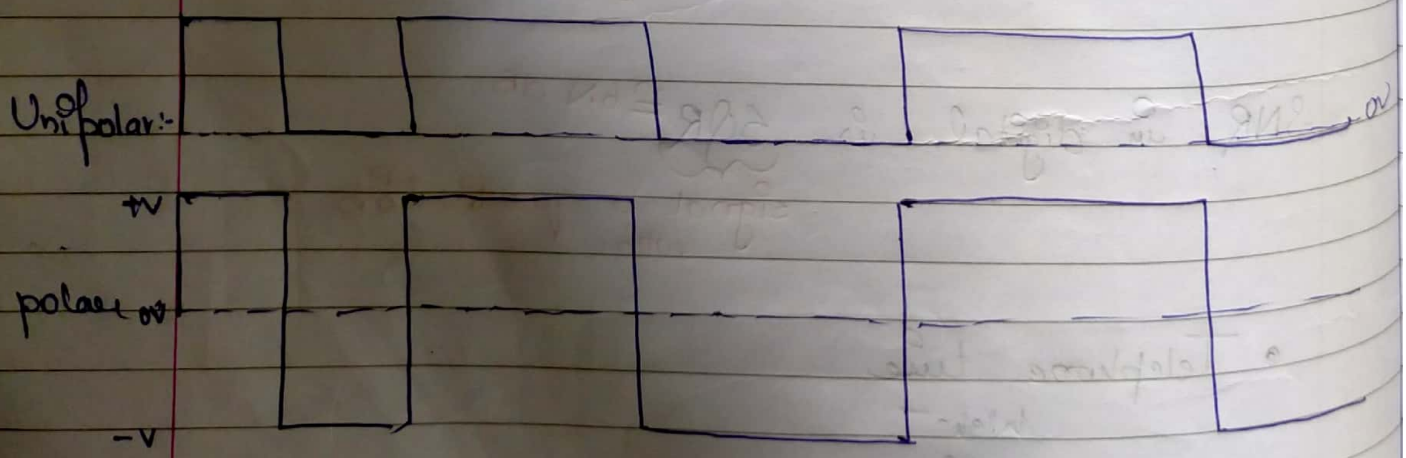
→ Unipolar [0 → 0V ; 1 → +V]
→ polar [0 → −V ; 1 → +V]
→ Bipolar [0 → 0V / +V/−V ; 1 → +V/−V]

Manchester - (2)
0 → (+V → −V)
1 → (−V → +V)

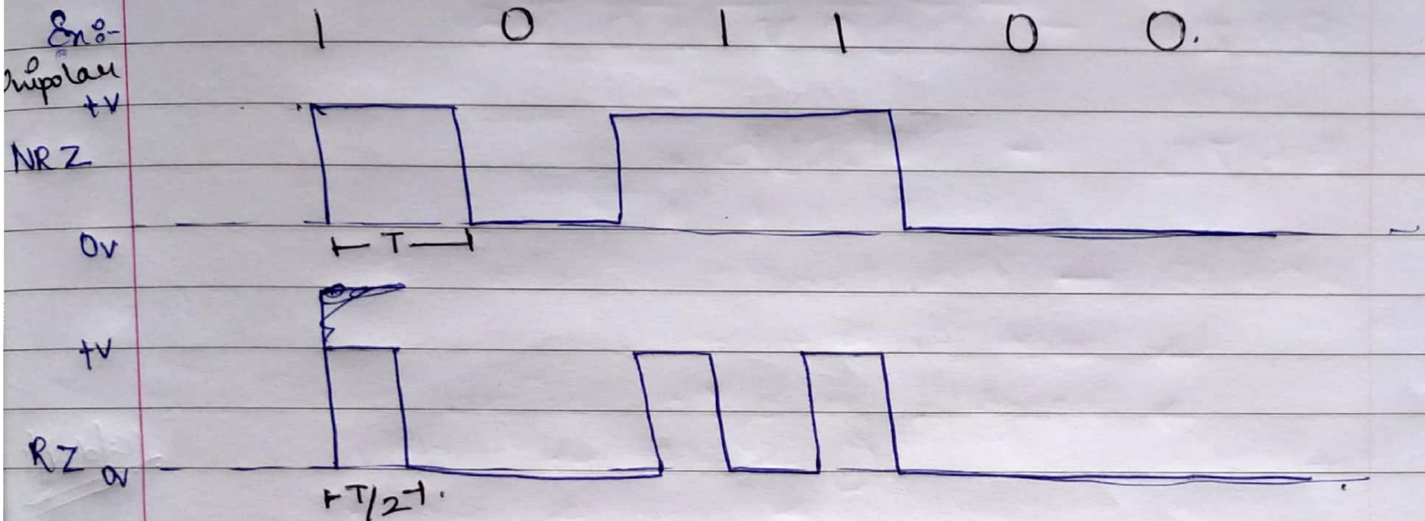
AMI - (1)
0 → 0V
1 → +V/−V.

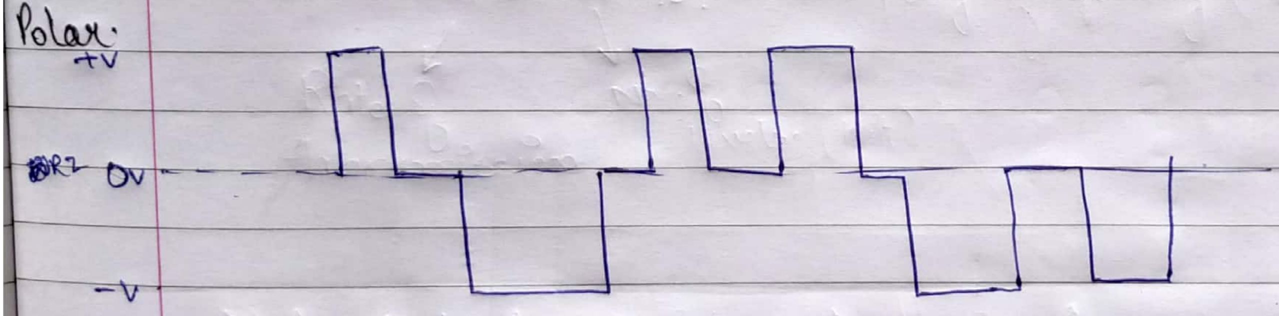
Ex:-

1 0 1 1 0 0 1 1 1 0 0



Unipolar & polar are again subdivided into two parts
↳ Not returned to zero [NRZ]
↳ Returned to zero [RZ].





17/feb/20

* Scrambling :-

To remove the continuity in 0's.

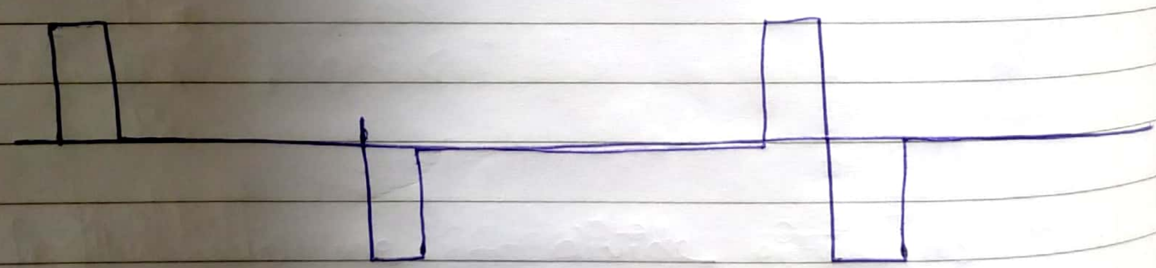
B8ZS - 000VB0VB.

B6ZS - 0VB0VB.

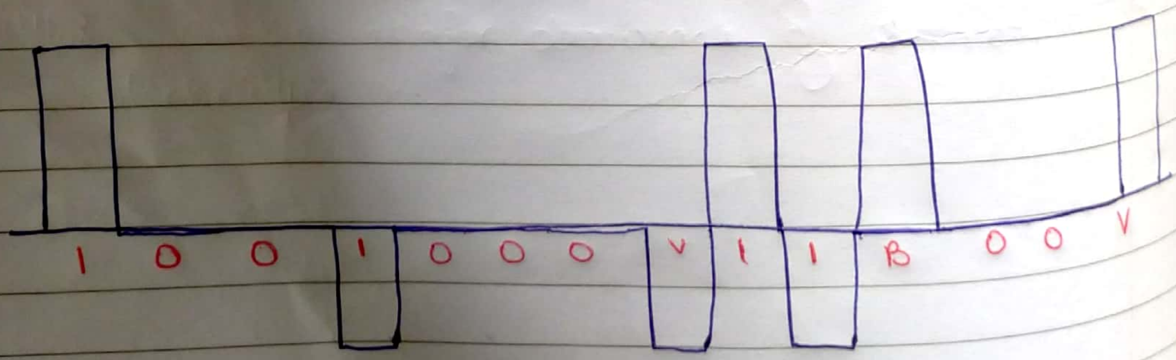
HDB3 — High Density Bipolar 3.
↳ used for 4 zero's.
↳ based of no. of 1's before substitution
① → odd → 000V
② → even → B00V

Ex :- 1 0 0 1 0 0 0 0 1 1 0 0 0 0

AMI

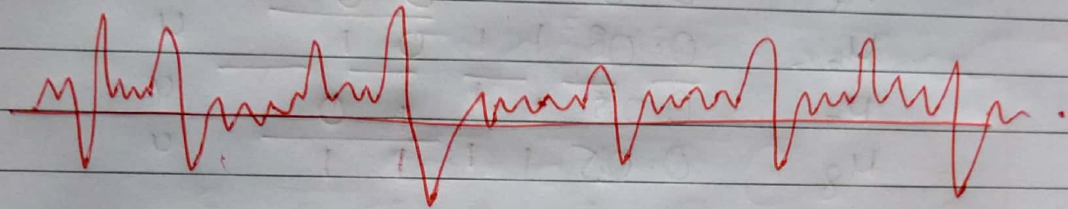


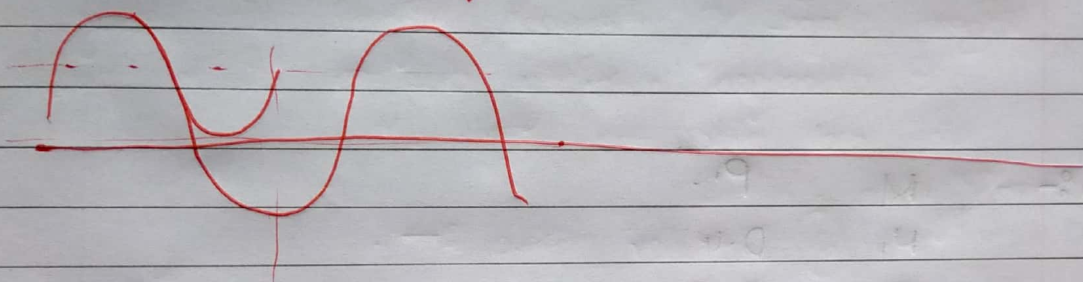
HDB3



* Source Coding

1] Shanon fano
2] Hoffmann.
} Source coding Technique.





Ex :-

M_1	0.25
M_2	0.2
M_3	0.25
M_4	0.15
M_5	0.05
M_6	0.10

Arrange in descending order.

M_1	0.25	0	0		
M_3	0.25	0	1		
M_2	0.2	1	0		
M_4	0.15	1	1	0	
M_6	0.10	1	1	1	0
M_5	0.05	1	1	1	1

(1) Divide in 50-50 And give upper side as 0 & lower as 1.

Page No.:
Date:

Ex:-

M	P	C				N
M_1	0.3	0	0			2
M_2	0.15	0	1			2
M_3	0.15	1	0	0		3
M_4	0.12	1	0	1		3
M_5	0.10	1	1	0	0	4
M_6	0.08	1	1	0	1	4
M_7	0.05	1	1	1	0	4
M_8	0.05	1	1	1	1	4

Ex:-

M	P
M_1	0.4
M_2	0.2
M_3	0.15
M_4	0.15
M_5	0.05
M_6	0.05

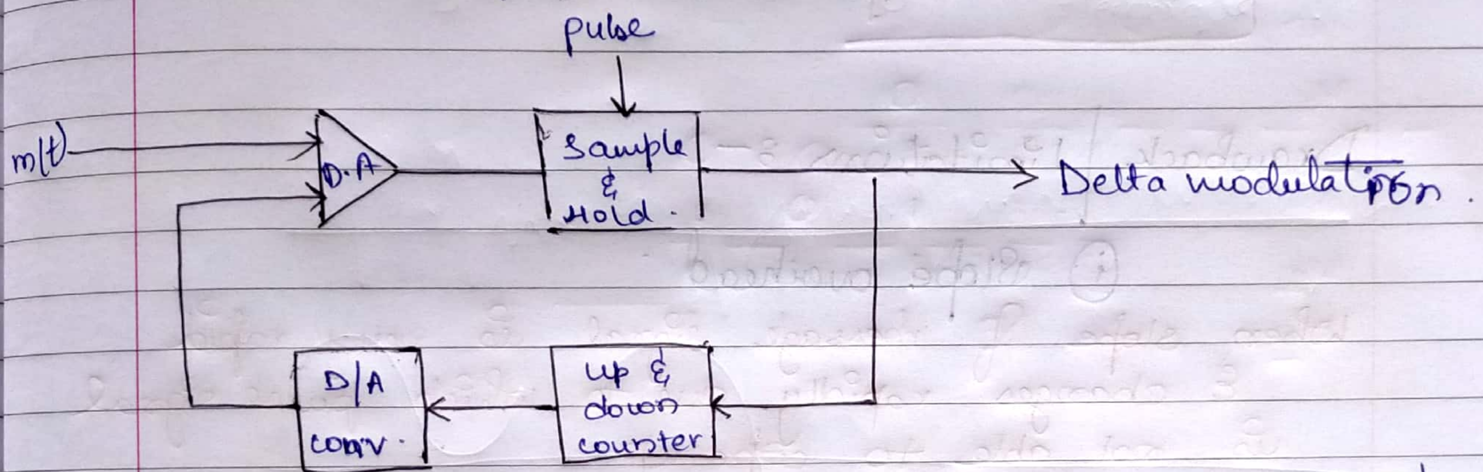
In this eqn we can divide either as 40 and 60 & also as 60 & 40.
This is the major drawback of shanon fano technique.

Page No.:
Date:

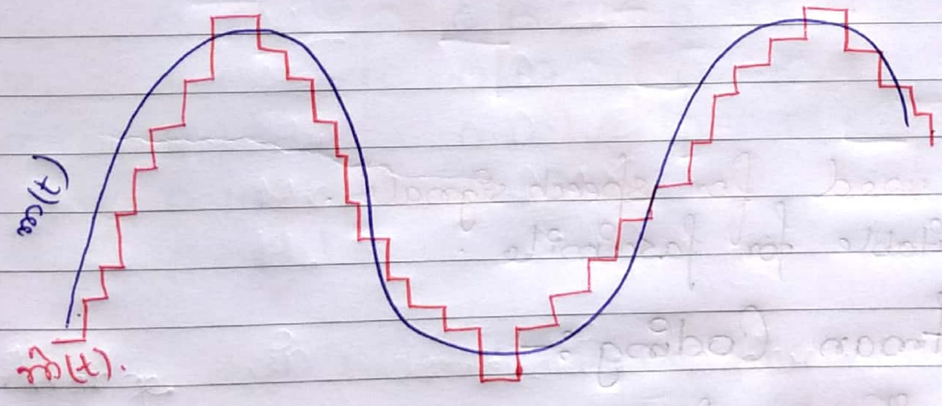
18/Feb/20

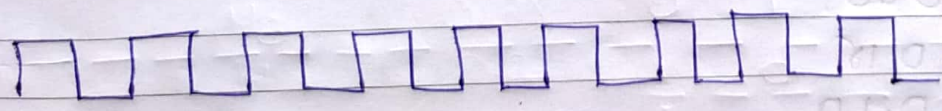
* Delta Modulation :-

↳ It is a 1-bit PCM scheme.



→ Accumulator → Filter → o/p.





$$\text{Slope of } m(t) \cong \text{slope of } \hat{m}(t).$$

$$\text{Slope of } m(t) = \frac{d}{dt}\left(A_m \cos 2\pi f_m t\right) = \left| -A_m \sin 2\pi f_m t \cdot 2\pi f_m \right|_{max}$$

$$= 2\pi A_m f_m$$

$$\text{Slope of } \hat{m}(t) = \frac{S}{T_s} = S f_s.$$

F.U

Page No.:
Date:

or,

$$\boxed{S f_s = 2\pi A_m f_m}$$

Drawback | Limitations :-

(i) Slope overhead.

When slope of message signal is very rapid & changes rapidly due to which pulse signal is not able to cope up.

(2) Granular noise :- .

DM is not used for speech signals.
Best suitable for fascimile.

20/feb/20 * Huffman Coding :-.

Ex:- Apply Shannon Fanon

0.40
0.15
0.10
0.10
0.10
0.10
0.05

Page No.:
Date:

M	P	P
M_1	~~0.05~~	0.40
M_2	0.10	0.15
M_3	0.10	0.10
M_4	0.10	0.10
M_5	0.10	0.10
M_6	0.15	0.10
M_7	0.40	0.05

Since one can divide as 55 & 45 or 40 & 60.
So, here we apply huffman coding :-

<M>	<P>					
M_1	0.40	0.40	0.40	0.40	0.40	0.60
M_2	0.15	0.15	0.20	0.25	0.35	0.40
M_3	0.10	0.15	0.15	0.20	0.25	
M_4	0.10	0.10	0.15	0.15		
M_5	0.10	0.10	0.10			
M_6	0.10	0.10				
M_7	0.05					

1.0

We can also reverse the '0's & '1's' but the same pattern has to be followed.

M_1	1
M_2	1 0 0
M_3	1 1 0
M_4	0 0 0 0
M_5	1 0 0 0
M_6	0 0 1 0
M_7	1 0 1 0

Ex:

<M>	M_1	M_2	M_3	M_4	M_5
<P>	0.10	0.15	0.40	0.20	0.08

Shanon :-

<M>	<P>			
M_3	0.40	0		
M_4	0.20	1	0	0
M_5	0.15	1	0	1
M_2	0.15	1	1	0
M_1	0.10	1	1	1

Huffman Coding

M_3	0.40	0.40	0.40	0.60 0	1.0
M_4	0.20	0.25	0.35 0	0.40 1	
M_5	0.15	0.20 0	0.25 1		
M_2	0.15 0	0.15 1			
M_1	0.10 1				

M_1	1	1	0
M_2	0	1	0
M_3	1		
M_4	0	0	0
M_5	1	0	0

Scanned with CamScanner