PRINCIPLES OF COMMUNICATION.

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BASIC BLOCK DIAGRAM OF COMMUNICATION SYSTEM:

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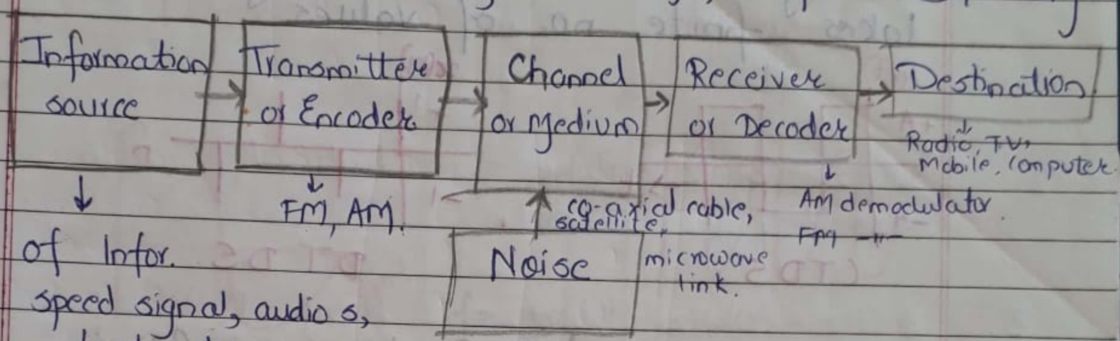


Eg. of Infor.
speed signal, audio s, text, etc.

NEED FOR MODULATION:

Imp **

1. It increases the range of communication.
2. Decrease in size of antenna.
3. Increase in the clarity of sound.
4. Avoid mixing of signals.
5. Multiplexity

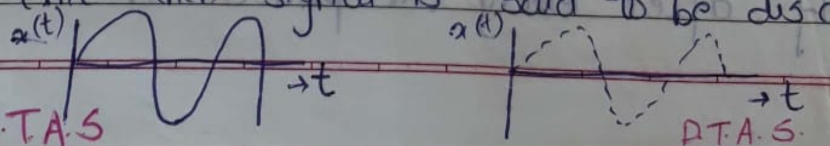
SIGNAL:
Signal is the func. of one or more than one independent variable.

If indepen. variable is 1 then it is called One dimensional signal.

Eg Speech Signal.

TYPES OF SIGNALS:

① Continuous & Discontinuous (CT & D.T):
A signal is said to be continuous if it is defined for all the instances for time.
If signal is defined only for certain instances of time then signal is said to be discontinuous.



C.T.A.S D.T.A.S.

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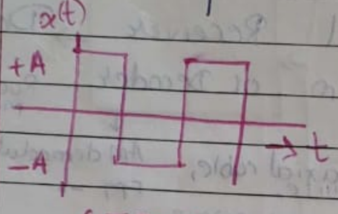
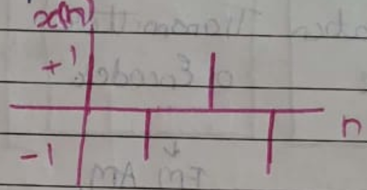
② Analog and Digital:
A signal is said to be analog if it takes infinite no. of values.
A signal is said to be Digital if it takes finite no. of values.



CTDS



DTDS.

③ Deterministic And Random signal:
A signal is said to be deterministic if it is defined by a well set of rule.
eg. Signal generated on CRO

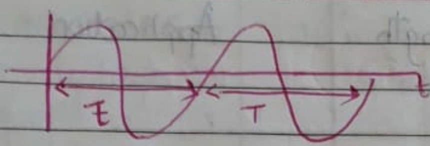
Otherwise signal is said to be random.
eg. Noise.

4. Symmetric And Asymmetric (Even/Odd):

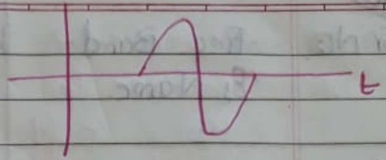
$x(t)$
put $t = -t$
$x(-t) = x(t) \Rightarrow$ Even
$x(-t) = -x(t) \Rightarrow$ Odd.

5. Periodic And Aperiodic:
$x(t) = x(t+T)$ Periodic
$x(t) \neq x(t+T)$ Aperiodic.

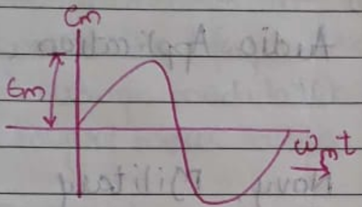
A signal is said to be periodic if it repeats itself after every time period T.

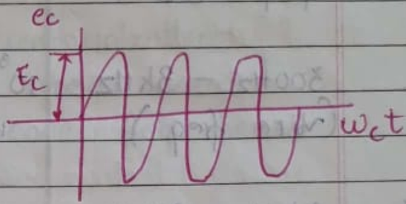


Periodic



Aperiodic





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

low freq

$e_m = E_m \sin \omega_m t$

Modulating / Audio frequency.

high freq.

$e_c = E_c \sin \omega_c t$

Carrier freq.

$e_m = E_m \sin (\omega_m t + \phi)$

$\uparrow$ A, $\uparrow$ F, $\uparrow$ P

A → Amplitude

F → frequency

P → Phase

\# Radio Frequency Spectrum OR.

Electromagnetic Spectrum OR

*** (5m) IEEE (Inst. of Electronics & Electrical Engg)

frequency band

Sr. No.	Freq Band & Name	Wavelength	Application
1	30Hz – 300Hz. Extremely Low freq (E.L.F)	10^4km – 10^3km.	Power transmission
2.	300Hz – 3kHz (voice freq)	10^3km – 100km	Audio Application.
3.	3kHz – 30kHz (VLF) very low freq	100km – 10km	Navy, Military Communication
4.	30kHz – 300kHz Low freq. (L.f)	10km – 1km.	Aeronautical / Marine
5.	300kHz – 3MHz Medium freq (M.f)	1km – 100m	Amp. Modulation (AM) Broad cast
6.	3MHz – 30MHz High freq. (H.F)	100m – 10m	Shortwave Transmission
7.	30MHz – 300MHz very high freq. (10^6)	10m – 1m	T.V. Broadcasting, FM Radio
8.	(10^9) 300MHz – 3 GHz ultra high f. (UHf)	1m – 10cm	Cellular Phones
9.	3GHz – 30GHz Super High freq.	10^{-1}m to 10^{-2}m.	Satellite Communication / RADAR.

10	30GHz - 300 GHz Extremely High freq	10^{-2} m - 10^{-3} m	Satellite Communication.

Need for Modulation

1) It increases the range of communication:
- Lower the freq less is the area covered
∴ using modulation we increase freq. hence cover more area.

2. Reduces the height of Antenna:
To transmit or to receive any signal we require an antenna. The height of that antenna must be $\lambda/4$. where $\lambda = \frac{c}{f}$ where

c = velocity of light = 3×10^{8} m/sec
f ⇒ freq which we are transmitting

If we want to transmit 3kHz signal the ht. of antenna must be $\lambda = \frac{3\times10^{8}}{3\times10^{3}} = 10^{5}$ mts.

$\therefore \frac{\lambda}{4} = \frac{10^{5}}{4} = 2.5$ km. which is very large.

Practically it is impossible to build such a large antenna. Instant we use modulation & increase in freq to 3×10^{6} Hz & calculate the antenna height

$\lambda = \frac{3\times10^{8}}{3\times10^{6}} = 100$ mts

$\therefore \lambda/4 = 25$ mts.

Hence height of antenna reduces.

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3. It avoids the mixing of signals.
4. Improve the quality of reception
Using diff modulation tech like AM, FM, PCM, TM you can get better quality.

5. Multiplexing is possible.
Using Modu. we can transmit more than one signal over a single commun. channel using techniques such as FDM (freq. div multi) TDM (time division multiplexing)

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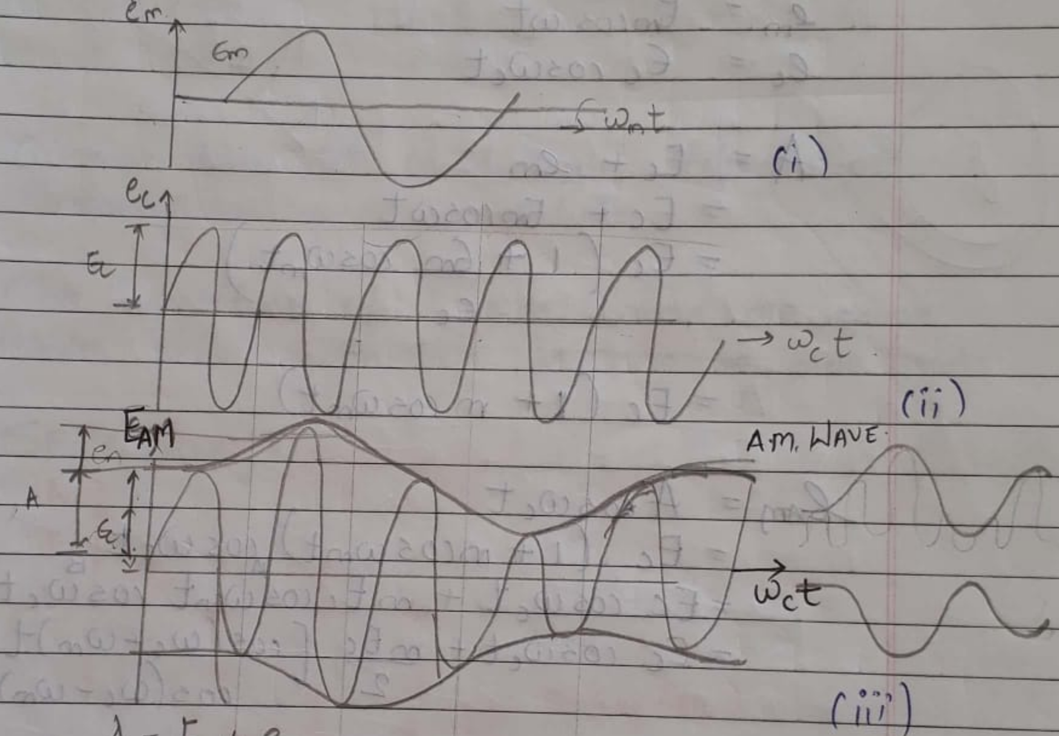
AMPLITUDE MODULATION.

* MODULATION: is the process of changing some of the parameters (Am, Fr, and phase) of high frequency carrier wave w.r.t instantenous value of modulating signal, keeping other two parameters constant.



$A = E_c + e_m$

Derive Expression For A.M:

Mathematically Define A.M:

The process of changing amplitude of high freq carrier wave w.r.t the instantaneous value of modulating signal keeping freq. and phase constant is known as Modulation.
Fig (i) (ii) (iii)

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Eq^n of AM

M → Modulating signal
C → carrier signal
A → pk amplitude of modulating signal
$m \Rightarrow (E_m / E_c)$ Modulation Index
$e_{AM} \Rightarrow A\cos\omega_c t$

$$e_m = E_m \cos \omega_m t$$
$$e_c = E_c \cos\omega_c t$$

$$A = E_c + e_m$$
$$= E_c + E_m \cos\omega_m t$$
$$= E_c\left(1 + \frac{E_m}{E_c}\cos\omega_m t\right)$$

$$\boxed{A = E_c(1 + m\cos\omega_m t)}$$

$$e_{AM} = A\cos\omega_c t$$
$$= E_c(1 + m\cos\omega_m t)\cos\omega_c t$$
$$= E_c\cos\omega_c t + mE_c \underset{A}{\cos\omega_m t}\ \underset{B}{\cos\omega_c t}$$
$$= E_c\cos\omega_c t + \frac{mE_c}{2}\left[\cos(\omega_c + \omega_m)t + \cos(\omega_c - \omega_m)t\right]$$

$$e_m = E_c\cos\omega_c t + \frac{mE_c}{2}\cos(\omega_c + \omega_m)t + \frac{mE_c}{2}\cos(\omega_c - \omega_m)t$$

Conclusion:

AM wave consist of 3 terms

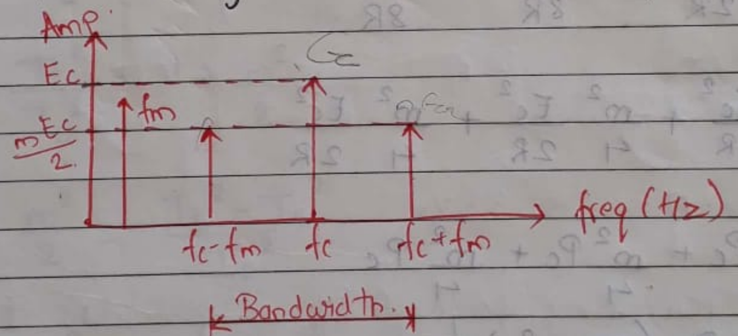
i. Original carrier
ii. Sum of two frequencies called as upper side band
iii. Difference of two frequencies known as lower side band

Sr. No	Name	Amplitude	Frequency
1.	Original carrier	E_c	f_c
2.	Upper side Band (USB)	$\frac{mE_c}{2}$	$f_c + f_m$
3.	Lower side Band (LSB)	$\frac{mE_c}{2}$	$f_c - f_m$

NOTE: Carrier does not contain any information. Information is in amplitude.

The amplitude of 2 side bands are same. Hence, same information is there in side bands.

SPECTRUM:



$$BW = f_c + f_m - f_c + f_m$$
$$= 2f_m$$

Modulation Index: In AM wave a Modulation Index (m) is defined as the ratio of ampli of the modulating waves and the carrier waves, $\boxed{m = \frac{E_m}{E_c}}$

if $E_m < E_c \Rightarrow$ 'm' has value betn 0 & 1 $\Rightarrow$ no distortion

$E_m > E_c \Rightarrow m > 1 \Rightarrow$ Distort the shape of AM

M.I of FM wave is ratio of max. freq deviation & modulating freq $\boxed{m_f = \frac{\delta}{f_m}}$

POWER RELATIONSHIP IN A.M:

$$P = \frac{V^2}{R} = \cancel{I^2R = VI}$$

$$P_t = P_c + P_{USB} + P_{LSB}$$

$$P_c = \frac{V^2}{R} = \frac{E_c^2}{R} = \frac{(E_c/\sqrt{2})^2}{R} = \frac{E_c^2}{2R} \quad (1)$$

$$P_{USB} = \frac{V^2}{R} = \frac{(mE_c/2)^2}{R} = \frac{(mE_c/\sqrt{2})^2}{2/R} = \frac{m^2E_c^2}{8R} \quad (2)$$

$$P_{LSB} = \frac{V^2}{R} = \frac{(mE_c/2)^2}{R} = \frac{(mE_c/\sqrt{2})^2}{2/R} = \frac{m^2E_c^2}{8R} \quad (3)$$

$$P_t = \frac{E_c^2}{2R} + \frac{m^2E_c^2}{8R} + \frac{m^2E_c^2}{8R}$$

$$= \frac{E_c^2}{2R} + \frac{m^2}{4}\frac{E_c^2}{2R} + \frac{m^2}{4}\frac{E_c^2}{2R}$$

$$= P_c + \frac{m^2}{4}P_c + \frac{m^2}{4}P_c$$

$$\boxed{P_t = P_c\left(1 + \frac{m^2}{2}\right)}$$

(10 marks)

CURRENT RELATIONSHIP:

It is very difficult to measure R.F. voltages rather than current therefore we go for current relationship.

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$$P_t = P_c\left(1+\frac{m^2}{2}\right)$$

$$P_t = I_t^2 R$$
$$P_c = I_c^2 R$$

$$I_t^2 R = I_c^2 R\left(1+\frac{m^2}{2}\right)$$

$$I_t = I_c\sqrt{1+\frac{m^2}{2}}$$

where $I_c \rightarrow$ carrier current
$I_t \rightarrow$ total current

Modulation Index (m) in Terms of Total Current and Carrier Current

$$I_t = I_c\sqrt{1+\frac{m^2}{2}}$$

$$I_t^2 = I_c^2\left(1+\frac{m^2}{2}\right)$$

$$\frac{I_t^2}{I_c^2} = 1+\frac{m^2}{2}$$

$$\frac{m^2}{2} = \frac{I_t^2 - I_c^2}{I_c^2}$$

$$m^2 = 2\left[\left(\frac{I_t}{I_c}\right)^2 - 1\right]$$

$$\therefore m = \sqrt{2\left[\left(\frac{I_t}{I_c}\right)^2 - 1\right]}$$

EFFICIENCY OF AM WAVE:

$$\eta = \frac{\text{useful power}}{\text{total power}}$$

$$= \frac{P_{USB} + P_{LSB}}{P_t} \rightarrow$$ [∵ Info is only in side band ∴ useful power = side band power]

$$= \frac{\frac{P_c m^2}{4} + \frac{P_c m^2}{4}}{P_c\left(1 + \frac{m^2}{2}\right)}$$

$$= \frac{\frac{P_c m^2}{2}}{P_c\left(\frac{2+m^2}{2}\right)}$$

$$\eta = \frac{m^2}{m^2+2} \qquad \therefore \eta\,\% = \frac{m^2}{m^2+2} \times 100$$

$$\max \eta = 33.33\%$$

The remaining part 67% is lost due to carrier wave power.

when $m = 1$

Efficiency is $\frac{1}{1+2} \times 100 = \frac{1}{3} \times 100 = 33.33\%$.

This is major drawback of AM wave since 67% of the power is wasted in the carrier.

Bandwidth required for video transmission → 4.2 MHz.
—"— audio transmission → 0.75

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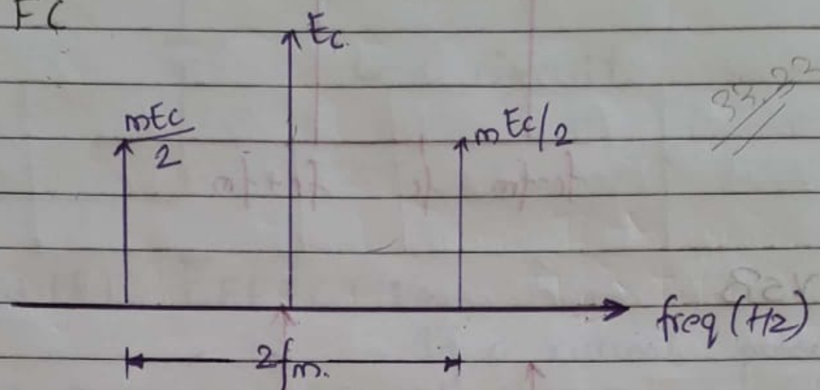
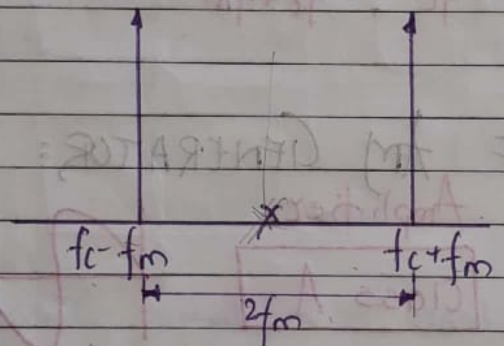
Types of AM Waves:

1 DSB-FC



2. DSB-SC

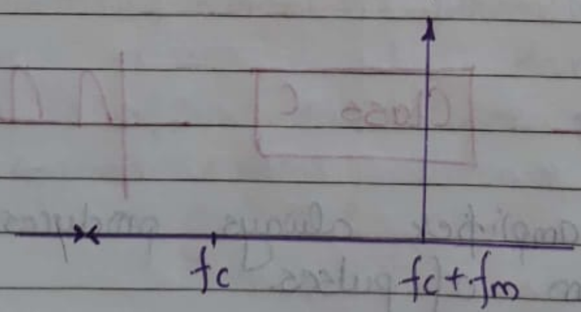


saves 67% power

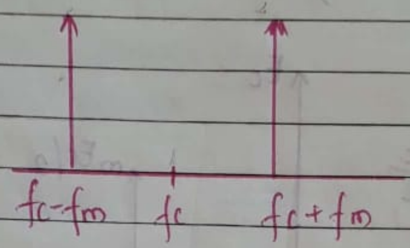
3 SSB-SC

Most Imp

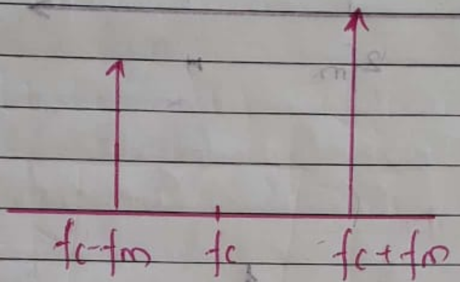
83% power saved
BW = Half
i.e. fm



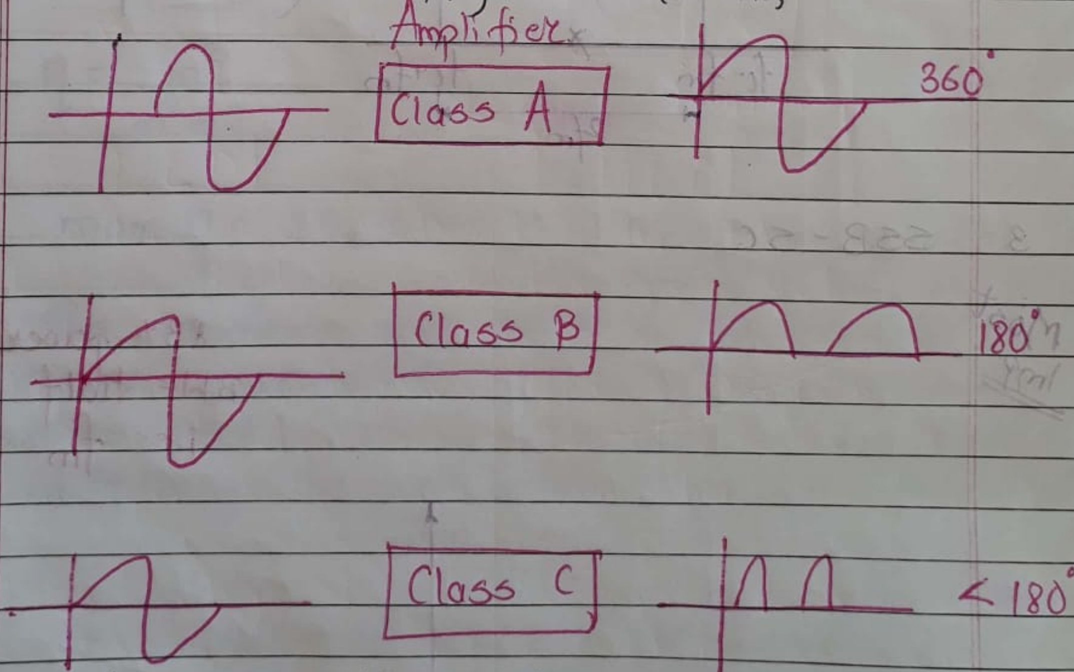
4. ISB



5. VSB

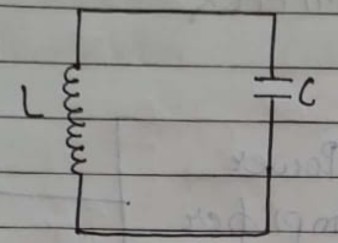


PRINCIPLES OF AM GENERATOR:



Class C amplifier always produces current in the form of pulses.

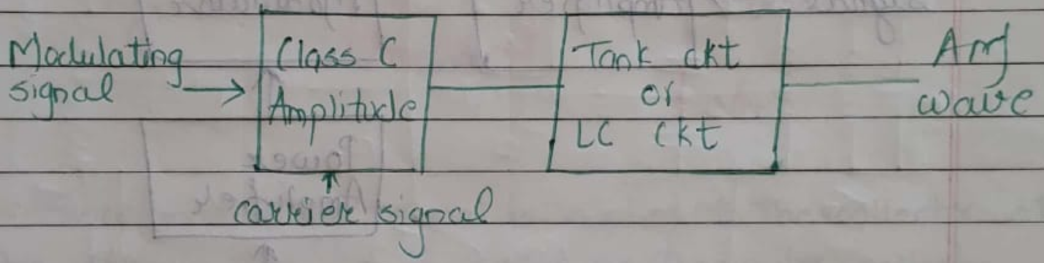
LC Circuit / Tank Circuit.



L-C circuit.

FLYWHEEL EFFECT:

If a current pulse is supplied to a LC circuit it will generate oscillations of the same amplitude and decay rate dependent on time factor.

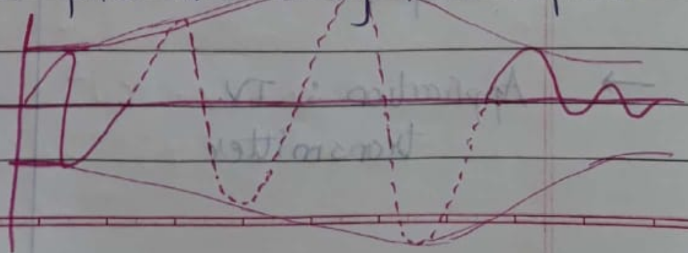


Class C amplifier is used to generate output in the form of pulses because it will conduct for less than 180°.

These current pulses when applied to the tank circuit generates AM wave across it by 'flywheel effect'.

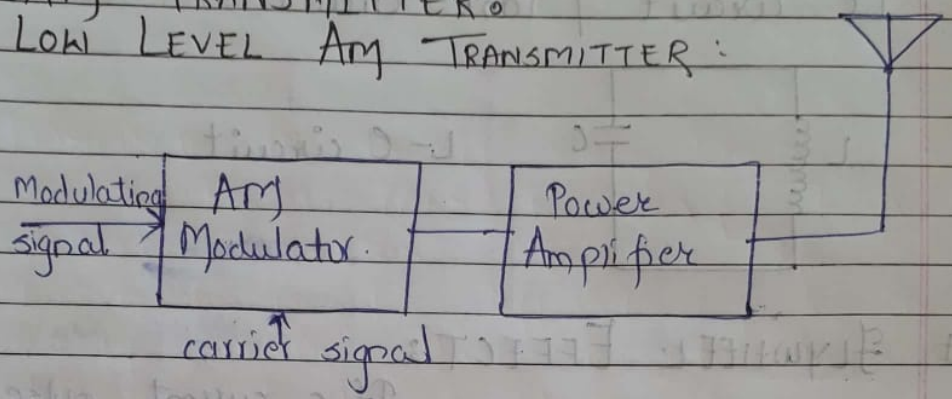
FLYWHEEL EFFECT:

When the current pulse is applied to a tank circuit it starts to oscillate. The amplitude of the oscillations are same as that of the applied current pulse and decay rate depends on time constant.

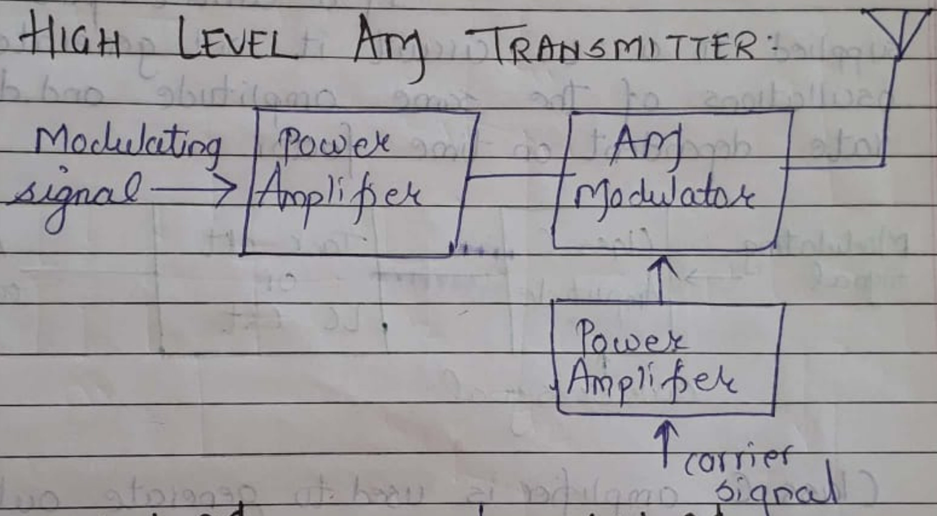


AM TRANSMITTER:

1 LOW LEVEL AM TRANSMITTER:

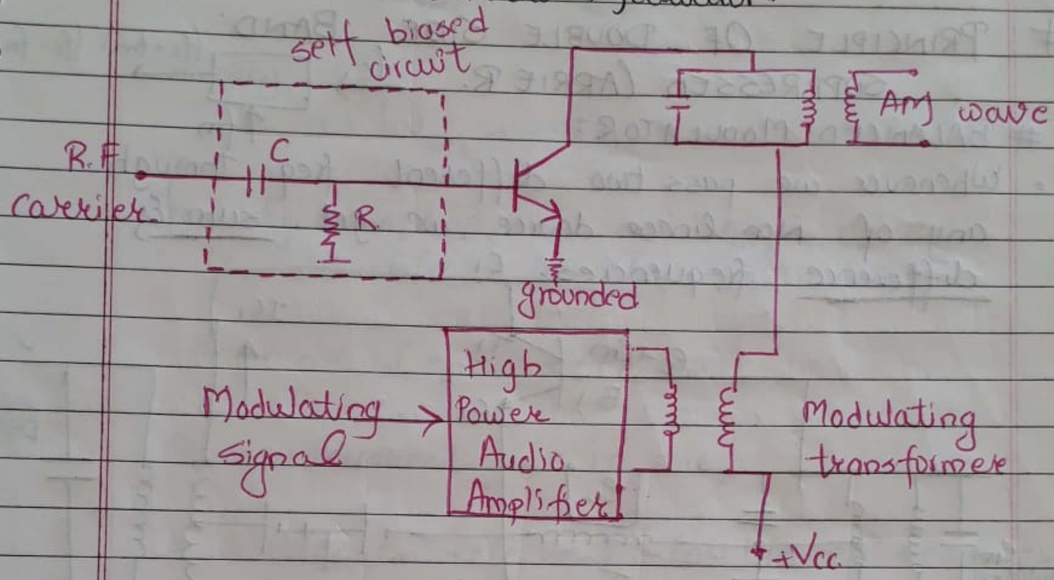


2. HIGH LEVEL AM TRANSMITTER:



LLM	HLM
→ Modulation takes place at low power level.	Modulation takes place at high power level.
→ Efficiency is low because we use class A & class B amplifier.	Efficiency is high because of use of class C amplifier.
→ Easy to design at low power	AF amplifier design is complex because high power is required.
→ Application : T.V. transmitter	High Power Broadcast Transmitter.

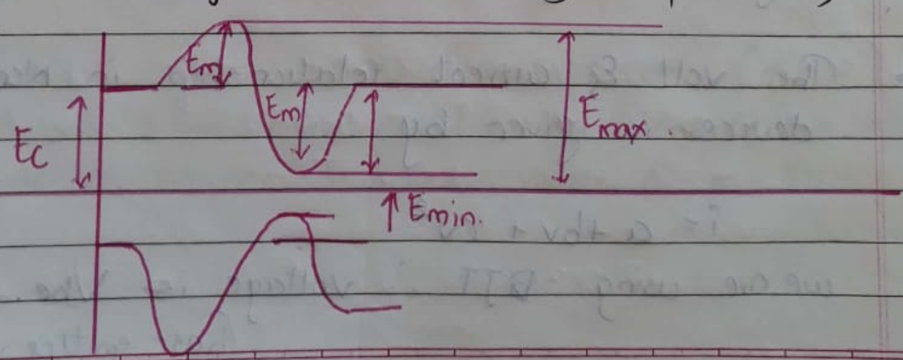
GENERATION OF DOUBLE SIDE BAND - FULL CARRIER AM
OR Transistor Collector Modulator:



Since modulating signal is applied to the collector at the transmitter it is called as transistor collector modulator.

Self biased circuit is used to bias transistor in cut-off boat so that transistor works as class C amplifier. This class C amplifier generates o/p in the form of current pulses and these current pulses applied to the tank circuit where because of flywheel effect AM wave is generated.

Calculation Of Modu. Index by Graphical Method



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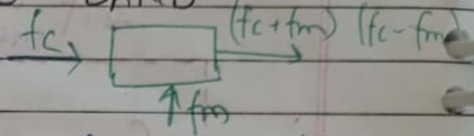
Non-linear : Diode, BJT. Base, Collector, emitter

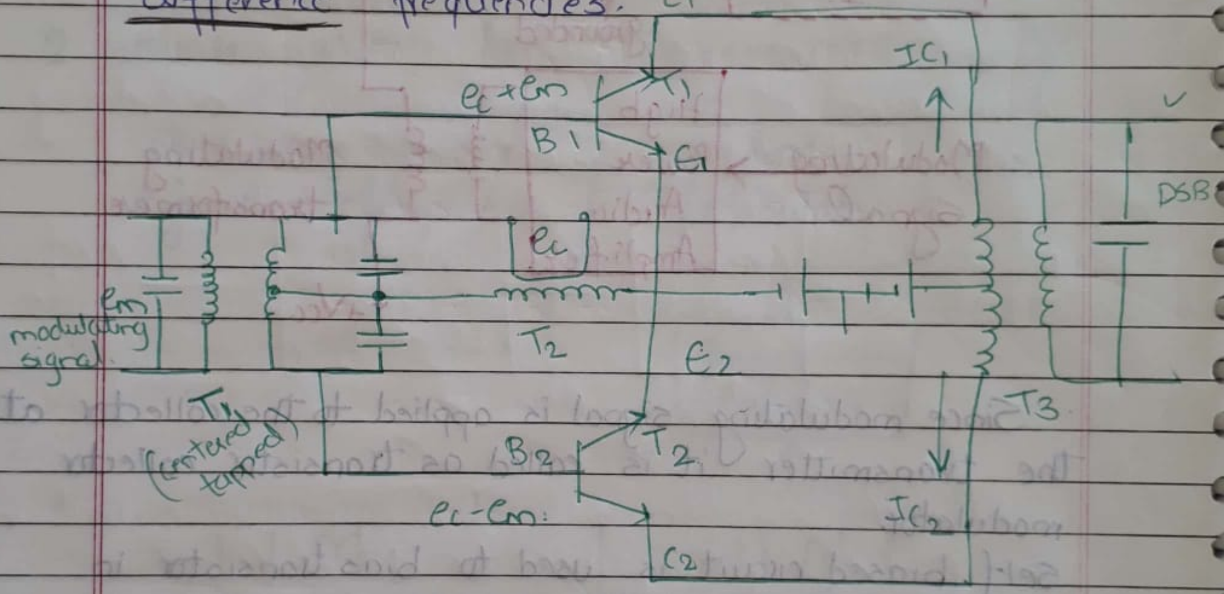
anode cathode

PRINCIPLE OF DOUBLE SIDE BAND SUPPRESSED CARRIER.



BALANCED MODULATOR:

- Whenever we pass two different freq. through any of Non linear device, we get sum & difference frequencies.



- We are using 3 transformer & to the transf T1 which is centered tapped modulating signal appears out of phase to both BJT's.
- Across the primary of the o/p trans. ie T3 we get collector current as. $i_c = i_{c_1} - i_{c_2}$
- The volt & current relationship in Non-Linear device is given by.

$$i = a + bv + cv^2$$

we are using BJT ∴ voltage is Vbe. and (base emitter volt) current is i_c.

- for T_1 current is given by

$$i_{c_1} = a + b v_{be_1} + c v_{be_1}^2$$

similarly

$$i_{c_2} = a + b v_{be_2} + c v_{be_2}^2$$

from fig. $v_{be_1} = e_c + e_m$ and $v_{be_2} = e_c - e_m$

$$\therefore\ i_{c_1} = a + b(e_c + e_m) + c(e_c + e_m)^2$$

$$i_{c_2} = a + b(e_c - e_m) + c(e_c - e_m)^2$$

Primary current $i_c = i_{c_1} - i_{c_2}$

$$= a + b(e_c + e_m) + c(e_c + e_m)^2 - (a + b(e_c - e_m) + c(e_c - e_m)^2)$$

$$= a + b(e_c + e_m) + c(e_c + e_m)^2 - a - b(e_c - e_m) - c(e_c - e_m)^2$$

$$= 2be_m + 4c e_c e_m$$

where $e_m = E_m \cos \omega_m t$

$e_c = E_c \cos \omega_c t$

i.e. $i_c = 2bE_m \cos \omega_m t + 4c E_c \cos \omega_c t\, E_m \cos \omega_m t$

$$= \underbrace{2bE_m}_{a} \cos \omega_m t + \underbrace{2c E_m E_c}_{b} [\cos(\omega_c t + \omega_m t) + \cos(\omega_c t - \omega_m t)]$$

$$= A \cos \omega_m t + B \cos(\omega_c + \omega_m) t + B \cos(\omega_c - \omega_m) t$$

The above eq. does not consist of original carrier terms. Hence we say carrier is suppressed.

SINGLE SIDE BAND GENERATOR (SSB)

Find out % power saving if carrier & one of the side bands are suppressed if ① m = 100% ② m = 50%

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(a) $m = 1$

$\% P.S = \dfrac{P_t - P_{1SB}}{P_t}$

$P_t = P_c\left(1 + \dfrac{m^2}{2}\right)$

$P_t = P_c(1 + 1/2)$

$P_t = 1.5 P_c$

$P_{1SB} = \dfrac{P_c m^2}{4} = \dfrac{P_c}{4} = 0.25 P_c$

$P.S = \dfrac{1.5 P_c - 0.25 P_c}{1.5 P_c} = \dfrac{1.25 P_c}{1.5 P_c} = 0.8333 \times 100$

$P.S = 83.33\ \%$

(b) $m = 50\% = 0.5$

$\% P.S = \dfrac{P_t - P_{1SB}}{P_t}$

$P_t = P_c\left(1 + \dfrac{0.5^2}{2}\right)$

$P_t = P_c(1.125)$

$P_t = 1.125 P_c$

$P_{1SB} = \dfrac{P_c (0.5)^2}{4} = 0.0625 P_c$

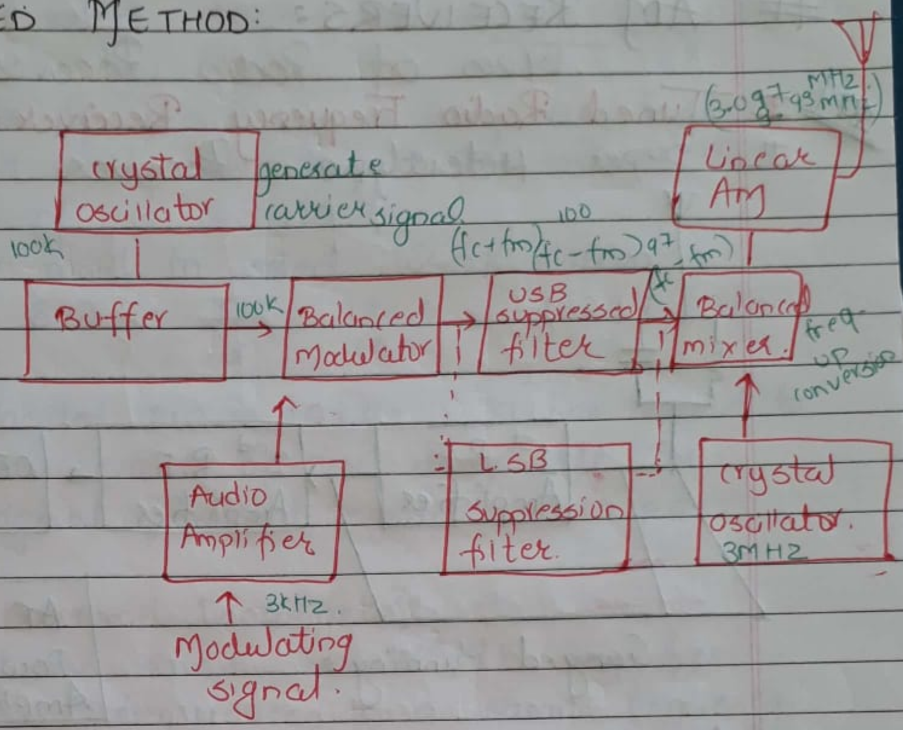
$P.S = \dfrac{1.125 P_c - 0.0625 P_c}{1.125 P_c}$

$P.S = \dfrac{1.0625 P_c}{1.125 P_c} \times 100 = 94.44\%$

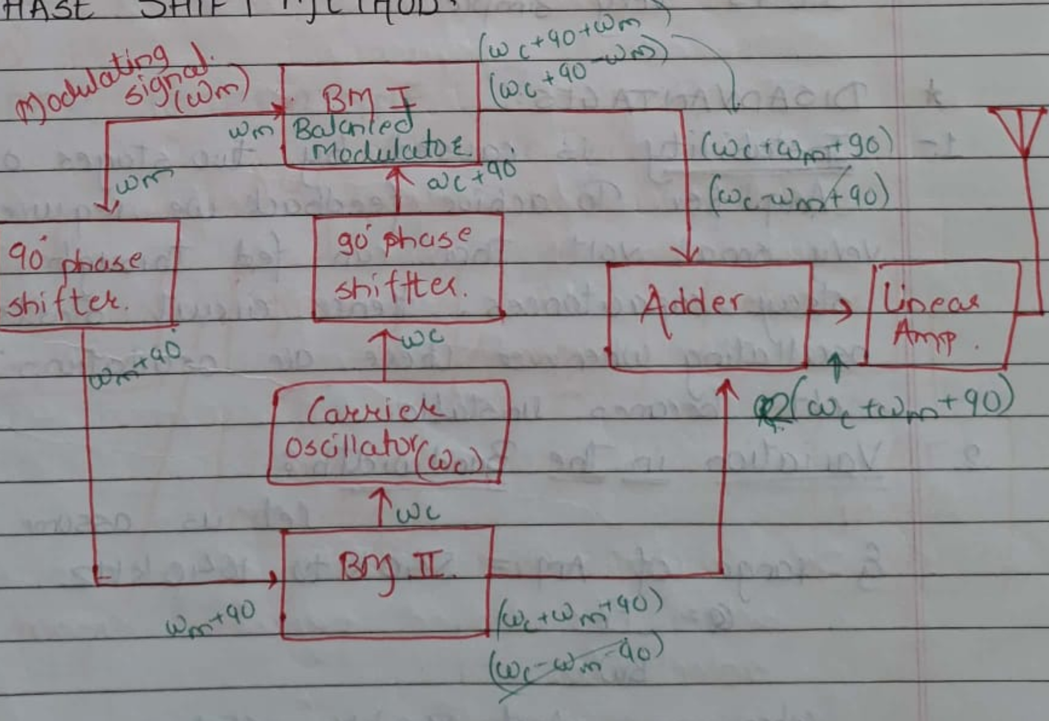
Scanned by CamScanner

SSB-SC

I. FILTERED METHOD:



II. PHASE SHIFT METHOD:



feedback volt = $\frac{1}{gain}$

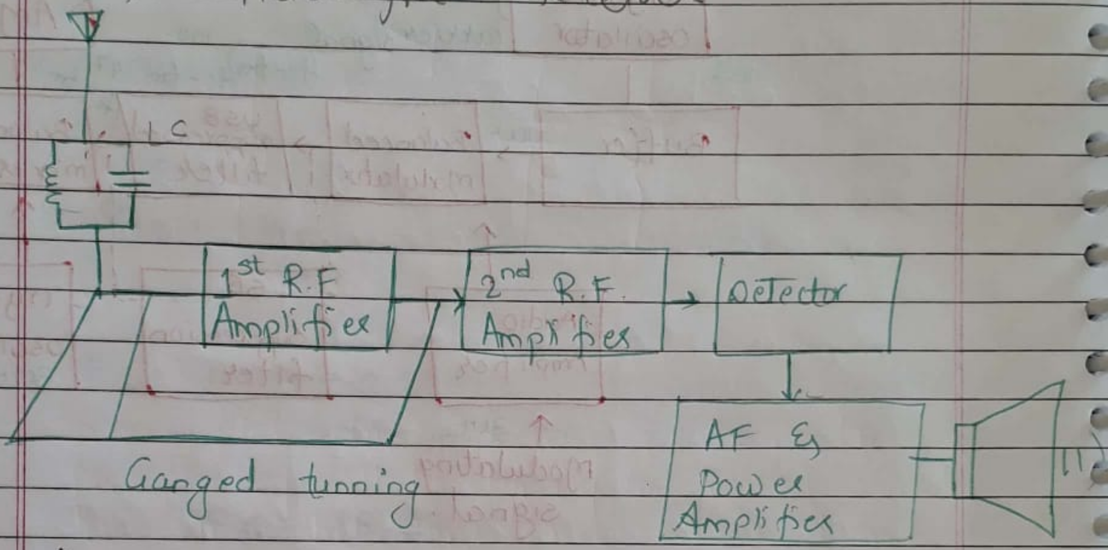
$Q = \frac{fr}{BW}$ fr → resonant freq
Q → quality factor

AM RECEIVERS:

Types of Radio Receiver:

I Tuned Radio Frequency Receiver. (T.R.F).

II Super Heterodyne Receiver



★ ADVANTAGE:

- It is very simple.

★ DISADVANTAGES:

1:- Instability is caused by two stages of RF Amplifier. To achive feedback we require a very small volt. than can fed through stray capacitances. Hence circuit starts oscillating. Whenever there are oscillations then ckt becomes unstable.

2. Variation in the Bandwidth:

let us assume BW as 10kHz

& range of AM = 540 k to 1640 kHz.

$Q = \frac{Fr}{BW}$

when we select 540 kHz station

Q becomes $\frac{540k}{10k} = 54$

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when we select 1640k station $Q = \frac{1640k}{10k} = 164$.

The value of Q ie 164 is very very high. Practically it is impossible to get this value. The max value of Q is 120.

∴ if we want to select 1640k station. required B.W is $\frac{Fr}{Q} = \frac{1640}{120} = 13.67$ kHz

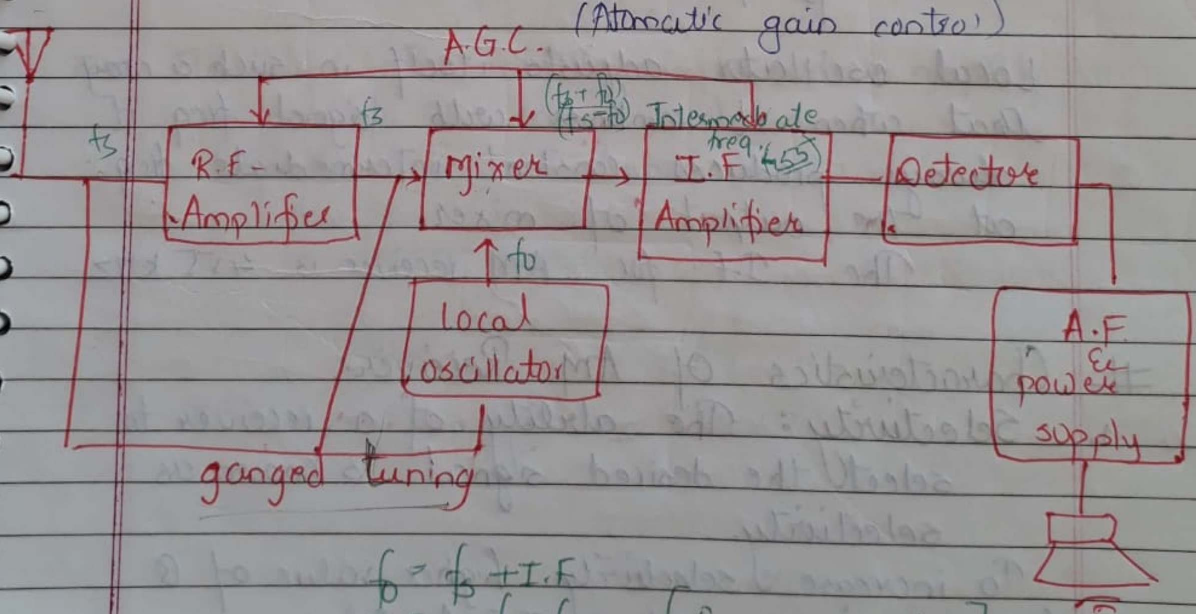
But allocated BW is 10kHz & it has varied to 13.67 kHz because of this along with the wanted signal, unwanted signal is also pass.

* How to overcome Drawbacks?:

i) for instability remove the 2nd RF Amplifier.

ii) Convert all frequencies in a same frequency to avoid BW variation.

SUPER HETERODYNE RECEIVER: (10M)



$f_0 = f_s + I.F$

$I.F. = f_0 - f_s$

f_0 = oscillator freq

f_s = signal freq

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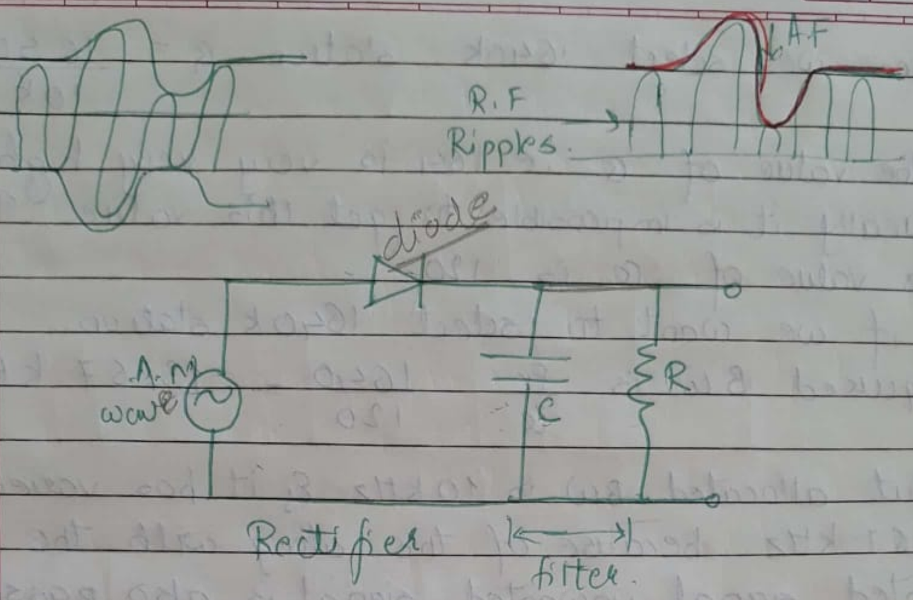

Super Heterodyne Receiver works on the principle of Heterodyning (mixing of signals). In super heterodyne receiver we down convert every received signal freq. into a constant fixed frequency called as Intermediate frequency.

$I.F = f_0 - f_s$

Local oscillator adjusts itself in such a way that when it combines with signal freq it always produces constant intermediate freq at the output of mixer.

The I.F for AM receiver is 455 kHz

Characteristics of AM Receiver:

1. Selectivity: The ability of a receiver to select the desired signal is known as selectivity.

To increase selectivity higher value of 'Q' (tunned ckt) is used in I.F Amplifier.

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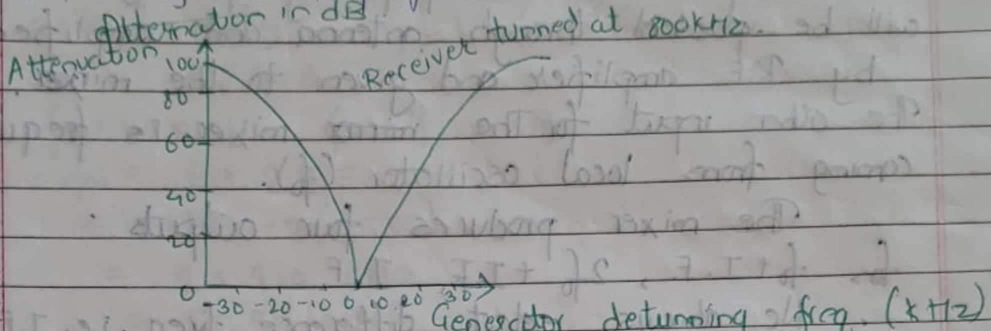
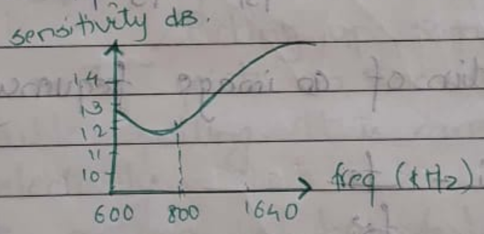
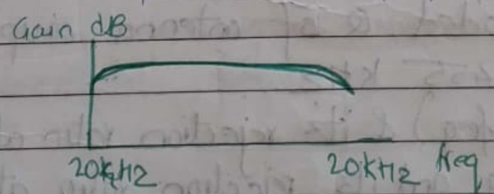
It is determined by freq. response of I.F Amplifier, mixer, & R.F Amplifier.



2. Sensitivity: The ability of receiver to amplify weak signal is sensitivity. OR
The voltage that must be applied to the receiver input terminal to give standard output power.
It is expressed in microvolts.



3. Fidility: The ability of receiver to amplify all signals to the same level.
Depends upon AF Amplifier.



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* IMAGE FREQUENCY & IT'S REJECTION RATIO :

If an unwanted frequency $f_{si} = f_0 + I.F.$ will be passed through antenna and amplified by R.F. amplifier and given to the mixer. The other input for the ~~mirror~~ mixer is frequency coming from local oscillator (f_0).

The mixer produces four outputs :

f_0, $f_0 + I.F.$, $2f_0 + I.F.$, $I.F.$

We always select difference freq. i.e. I.F. which is produced by unwanted signal which will create the interference.

The effect of image frequency is two stations heard simultaneously. Naturally, it is undesirable.

Image frequency is given by $f_{si} = f_0 + I.F.$

But $f_0 = f_s + I.F.$ $\therefore f_{si} = f_s + 2\,I.F.$

The rejection of an image frequency is given by

$$\alpha = \sqrt{1 + Q^2 \rho^2}$$

where $\rho = \frac{f_{si}}{f_s} - \frac{f_s}{f_{si}}$

Q = quality factor of the tank circuit

Q. In broadcast superheterodyne receiver having no. R.F amplifier. The loaded Q of antenna coupling circuit is 100. If I.F. is 455 kHz.

i) Find f_{si} (image freq.) & it's rejection ratio at 1000 kHz.

ii) Find image freq and its rejection ratio at 25 MHz.

Soln: i) $Q = 100$, $I.F = 455$ kHz, $f_s = 1000$ kHz, $f_{si} = ?$, $\alpha = ?$

$f_{si} = f_s + 2\,I.F$

$= 1000 + 2(455)$

$= 1910$ kHz

$$S = \frac{1910}{1000} - \frac{1000}{1910} = 1.386$$

$$\alpha = \sqrt{1 + Q^2 S^2} = \sqrt{1 + (100)^2 (1.386)^2}$$

$$= 138.603$$

ii. $f_s = 25\,MHz$, $f_{si} = ?$, $\alpha = ?$

$$f_{si} = f_s + 2\,I.F$$

$$= 25000 + 2(455)$$

$$= 25910\ KHz$$

$$= 25.91\ MHz$$

$$S = \frac{25.910}{25} - \frac{25}{25.910} = 0.0715$$

$$\alpha = \sqrt{1 + (100)^2 + (0.0715)^2}$$

$$= 7.219$$

★ DOUBLE SPOTTING:

Picking up same shortwave station at two nearby points on the receiver dial is called double spotting. It is caused by poor front end selectively.

Double spotting is harmful because weak station may be masked by reception of nearby strong station at spurious point on the dial.

Double spotting is used to find intermediate frequency.

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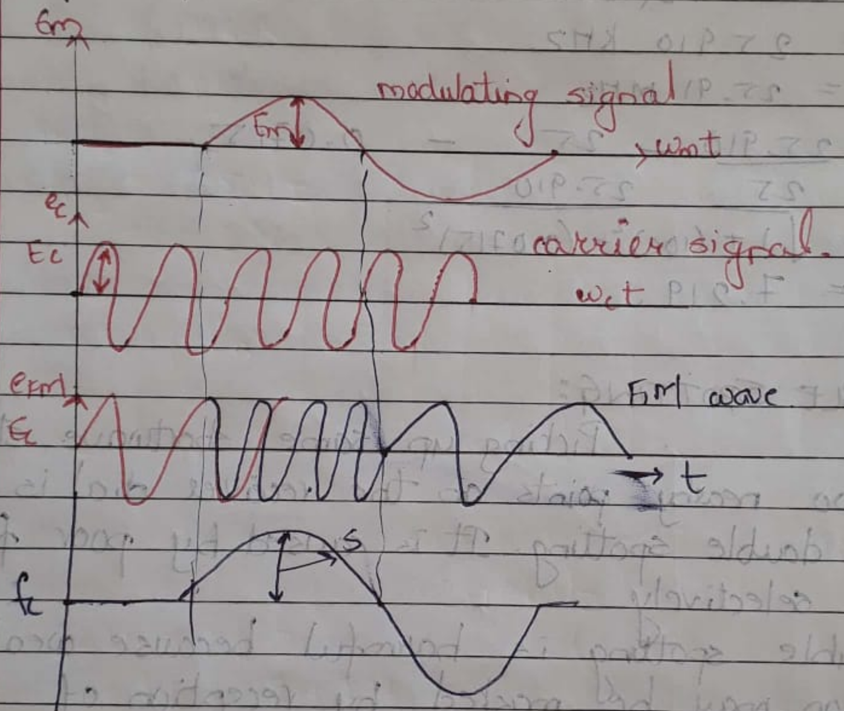
FREQUENCY MODULATION

The process of changing frequency of the carrier wave with respect to the instantaneous value of the modulating signal keeping amplitude constant.

Q. Derive equation for FM or mathematical representation of FM.



Step 1: Frequency of frequency modulated wave depends upon carrier frequency & carrier frequency as well as instantaneous value of the modulating signal.

$f = f_c + kf_c e_m$

$e_m = E_m \cos \omega_m t$

$f = f_c + kf_c E_m \cos \omega_m t$.

The second term $(kf_c E_m \cos \omega_m t)$ is called as deviation and is maximum when $\cos \omega_m t$ is ± 1.
Therefore maximum deviation is $\delta = kf_c E_m$.

$\omega = \omega_c + k\omega_c E_m \cos \omega_m t$ —— (i)

Step 2: Instantaneous value of FM wave is given by

$$e_{FM} = E_m \cos[F(\omega_c, \omega_m)]$$

$$e_{FM} = E_c \cos\theta \quad \text{—— (ii)}$$

Step 3: $\frac{d\theta}{dt} = \omega \quad \therefore \theta = \int \omega\, dt = \int (\omega_c + k\omega_c E_m \cos\omega_m t)\, dt$

$$= \int \omega_c\, dt + k\int \omega_c E_m \cos\omega_m t\, dt$$

$$= \omega_c t + \frac{k\omega_c}{\omega_m} E_m \sin\omega_m t$$

$$= \omega_c t + \frac{k\, 2\pi f_c E_m \sin\omega_m t}{2\pi f_m}$$

$$= \omega_c t + k\frac{f_c}{f_m} E_m \sin\omega_m t$$

$$= \omega_c t + m_f \sin\omega_m t \quad \text{—— (iii)}$$

$$\theta = \omega_c t + m_f \sin\omega_m t$$

substituting in (ii)

$$e_{FM} = E_c \cos(\omega_c t + m_f \sin\omega_m t)$$

There is no solution for cos of sine function. It can be expanded using Bessel's function.

$$e_{FM} = E_c \{ m_f J_0 \sin\omega_c t + m_f J_1 [\sin(\omega_c + \omega_m)t - \sin(\omega_c - \omega_m)t] +$$

$$m_f J_2 [\sin(\omega_c + 2\omega_m)t + \sin(\omega_c - 2\omega_m)t] +$$

$$m_f J_3 [\sin(\omega_c + 3\omega_m)t - \sin(\omega_c - 3\omega_m)t] +$$

$$m_f J_4 [\sin(\omega_c + 4\omega_m)t + \sin(\omega_c - 4\omega_m)t] +$$

$$\vdots$$

ex. When modulating frequency in F.M is 400Hz & modulating voltage is 2.4V & modulation index is 60. Cal max. deviation. What is modulation index when modulation freq. is reduced to 250Hz & m.v raised to 3.2V.

Given:

$f_{m_1} = 400Hz$

$E_{m_1} = 2.4V.$

$m_{f_1} = 60$

$m_{f_2} = ?$

$f_{m_2} = 250Hz.$

$E_{m_2} = 3.2V.$

① $\delta = k f_c E_m$

$$m_{f_1} = \frac{\delta}{f_m} \quad \therefore \delta = m_{f_1} f_{m_1}$$

$$= 60 \times 400$$

$$= 240kHz$$

② $24kH = kf_c \, 2.4$

$$\therefore kf_c = \frac{24kH}{2.4V}$$

$$= 10\,kHz/V.$$

$$m_{f_1} = \frac{\delta}{f_m} = \frac{kf_c E_{m_2}}{f_{m_2}} = \frac{10 \times 3.2V}{250}^{kHz}$$

$$= 12.8$$

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Q.2. The equation of angle modulated voltage is given by
$v = 10\sin(10^8 t + 3\sin 10^4 t)$.
Calculate carrier & modulating frequency, modulation Index, deviation, power descipated in 10 Ω resistor.

⇒ Comparing given eq with standard fm eq^n, we get foll. parameters:

$e_{fm} = E_c \sin(\omega_c t + m_f \sin \omega_m t)$

$E_c = 10V$, $\omega_c = 10^8$ $m_f = 3$ $\omega_m = 10^4$

i) $2\pi f_c = 10^8$ $2\pi f_m = 10^4$

$f_c = \frac{10^8}{2\pi}$ $f_m = \frac{10^4}{2\pi}$

$f_c = 15.91\,MHz$ $f_m = 1.59\,kHz$

ii) Modulatio Index = $m_f = 3$

iii) deviation:

$\delta = m_f f_m$
$= 3 \times 1.59$
$= 4.77\,kHz$

iv Power dissipated $= \frac{V^2}{R} = \frac{100}{10} = 10W$.

$\frac{E_c^2}{2R} = \frac{(10)^2}{2 \times 10} = 5$

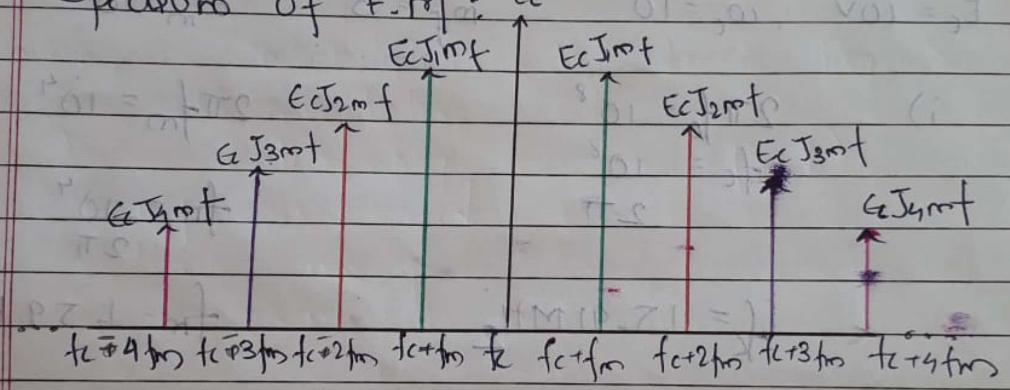
CONCLUSION:

1. F.M. wave consists of carrier and infinite no. of side bands.

2. The amplitude of side bands are decreasing in nature.

3. Amplitude of the FM wave is constant i.e. E_c.

→ Spectrum of F.M.:



Bandwidth of F.M. is infinite. Bandwidth can be found out by carson's rule.
Carson rule found out side bands which are having significant amplitude's of the side band and formulated bandwidth as

$B.W = 2[\delta + f_m]$

δ = max. deviation

OR

$B.W = 2nf_m$

n = no. of side-bands.

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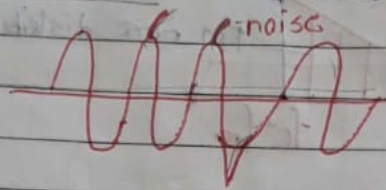
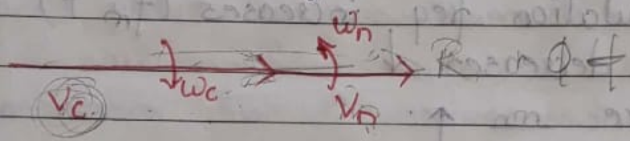
★★★ NOISE IN FM / NOISE TRIANGLE

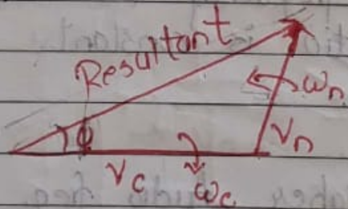
i. When noise changes Amp part of FM signal we use limiter circuit to remove these amplitude variations.



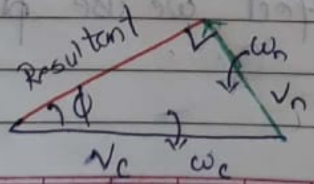
ii. When noise vector super imposes on carrier vector which is in phase with the carrier produces Amp change there is no phase change as shown in vector diagram.



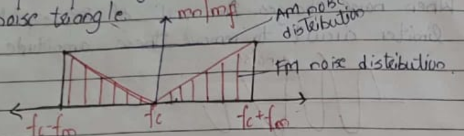
iii. This noise vector rotating with an angular velocity ω_n makes an angle ϕ with resultant. Hence, there is a phase change Hence freq. change also occurs. ∴ we say that noise is present in fm. FM.



iv. When this noise vector makes an angle 90° with resultant that time phase change is maximum. Hence frequency change is also maximum as shown below.



v. The distribution of noise in FM is taking a shape of triangle. Hence it is called as noise triangle.

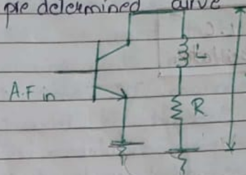


vi. • m_n is modulation index due to noise which is constant.
• m_f is modulation index due to frequency modulation
• As modulation freq increases ($f_m \uparrow$)
  m_f decreases ↓
  Hence $\frac{m_n}{m_f} \uparrow$

Because of This distribution of noise is triangle in FM.
Since modulation index in AM does not depend on modulating frequency ($m = E_m / E_c$)
hence $\frac{m_n}{m_f}$ ratio is constant.

Pre Emphasis: Higher Audio freq. are having lower amp & low amp freq. are having high amp.
Because of This deviation in carrier freq. is diff which leads to noise.
To reduce this effect we use pre emphasis & de-em circuit.

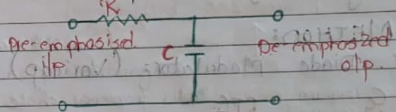
Pre Emphasis: Artificially boosting higher audio frequencies at the transmitter with standard pre determined curve



$V_0 = X_L = 2\pi f L$

$f\uparrow \Rightarrow X_L \uparrow \Rightarrow V_0 \uparrow$

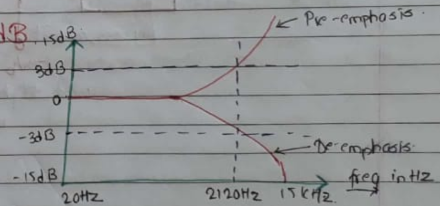
De-Emphasis: The artificially boosted signal at the transmitter must be brought to its original value which is known as de-emphasis.
OR
compensation done at receiver is known as de-emphasis.



$V_0 = X_C = \frac{1}{2\pi f c}$

$f\uparrow \Rightarrow X_C \downarrow \Rightarrow V_0 \downarrow$

Gain in dB



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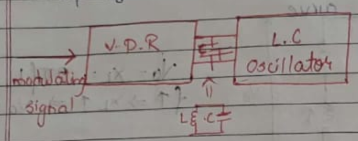
Principle of FM Generation:

~~$C_T + C_d = C$~~ $C_T = C_d + C$

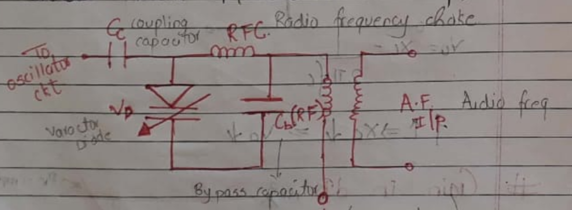


$$f = \frac{1}{2\pi\sqrt{LC_T}}$$

when modulating signal is zero, Reactance of VDR ckt is zero.
Hence, it generates carrier freq.
When modula. signal changes, reactance of VDR changes Hence total reactance changes.
$\therefore$ frequency changes.

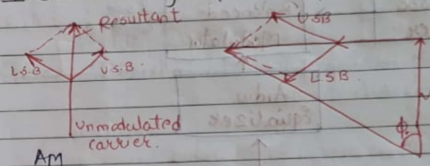
I] DIRECT METHOD:

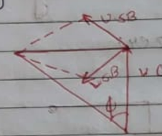
(5M) Varactor Diode Modulator: (Varicap) (variable capacitance)



$-V_b$ is used to bias varactor diode in Reverse bias condn. so that it provides junction capacitance effect.
RFC is used to block carrier frequency entering into modulating signal.
If some RF manage to pass R.F.C. they are grounded by bypass capacitor.
As modulating signal changes, reactance of varactor diode changes & hence total reacta. changes $\therefore$ the frequency changes.

II INDIRECT METHOD: of FM Generation





ϕ change which is linear.

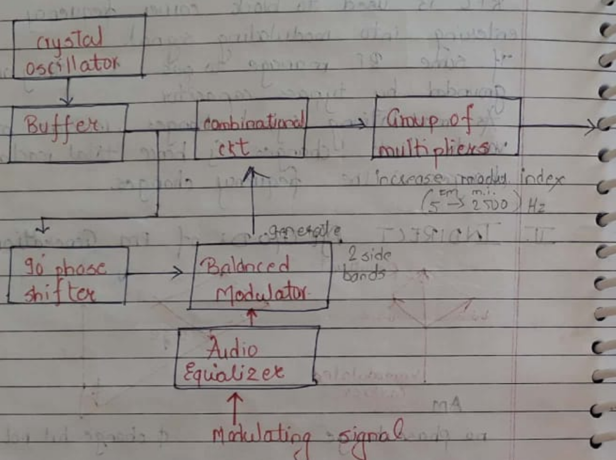
$$e_{FM} = E_c \sin(\omega_c t + m_f \sin\omega_m t) \quad \text{--- (i)}$$

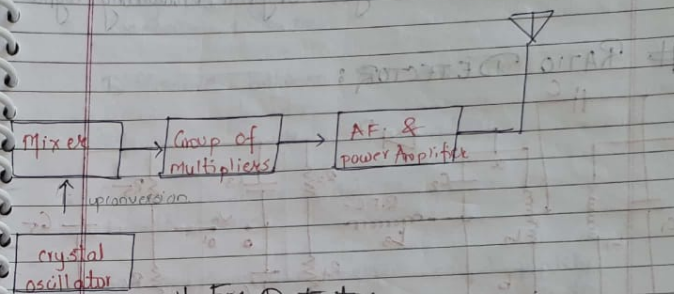
$$m_f = \frac{\delta}{f_m}$$

$$e_{PM} = E_c \sin(\omega_c t + m_p \sin\omega_m t) \quad \text{--- (ii)}$$

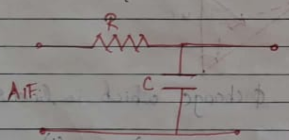
$$m_p \propto \delta \qquad \boxed{m_p = m_f}$$

** 10m Amstrong Method / Indirect Method Of Amplitude generator.





R.C. Audio Equilizer:



$m_p = m_f$

$m_f = \frac{\delta}{f_m}$

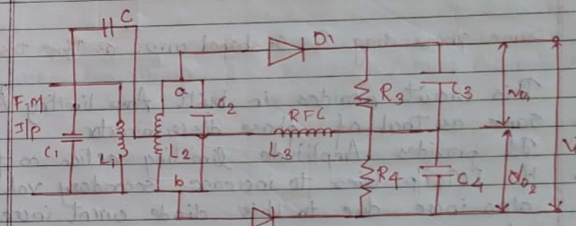
$f_m \uparrow \quad m_f \downarrow$

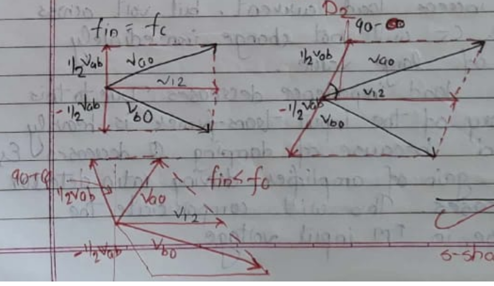
$V_0 = X_c = \frac{1}{2\pi f_c}$

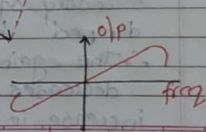
$f \uparrow \quad X_c \downarrow \quad V_0 \uparrow$

FM Detector

Phase Discriminator or Foster Sedy discriminator:



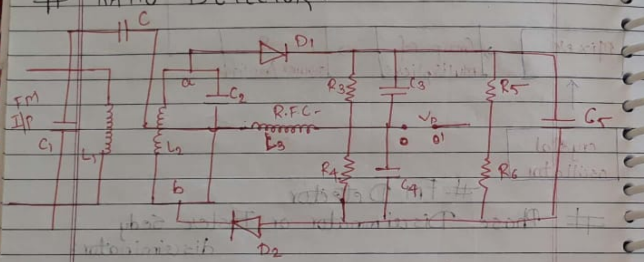




S-shaped curve

The principle of FM Detector is freq to voltage conversion which results in AM and we use AM detector to get original Modulating signal.

RATIO DETECTOR :



Same phasor diag & S-shaped curve as Phase Discriminator.

This circuit provides in built Amp limiting Action.

i. Same as that of phase discriminator.

ii) It provides Amplitude limiting action as follows:

- If FM i/p tries to increase, secondary vol. also incre. due to this diode current incre. which increas load current. but volt across capac. C_5 will not change immediately because of large value.

Hence load impedence decreases. Due to this secondary of the input transformer is heavily damped because of damping Q decreases E_s ∴ the gain of amplifier driving ratio detector decreases. This will compansate the increase in FM input voltage.

ADVANTAGES :

1. In built Amplitude limiting
2. Easy to align
3. Linearity is better

Difference between AM and FM.

AM	FM
• frequency & phase remains constant.	amp & phase remains same.
• poor sound quality.	better sound quality
• transmit longer distance.	higher bandwidth
• freq range of AM radio varies from 535 to 1705 kHz.	freq range of FM is 88 to 108 MHz in higher spectrum
• More susceptible to noise.	Less susceptible to noise.

01/09/2017

Noise is an unwanted signal which interferes with the original message signal & corrupts the parameters of the message signal.

NOISE

NOISE — unwanted electrical disturbance.

- Co-related Noise — when signal is present noise present
  - Intermodulation Distortion (f_c, f_m, $(f_c + f_m)$) — f_c carrier → Mixer ← f_m modulating
  - Harmonic Distortion — produced by harmonics of fundamental fq — FM
- Uni co-related Noise — even signal not present, noise present
  - Internal Noise (Radio)
    - Short Noise — when the o/p electrode start behaving randomly
    - Transitive Time Noise — not removed properly from place
    - *Thermal Noise — Johnson, White. affect all noise.
    - Flicker Noise — low freq noise (tubelight)
  - External Noise
    - Atmospheric Noise
    - Man made Noise
    - Extra Terestrial Noise
      - Solar — sun rays, x-rays, γ-rays
      - Cosmic

⇒ Can reduce the effect of Noise → Statistical

If noise produced

Internal :- noise generated inside the receiver

External : — " — outside — " —

TYPES OF INTERNAL NOISE:

* Shot Noise : It is caused by random arrival of carriers (electrons / holes) at the o/p element of an electronic device such as diode, FET, BJT.

When amplified shot noise sounds similar to metal palates falling on a tin roof.

Shot Noise for diode is given by

$I_n = \sqrt{2 q I_0 B}$

I_n = r.m.s noise current

I_0 = DC current in device

B = Bandwidth

q = Charge 1.6×10^{-19} Columbs.

* Transit Time Noise:

Any modulation to a stream of carriers as they pass from i/p to o/p of device produces an irregular random variation. This is called Transit Time Noise. This are excessive at high frequency.

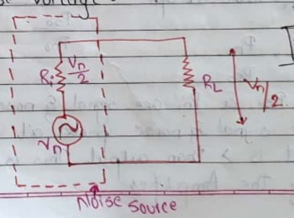
* Thermal Noise / White / Johnson / Thermal Agitation Noise:

Rapid and random movement of electrons within conductor due to heat is thermal Noise.

* Flicker Noise: In semi conductor device flicker noise is generated due to fluctuations in the carrier density. These exist for very low frequency.

NOISE PARAMETERS:

1 Noise Voltage:



$\boxed{P_n = KTB}$

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$$P = \frac{V^2}{R}$$

$$V^2 = PR$$

$$V = \sqrt{PR}$$

$$\frac{V_n}{2} = \sqrt{KTB.R}$$

$$\boxed{V_n = \sqrt{4KTB.R}}$$

T = Temperature
R = Resistance
B = Bandwidth
K = Boltsmann Constant 1.38×10^{-23}

2] SIGNAL TO NOISE POWER RATIO:

It is a ratio of signal power to the noise power. $\frac{S}{N} = \frac{P_s}{P_n}$ and it is always expressed in dB.

$$(S/N)_{dB} = 10 \log (P_s/P_n) = 10 \log \left(\frac{V_s^2/R_{in}}{V_n^2/R_{out}} \right)$$

$$R_{in} = R_{out}$$

$$\therefore (S/N)_{dB} = 10 \log (V_s/V_n)^2$$

$$(S/N)_{dB} = 20 \log (V_s/V_n)$$

3] NOISE FACTOR AND NOISE FIGURE:

It is defined in terms of signal to noise ratio at the input & the output of the system.

$$F = \frac{S/N \text{ ratio at input}}{S/N \text{ ratio at o/p}} = \frac{\frac{P_{si}}{P_{ni}}}{\frac{P_{so}}{P_{no}}}$$

$$F = \frac{P_{si}}{P_{ni}} \times \frac{P_{no}}{P_{so}}$$

where P_{si} & P_{ni} are signal & noise power at I/P, P_{so} & P_{no} are signal & noise power at o/p.
SNR at input is > than output. This is due to the noise added by the Amplifier.

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Noise factor is the means to measure the amount of noise added.
The ideal value of Noise factor is unity.

NOISE FIGURE: Noise factor expressed in decibels dB is Noise figure.

$$10 \log F$$

$$= 10 \log \left[\frac{S/N \text{ at i/p}}{S/N \text{ at o/p}} \right]$$

$$N.F. = 10 \log (S/N)_i - 10 \log (S/N)_o$$

N.F can be improved by using amplifier & mixtuer stages that produce low noise.

4] NOISE TEMPERATURE:

It is defined as temperature at which noisy register has to be maintained so that by connecting this resistor to the input of noiseless system it will produce the same amount of noise power at the system o/p as that produced by actual system.

5] Equivalent Noise Temp. (T_{eq}) at Amplifier I/p:

The noise at the i/p of the amplifier is given by $P_{no} = (F-1) k T_0 B$. This noise power can be alternatively represented by

$$k T_{eq} B = (F-1) k T_0 B$$

$$\boxed{\therefore T_{eq} = (F-1) T_0} \quad T_0 = \text{reference temp.}$$

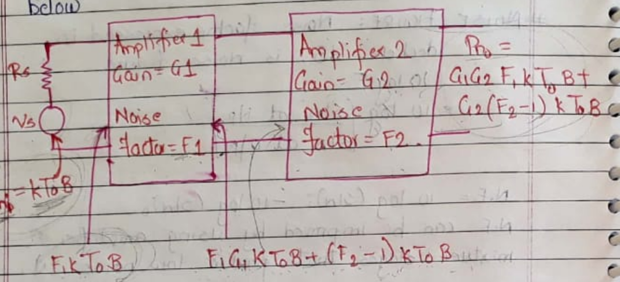
U.T. 5m

**# Noise factor of Amplifier in cascade (Friss formula)

Gain = $\frac{o/p}{i/p}$

NOISE FACTOR OF AMPLIFIER IN CASCADE (FRISS FORMULA) 3

Consider 2 Amp connected in cascade as shown below



The total noise power at the i/p of 1st Amplifier is

$P_{ni\ total} = F_1 k T_0 B$

The total noise power at the o/p of 1st Amplifier will be addition of two terms

*Noise i/p to amplifier 2 $= F_1 G_1 k T_0 B + (F_2 - 1) k T_0 B$

The first term represent the Amplified Noise Power & second term represents Noise Configurated by 2nd Amplifier

The noise power at o/p of 2nd Amplifier is G2 times the i/p noise power to the Amplifier 2.

$P_{no} = G_2 \times$ (Noise i/p to amplifier 2)

$= G_2 (F_1 G_1 k T_0 B + (F_2-1) k T_0 B)$

$= G_1 G_2 F_1 k T_0 B + G_2 (F_2 - 1) k T_0 B$

The overall gain of cascode connection is

$G = G_1 \times G_2$

The overall Noise Factor 'F' is defined as

$F = \frac{P_{no}}{G_1 G_2 P_{ni}}$ where P_{ni} is Noise Power supplied by i/p source. (kT_0B).

substitute the values of P_{no} & P_{ni} we get F as.

$$F = \frac{G_1 G_2 F_1 k T_0 B + G_2 (F_2 - 1) k T_0 B}{G_1 G_2 k T_0 B}$$

$$\boxed{\therefore F = F_1 + \frac{(F_2 - 1)}{G_1}}$$

Same logic can be extended for more no. of amplifiers connected in cascade

$$\therefore F = F_1 + \frac{(F_2-1)}{G_1} + \frac{(F_3-1)}{G_1 G_2} + \frac{(F_4-1)}{G_1 G_2 G_3} + \dots$$

This is Friss Formula.

NUMERICAL:

Q An Amplifier operating over freq. range from 18 – 20 MHz as 10k Ω i/p resistance. What is rms voltage at i/p to this Amplifier if temp is 27°.

Soln:

$V_n = \sqrt{4kTBR_n}$

$V_n = \sqrt{4 \times 1.38 \times 10^{-23} \times 300 \times 2 \times 10^6 \times 10 \times 10^3}$

$= 1.05 \times 10^{-6}$

$= 18.19 \times 10^{-6}$

$T = °C + 273$

$= 27 + 273$

$= 300K$

$B = 20 - 18$

$= 2 \times 10^6$ Hz.

$R = 10 \times 10^3$

$k = 1.38 \times 10^{-23}$

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Q. Calculate Noise Voltage at the i/p of R.F Ampli using device that has 200 Ω equivalent & 300 Ω i/p resistance at temp of 17° & Bandwidth of 6MHz

Soln. Given

$R_1 = 200\ \Omega$

$R_2 = 300\ \Omega$

$B = 6 \times 10^6\ Hz$.

$T = 17 + 273\ K$

$= 290\ K$.

$V_{n_1} = \sqrt{4KTBR_n}$

$= \sqrt{4 \times 1.38 \times 10^{-23} \times 290 \times 6 \times 10^6 \times 200}$

$=$

$V_{n_2} = \sqrt{4 \times 1.38 \times 10^{-23} \times 290 \times 6 \times 10^6 \times 300}$

$=$

$V_n = \sqrt{V_{n_1}^2 + V_{n_2}^2}$

$V_n = 6.93$

In radio communication, a radio receiver is an electronic device that receives radio waves & converts the information carried by them to a usable form. It is used with an antenna. The receiver uses electronic ~~signals~~ filters to separate the desired radio freq. signal from all the other signals picked up by the antenna, an electronic amplifier to increase the power of signal for further processing

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2m Q1. Draw basic block diag. of communication.
2. Modulation, Demodulation Defination
3. Define Modulation Index ?
4. Define AM ?
5. Need for Modulation.
Define Noise
Types of Internal Noise (Noise defination) } Definition
All → Noise parameter
Radio Receivers - Definition & types.
Pre Emphasis & Demphasis
Noise Triangle.

5m.
Q2. Derive eq of FM (find bandwidth) & AM. (till AM Spectrum)
Power Relationship AM w.r.t a.
Friss formula
Super heterodyne Receiver.
Indirect FM Generation (Amstrong)
Explain Different types of AM.

Q. A 3 stage Amplifier has the following power gains & noise figure for each stage

Stage	Power Gain	Noise figure
1	10	2
2	20	4.
3.	30	5

Calculate power gain, n.fig. & noise temperature for entire Amplifier assuming matched condition.

Amp 1 → Amp 2 → Amp 3

$G_1 = 10$ $G_2 = 20$ $G_3 = 30$

$F_1 = 2$. $F_2 = 4$ $F_3 = 5$

$\begin{bmatrix} t \to x \\ \omega, f \to X \end{bmatrix}$

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G = ?
F = ?
T = ?

i) $G = G_1 \times G_2 \times G_3$
$= 10 \times 20 \times 30$
Gain = 6,000.

ii) Noise figure:
$F = F_1 - 1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2}$ (using this formula.

$F = 2 + \frac{4-1}{10} + \frac{5-1}{10 \times 20}$

$= 2.32$

Noise figure (in dB) = $10 \log 2.32$
$= 3.655$ dB

iii) $T_{eq} = T_0(F-1)$

$T_0 = 27° + 273$ K
$= 300$ K

$T_{eq} = 300(2.32 - 1)$
$= 396°$K. in dB

FOURIER TRANSFORM:

$x(t) \xleftrightarrow{F.T} X(f) \Rightarrow X(\omega)$

$F.T[x(t)] = X(\omega)$

$$X(\omega) = \int_{-\infty}^{\infty} x(t)\, e^{-j\omega t}\, dt$$

$$X(f) = \int_{-\infty}^{\infty} x(t)\, e^{-j2\pi f t}\, dt.$$

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Inverse fourier transform:

$X(\omega) \xleftrightarrow{IFT} x(t)$

$I.F.T\,(X(\omega)) = x(t)$

$$x(t) = \frac{1}{2\pi} \int_{-\infty}^{\infty} X(\omega)\, e^{j\omega t}\, d\omega.$$

CONDITIONS:

(1) Function $x(t)$ should be single valued in any finite time interval.
(2) It should have finite no. of discontinuties.
(3) Function $x(t)$ should have finite no. of maxima and minima.
(4) $x(t)$ should be absolutely integral function.

PROPERTIES:

(i) Time Shifting:
If $x(t)$ & $X(f)$ form fourier transform pair then $x(t - t_d) \xleftrightarrow{F.T} e^{-j2\pi f t_d} X(f)$.

Proof:

$$F.T[x(t - t_d)] = \int_{-\infty}^{\infty} x(t - t_d)\, e^{-j2\pi f t}\, dt$$

put $t - t_d = \tau$
$\therefore dt = d\tau$

$$F.T[x(t - t_d)] = \int_{-\infty}^{\infty} x(\tau)\, e^{-j2\pi f(t_d + \tau)}\, d\tau$$

$$= \int_{-\infty}^{\infty} x(\tau)\, e^{-j2\pi f t_d}\, e^{-j2\pi f \tau}\, d\tau$$

$$F.T(x(t - t_d)] = e^{-j2\pi f t_d} \int_{-\infty}^{\infty} x(\tau)\, e^{-j2\pi f \tau}\, d\tau$$

$$\boxed{= e^{-j2\pi f t_d} X(f).}$$

11/09/17

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ii) Frequency Shifting:

If $x(t)$ & $X(f)$ form fourier transform pair

Then $e^{j2\pi f_0 t}x(t) \xleftrightarrow{F.T} X(f-f_0)$

$$\Rightarrow F.T\left[e^{j2\pi f_0 t}x(t)\right] = \int_{-\infty}^{\infty} x(t)\, e^{j2\pi f_0 t} \cdot e^{-j2\pi f t}\, dt$$

$$= \int_{-\infty}^{\infty} x(t)\, e^{-j2\pi (f-f_0)t}\, dt$$

$$= X(f-f_0)$$

iii Convolution in Time Domain.

$$[x_1(t) * x_2(t)] \xleftrightarrow{F.T} X_1(f)X_2(f)$$

$$x_1(t) * x_2(t) = \int_{-\infty}^{\infty} x_1(\lambda)x_2(t-\lambda)\, d\lambda.$$

Proof:

$$F.T\,[x_1(t) * x_2(t)] = \int_{-\infty}^{\infty}\left[\int_{-\infty}^{\infty} x_1(\lambda)x_2(t-\lambda)\, d\lambda\right] e^{-j2\pi f t}\, dt.$$

Multiply & divide R.H.S by $e^{-j2\pi f\lambda}$

$$F.T\,[x_1(t) * x_2(t)] = \int_{-\infty}^{\infty}\left[\int_{-\infty}^{\infty} x_1(\lambda)x_2(t-\lambda)\, d\lambda\right] e^{-j2\pi f t}\, dt \cdot \frac{e^{-j2\pi f\lambda}}{e^{-j2\pi f\lambda}}$$

$$= \int_{-\infty}^{\infty}\left[\int_{-\infty}^{\infty} x_1(\lambda)x_2(t-\lambda)\, d\lambda\right] e^{-j2\pi f t}\, dt\; e^{-j2\pi f\lambda}\; e^{j2\pi f\lambda}$$

$$= \int_{-\infty}^{\infty} x_1(\lambda)\, e^{-j2\pi f\lambda}\, d\lambda \cdot \int_{-\infty}^{\infty} x_2(t-\lambda)\, e^{-j2\pi f(t-\lambda)}\, dt$$

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put $(t-\lambda) = m$

$$= \int_{-\infty}^{\infty} x(\lambda)\, e^{-j2\pi f\lambda}\, d\lambda \int_{-\infty}^{\infty} x_2 m\, e^{-j2\pi f m}\, dt.$$

11/09/2017

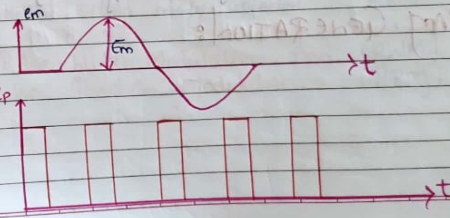
PULSE MODULATION

Instead of using continuous carrier for modulation we use discontinuous train of pulses as carrier. Hence this type of modulation is called Pulse Modulation.

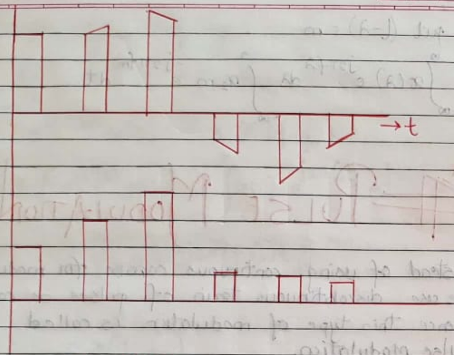
Pulse Modulation

- Analog Pulse Modulation
  - PAM
  - PWM
  - PPM
- Digital Pulse Modulation
  - PCM
  - DM
  - ADM.

1) Pulse Amplitude Modulation: The process of changing amplitude of the high frequency carrier train pulse w.r.t instantaneous value of modulating signal keeping width & position constant is called PAM.



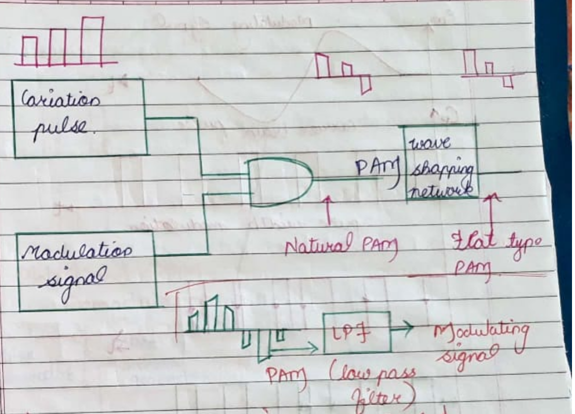
$f_s \geq 2f_m$



Types of PAM:

- If the top of the PAM pulse are flat then it is called flat top PAM
- If top of PAM pulses is the shape of the Modulating signal then it is called Natural PAM.
- If PAM polarities are +ve & −ve then it is called double polarity PAM.
- If PAM is having either +ve / −ve polarity then it is called single polarity PAM.

PAM GENERATION:



Advantages:

i. Compared to continuous wave modulation power requirements are less.

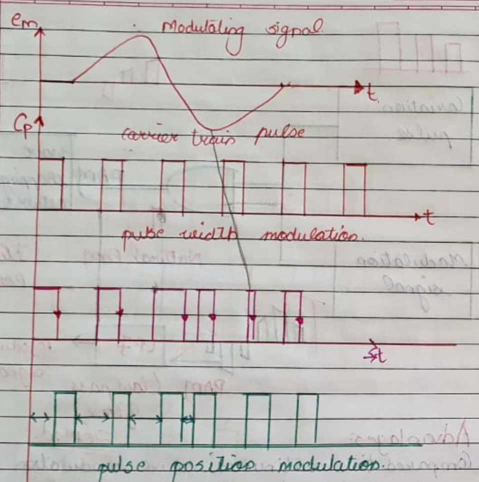
ii. PAM modulators & de-modulators are simple to design & cost effective

iii. Efficiency is more compared to continuous wave.

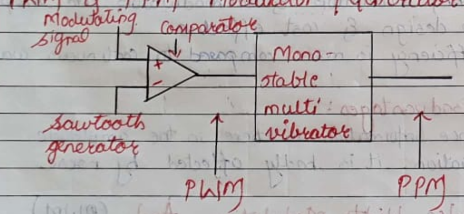
Disadvantages:

i. Since information is there in the amplitude variation it is badly affected by noise.

Pulse Width Modulation (PWM) And Pulse Position Modulation. (PPM)



PWM & PPM Modulator / Generator:



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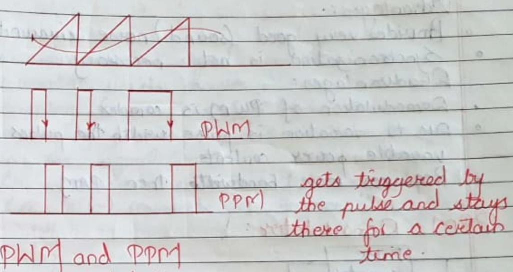
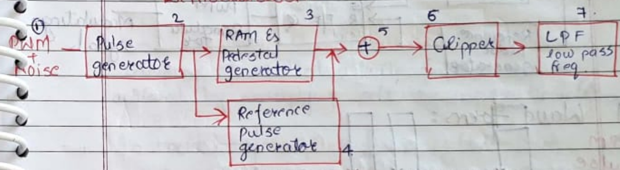
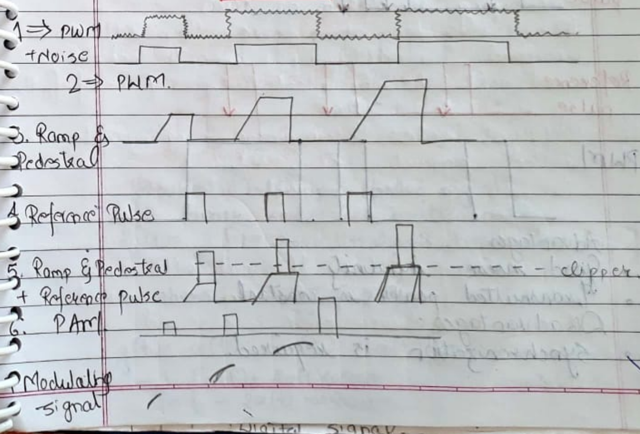


* PWM and PPM Demodulation:





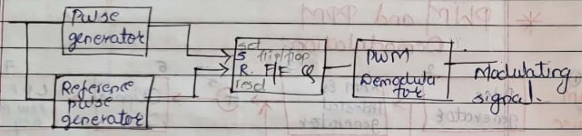
Advantages:

- Provides very good (sound) noise immunity
- Synchronization is not necessary

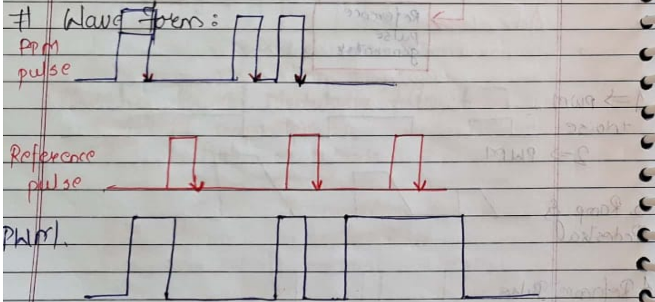
Disadvantages:

- Demodulation of PWM is complex.
- Due to variation is pulse width the pulses have variable power contents
- Requires more bandwidth than PAM.

PPM Demodulator:



Wave forms:



Advantages:

- Good noise immunity
- Transmitted power is constant.

Disadvantages:

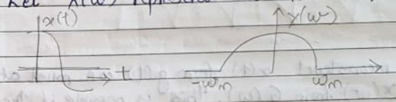
- Synchronization is required.

VVIMP:

State & Proof sampling theorem:

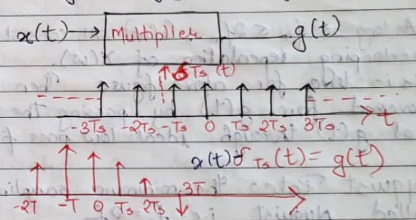
Def^n ⇒ A continuous tank signal may be completely represented in its samples and recovered back if sampling frequency is $f_s \geq 2f_m$, where f_s = sampling frequency & f_m = maximum freq present in the signal.

Proof ⇒ Let us consider continuous time signal $x(t)$. Let $X(\omega)$ represents it fourier transform.



$$X(\omega) = 0 \text{ for } |\omega| \geq \omega_m$$

Sampling of $x(t)$ at a rate f_s Hz may be achieved by multiplying $x(t)$ by impulse train ($\delta_{T_s}(t)$)



Impulse $\delta_{T_s}(t)$ is a period signal

∴ Its fourier series is written as

$$\delta_{T_s}(t) = \frac{1}{T_s}\left[1 + 2\cos\omega_s t + 2\cos 2\omega_s t + 2\cos 3\omega_s t + \dots\right]$$

where $\omega_s = \frac{2\pi}{T_s} = 2\pi f_s$.

$$g(t) = x(t) \cdot \delta_{T_s}(t) = x(t) \cdot \left[\frac{1}{T_s}\left(1 + 2\cos\omega_s t + 2\cos 2\omega_s t + 2\cos 3\omega_s t + \dots\right)\right]$$

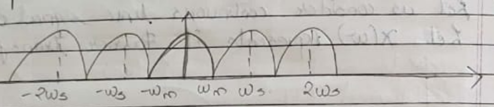
$$= \frac{1}{T_s}\left[x(t) + 2x(t)\cos\omega_s t + 2x(t)\cos 2\omega_s t + \dots\right]$$

Taking fourier transform of g(t)

$$\therefore G_T(\omega) = \frac{1}{T_s}\left[X(\omega) + X(\omega-\omega_s) + X(\omega+\omega_s) + X(\omega-2\omega_s) + X(\omega+2\omega_s) + X(\omega-3\omega_s) + X(\omega+3\omega_s) \ldots\right]$$

$$G_T(\omega) = \frac{1}{T_s}\sum_{n=-\infty}^{\infty} X(\omega - n\omega_s)$$

Spectrum ($G_T(\omega)$):



Step 1: To reconstruct $x(t)$ from $g(t)$ we must able to recover $X(\omega)$ from $G(\omega)$. This is possible if there is no over lap been sucessive cycle of $G(\omega)$.

$f_s \geq 2f_m$. $\quad T_s = \frac{1}{f_s}$, $\therefore T_s \leq \frac{1}{2f_m}$.

$\therefore$ As long as $f_s \leq 2f_m$, $G(\omega)$ will consist of non-overlapping repetation of $X(\omega)$.
This is true for above figure. Then $X(t)$ can be recovered from $g(t)$ by passing the samples signal $g(t)$ through ideal low pass filter of f_m Hz.

Nyquist Rate: The minimum sampling rate is called Nyquist i.e. $f_s = 2f_m$.
$T_s = \frac{1}{2f_m}$ is called nyquist interval.

Anti aliasing filter: If signal $x(t)$ is not band limited or if $f_s < 2f_m$ then an error called aliasing or fold over error is observed.
OR

The phenomenon of high frequency in the spectrum of the original $x(t)$. taking on the identity of the lower frequency in the sampled signal.

Effect Of Aliasing: Some information contain in the original signal is lost in the process of sampling.

25/9/2017

DIGITAL COMMUNICATION

* Advantages:

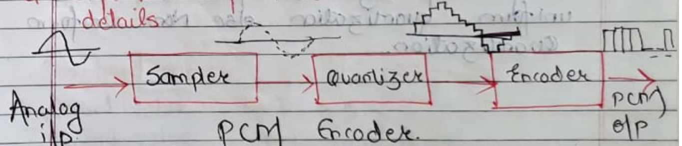
i. Very high noise immunity.
ii. Coding is possible, Therefore we can transmit or send secret information.
iii. High quality reception.
iv. Repeaters are very easy to build for digital inputs.
v. Mathematical operations are easy to perform.

* Disadvantages:

i. Larger Bandwidth requires.
ii. Designer of Analog to Digital converters
iii. Circuits are complex.

⟹ PULSE CODE MODULATION:- PCM.

Q. Explain PCM encoder & decoder in details.



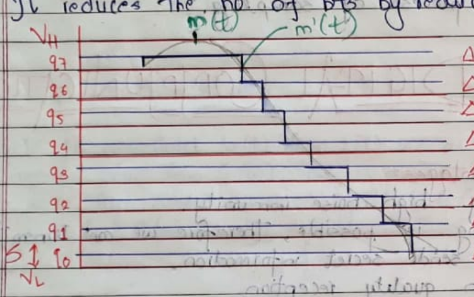
PCM Encoder.

Samplers:

1. Write everything about PAM modular & sampling theorem.

II. Quantizer.

Quantization is a process of approximation.
It reduces the no. of bits by reducing samples.



$$S = \frac{V_H - V_L}{8}$$

Quantization is a process of approximation or rounding of

There are two types of quantizers.

i Uniform quantization

ii Non uniform Quantization.

If step size are equal then it is uniform quantization else Non-Uniform Quantization.

In the above fig., Δ_0 to Δ_7 are 8 levels in betn those levels # we have choosen 8 quantization level q_1 to q_2

The step size is $(s) = \frac{V_H - V_L}{8}$

m(t) is Analog input & m'(t) is quantized outpu

Quantization Error:

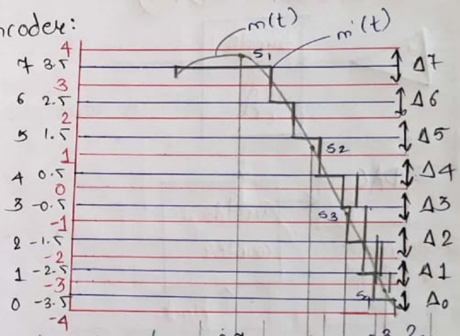
The difference betn original signal & quantized signal is called quantization error.

To reduce quantization error we increase no. of steps.

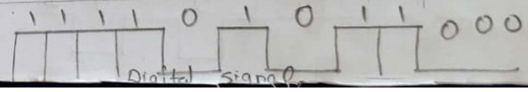
Mean square quantization error $= \frac{S^2}{12}$

$q_e = m(t) - m'(t)$

iii] Encoder:



Exact value of sample.	3.7	1.2	-0.7	-3.2
Quantized sample	3.5	1.5	-0.5	-3.5
Decimal value	7	5	3	0
Binary value	111	101	011	000



PCM Decoder:

PCM i/p → Decoder → Requantizer → LPF Low pass filter → Analog.

Advantage: } ⟹ Same as Digital Circuit.
Disadvantage

Application:

i) Telephone (Fibre Optics)
ii) Satellite
iii) Military applications.

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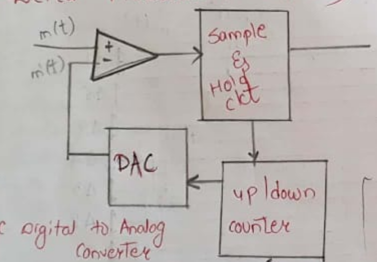
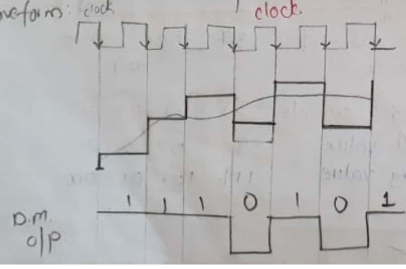
Delta Modulation: (DM)



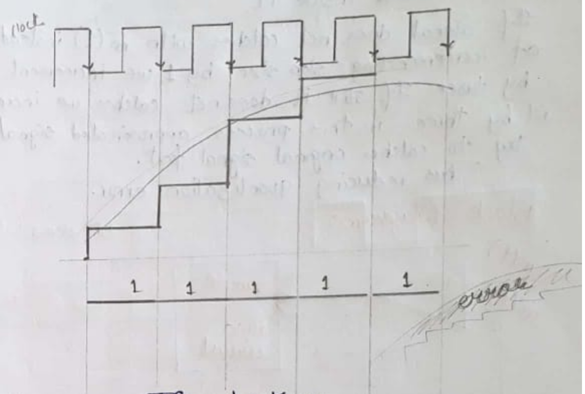
DAC Digital to Analog Converter

Waveform:

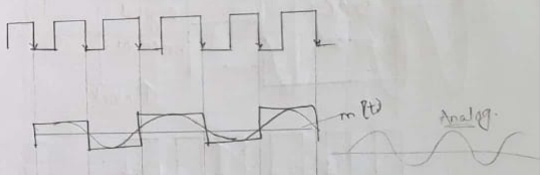


Drawbacks of DM:

i) Slope overload error: The signal which are having high slope delta modulated o/p try to catch up but fails leading to high cantilation error. quantization error.



2) Hunting error or Triangular Error:

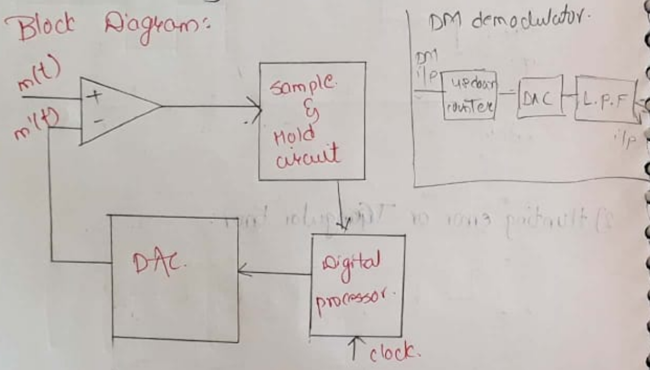


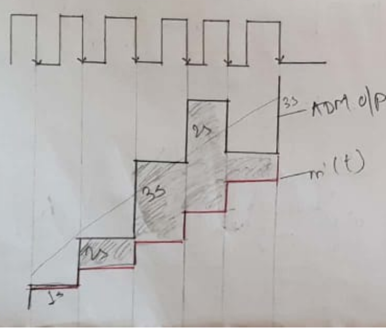
Adaptive DM (ADM)

The problems of DM are overcome by ADM where we are replacing up/down counter by higly intelligent digital processor which is having accumulator inside it.

If signal does not catches with m'(t) instead of incrementing step size by 1 we increement it by twice. If still it does not catches we incremend it by three in this process approximated signal try to catches original signal fast. Thus reducing quantization error.

Block Diagram:



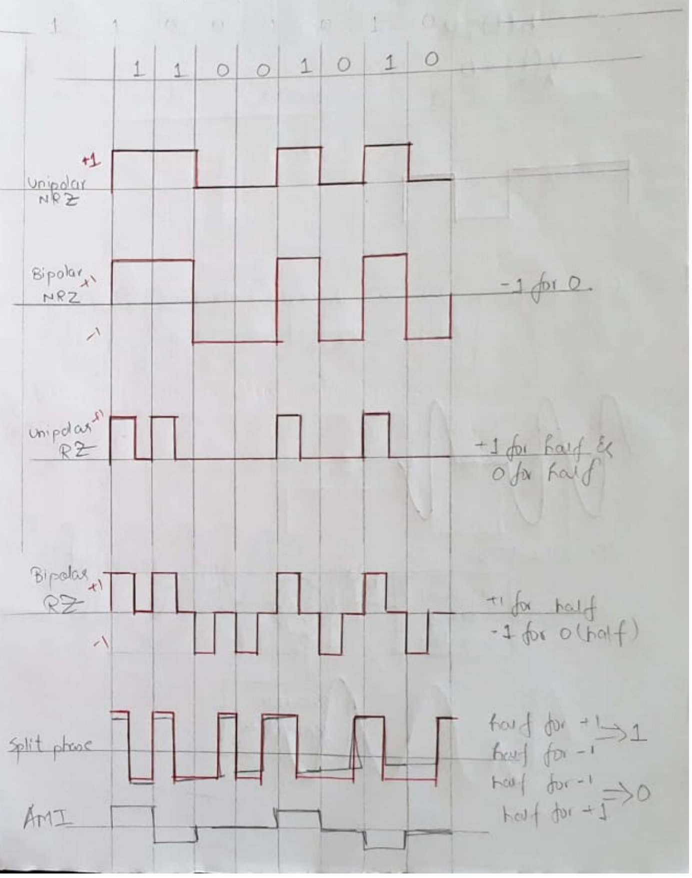


Q. For the given signal draw the line course codes (PCM waveforms) for

09/10/2017

i) Unipolar NRZ
ii) Polar NRZ
iii) Unipolar RZ
iv) Polar RZ
v.) Split phase Manchestor.

AMI
Alternate Mark Invector



Amplitude Shift Keing (ASK)

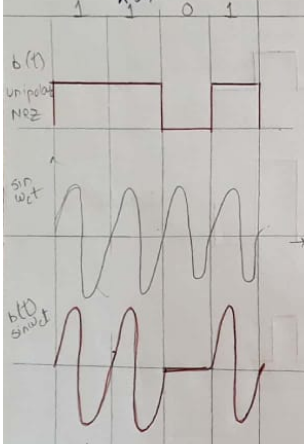
$V_{ASK}(t) = b(t)\sin W_c t$

$b(t) = 1$

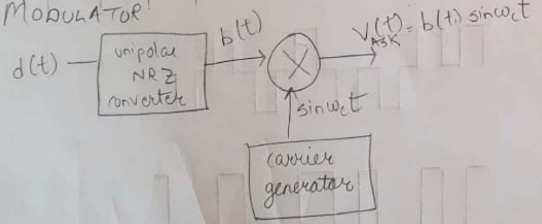
$V_{ASK}(t) = \sin W_c t$

$b(t) = 0$

$V_{ASK}(t) = 0.$

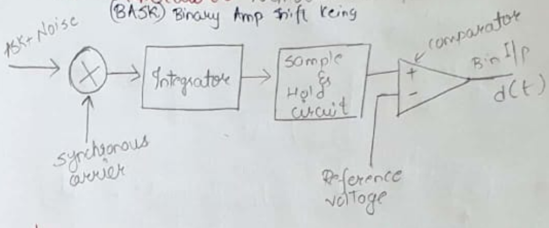


MODULATOR



ASK Generator:- Demodulator / Decoder / Receiver

(BASK) Binary Amp Shift Keing



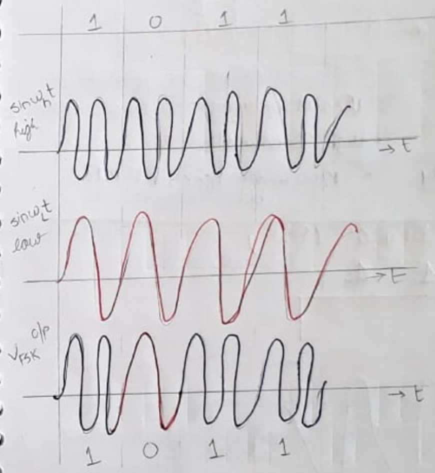
★ Advantage:

1) ASK is simple.

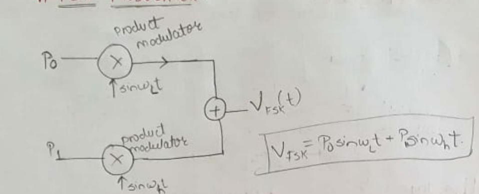
★ Drawback:

- Sensitive to noise.

Frequency Shift Keing.

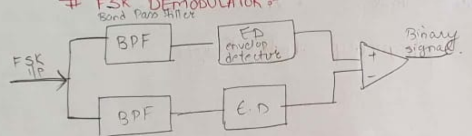


FSK MODULATOR :-



$$V_{FSK} = P_0 \sin\omega_c t + P_1 \sin\omega_h t$$

FSK DEMODULATOR :-



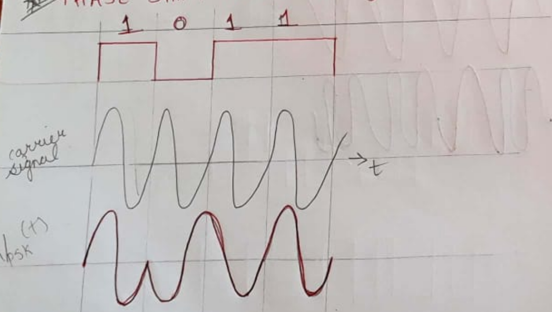
* Advantage :

- Easy To Implement
- Better Noise Immunity

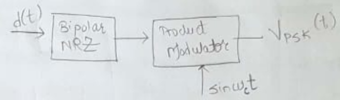
* Disadvantage

- High Bandwidth
- 1200 ~~width~~ bit/sec (bit rate)

PHASE SHIFT KEING (PSK)



* PSK MODULATOR *



Used in Telephone system

DEMODULATOR ⇒ SAME AS BASK

* Advantage

- Bandwidth is less than FSK
- Best performance in presence of Noise.

* Disadvantage

- Generator & detector not easy
- 800 bit/sec.

MULTIPLEXING TECHNIQUE

- Multiplexing is a Process Of transmiting more than 1 signal over a single communication channel.
- Due to multiplexing it is possible to increase no. of communication channel so that more information can be transmited.
- Multiplexing is used in telephone, satellite, radio & delemetry.

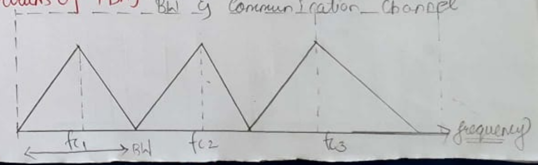
IAE 2

** Types Of Multiplexing :

I] FREQUENCY DIVISION MULTIPLEXING :

FDM is a process of transmitting many signals to each signal occupying different frequency slot within common bandwidth.

* Spectrum Of FDM : BW & Communication Channel



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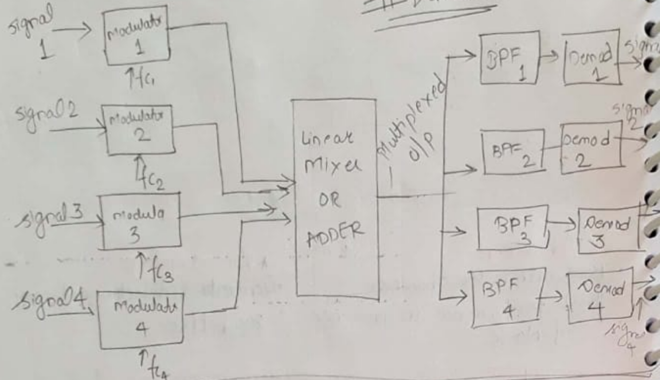
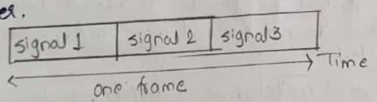
TRANSMITTER:

Demodulator

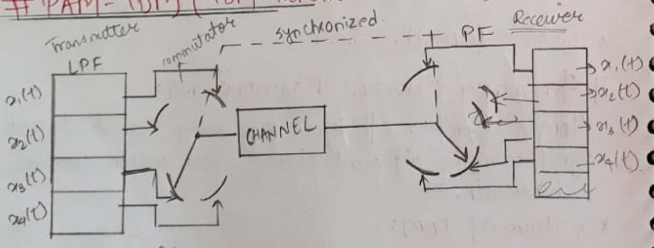


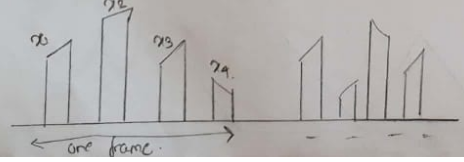
II] TIME DIVISION MULTIPLEXING:

In TDM each signal occupy entire Bandwidth & after sometime the entire BW is used by the other user.



PAM-TDM (TDM Transmitter /Receiver)





*Advantages:

- Full Bandwidth is utilized for each channel.
- Circuit is simple.
- Crosstalk is not there. There is no intermodulation.

*Disadvantages:

- Synchronization is essential.

Difference betn FDM & TDM:

FDM	TDM
• The signals which are to be multiplexed are added in Time Domain but occupy different slots in frequency domain.	• The signals to be multiplexed can occupy entire Bandwidth but they are isolated with Time Domain
• FDM is used for analog signals	TDM is used for digital signals.
• Synchronization is not required.	• Synchronization is required.
• Circuit of FDM is complex	• Circuit of TDM is simple.
• Cross talk is severe	• Cross talk is not that severe

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UT II

5m * FM Demodulator
(Ratio Detector)

* Delta Modulation
- Drawbacks
- Overcome

* PWM / PPM Modul & DeModul.

* Sampling Theorem for LPBS.

* Diff betn PAM, PWM & PPM

* PCM transmitter, receiver.

2m * What is quantization
- quantiz error
- sampling thm - statement
- Nyquist criteria
- PAM, PWM, PPM - waveform
- Slope overload - waveform (errors
- PAM Modulation & DeModulation.