Chapter 1 – Introduction to Electronic Communicatn

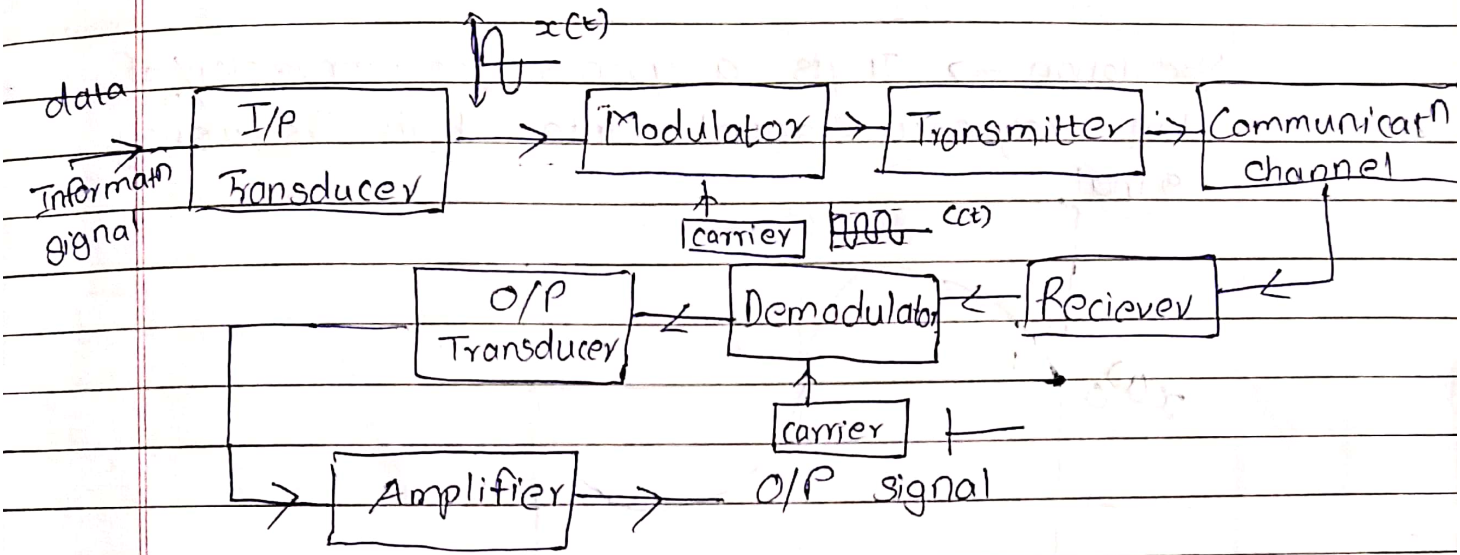
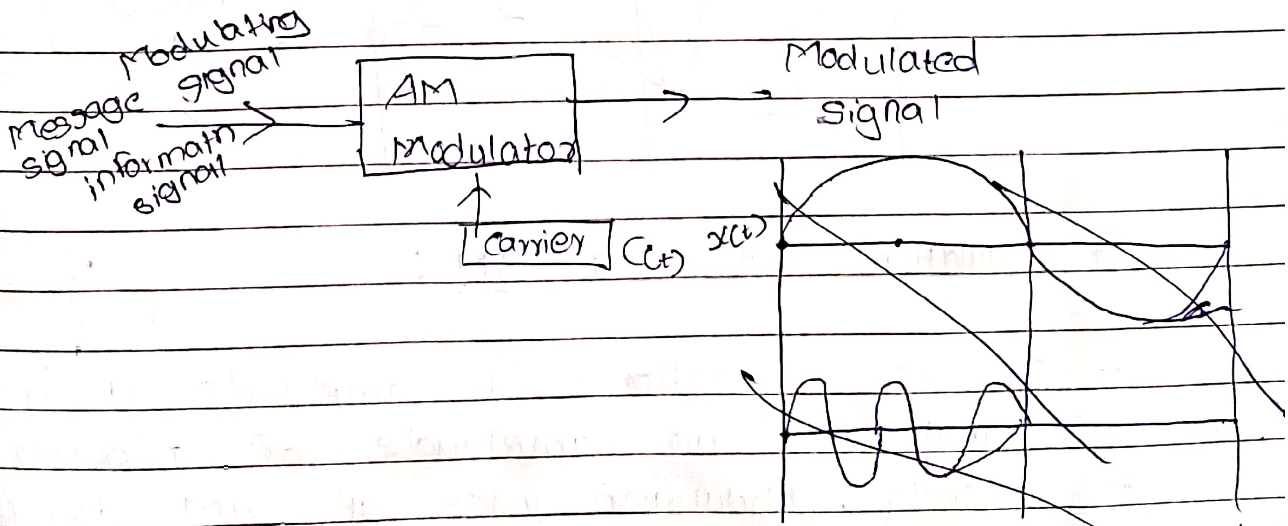


fig:- Basic Block Diagram of communicatn system.

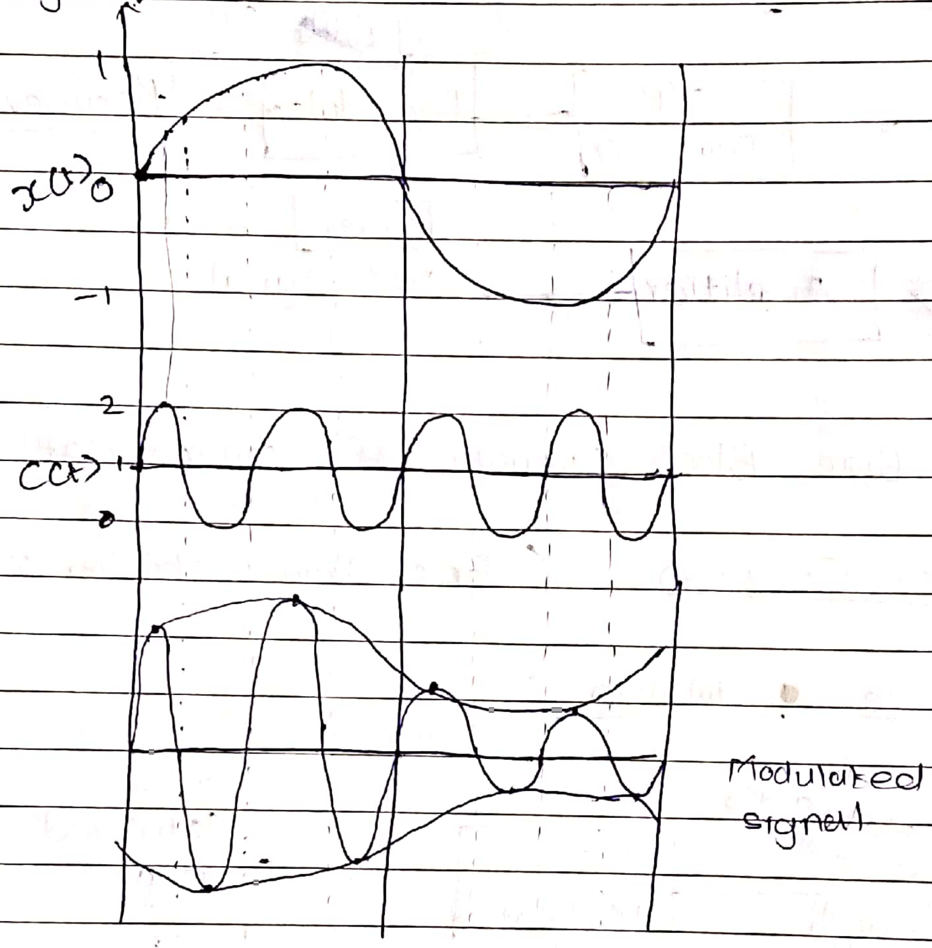
* Practical (10/07/23) (Topic from chapter 2)

Amplitude Modulation :-



- The change in amplitude of carrier signal C(t) with respect to instantenous amplitude of message signal x(t) by keeping frequency & phase of a carrier signal to be constant, this process is known as Amplitude Modulation.

Modulation → It is a process of conversion/superimposi of low frequency signal into high frequency signal.



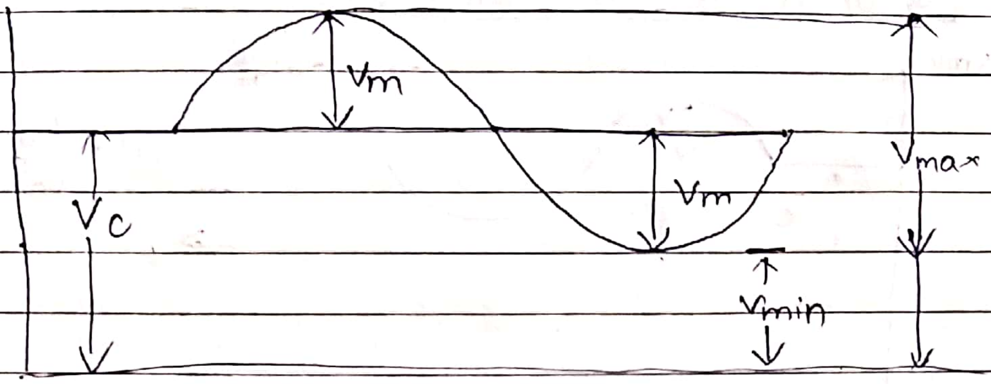
* Modulation Index of AM :- $\boxed{m = \frac{V_m}{V_c}}$

- It is a ratio of amplitude of message signal to the amplitude of a carrier signal.
- Generally, Modulation index of AM is less than 1.

i) Under Modulation → $\boxed{m << 1}$ & $\boxed{V_m << V_c}$

ii) Perfect Modulation → $\boxed{m = 1}$ & $\boxed{V_m = V_c}$

iii) Over Modulation → $\boxed{m >> 1}$ & $\boxed{V_m >> V_c}$



Modulation Index :- (of air)

$$m = \frac{V_m}{V_c}$$

$$\cancel{V_c = V_m + V_{min}}$$

$$\therefore V_m = V_c - V_{min} \quad \text{—} \; (1)$$

$$V_c = V_{max} - V_m$$

$$V_c = V_{max} - V_c + V_{min}$$

$$\boxed{V_c = \frac{V_{max} + V_{min}}{2}} \quad \text{—} \; (1)$$

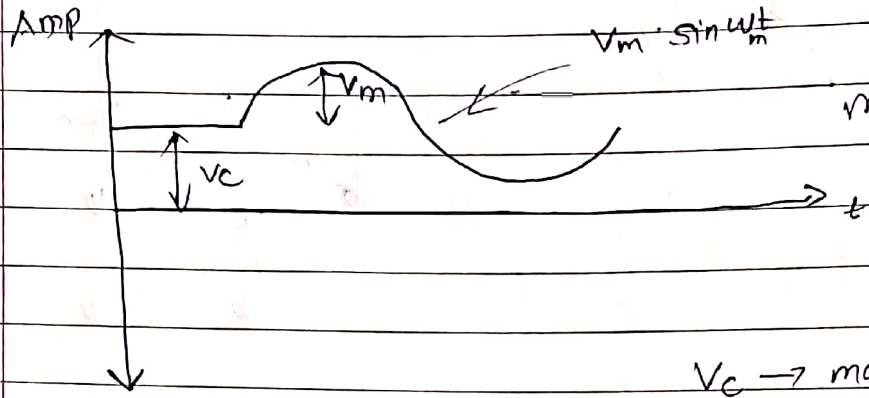
$$V_m = \frac{V_{max} + V_{min}}{2} - V_{min}$$

$$= \frac{V_{max} + V_{min} - 2V_{min}}{2}$$

$$\boxed{V_m = \frac{V_{max} - V_{min}}{2}} \quad \text{—} \; (2)$$

$$\boxed{m = \frac{V_{max} - V_{min}}{V_{max} + V_{min}}}$$

* Derivation of AM signal :-



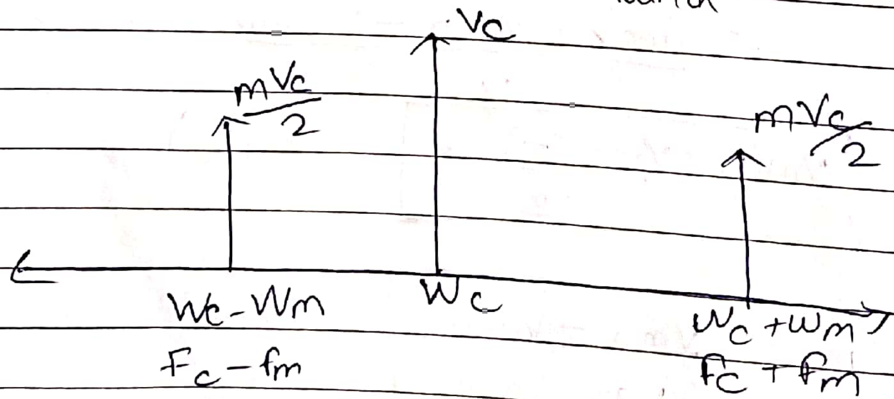
$m = \frac{V_m}{V_c}$

$V_c \rightarrow$ max amp.

$$v_c = V_c \sin \omega_c t$$
$$v_m = V_m \sin \omega_m t$$

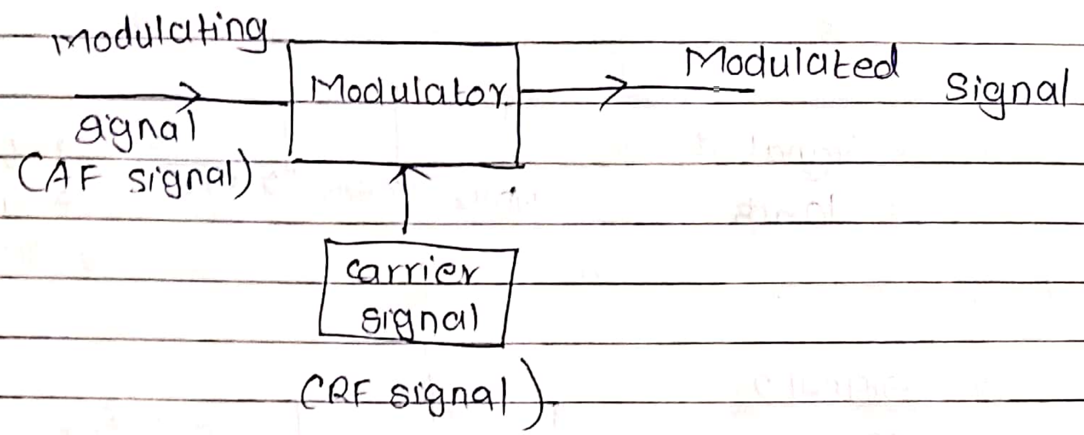
$$A = V_c + V_m$$
$$= V_c + V_m \sin \omega_m t$$
$$A = V_c + m.V_c \sin \omega_m t$$

$$A = V_c(1 + m \sin \omega_m t)$$
$$= V_c \sin \omega_c t \,(1 + m \sin \omega_m t)$$
$$= V_c \sin \omega_c t + m V_c \sin \omega_m t . \sin \omega_c t$$
$$= V_c \sin \omega_c t + \frac{mV_c}{2}\left[\underbrace{\cos(\omega_c - \omega_m)t}_{\text{lower side band}} \pm \underbrace{\cos(\omega_c + \omega_m)t}_{\text{upper side band}}\right]$$



$$BW = f_c + f_m - f_c + f_m$$
$$\boxed{BW = 2f_c}$$

* Modulation



Need of modulation :-

i) To reduce the height of antenna

$$h = \frac{\lambda}{4}$$

as, $\lambda = \frac{c}{F}$

$$\therefore \boxed{h = \frac{c}{4F}}$$

$$\boxed{h \propto \frac{1}{F}}$$

$h \rightarrow$ height of antenna
$\lambda \rightarrow$ ~~Lam~~ Wavelength
$c \rightarrow$ speed of light
$F \rightarrow$ Frequency.

case 1 :- If $F_1 = 10KHz$

$$h_1 = \frac{3\times10^8}{4\times10^4} = 75Km$$

$$\boxed{h_1 = 75Km}$$

case 2 :- If $F_2 = 10MHz$

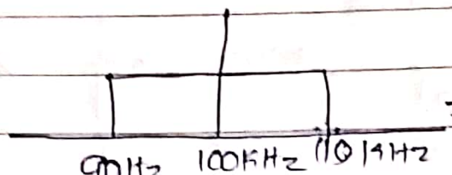
$$h_2 = \frac{3\times10^8}{4\times10^7} = 75m$$

As the frequency of signal increase then height of antenna decreases.

ii) To avoid mixing of the signal

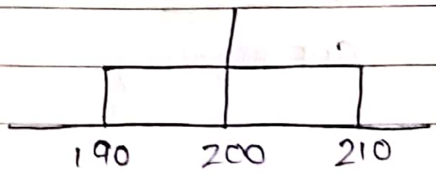
100 KHz - 500KHz

Signal 1
10KHz



=> Freq. band for signal 1
=> 90K to 110K

Signal 2
10KHz



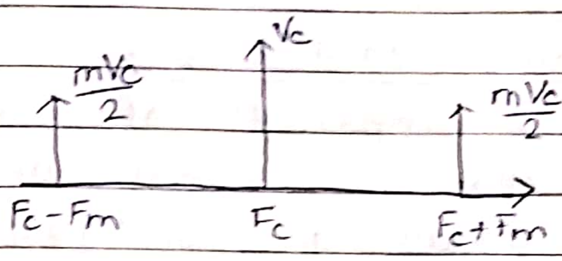
=> freq. band for Signal 2
=> 190K to 210K

iii) ~~Noise~~ Minimize interfacing of noise :

iv) Provide Multiplexing

v) Long distance communication

* Power calculation for AM wave :-



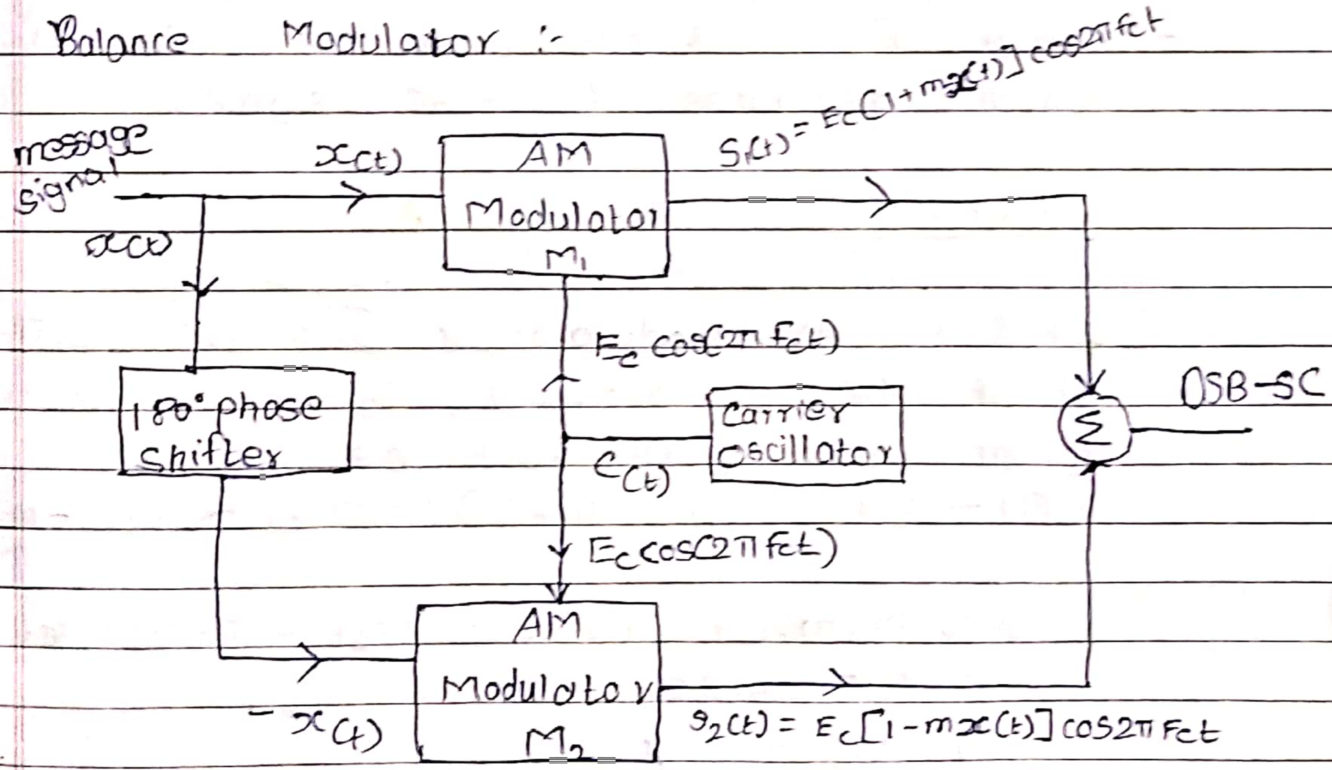
$$P_t = \frac{(mV_c)^2}{4R} + \frac{V_c^2}{R} + \frac{(mV_c)^2}{4R}$$

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

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

* DSB-SC (Double side band suppress carrier)

Balance Modulator :-



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constructions →

- **Principle of balance Modulator :-**
- The principle of operatn of balance modu states that if two signal at diff. freq are passed through a non-linear device at the o/p, we will get an AM signal with suppressed carrier.

- **Construction :-**
- Balance modulator consists of 2 AM modulc
- For AM m_1, inputs are message signal $x(t)$ and carier signal $c(t) = E_c \cos(2\pi F_c t)$.
- For AM modulator 2, inputs are 180° phase shift message signal $(-x(t))$ and carrier signal $c(t) = E_c . \cos(2\pi F_c t)$
- Output of M_1 & M_2 given to adder block which generates DSB-SC signal.

- **Working :-**

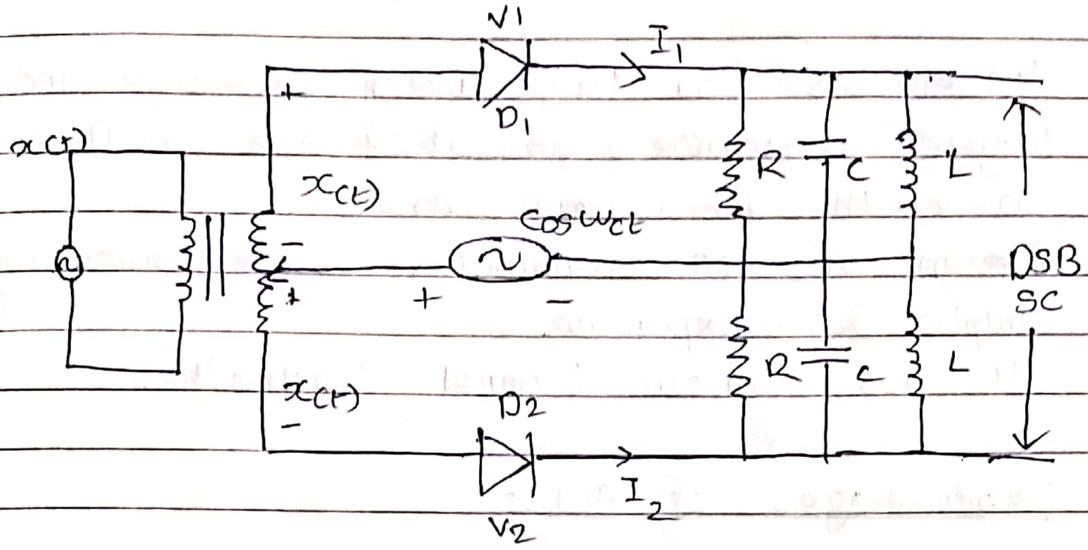
- O/P of AM modulator 1, $s_1(t) = E_c(1+m x(t)) \cos 2\pi F_c$
- O/P of AM modulator 2, $s_2(t) = E_c[1-m x(t)] \cos 2$
- O/P of Adder block will be,

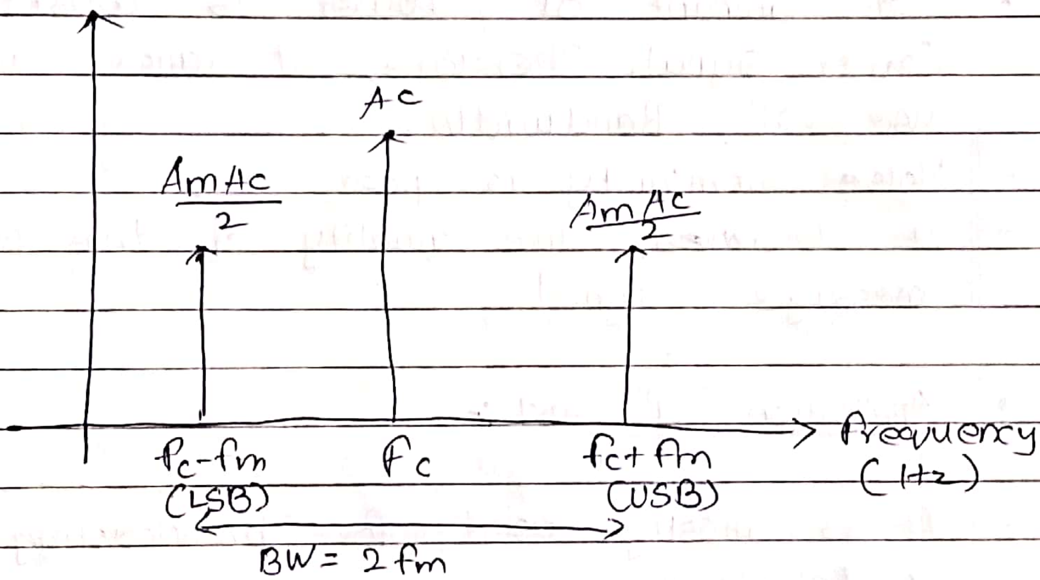
$s_1(t) - s_2(t) = E_c(1+m x(t)) \cos 2\pi F_c t - E_c(1-m x(t)) \cos 2\pi F_c t$

$= E_c \cos 2\pi F_c t + m x(t) \cos 2\pi F_c t - E_c \cos 2\pi F_c t + m x(t) E_c \cos 2\pi F_c t$

$= 2m(t) E_c \cos 2\pi F_c t$

- Circuit diagram of balance Modulator :-





$$w_m = 2\pi f_m$$

$$m(t) = A_m \cos w_m t$$

$$c(t) = A_c \cos w_c t$$

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- Advantages of AM :

- AM signals has ~~large~~ wider coverage and travels longer distance as they are reflected back to earth from inosphere.
- Design of AM transmitter & receiver is relati simple & inexpensive.
- It has narrow Channel bandwidth.

- Disadvantages of AM :-

- More amount of power is wasted in transmi Carrier signal. Therefore, it causes inefficient use of Bandwidth..
- Noise immunity is poor.
- It detoriates the quality of the original message signal.

- Application of AM :-

- It is mostly used for broadcasting by radio & television.
- In airband radio, used for ground to air communication to
- It is also used in Police & navy dispatch radio system.

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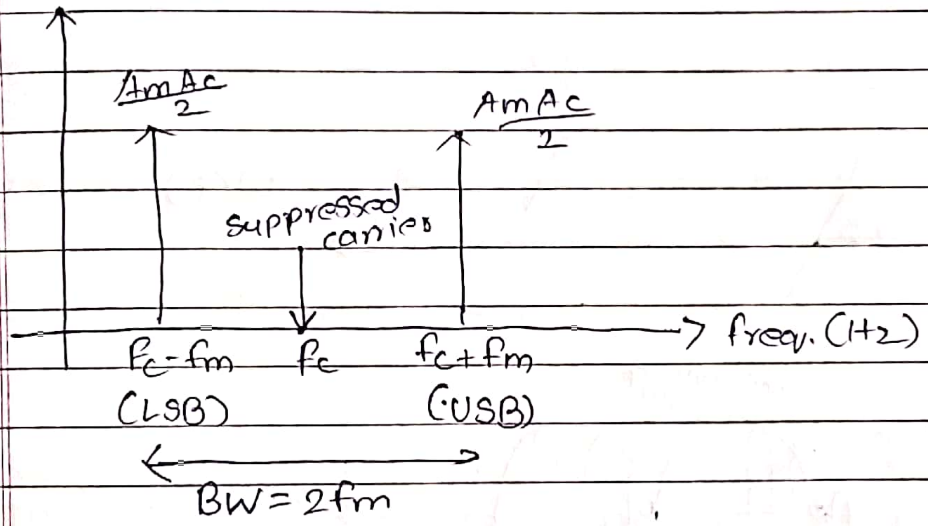
• Types of AM :-

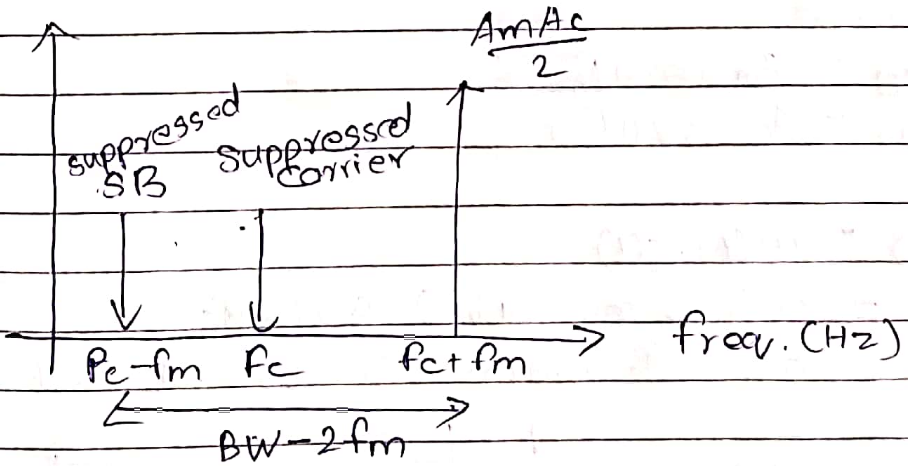
- Depending on freq. components present in the spectrum, AM can be classified as :-

i) DSB - SC
ii) SSB - SC

i) DSB - SC :-



ii) SSB - SC



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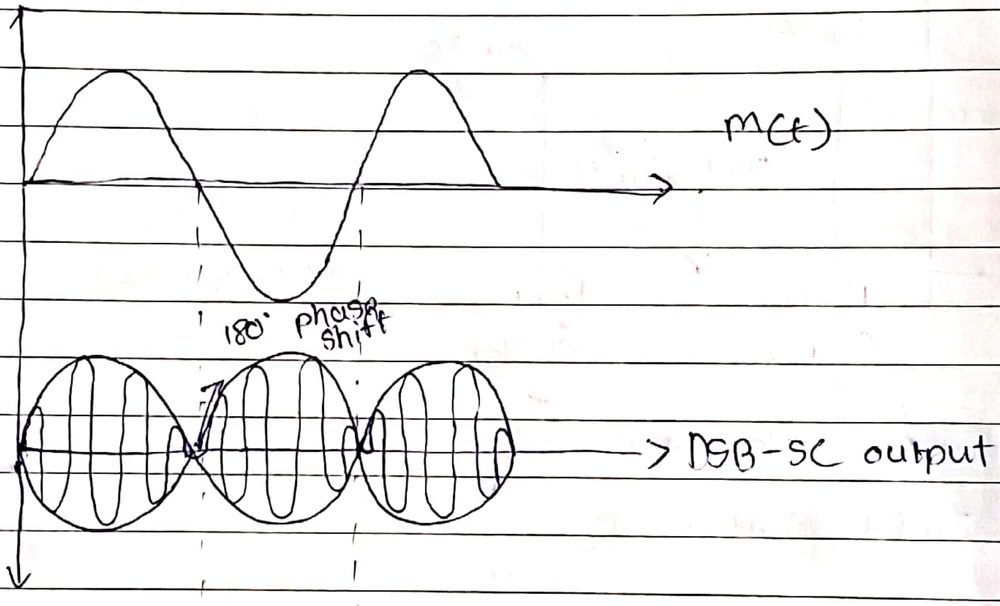
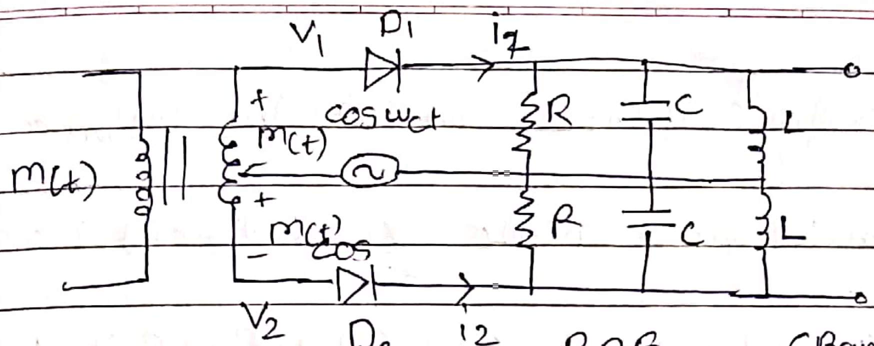
DSB-SC

- In DSB-SC only upper side band & lower side band are transmitted, while suppressing the carrier component.
- Since, carrier component does not transmit any message, it is suppressed and only LSB & USB are transmitted.
- Hence, total power is utilized only ~~to~~ for transmission of side bands, resulting in modulation efficiency to be 100%.



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

$$S(t) = m(t) \cdot c(t)$$
$$= A_c A_m \cdot \cos(2\pi f_m t) \cdot \cos(2\pi f_c t)$$
$$= \underbrace{\frac{A_c A_m}{2} \cos 2\pi (f_c + f_m) t}_{USB} + \underbrace{\frac{A_c A_m}{2} \cos 2\pi (f_c - f_m) t}_{LSB}$$



BPF (Band Pass filter)
centred at ω_c

$$V_1 = m(t) + \cos \omega_c t$$
$$= A_m \cos \omega_m t + \cos \omega_c t$$
$$V_2 = m(t) - \cos \omega_c t$$
$$= A_m \cos \omega_m t - \cos \omega_c t$$

$$i_1 = a v_1 + b v_1^2 \; ; \quad i_2 = a v_2 + b v_2^2$$

$$i_1 = a[A_c \cos \omega_c t + m(t)] + b[A_c \cos \omega_c t + m(t)]^2$$
$$= a A_c \cos \omega_c t + a m(t) + b A_c^2 \cos^2 \omega t + b m^2(t) + 2bA_c \cos \omega_c t \, m(t)$$

$$i_2 = a[A_c \cos t - m(t)] + b[A_c \cos \omega_c t - m(t)]$$
$$= a A_c \cos \omega_c t - a m(t) + b A_c^2 \cos^2 \omega_c t + m^2(t) - 2bA_c \cos \omega_c t \, m(t)$$

$$V_o = i_1 R - i_2 R$$
$$= R[i_1 - i_2]$$
$$= R[\underbrace{2am(t)}_{\text{message signal [modulated]}} + \underbrace{4bA_c \cos \omega_c t \, m(t)}_{\text{DSB-SC signal}}]$$

$= 2aRA_m \cos\omega_m t + 4bRA_cA_m \cos\omega_m t \cos\omega_c t$

$= 2aRA_m \cos\omega_m t + 2bRA_c \cos(\omega_m t + \omega_c t) + \cos(\omega_m t - \omega_c t)$

$= 2R_aA_m \cos\omega_m t + 2R_bA_mA_c \cos 2\pi(f_m + f_c)t + 2R_BA_mA_c \cos 2\pi(f_m - f_c)t$

On Passing this (V_o) through Lc Band Pass filter, the modulating signal term will be eliminated.

Advantages :-

i) Transmission power is same as the carrier is supposed.

ii) Generation & detection is relatively simply & inexpensive.

Disadvantages :

i) Wastage of Power in Transmitting to ~~st~~ side Band which carring same information

ii) Less noise immunity.

iii) Require same bandwidth as AM i.e $BW = 2f_m$

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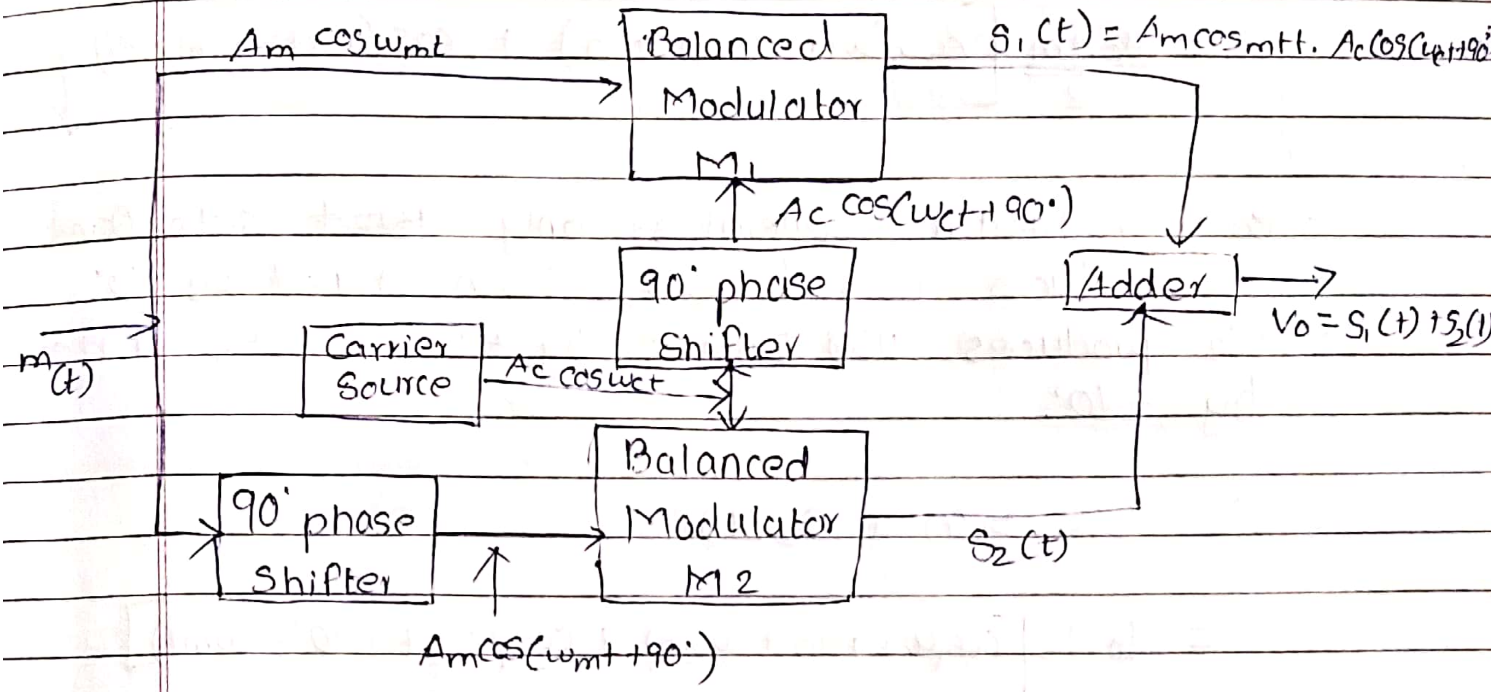
* Generation of SSB-SC using phase shift method :-



- Figure shows, block diagram of phase shift method of to general USB of SSB-SC (LSB suppression).
- It consists of two balanced modulators M_1 & M_2.
- For M_1 → Carrier signal shifted by 90° & Modulating signal is applied.
- For M_2 → Carrier signal & Modulating signal shifted by 90°

$$2\cos A \cos B = \cos(A+B) + \cos(A-B)$$

$$S_1(t) = Am \underbrace{\cos \omega_m t}_{B} \cdot A_c \underbrace{\cos(\omega_c t + 90^\circ)}_{A}$$

$$= \frac{Am\,Ac}{2}\left[\cos(\omega_c t + 90^\circ + \omega_m t) + \cos(\omega_c t + 90^\circ - \omega_m t)\right]$$

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$S_2(t) = A_c \cos\omega_c t \; A_m \cos(\omega_m t + 90^\circ)$

$= \cancel{\frac{A_c A_m}{2}\left[\cos(\omega_m t + 90 + \omega_c t) + \cos(\omega_m t + 90)\right]}$

$= \frac{A_c A_m}{2}\left[\cos(\omega_c t + \omega_m t + 90^\circ) + \cos(\omega_c t - \omega_m t - 90^\circ)\right]$

- Both modulator generates only ~~Band~~ side Bands. Both shifed by 90°
- M_1 produces USB & LSB,
- M_2 produces USB Shited by $+90^\circ$ & LSB Shifted by -90°.

$\therefore V_0 = S_1(t) + S_2(t)$

$= \frac{A_m A_c}{2}\left[\cos(\omega_c t + 90^\circ + \omega_m t) + \cos(\omega_c t + 90^\circ - \omega_m t)\right]$

$+ \frac{A_m A_c}{2}\left[\cos(\omega_c t + \omega_m t + 90^\circ) + \cos(\omega_c t - \omega_m t - 90^\circ)\right]$

$\Downarrow$

$\cos(-(\omega_c t + \omega_m t) + 90^\circ)$

$\cos(\omega_c t + \omega_m t + 90^\circ)$

$\cos(90^\circ + \theta) = -\sin\theta$

$= \frac{A_m A_c}{2}\left[-\sin(\omega_c t + \omega_m t) - \sin(\omega_c t - \omega_m t)\right]$

$+ \frac{A_m A_c}{2}\left[-\sin(\omega_c t + \omega_m t) - \sin(\omega_m t - \omega_c t)\right]$

$\Downarrow$

$\sin(\omega_c + \omega_m$

$= \frac{A_m A_c}{2}\left[-\sin(\omega_c t + \omega_m t) - \sin(\omega_c t - \omega_m t)\right]$

$+ \frac{A_m A_c}{2}\left[-\sin(\omega_c t + \omega_m t) + \sin(\omega_c t - \omega_m t)\right]$

$= -\frac{A_m A_c}{2}\left[2\sin(\omega_c t + \omega_m t)\right]$

$= -A_m A_c \cdot \sin(\omega_c t + \omega_m t)$

$\therefore V_0 = A_m A_c \cos(\omega_c t + \omega_m t + 90^\circ)$

- Output of Balanced modulator are added by summing amplifier.
- two USBs are in phase so they are added, two LSBs are out of phase. (180° phase diff) so they cancel each other.

★ For USB suppression :-

- The phase shifted version of both the carrier and modulating signal are fed to one of the Balance modulator.
  (feed 90° shifted signals to M_2 & plain to M_1)

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* Advantages of SSB

- Required bandwidth is smaller in comparison with AM & DSB-SC.
- ~~As only one~~ Power is saved as only one band is to be transmitted.
- Will give more noise immunity / Amount of noise is less.
- Less loss of signal.

* Disadvantages of SSB-SC

i) Detection & generation process of SSB is complex.
ii) Signal quality will degrade.

* Applications of SSB-SC

- Air, land, marine communication.
- Radio Broadcasting.
- It is used TV & radar.
- It is used in Military communication.

$c(t) = A \cos(\omega t + \Phi)$

A -> amplitude -> AM
w -> angular freq. -> FM
Φ -> phase angle -> Angle
-> phase modulation.

FM → frequency of ~~carrier~~ msg signal changes w.r.t carrier signal by keeping amplitude and phase constant.

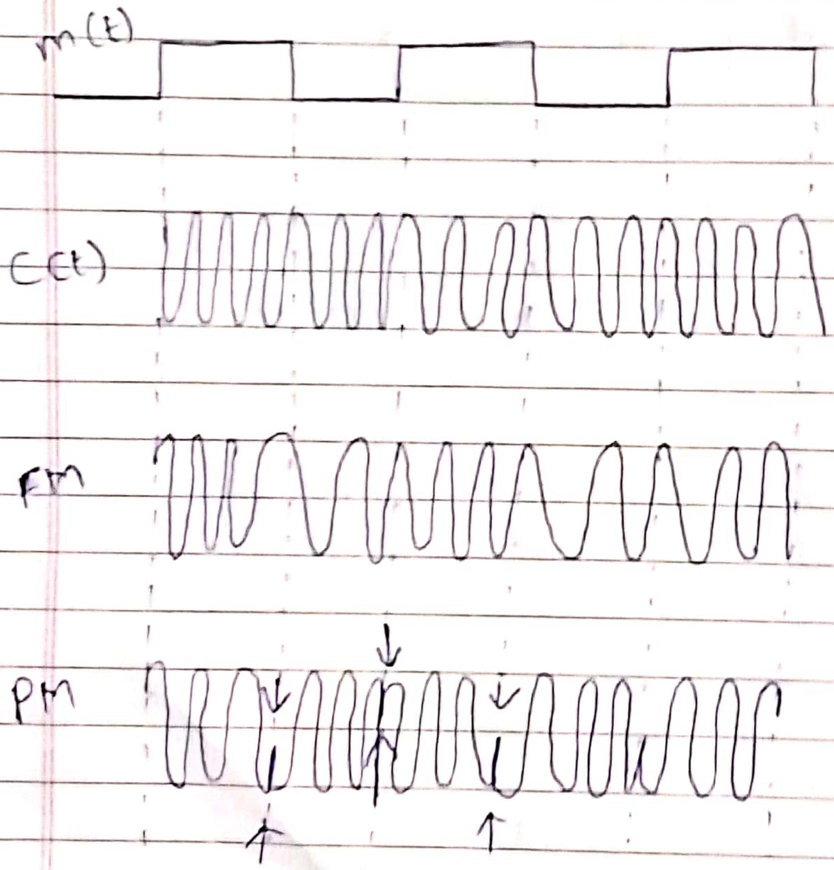
$$y(t) = A_c \cos(\omega(t)t + \phi)$$

where $\omega(t) = F[m(t)]$

PM →

$$y(t) = A_c \cos(\omega_c t + \phi(t))$$

where $\phi(t) = F[m(t)]$



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* Advantages of Angle Modulation :

i) Noise Reduction
ii) Better system fidility
iii) Efficient use of power
iv) Operates in very high frequency range (88 MHz - 108 MHz)

* Disadvantages

- Increased bandwidth.
- Used of complex circuits.

* Applications of Angle Modulation

i) Radio Broadcasting.
ii) TV sound transmission.
iii) Cellular Radio.
iv) Microwave Communication.
v) Satellite communication.

* Frequency Modulation :-

Unmodulated carrier $c(t) = A_c \cos(\omega_c t + \theta)$ -(i)

$C_{(t)} = A \cos \Phi$ - (ii)

where $\Phi = \omega_c t + \theta$

Φ is the total phase angle of the unmodulated carrier.

FM wave :- $S_{(t)} = A \cos \Phi_i$

($\Phi_i \rightarrow$ Instantaneous value of the phase angle)

$\Phi = \omega_c t + \theta$

$\frac{d\Phi}{dt} = \omega_c \longrightarrow \Phi = \int \omega_c \, dt$ — (3)

Instantaneous frequency $\rightarrow \omega_i$

$\omega_i = \omega_c + K_f m(t)$

$\Phi_i = \int \omega_i \, dt$

$= \int (\omega_c + K_f m(t)) \, dt$

$\boxed{\Phi_i = \omega_c t + K_f \int m(t) \, dt}$ — (4)

$s(t) = A\cos\left(\omega_c t + K_f \int_0^t m(t)\,dt\right)$ — (5)

~~$s(t) = A\cos\Phi$~~
~~where $\Phi =$~~

- Frequency sensitivity of modulator is expressed in Hz/volt
- This is expression for frequency modulated signal in time domain
- Eqn. 5 shows $s(t)$ is a non linear function of $m(t)$ which makes F.M or non linear modulation technique

From 4,

$W_i = \omega_c + K_f m(t)$

$f_i = f_c + \underbrace{K_f A_m}_{\Delta f} \cos(2\pi f_m t)$

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Δf → frequency deviation which represents the difference between min & max amplitude of FM & signal & the carrier frequency.

~~$\Delta f \propto A_m$~~ $\therefore \Delta f = K_f A_m$

$\therefore \Delta f \propto A_m$

Δf is directly proportional A_m but ~~tad~~ independent of f_m.

from 3,

$$\phi = \int_0^t \omega(t) \cdot dt$$

$$\phi_i = 2\pi \int_0^t f_i(t) \cdot dt$$

$$= 2\pi \int_0^t (f_c + \Delta f \cos(2\pi f_m t)) dt$$

$$\phi_i = 2\pi f_c t + \Delta f \frac{\sin(2\pi f_m t)}{2\pi f_m}$$

$$\phi_i = 2\pi f_c t + \underbrace{\frac{\Delta f}{f_m}}_{\beta} \sin(2\pi f_m t)$$

$$\phi_i = 2\pi f_c t + \beta \sin 2\pi f_m t$$

$$s(t) = A_c \cdot \cos(2\pi f_c t + \beta \sin 2\pi f_m t)$$

β → represents phase deviation of fm signal i.e. max dif. ~~of fm~~ of ϕ_i from the angle $2\pi f_c t$

Therefore, β is measured in radians.

$$\beta < 1 \longrightarrow NBFM$$
$$\beta > 1 \longrightarrow WBFM$$

∴ Diff. betn Narrow band fm & Wide band fm.

	Parameters	Narrow band	Wide band
i)	Modulation Index (β)	less than 1	Greater than 1
ii)	Max. deviation	5 KHz	75 KHz
iii)	Range of modulated freq.	30Hz - 3KHz	30Hz - 15KHz
iv)	Band width	Small ($BW = 2f_m$) (approx. same as of Am)	Large by 15 times greater than NBFM [$BW = 2(\Delta f + f_{m_{max}})$]
v)	Applications	Entertainment broadcasting / high quality music transmission.	FM mobile communication like police wireless.

* Spectral Analysis of FM :-

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

expanding eqn. (6)

using $\cos(A+B) = \cos A \cos B - \sin A \cdot \sin B$

$$s(t) = A_c \left[\cos(2\pi f_c t).\cos(\beta \sin 2\pi f_m t) - \sin(2\pi f_c t).\sin(\beta \sin 2\pi f_m t)\right]$$

In the above eqn, we have terms having or consisting of cos(sinθ) and sin(sinθ), which on expansion gives complex terms.

The soln to such equation can be found using bessel's function.

$$\boxed{s(t) = A_c \{ J_{-n}(\beta) \cos(\omega_c - n\omega_m) t}$$

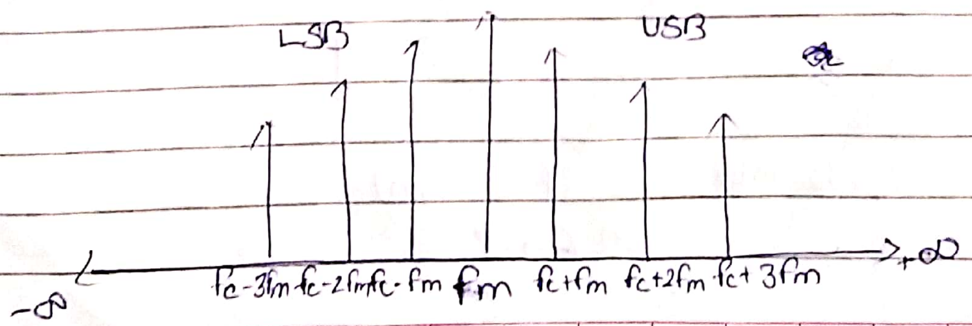
where $J_{-n}, \ldots J_{-2}, J_{-1}, J_0, J_1, J_2 \ldots J_n$ are Bessel's function.

$J_0 \rightarrow$ Amplitude of carrier Signal

$J_1 \rightarrow$ 1st USB & LSB

$J_2 \rightarrow$ 2nd USB & LSB

$J_n \rightarrow$ Amplitude of n^{th} side band.



- Amplitude of each side band depends on the Bessel's function and modulation index β.
- Amplitude of each side band is determined by using Bessel table.

- In FM, theoritically there are infinite no. of sidebands ~~the~~ and therefore bandwidth in FM is also finite.
- FM bandwidth can be determined by using Bessel's Table or Carson's Rule.
- FM band width by using Table: $BW = 2n f_{m(max)}$
  where n is no. of signif

Q) In a FM system, when the audio frequency is ~~....~~ 400Hz, the AF voltage is 4V, the deviation is 4.8 KHz. Calculate the modulation Index and the bandwidth required. If the modulation frequency is ~~..~~ half, what is the bandwidth?

Given :- $f_m = 400Hz$, $A_m = 4V$, $\Delta f = 4.8KHz$

To find :- $\beta = ?$

soln :-

$$\beta = \frac{\Delta f}{f_m}$$

$$= \frac{4.8 \times 10^3}{400} = \frac{12}{1} = 12$$

$$\boxed{\beta = 12}$$

$$\therefore BW = 2(\Delta f + f_m)$$

$$= 2(4.8 \times 10^3 + 400)$$

$$= 10400 = 10.4KHz$$

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Q) A 100 MHz carrier signal is frequency modulated by an analog modulating signal. The Max frequency deviation is 100 KHz. Determine the Approx. transmis^n B.W of fm signal using Carson's B.W rule. If the freq. of modulating signal is i) 1 KHz ii) 500 KHz.

Given :- $f_c = 100\,MHz$

$\Delta f = 100\,KHz$

i) $f_m = 1\,KHz$

$BW = 2(\Delta f + f_m)$

$= 2(100K + 1K)$

$= 2(101K)$

$= 202\,KHz$

ii) $f_m = 500\,KHz$

$BW = 2(\Delta f + f_m)$

$= 2(100K + 500K)$

$= 1200\,KHz$

Q) A modulating signal $15\cos(2\pi 15 \times 10^3 t)$ angle modulates a carrier. Find modulation index and B.W of the system.

i) Determine the change in B.W & Modulat^n Index for FM, if modulating signal frequency is reduced to 5KHz. Assume $K_f = 15\,KHz/V$

ii) Find B.W & Modulat^n Index, If Amplitude is reduced to half.

soln :-

$15\cos(\underbrace{2\pi 15 \times 10^3}_{w_m} t)$, A_m = 15

$A_m = 15$, $w_m = 2\pi 15 \times 10^3$

$\therefore f_m = 15 \times 10^3$

$\Delta f = K_f A_m$

$= 225\,KHz$

$\therefore \beta = \frac{\Delta f}{f_m} = \frac{225 \times 10^3}{15 \times 10^3} = 15$

$B.W = 2(\Delta f + f_m)$

$= 2(225K + 15K)$

$= 480K$

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$BW = 2(225 \times 10^3 + 15 \times 10^3)$

i) $f_m' = 5KHz$

$$\beta' = \frac{\Delta f}{f_m} = \frac{225K}{5} = 45'$$

$B.W' = 2(\Delta f + f_m')$
$= 2(225K + 5K)$
$= 2(230K)$
$= 460KHz$

change in $\beta = 45 - 15 = 30$
change in $BW = 20KHz$

ii) If amplitude is Half
$\therefore Am = 7.5$

$BW = 2(\Delta f + f_m)$
$= 2(112.5K + 15K)$
$= 2(127.5K)$
$BW = 255KHz$

$\Delta f = Kp \cdot Am$
$= 15 \times 7.5$
$= 112.5K$

$$\beta = \frac{\Delta f}{F_m} = \frac{112.5 \times 10^3}{15 \times 10^3}$$
$= 7.5$

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Q) A single tone fm signal is given by
$e_{FM}(t) = 20\cos(16\pi 10^6 t + 25\sin 2\pi 10^3 t)$
Find Modulatn Index, Modulating freq, deviation, carrier freq. & power in FM Signal.

Soln :-

$$e_{FM}(t) = \underset{\downarrow}{20} \cos(16\pi 10^6 + 25\sin 2\pi 10^3 t)$$

~~Am~~ ~~wm~~

~~Am = 20 , wm~~

compare with,

$$s(t) = A_c \cos(\omega_c t + \beta \sin \omega_m t)$$

$$A_c = 20 ; \omega_c = 16\pi 10^6 ; \beta = 25, \omega_m = 2\pi 10^3$$

$$\therefore f_c = \frac{\omega_c}{2\pi} = \frac{16\pi \times 10^6}{2\pi} = 8MHz$$

$$\therefore f_m = \frac{\omega_m}{2\pi} = \frac{2\pi 10^3}{2\pi} = 1KHz$$

$$\therefore \Delta f = \beta f_m$$
$$= 25 \times 1KHz = 25KHz$$

$$\therefore P_{FM} = \frac{A_c^2}{2} = \frac{400}{2} = 200$$
(Power)

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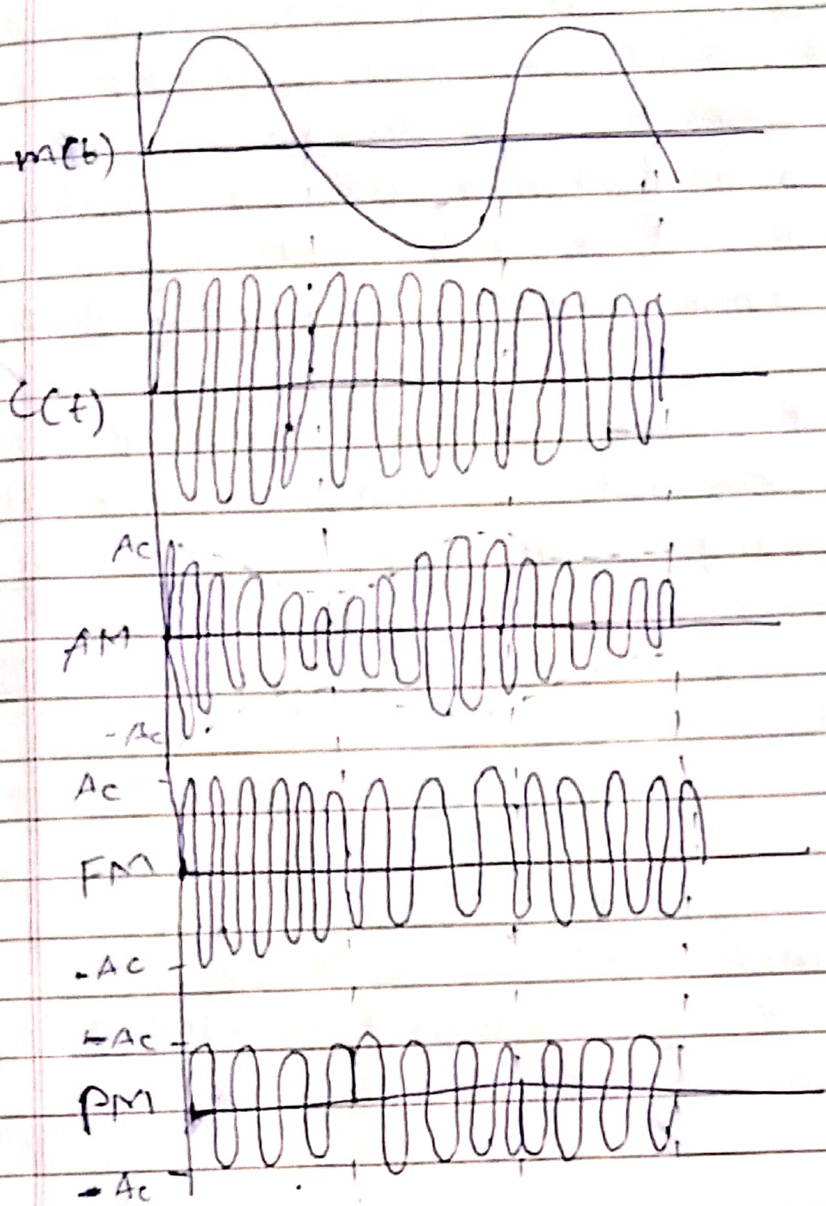
*

Parameter	Am	Fm	PM
Variable Parameter of Carrier wave	Amplitude	Frequency	Phase (angle)
Mathematical eqn for s(t)	$A_c \cos w_c t + \frac{m A_c}{2} \cos(w_c - w_m)t + \frac{m A_c}{2} \cos(w_c + w_m)t$	$A_c \cos(w_c t + m_f \sin w_m t)$	$A_c \cos(w_c t + M_p \sin w_m t)$
Noise impunity	Low / Poor	Better	Better
B.W	2 fm (constant)	$2(\Delta f + f_m)$ (Carsal's Rule)	Moderate
no. of sidebands	2	infinite ~~(Ideally)~~ (Ideally)	More than 2 side band
Applicatn	Radio, TV broadcasting	Radio, TV & Police wireless.	Data communication
Signal to noise ratio	Poor	Best	Better



* Noise Triangle FM :-

- Noise Triangle is a study effect of noise on the carrier signal of the FM way.
- It is a triangular noise ~~dritibu~~ distribution for FM in which ~~signal~~ signal to noise ratio verses frequency is ploted.
- The carrier and noise voltages will mix and if the difference is significant (audible); it will naturally interfere with reception of messag signal producing an unwanted deviation of carrier frequ.

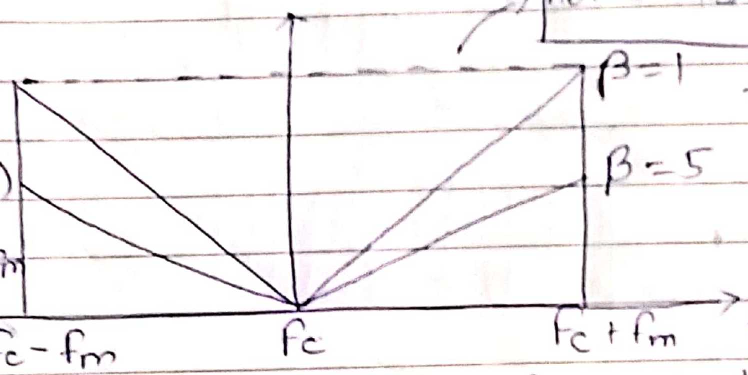
- The magnitude of this unwanted frequency deviation depends on the amplitude of noise with respect to carrier.
- When this unwanted carrier deviation is demodulated it becomes noise if it has frequency components that falls within the message signal frequency spectrum.
- The effect of noise at the output of FM demodulator does not remain constant, it increases linearly with the increase in FM.

noise distributⁿ for AM

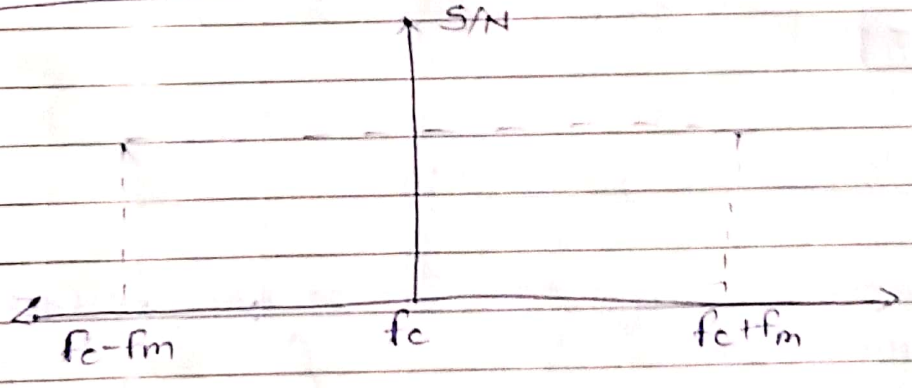
- The demodulated noise voltage is higher for ~~higher modulating~~ (msg) signal freq.
- as the modulating freq fm increases, β ↓ & effect of noise for lower modulatⁿ index is more.
- Therefore to reduce effect of noise on higher freq. of msg signal it β should remain constant.
- which is possible by increasing freq. deviatⁿ.

$$\boxed{\beta = \frac{\Delta f}{f_m}}$$

- Inorder to increase the freq. deviation we have to in... the Amp of ... signal



Noise Spectrum for in FM



Noise distribution for AM & PM

S/N remains constants for all modulating freq.

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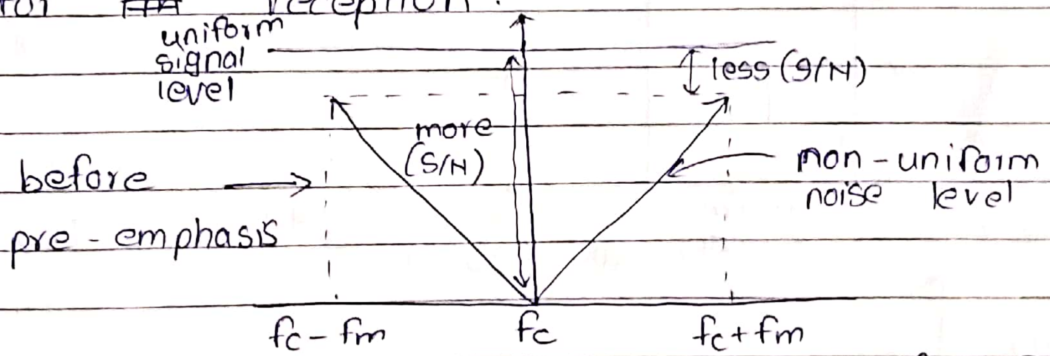
* Pre emphasis & De-emphasis :

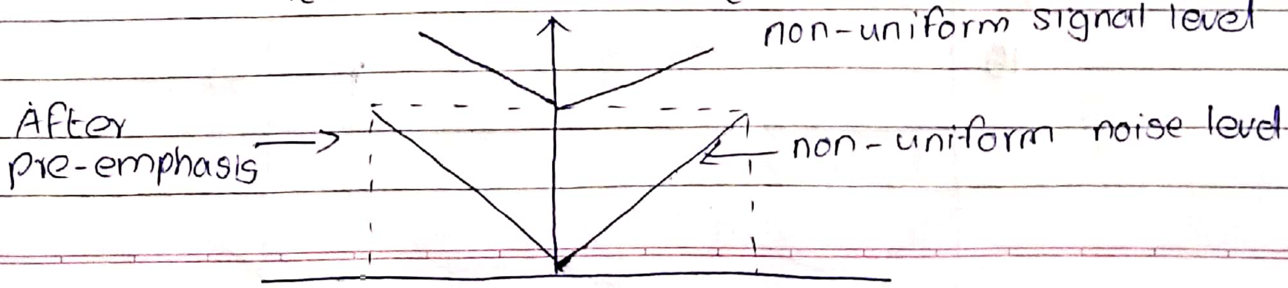
- An alternative way to increase the signal to noise ratio (SNR)

$$(\text{Noise voltage})_{\text{high freq}} > (\text{Noise voltage})_{\text{low freq.}}$$

$$(S/N)_{\text{high freq}} < (S/N)_{\text{low freq.}}$$

- To compensate this high modulated freq. (FM) (2KHz – 15KHz) are boosted (emphasised) in amplitude. in the transmitter before performing modulation.
- This artificial boosting is called pre-emphasis.
- To neutralize (compensate) for this boost the high frequency signal are ~~deten~~ attenuated (de-emphasis) at the reciever after demodulation. This is called de-emphasise.
- Objective of these two technique is to ~~increas~~ improve signal to Noise ratio SNR for ~~FM~~ FM reception.





Q) An AM modulator modulates modulating signal of 25KHz, 10Vp with carrier signal of 800 KHz, 40Vp. Calculate
i) USB & LSB frequency.
ii) Modulation coefficient & % Modulation
iii) Draw O/P freq. spectrum.
iv) Draw the ~~Ag angu~~ envelope & label it.

Given : $A_m = 10V$

$f_m = 25K\ H$

$f_c = 800KHz$

$A_c = 40V$

i) ~~$P_{USB} = P_c = \frac{A_c^2}{2R}$~~ $\Rightarrow$ $f_{LSB} = f_c - f_m$

$= 800K - 25K$

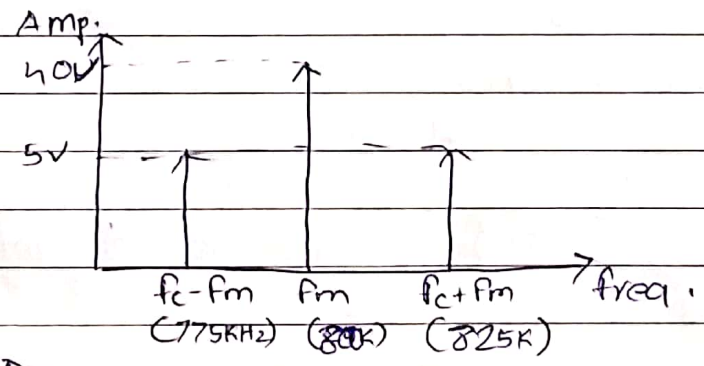
$= 775K$

$f_{USB} = f_c + f_m = 800K + 25K = 825KHz$

ii) $m = \frac{A_m}{A_c} = \frac{10}{40} = 0.25$

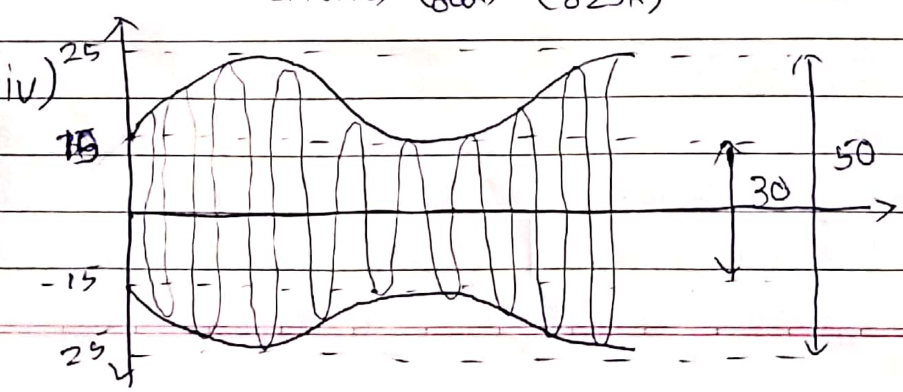
$\% m = 25\%$

$\frac{A_m}{2} = 5V$

iii)


$A_{max} = A_c + A_m = 50V$

$A_{min} = 30V$

iv)


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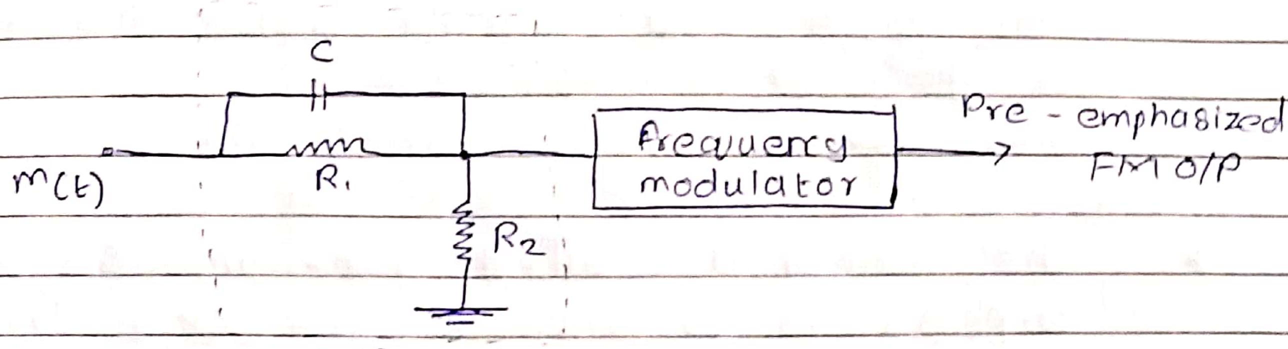
* Pre-emphasis circuit :-



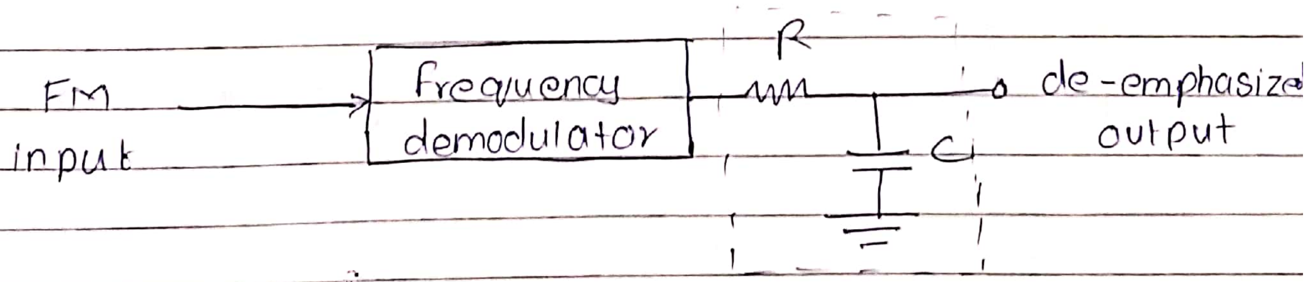
HPF

- Let the transmitter m(t) is passed through a high pass filter which amplifies high frequency components more than low freq. components.

+ Specifications :- time constant, $T = 75\mu s$
$f = \frac{1}{T} = 13.3 kHz$

- Any combination of RNC giving this time constant can be used.
- Such a circuit has a cutt off frequency means frequencies higher than f_{cutoff} will be linearly enhanced or boosted.

* De-emphasis Circuit :



LPF

- At the reciever, the demodulated O/P is passed through a low pass filter with time

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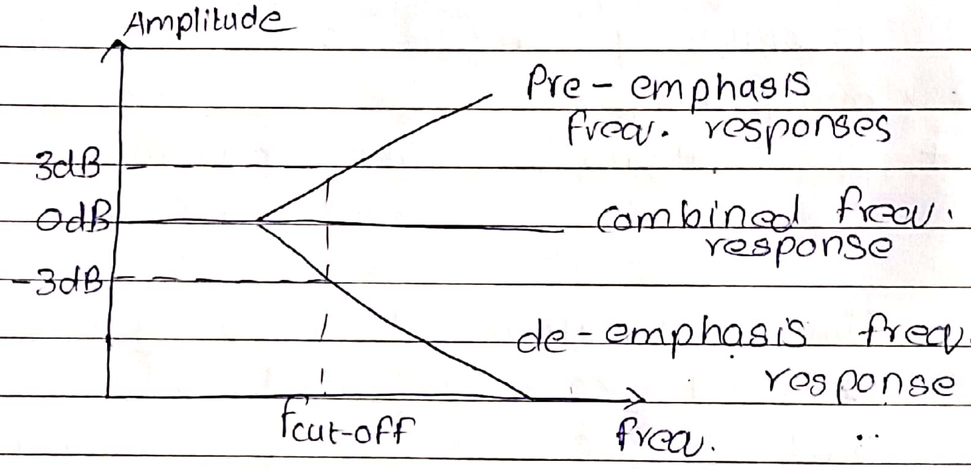
constant of 75 μs.

- Such a circuit features a cut-off frequency that causes ~~singt~~ signals above this frequency to ~~the~~ be attenuated.

~~- The com~~

* The combined effect pre-emphasis & de-emphasis is to increase the high frequency components During transmission so that they will be stronger and ~~not~~ not masked by the noise.



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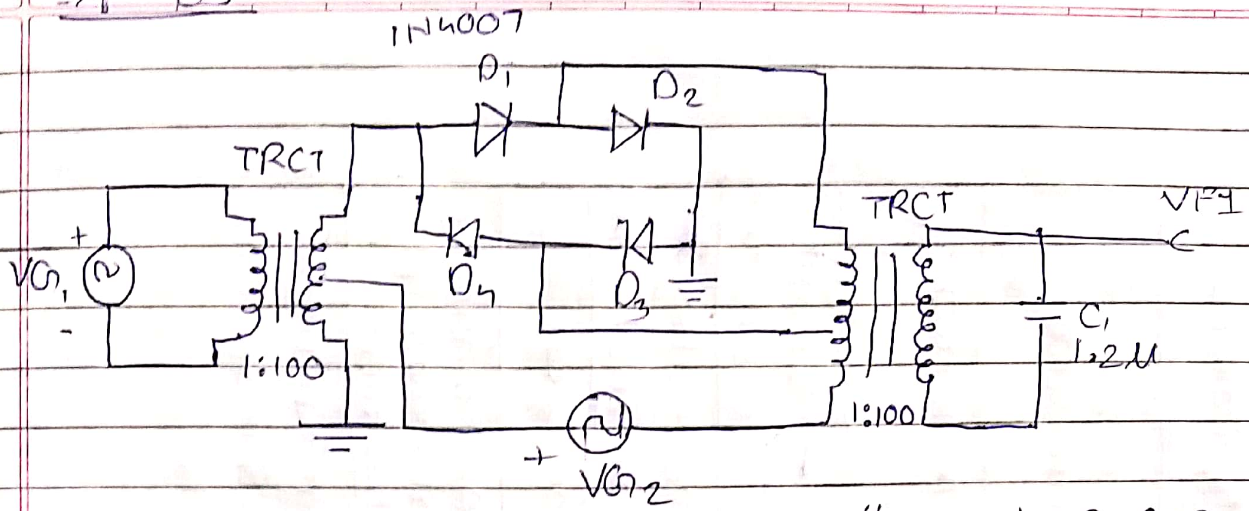

//open loop sys

VG1 : 5, 10K

VG2 : 1, 1K

- Range of wave of energy that are oscillating electric & magnetic fields which ~~towards~~ travels and spreads out as it goes.

READ MY INSTRUCTIONS VISIBLE UNDER X-RAY GLASSES.

Radio wave ~~Region~~	Micro wave	infra ray	Visible rays	UV	X-RAY	Gamma

Region	Frequency	Wavelength	Source	Applications
R	$< 3\times10^{9}$	$> 10cm$	oscillating circuits	TV, Radio communication
M	$3\times10^{9} - 3\times10^{11}$	$10 - 0.1cm$	oscillating currents in special vacuum tubes	TV, microowen
I	$3\times10^{11} - 4\times10^{14}$	$1000 - 0.7\mu m$	Excitation of atoms & molecules	Gives information about the structure
V	$4\times10^{14} - 7.5\times10^{14}$	$700 - 400nm$	The excitation of atoms, spark & arc flame	of molecules & of external atomic
U	$7.5\times10^{14} - 3\times10^{16}$	$400 - 10nm$	excitation of atoms & vacuum spark	electron shell
X	$3\times10^{16} - 3\times10^{19}$	$10 - 0.01nm$	Sudden retardation of high energy electrons	~~X~~ X-Ray theoraphy, industrial radiography cancer treatment
γ	$> 3\times10^{19}$	$< 0.1nm$	decay of radioactive neucleai, ~~decay~~ fussion & fission of atomic nuclei	Gives information about the structure of nuclei

* **Noise** :-

- It is an unwanted form of energy or electrical disturbance that can cause audible or visual disturbance in communication system and errors in digital communicatn system.
- It limits the performance of the communicatn system.
- Noise gets superimposed on the message signal & makes it impossible to separate the signal from the noise.
-

- External noise
  - Atmospheric nois
  - Extra-terrestrial noise
  - Man made / industrial noise
- Internal noise
  - shot noise
  - partition noise
  - flicker noise / low freq
  - transmit time / high freq
  - thermal noise / Johnson noise.

• **External Noise** :-

- "Generated external to a communicatn system"

1) Atmospheric noise

source → Lighting discharge

Field strength → vheense approx. inverse with the frequency.

- It becomes less severe & signifigant at freq. above 30MHz.

ii) Extra - Terrestrial Noise

- "Orginates from sources outside the earth atmosphere." hence called ~~deep~~ deep space noise.

Types :-

(i) Solar Noise → Noise radiated by sun varies according to its surface temperature

(ii) Cosmic Noise → The noise radiated by distant stars also known as black body noise.

iii) Man made / Industrial Noise

→ Noise produced by automobile, electrical motor, switch ~~gates~~ gears, etc.

- <u>Internal Noise / Fundamental Noise</u>

- Noise produced internally or within an electronic equipement. - can be reduced by proper system design.

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i) Shot Noise :-

- Arising in active devices due to random behaviour of charge carriers.
- Can be generated due to random emission of electrons from cathodes or due to random diffusion of minority carriers or simply random generation and recombination of electron whole pairs.
- For amplifying devices shot noise is inversely proportional to the trans conductance of the device & directly proportional to the output current.

ii) Partition Noise :-

- Generated in the circuit where a current has to divide between two or more paths.
- It's freq. spectrum is a flat spectrum.
- Partition noise in a transistor will be higher than in a diode.
- Mosfet has low partition noise.

iii) Low Frequency / Flicker Noise

- In semiconductor devices, flicker noise is generated due to fluctuations in charge carrier density
- Power spectral density of this noise increases as freq. decreases.
- Flicker Noise appears at freq. below a few KHz and hence is sometimes called "1/f" noise.

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iv) High frequency / transiant time noise :-

- Time taken by a ~~tim~~ current carrier (electrons / holes) to travel from input to output of a device.
- High freq. is generally observed in semi-conductor devices when transiant time of charge carriers crossing a junction is comparable with time period of signal which is been amplified.
- Once, this noise appears it goes on increasing with frequency at a rate of ~~6P~~ 6dB per octave

v) Thermal Noise

- It is called as White noise / Johnson noise
- Produced due to random thermal ~~edu~~ egitation of electrons in a conductor which increases with freq. and temperature
- Avg thermal noise power $P_n = KTB$

K => Boltsman constant
T => Temp. of conductor in Kelvin
B => Bandwidth of noise spectrum.

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* Signal to Noise Ratio (SNR)

- It is defined as the Ratio of signal power to the noise power.

~~SNR =~~

$$\frac{S}{N} = \frac{P_s}{P_n} = \frac{V_s^2/R}{V_n^2/R} = \frac{V_s^2}{V_n^2}$$

- It's expressed in dB.
- Higher the value of $\frac{S}{N}$ ratio better is the system performance in presence of noise.

$$\left(\frac{S}{N}\right)_{dB} = 10 \log \left(\frac{P_s}{P_n}\right)$$

$$= 10 \log \left(\frac{V_s}{V_n}\right)^2$$

$$= 10 \log \left(\frac{V_s}{V_n}\right)$$

- SNR is a key parameter for any radio reciever as it determines the noise performance of the reciever which implies that the reciever is able to reproduce and adequate / sufficient quality signal even in the presence of noise.

* Noise figure :-

- It is denoted by F.

$$F = \frac{\text{S/N ratio at input}}{\text{S/N ratio at output}}$$

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$$= \frac{P_{si}}{P_{ni}} \div \frac{P_{so}}{P_{no}}$$

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

$$\frac{P_{si}}{P_{so}} = G \quad \text{(Power gain)}$$

- Noise factor is a means to measure the amount of noise added by the device and will always be greater than 1.

$$= \frac{P_{no}}{P_{ni} G}$$

as, we know

$$P_{ni} = KTB \quad -(1)$$

$$\therefore F = \frac{P_{no}}{P_{ni} G}$$

$$P_{no} = P_{ni} FG$$

From (1)

$$P_{no} = KTBFG$$

or

$$\frac{P_{no}}{G} = KTBF = P_{ni}(\text{Total})$$

$$P_{ni}(\text{total}) = \underset{\text{(input source)}}{P_{ni}} + \underset{\text{(device)}}{P_{na}}$$

$$P_{na} = P_{ni}(\text{total}) - P_{ni}(\text{input source})$$

$$= KTBF - KTB$$

$$\boxed{P_{na} = (F-1) KTB} \quad -(2)$$

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* Noise Temperature :-

- It is the temp. which generates noise power in the system.
- Noise power by the device :

$$P_{na} = K T_0 B (F-1) \quad -(2)$$
(device)

where T_0 is the environment temperature

- Input Noise power in terms of noise temperature.

$$P = K T_{eq} B$$

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

$$\boxed{T_{eq} = T_0 (F-1)} \quad -(3)$$

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Module 4 - Pulse Modilation

* Pulse Modulation :-

→ Sampling - To transmit Analog signal that is used ~~to~~ in real world such as voice & video signal by digital mean th has to be converted to a digital signal.

- While an analog signal is continues in both time and magnitude, a digital signal is discrete in both time & amplitude.
- To make a signal discrete value of a signal is measured in certain interval of time.
- Each measurement is called as sample.
- Inorder to preserve the information contained in the signal it is necessary to get samples at a particular time interval or specific frequency. → ~~Nyquist rate~~

* Sampling Theorem

- Let $m(t)$ be ~~is~~ a band limited signal with maximum frequency f_m
- The continuous time signal can be represent as $m(nT_s)$ using sampling with the help of periodic ~~trend~~ train of impulses.
* With period T_s seconds
- From discrete time signal $m(nT_s)$, the Original signal $m(t)$ can be regenerated without any distortion using low pass filter. (reconstruction Filter).

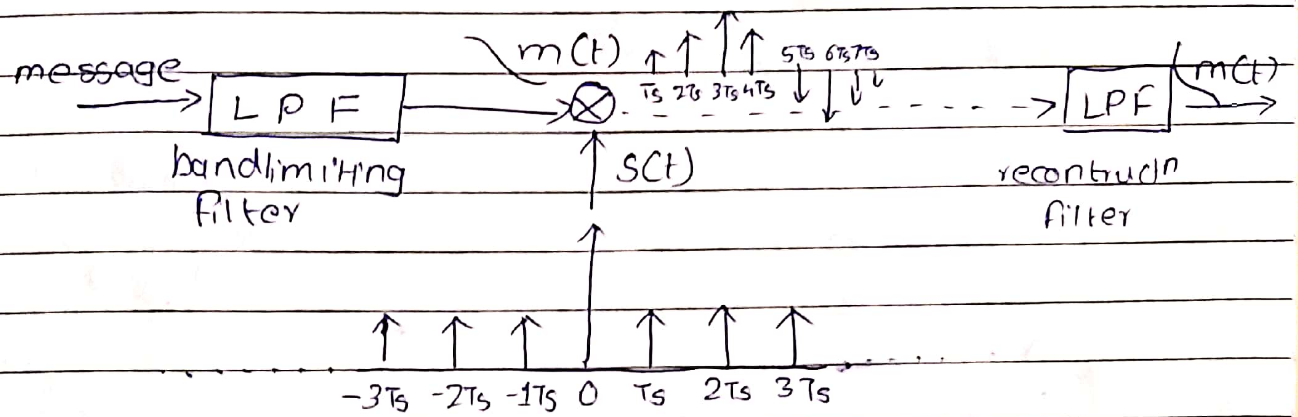
- With cutoff freq. ~~GHz~~ f_m Hz, If :-

$f_s \geq 2 f_m$

OR

$T_s \geq \dfrac{1}{2 f_m}$

- where, $f_s \Rightarrow$ Sampling OR Nyquist Rate
  $T_s \Rightarrow$ Sampling interval



$f_s \leq 2 f_m$

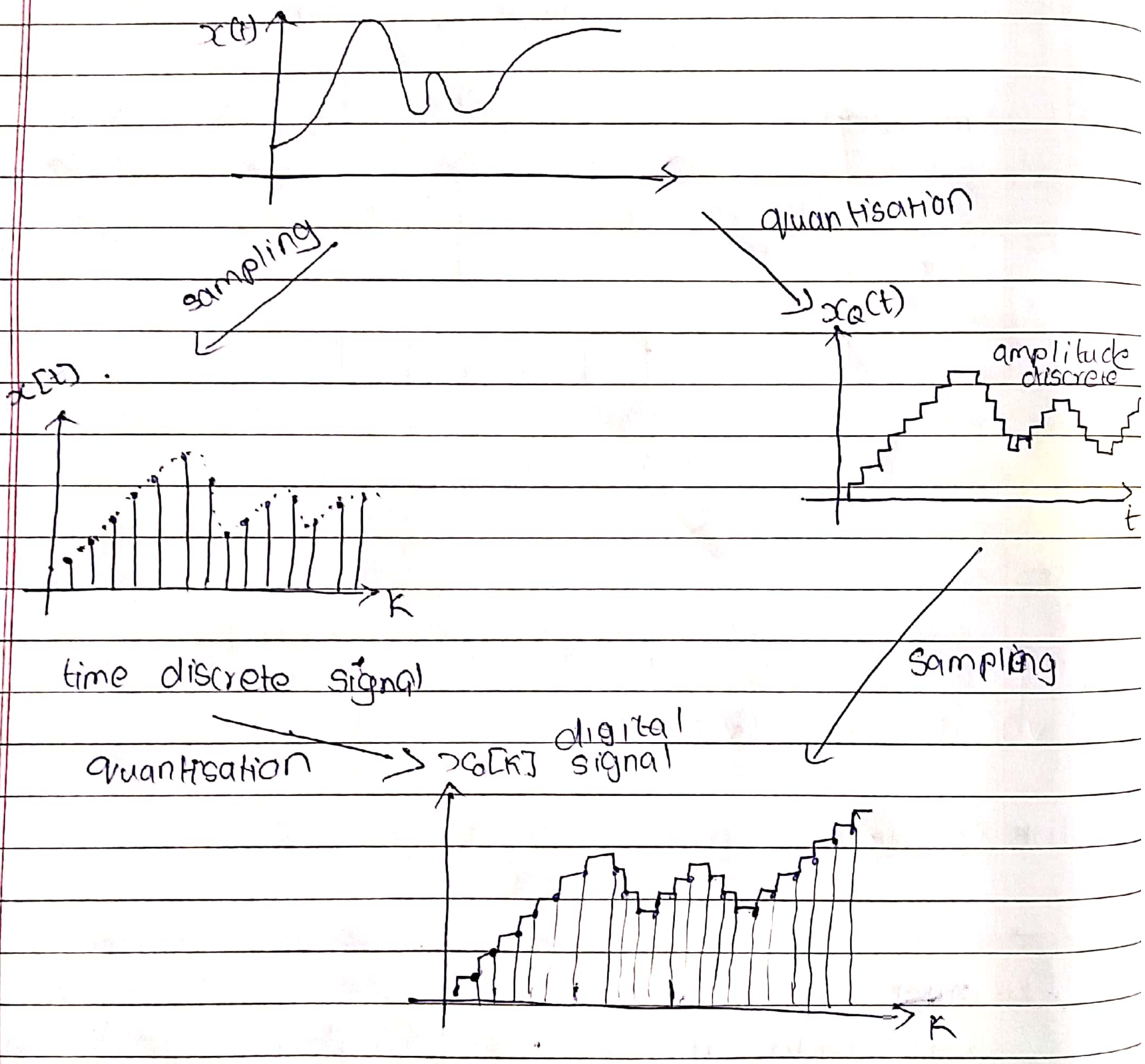
$f_s > 2 f_m \rightarrow$ under sampling

$f_s = 2 f_m$

* <u>Quantisation</u> :-

- The sample values measured during sampling must be quantised to produce a digital representation of the analog signal. i.e each value is approximated to it's nearest quantisatn level.
- The process of digitizing the domain (time) is called sampling and the process of digitizing the amplitude rang is called the Quantisation.

- A ~~Queue~~ Q - level quantiser compares the discrete type input m(nTs) with its fixed digital levels.
- It assigns anyone of the digital levels to m(nTs) which results in minimum distortion or error.



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Q) The AM transmitter develops an unmodulated power output of 400W. Across a 50Ω resistive load, the carrier is modulated by a sinosoidal signal with a modulatn ~~induction~~ index of 0.8. Assuming, FM = 5KHz, Fc = 1MHz.

i) Obtain the value of carrier amplitude & hence, write the expression for AM signal.

ii) Find the total sideband power.

iii) Draw the AM wave for the given modulatn index.

Given :- $P_c = 400W$ To find :- i) A_c & eqn = ?

$R_L = 50\Omega$

signal $m = 0.8$ ii) $P_{SB} = ?$

$f_m = 5KHz$

$f_c = 1MHz$

i) $P_c = \dfrac{A_c^2}{2R}$

$\omega_m = 2\pi f_m$

$A_c^2 = 2P_cR$ $= 2 \times 3.14 \times 5KHz$

$A_c = \sqrt{2 \times 400 \times 50}$ $= 31.4 \times 10^4$

$A_c = 200W$ $\omega_c = 2\pi f_c$

$= 2 \times 3.14 \times 10^6$

$s(t) = A_c[1 + m\cos\omega_m t]\cos\omega_c t$ $= 2\pi 10^6$

$= 200[1 + (0.8)(\pi 10^4)]\cos(2\pi 10^6 t)$

ii) $P_{SB} = \dfrac{m^2 A_c^2}{8R} = \dfrac{m^2 P_c}{4}$

$= \dfrac{(0.8)^2 \times 400}{4}$

$\boxed{P_{SB} = 64W}$

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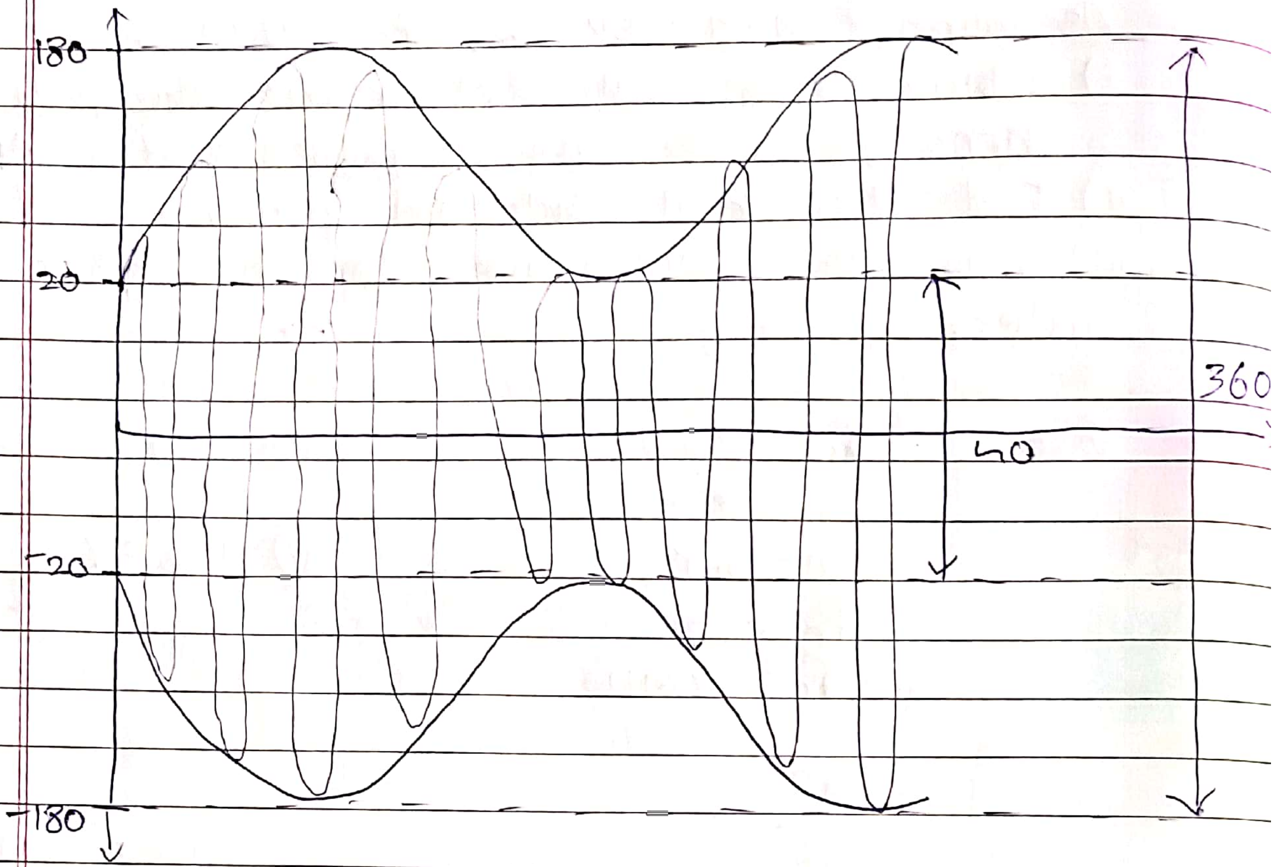
iii) $A_{max} = A_c + A_m = 360V$

$A_{min} = A_c - A_m = 40V$

$m = \frac{A_m}{A_c}$

$A_m = 0.8 \times 200$

$A_m = 160V$



Q) An AM signal is produced by modulating a carrier signal with peak voltage of 10v & frequency of 100 KHz by a sinosoidal signal of Amplitude 4V & freq. 4 KHz. Calculate the i) modulat^n index & write it's mathematical expression.

ii) Bandwidth of Am & sketch it's two sided spectrum.

iii) Total power of the modulated wave, developed across load resistance, $R_L = 50$ & power content in each sideband and carrier.

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Given :- $A_c = 10V$

$f_c = 100 KHz$

~~$A_m = 100KHz$~~

$A_m = 4V$

$f_m = 4KHz$

$\omega_m = 2\pi f_m$

$= 8\pi 10^3$

$\omega_c = 2\pi f_c$

$= 2\pi 10^5$

i) $m = \frac{A_m}{A_c} = \frac{4}{10} = 0.4$

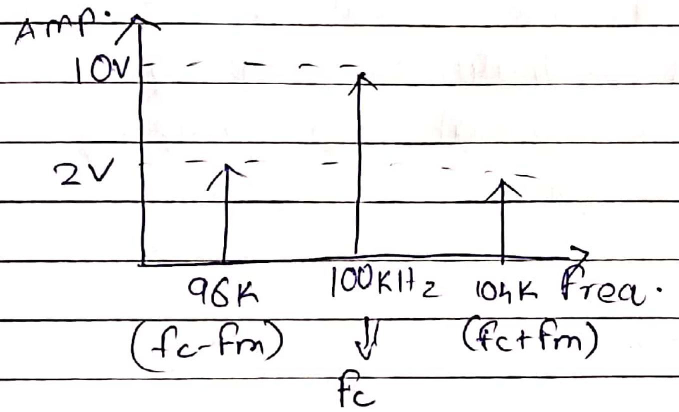
$S(t) = [1 + m \cos \omega_m t] \cos \omega_c t$

$= [1 + (0.4) \cos(8\pi 10^3 t)] \cos(2\pi 10^5 t)$

ii) $B.W = 2 f_m$

$= 2 \times 4$

$= 8 KHz$



$f_c - f_m = 96 KHz$

$F_c + f_m = 104 KHz$

$\frac{A_m}{2} = \frac{4}{2} = 2$

Amp. of SB $= \frac{A_m}{2}$

iii) Total Power $= P_{LSB} + P_c + P_{USB}$

$P_c = \frac{A_c^2}{2R} = \frac{100}{2 \times 50} = 1W$

$P_{LSB} = \frac{m^2 P_c}{4} = \frac{0.4 \times 0.4 \times 1}{4} = 0.04W$

$\therefore P_{USB} = 0.04W$

$\therefore$ Total Power $= 0.04 + 1 + 0.04$

$= 1.08W$

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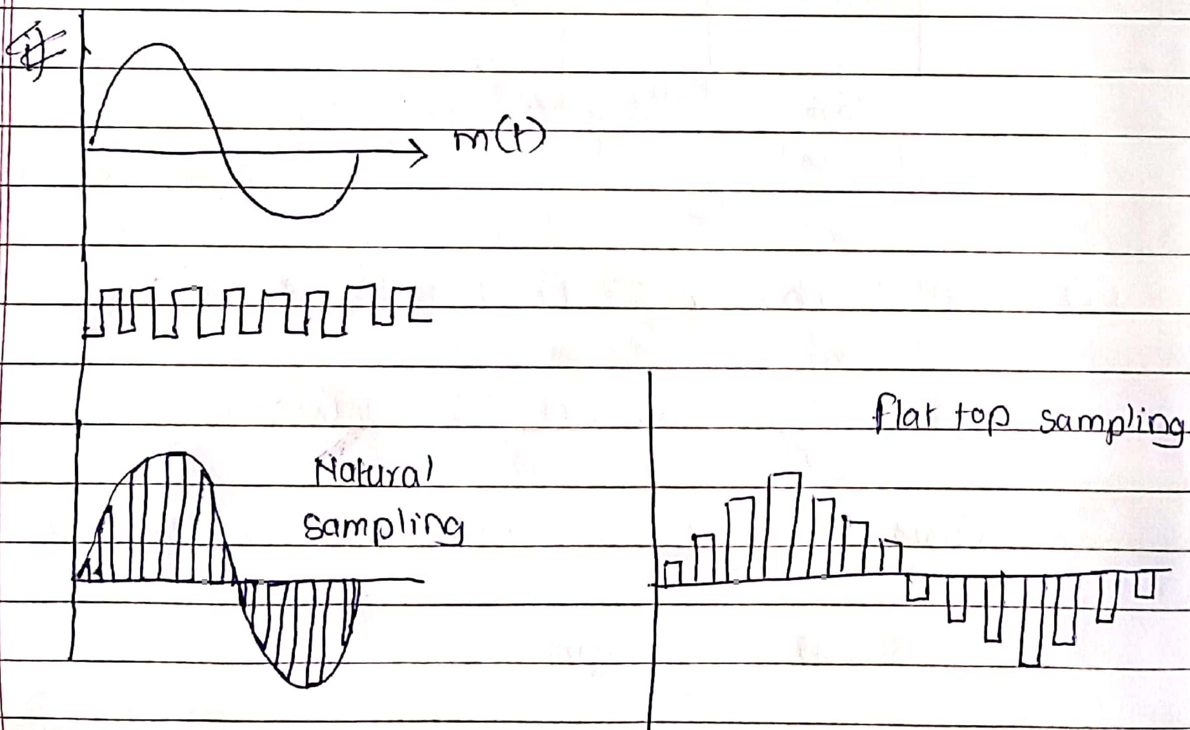
* Pulse Amplitude Modulation :-

- It is a modulatn technique in which the amplitude of each pulse is controlled by the amplitude of the modulating signal.
- Signal is sampled at regular interval & each sample is made proportional to the amplitude of the signal at the instinct of sampling.

* diff. betn continuous signal (carrier signal) & PM is that continuous signal has sinosoidal wave & PM has square wave.

- The sampling of the signal is basically done in two ways - i) natural sampling
  ii) flat top sampling



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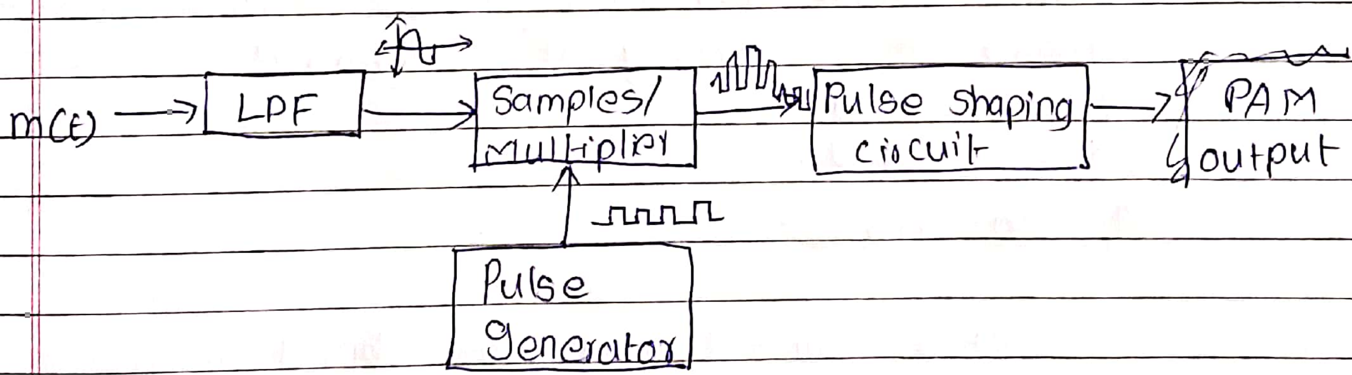
i) Natural Sampling

→ Here, the variatn in the amplitude of each pulse is directly proportional to the modulati signal amplitude at the time of pulse occurrance

ii) Flat top Sampling

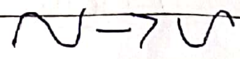
→ Here, the top of each sample / pulse is flat.
- Flat top sampling is widely used because at the time of signal transmission the channel noise introduces some ~~of~~ form of distortion which can be easily eliminated incase of flat tops.
- As against natural sampling where the top of pulses varies according to the modulating signal
- The eliminatn of noise component from the sampled signal becomes difficult comparatively during detectn. (Demodulatn)
- Hence, flat top sampling is prefered & also called as practical sampling.



Detection :-

eliminates high frequency noise components

PAM → LPF → original m(t)



- The low passed filter used for ~~dect~~ detection eliminates high freq. noise components.
- This m(t) is then passed to an inverting amplifie to amplify its signal level to have the demodul output almost same as m(t)

Advantages of PAM :-

- High efficiency
- Construction of transmitter & reciever in PAM is not complex.
- As it doesn't require synchronize of pulses PAM has low noise.
- Quick transmission & reception

Disadvantages of PAM :-

- PAM is quantized in both Amplitude & time which increases noise interference – Effects the quality of informatn being transmitted.
- Large B.W.

Applications

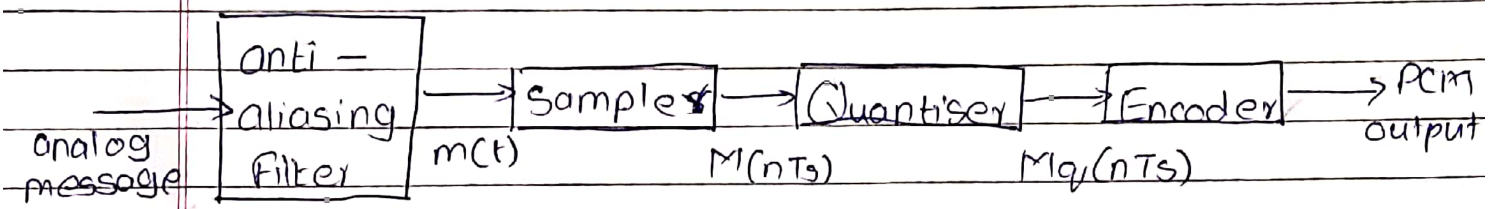
- Ethernet connectivity broadband interface communication.
- To control signal in micro controllers.
- For energy efficient lighting in LED drivers.

- For better signal clarity & clearer picture in digital television.

* <u>Pulse Code Modulation</u> :- (PCM)

- ~~PCM or~~ A digital technique that involves sampling & analog signals at regular interval & coding, the measured amplitude into a series of binary values (0s & 1s)

• <u>Generation of PCM</u>:



<u>Anti - Aliasing filter</u>

→ It is a low pass filter used to band limit the input message signal with maximum Freq. fm Hz.

<u>Sampler</u>

→ It is used to convert continuous time m(t) to descripte time M(nTs), This process is called as sampling, According Sampling theorom the sampling Frequency $f_s \geq 2f_m$ to regenerate the original signal m(t) from M(nTs).

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Quantiser :

→ It is used to convert continuous amplitude $M(nTs)$ to discrete amplitude $Mq(nTs)$. This process is called Quantisation, which is an amplitude approximation process.