18-12-24

Communication :-

Exchange The Information b/w two Entities

Types :-

1) wired Communication

connection b/w two entities through a wire

Ex :- optical fiber

2) wireless Communication

Through a medium can be wired or wireless.

* In wireless Communication freespace is medium.
* wireless Communication is not possible without Antenna. (metalic device) it can be rod or wire.

1) Transmitted Antenna :-

The Antenna which radiats message signal into freespace is called Transmitted Antenna.

2) recieve Antenna :-

The Antenna which recieve message signal from the freespace is called recieve Antenna.

Antenna system :-

Antenna is also called as Transistor. because it converts electrical signals into electromagnetic signals.

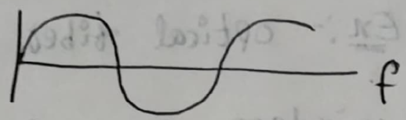
* The electric signal cann't be Transmitted Through free space but The electromagnetic signals can be Transmitted.
* The Transmitter and receiver devices Process electrical signals. These signals as to be converted into electromagnetic signals.

Block Diagram :-

Source → Transmitter
↓
Channel ← Noise
↓
(demodulator) Receiver → Destination

20-12-24

* any wave form consist of
1) frequency 2) Amplitude 3) space
↓
no. of cycles for second.



Modulation :-

modification of message signal. The msg signal is also called as a modulating signal or base band signal and carrier signal.

* The carrier signal which fulfill carried the msg signal and it is a high frequency signal.

Modulated signal :-

The resultant of signal after modulation is called modulated signal.

① need for modulation :-

1) base band signals are Incompatable for Transmission over the medium.

2) It allows frequency multiflexing.

Multiflexing :-

Transmitting multiple signals through a same channel at a time is called multiflexing

frequency multiflexing :-

The signals to be elegated with different frequencies such that, frequency multiflexing is possible

3) reduces The Antenna height. Measured in λ

$$f \propto \frac{1}{\lambda} = f = \frac{c}{\lambda}$$

* frequency is decreses, λ is Increases even height ↑.
* reduce noise and Interberence and ebbicient Transmission.

③ 1.5

Types of modulation :-

① Amplitude Modulation (AM) :-

The amplitude of The carrier signal will varied according to the amplitude of The msg signal.

i) DSBSC (Double side band supresed carrier)
ii) SSBSC (single side band supresed carrier)
iii) VSB (vestigial side band modulation)

② Angle Modulation

1) frequency — narrow FM, while band FM

2) space — narrow band PM, while band PM.

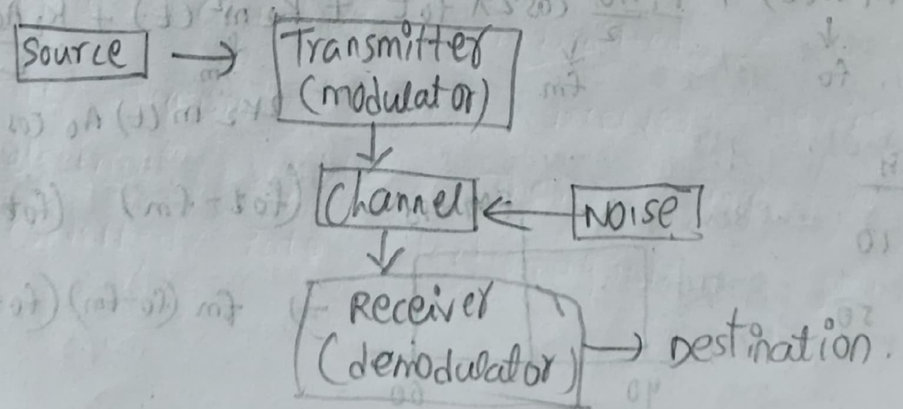
③ Pulse Modulation :-

The carrier signal is a train of Pulses.

1) Pulse Amplitude modulation (PAM)
2) Pulse width Modulation (PWM)
3) Pulse Position Modulation (PPM)

① m

Block Diagram of Communication systems



3-1-25

current equation $= I_0 (e^{V_D/\eta V_T} - 1.)$

$$e^x = 1 + \frac{x}{1!} + \frac{x^2}{2!} + \frac{x^3}{3!} + \cdots\cdots$$

η = Intrinsic constant.

$$e^x = \cancel{1} + \frac{e^{V_D}}{\eta V_T} + \frac{\left(\frac{e^{V_D}}{\eta V_T}\right)^2}{2} + \cdots - \cancel{1}$$

$V_T = 25\,mV$

$$I_D = I_0\left(\frac{e^{V_D}}{\eta V_T} + \frac{\left(\frac{e^{V_D}}{\eta V_T}\right)^2}{2}\right)$$

$$I_D = I_0\left[\frac{V_D}{\eta V_T} + \frac{1}{2}\left(\frac{V_D^2}{\eta V^2_T 2}\right)\right]$$

$$I_D = a_1 V_D + a_2 V_D^2$$

$$I_O = I_D R$$

$$= a_1 R V_O + a_2 R V_D^2$$

$$V_O = K_1 V_i + K_2 V_i^2$$

$$V_i = m(t) + c(t) \Rightarrow m(t) + A_0 \cos 2\pi f_0 t$$

$$c(t) = A_0 \cos 2\pi f_0 t$$

$$\therefore V_O = K_1(m(t) + A_0 \cos 2\pi f_0 t) + K_2 (m(t) + A_0 \cos 2\pi f_0 t)$$

$$= K_1 m(t) + K_1 A_0 \cos 2\pi f_0 t + K_2 m^2(t) + K_2 A_0^2 \cos^2 2\pi f_0 t + 2K_2 m(t) \cdot A_0 \cos 2\pi f_0$$

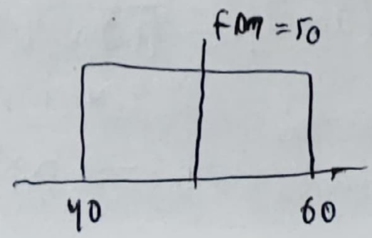
$$V_O = K_1 m(t) + K_1 A_0 \left(\frac{1+\cos 2\pi t}{2}\right) f_0 t + K_2 m^2(t) + K_2 A_0^2 \left(\frac{1+\cos 2\pi t}{2}\right)^2 f_0 t + 2K_2 m(t) A_0 \cos 2\pi f_0 t$$

$$V_O = \underset{\substack{\downarrow \\ f_0}}{K_1 m(t)} + \underset{\substack{\downarrow \\ f_m}}{\frac{K_1 A_0}{2}} \cos 2\pi f_0 t + K_2 \underset{\substack{\downarrow \\ f_m}}{m^2(t)} + \frac{K_2 A_0^2}{2} \cos 4\pi_0 + 2K_2 m(t) A_0 \cos 2\pi f_0 t.$$

<u>Band pass</u>

$f_t = 10$

$f_m = 50$

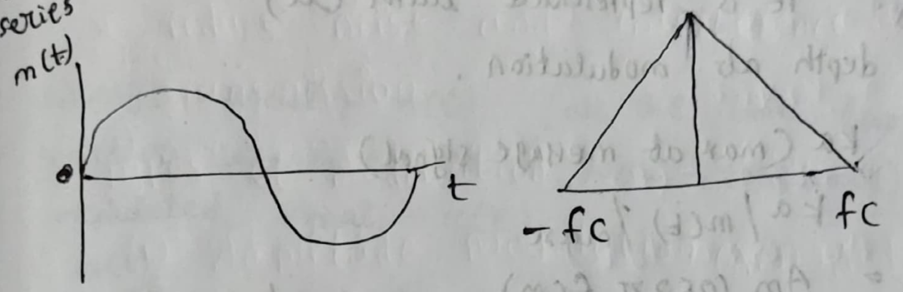


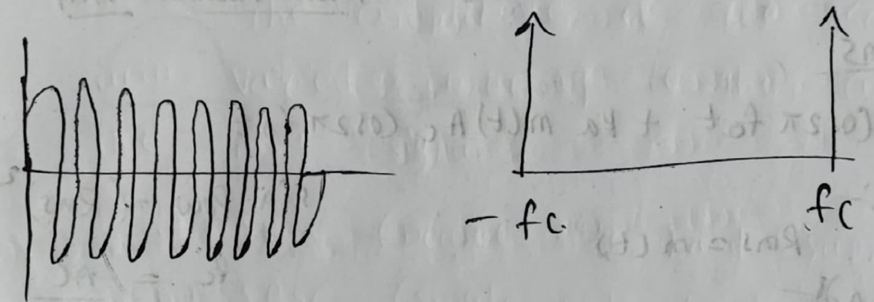
$(f_0 t - f_m) \quad (f_0 t + f_m)$

$\Rightarrow f_m \; (f_0 - f_m)(f_0 + f_m)$

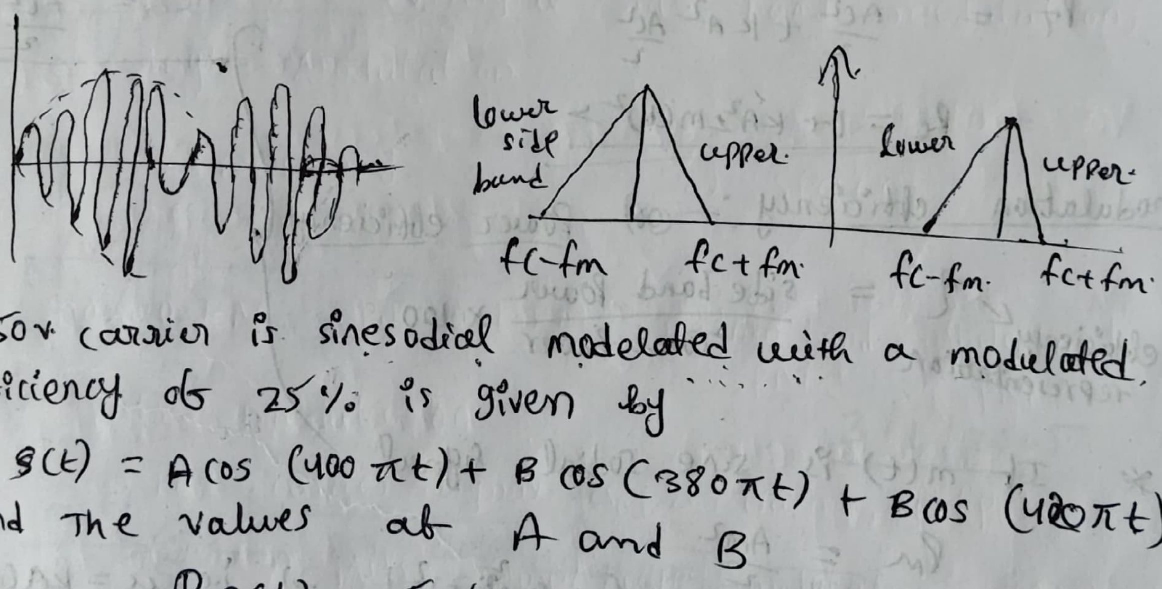
KA is The Amplitude sensitivity factor.

fourier series [time Domain signal to frequency Domain signal]





Am spectrum



a 50v carrier is sinesodial modelated with a modulated ebbiciency of 25% is given by

$s(t) = A\cos(400\pi t) + B\cos(380\pi t) + B\cos(420\pi t)$

Find The values of A and B

$P_C \cancel{(t)} = 50V$ $\qquad$ $\%\eta = 25\%$

$\%\eta = 25\%$ $\qquad$ $\frac{P_{SB}}{P_c + P_{SB}} \times 100 = 25$

$\frac{A_C^2}{2} = 50$ $\qquad$ $\frac{P_{SB}}{50 + P_{SB}} \times 100 = 25$

$A_C = \sqrt{100}$

$A_C = 10 = A$ $\qquad$ $P_{SB} = 16.66$

$s(t)\ P_{SB} = P_{LSB} + P_{USB}$ $\qquad$ $P_{SB}(100) = 25(50 + P_{SB})$

$100P_{SB} = 1250 + 25P_{SB}$

$4P_{SB} = 750$ [sic]

$P_{SB} = 750/4 = 16.66$

Bandwidth frequency :-

The range ab frequency is The signal is ccupiying.

(or)

high frequency − law frequency.

Modulation index :- it is, represented with (μ)

also Called of depth ab modulation.

$$\mu = ka \text{ (max ab message signal)}$$

$$\mu = ka\,|m(t)|\,max$$

$$m(t) = Am \cos 2\pi f(m) \qquad \text{max value} - Am$$

Power Calculations

$$A.m = AC \cos 2\pi f_0 t + ka\, m(t) A_c \cos 2\pi f_0 t$$

side band Power :-

$$\text{sin. Pow} = (Rms)^2$$

$$Rms = m(t)$$

$$P_c = \frac{AC}{\sqrt{2}}$$

$$P_{sb} = \frac{(KA^2\ AC)^2}{2}$$

$$P_c = \frac{AC^2}{2}$$

$$P_T = \frac{AC^2}{2} + KA^2 \frac{AC^2}{2}$$

$$P_c = 1 + KA^2 \Sigma m(t)^2 >$$

modulation efficiency :- (or) Power efficiency

$$\eta = \frac{\text{side band Power}}{\text{Total Power}} \times 100$$

efficiency representation

* If m(t) is sine sodial signal

$$P_m = \frac{Am^2}{2}$$

$$P_T = P_c \left(1 + \frac{(KA^2 AC)^2}{2}\right) \rightarrow \text{i.e } \mu = Ka(Am)$$

$$\%\ \eta = \frac{P_c \frac{\mu^2}{2} \frac{P_{SB}}{P_T}}{P_c} \times 100 \Rightarrow \left(\frac{\mu^2}{\cancel{2}} \times \frac{\cancel{2}}{2+\mu^2}\right) \times 100$$

$$\eta = \frac{\mu^2}{2+\mu^2} \times 100$$

$$\eta = 3.33\ \%$$

when The modulated percentage is 75% and radiun transmeter radiation 10K. watt Power. what is The carrier Power

$$P_T = 10kw \qquad \%\ \mu = 75\%$$

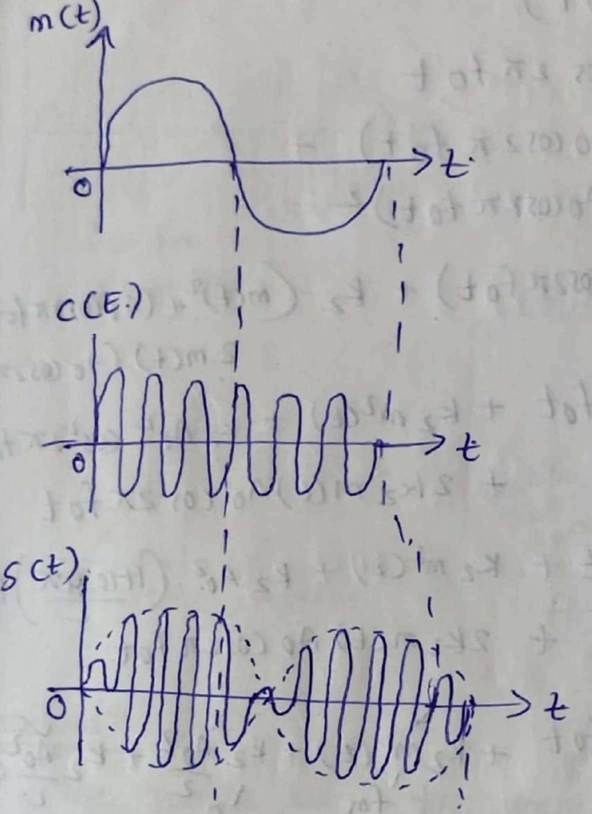
$$P_C = ? \qquad \mu = 0.75$$

1-1-2025

Information source → Transducer → Transmitter [modulator] → Antenna (Tx) → channel

destination ← Transducer ← [demodulator] ← Rx Antenna

* Message signal - m(t) (all the time low - frequency)
* carrier signal - c(t) (high - frequency) sinusoidal signal
* modulated signal - s(t)



3/1/2025

m(t) → Σ ← c(t); V_i → [non - linear device] (Diode) → V_0 → [BPF] (Band pass Filter) → [Am]

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

$$I_D = I_0 \left(e^{\frac{V_D}{\eta V_T}} - 1\right)$$

$$I_D = I_0 \left[\cancel{1} + \frac{V_D}{\eta V_T} + \frac{1}{2}\left(\frac{V_D}{\eta V_T}\right)^2 - \cancel{1}\right]$$

$$= \frac{I_0 V_D}{\eta V_T} + \frac{1}{2}\frac{I_0 V_D^2}{\eta^2 V_T^2} \;\; //$$

η = Intrinsic constant

V_T = Thermal voltage

I_0 = Reverse saturation carriers

= minority charge carriers.

$$I_D = a_1 V_D + a_2 V_D^2$$

$$V_D = I_D R$$

$$\boxed{V_0 = (a_1 V_D + a_2 V_D^2) R}$$

$$V_0 = a_1 V_D R + a_2 V_D^2 R$$

$$= a_1 R v_i + a_2 R v_i 2$$

$$\boxed{V_0 = K_1 v_i + K_2 v_i 2}$$

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

$$(\therefore c(t) = A_0 \cos 2\pi f_0 t)$$

$$v_i = m(t) + A_0 \cos 2\pi f_0 t$$

$$V_0 = K_1 (m(t) + A_0 \cos 2\pi f_0 t) + K_2 (m(t) + A_0 \cos 2\pi f_0 t)^2$$

$$V_0 = K_1 (m(t) + A_0 \cos 2\pi f_0 t) + K_2 (m(t)^2 + (A_0 \cos 2\pi f_0 t)^2 + 2m(t)(A_0 \cos 2\pi f_0$$

$$V_0 = K_1 m(t) + K_1 A_0 \cos 2\pi f_0 t + K_2 m^2(t) + K_2 A_0^2 \cos^2 2\pi f_0 t + 2K_2 m(t) A_0 \cos 2\pi f_0 t$$

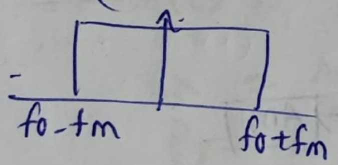
$$V_0 = K_1 m(t) + K_1 A_0 \cos 2\pi f_0 t + K_2 m^2(t) + K_2 A_0^2 \left(\frac{1+\cos 4\pi}{2}\right) f_0 t + 2K_2 m(t) A_0 \cos 2\pi f_0 t$$

$$V_0 = \underset{f_m}{\overset{\times}{K_1 m(t)}} + \underset{f_0}{\overset{\checkmark}{K_1 A_0 \cos 2\pi f_0 t}} + \underset{f_m}{\overset{\times}{K_2 m^2(t)}} + \underset{0}{\overset{\times}{K_2 \frac{A_0^2}{2}}} + \underset{2f_0}{\overset{\checkmark}{K_2 \frac{A_0^2}{2} \cos 4\pi f_0 t}}$$

$$+ \underset{f_m \ \ f_0}{2K_2 m(t) A_0 \cos 2\pi f_0 t}$$

$f_0 + f_m \quad f_0 - f_m$

(band-pass filter)



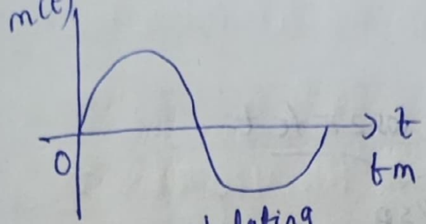
O/P of BPF

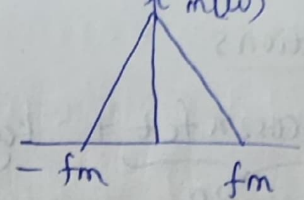
$$s(t) = K_1 A_0 \cos 2\pi f_0 t + 2K_2 m(t) A_0 \cos 2\pi f_0 t$$

$$= K_1 A_0 \cos 2\pi f_0 t + \left[1 + \frac{2K_2}{m_1} m(t)\right]$$

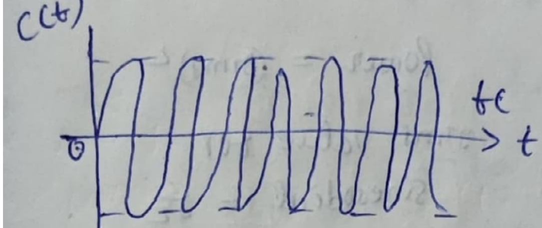
$$s(t) = A_c \cos 2\pi f_c t \, (1 + k_a m(t)]$$

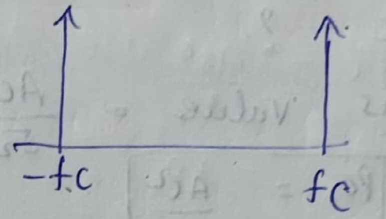
* k_a is the Amplitude sensitivity factor.

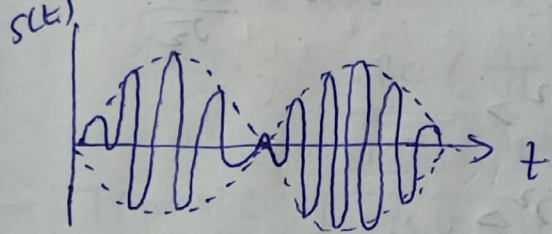




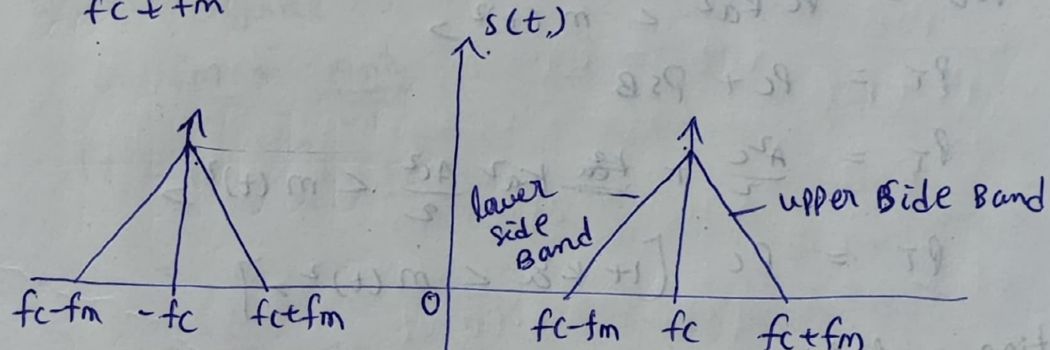
modulating







fc-fm
fc+fm



Bandwidth :

The range of frequency That signal is Occupying (or) high frequency - low frequency.

$$BW = f_H - f_L$$

$$BW = f_c + f_m - [f_c - f_m)$$

$$\boxed{BW = 2f_m}$$

Modulation Index : (μ) or depth of modulation

$$\mu = k_a / m(t) /_{max}$$

$m(t) = A_m \cos 2\pi f_m t$ $\qquad$ cos (max) = 1

$$\boxed{\mu = k_a A_m}$$

Power Calculations

$$s(t) = \underbrace{A_c \cos 2\pi f_c t}_{P_C} + \underbrace{k_a m(t) A_c \cos 2\pi f_c t}_{P_{SB}}$$

$$P_T = P_C + P_{SB}$$

$P_C = ?$

Power $= (\text{rms})^2$

rms value for sinesodial $= \sqrt{2}$

$\text{rms} = \frac{\max}{\sqrt{2}}$

rms value $= \frac{A_C}{\sqrt{2}}$

$$\boxed{P_C = \frac{A_C^2}{2}}$$

$$P_{SB} = \frac{(k_a A_C)^2}{2} \langle m(t)^2 \rangle$$

$$P_{SB} = k_a^2 \frac{A_C^2}{2} \langle m(t)^2 \rangle$$

$$P_{SB} = P_C k_a^2 \langle m(t)^2 \rangle$$

$$P_T = P_C + P_{SB}$$

$$P_T = \frac{A_C^2}{2} + \cancel{k_a} k_a^2 \frac{A_C^2}{2} \langle m(t)^2 \rangle$$

$$P_T = P_C \left[1 + k_a^2 \langle m(t)^2 \rangle\right]$$

modulation efficiency (or) Power efficiency

$$\boxed{\%\eta = \frac{P_{SB}}{P_T} \times 100}$$

if $m(t)$ is sinesodial signal

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

$$P_m = \frac{A_m^2}{2}$$

$$\boxed{P_T = P_C \left[1 + k_a^2 \frac{A_m^2}{2}\right]}$$

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

$$\%\eta = \frac{\cancel{P_C} \frac{\mu^2}{2}}{\cancel{P_C}\left(1 + \frac{\mu^2}{2}\right)} \times 100$$

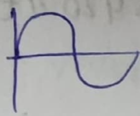
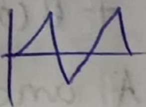
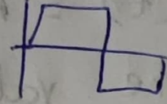
$$= \frac{\mu^2}{2} \times \frac{2}{2 + \mu^2} \times 100$$

in generally $\mu = 1$

$$\boxed{\%\eta = \frac{\mu^2}{2 + \mu^2} \times 100}$$

$\% \eta = \frac{1}{3} \times 100$

$\boxed{\% \eta = 33.33\%}$

 $\frac{A_m}{\sqrt{2}}$  $\frac{A_m}{\sqrt{3}}$  $\frac{A_m^2}{\sqrt{1}}$

* The square wave has highest efficiency

$P_T = P_C \left(1 + k_a^2 \frac{A_m}{\sqrt{3}}\right)$

$= P_C \left(1 + \frac{1}{\sqrt{3}}\right)$

$\mu\% = \frac{P_C\left(\frac{1}{\sqrt{3}}\right)}{P_C\left(1+\frac{1}{\sqrt{2}}\right)} = \frac{1}{\sqrt{3}} \cdot \frac{\sqrt{3}}{3+1} \times 100 = \frac{1}{4} \times 100 = 25\%$

Triangle $\boxed{\mu\% = 25\%}$

* Square signal

$P_m = \frac{A_m^2}{\sqrt{1}}$

$P_T = P_C \left(1 + \frac{k_a^2 A_m^2}{\sqrt{1}}\right)$

$= P_C \left(1 + \frac{\mu^2}{\sqrt{1}}\right)$

$= P_C \left(1 + \frac{1}{1}\right) = 2P_C$

$\mu\% = \frac{2P_C}{P_C\left(1+\frac{1}{2}\right)}$

8/01/25

if $m(t) = A_m \cos 2\pi f_m t$

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

$= A_c \cos 2\pi f_c t + k_a A_c A_m \cos 2\pi f_m t \cos 2\pi f_c t$

$= A_c \cos 2\pi f_c t + \frac{k_a A_m A_c}{2} \left(\cos 2\pi (f_c + f_m)t + \cos 2\pi (f_c - f_m)t\right.$

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

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

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

$\frac{1}{2}\left[\cos(A+B) + \cos(A-B)\right] = \cos A \cos B$ //

Prb-1 :- A 50W carrier is a sinsodial modulator with a modulates ebbiciency ob 25%. is given by $s(t) = A \cos 400\pi t + B \cos 360\pi t + B \cos 420\pi t$ find The value ab A and B.

$$P_C = \frac{A_C^2}{2}$$

$$\frac{A_C^2}{2} = 50$$

$$A_C^2 = 100$$

$$A_C = \sqrt{100}$$

$$\boxed{A_C = 10}$$

$$\%\eta = 25$$

$$\frac{P_{SB}}{P_C + P_{SB}} \times 100 = 25$$

$$\frac{P_{SB}}{10 + P_{SB}} \times 100 = 25$$

$$P_{SB} = 16.66 \text{ wt}$$

$$P_{SB} = P_{LSB} + P_{USB}$$

$$P_{SB} = \left(\frac{B}{\sqrt{2}}\right)^2 + \left(\frac{B}{\sqrt{2}}\right)^2$$

$$16.66 = \frac{B^2}{2} + \frac{B^2}{2}$$

$$B = \sqrt{16.66}$$

$$B = 4.08$$

Prb-2 when The modulation % is 75% and Am Transmates radiats 10kwt Power how much ob The carrier Power is wasted ?

$\eta = 75\%$ or 0.75

(PT) total Power = 10 kilowt
= 10 kwt

$$P_T = P_C\left[1 + \frac{\mu^2}{2}\right]$$

$$10 = P_C\left(1 + \frac{(0.75)^2}{2}\right)$$

$$10 = P_C(1 + 0.28125)$$

$$10 = P_C(1.28125)$$

$$P_C = 7.804 \text{ kwt}$$

Prbm:- A Am transmites radiates 20kws if The modulation idex is 0.7 find the carrier Power?

$P = 20\,kW$

modulation index = 0.7

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

$$20 = P_c\left(1+\frac{(0.7)^2}{2}\right)$$

$$20 = P_c\,(1+0.245)$$

$$20 = P_c\,(1.245)$$

$$P_c = 16.06\ kwt$$

Prbm:- The total Power Content of an am single is 100wt determain The Power being Transmitted at carrier froquency and at each side band when modulation % in 100%.

$P_C = ?$ $\quad P_T = 1\,kW = 100\,wt$

$P_{LSB} = ?$ $\quad \%\mu = 100\%$

$P_{USB} = ?$

$$P_T = P_c\left(1+\frac{\mu^2}{2}\right)$$

$$P_T = P_c\,(1+0.5)$$

$$P_T = P_c\,(1.5)$$

$$P_c = 0.6\ kwt$$

$$s(t) = A_c\cos 2\pi f_c t + \frac{k_a A_m A_c}{2}\cos 2\pi f t$$

$$P_{LSB} = \left(\frac{\frac{k_a A_m A_c}{2}}{\sqrt{2}}\right)^2$$

$$P_{LSB} = \left(\frac{k_a A_m A_c}{2\sqrt{2}}\right)^2$$

$$P_{LSB} = \frac{\mu^2 A_c^2}{2\times 4} = \frac{\mu^2}{4}\frac{A_c^2}{2} = \frac{\mu^2 P_c}{4} = \frac{1}{4}\times 0.66$$

$P_{LSB} = 0.6\,kW$

$P_{LSB} = P_{USB} = 0.16\,kW$

A 500wt, 100KHz carrier is modulated to a depth of 60% by modulating frequency of 1KHz. calculate the total power transmitted and what are the side band components of Am variable?

$A_c = 500W = 0.5kW$

$f_c = 100KHz$; $f_m = 1KHz$

$f_c + f_m = 100+1 = 101\ KHz$

$f_c - f_m = 100-1 = 99\ KHz$

$P_T = P_c\left(1+\frac{\mu^2}{2}\right) = 0.5\left(1+\frac{(0.6)^2}{2}\right)$

$= 0.5\left(\frac{2+0.36}{2}\right) = 0.5\left(\frac{2.36}{2}\right) 1.18$

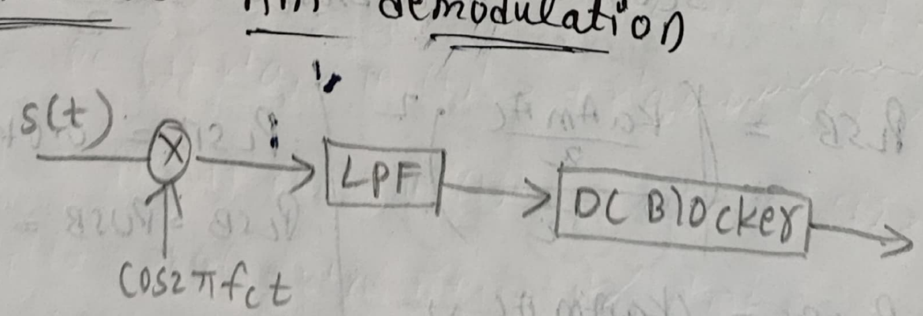
$= 0.59\%$

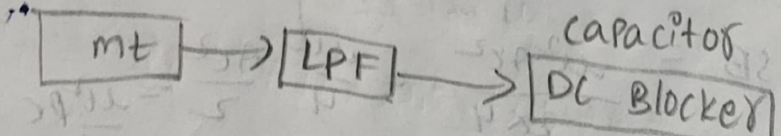
Am demodulation

1. Synchronous
2. Asynchronous

* The carrier used in The modulation technique has to be used in the demodulation as wel

Synchronous Am demodulation



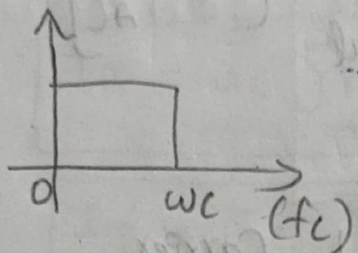


time domain ⇌ frequenc

① Gain = $\frac{O/P}{i/P}$ TF

$[b_N \; a_D]$ = butter [1. 0.01]

↓ order of the filter ↓ cut of frequency (ωc)



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

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

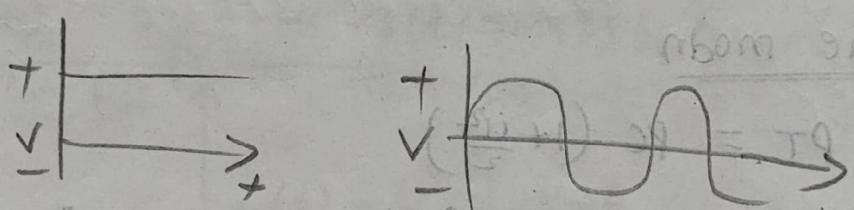
$= \left[\frac{1+\cos^2 2\pi f_c t}{2}\right] A_c [1+k_a m(t)]$

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

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

$\Rightarrow \underbrace{\frac{A_c}{2}}_{f_0} + \underbrace{\frac{A_c}{2}k_a m(t)}_{f_m} + \underbrace{\frac{A_c\cos 4\pi f_c t}{2}}_{2f_c} + \underbrace{\frac{A_c}{2}k_a m(t)\cos 4\pi f_c t}_{2f_c+f_m,\; 2f_c-f_m}$

— o/p LPF



→ number of cycles per second – frequency

→ one cycle consists as, positive peak and 1 negative peak.

low pass signal → it allows low pass signal and regecting high pass signal

<u>O/P LPF</u>

$x(t) = \frac{A_c}{2} + \frac{A_c}{2} k_a m(t)$

O/P of DC blocker

$$= \frac{AC}{2} \, ka \, m(t)$$

$$= \frac{AC}{2} \, ka \, Am \cos 2\pi fmt \qquad \left[ka = \frac{1}{AC}\right]$$

Pure msg signal

DSB-SC

Double side band supressed Carrier

$$\% \eta = \frac{PSB}{Pc + PsB} \times 100 \qquad PSB \rightarrow S.B.P$$

$Pc \downarrow$ S.P, $PsB \downarrow$ S.B.P

$$\% \eta = \% 100$$

$$S(t) = AC \cos 2\pi fct + ka \, m(t) \, AC \cos 2\pi fct$$

AM spectrum

efficiency 100% improve in DSB-SC

no change in band width

24-1-25

Multitone modn

$$PT = PC\left(1 + \frac{\mu^2}{2}\right)$$

$$m(t) = Am_1 \cos 2\pi fm_1 t + Am_2 \cos 2\pi fm_2 t + \cdots$$

$$P_T = PC\left(1 + k^2 a_1 < m_1(t)^2 > + k^2 a < m_2^2(t) >\right) + \cdots$$

$$PT = Pc\left(1 + ka_1^2 + m_1(t)^2 > + ka^2 < m_2^2(t) > +\right]$$

$$P_T = Pc\left(1 + k^2 a_1 \frac{A^2 m_1}{2} + k^2 a_2 \frac{A^2 m_2}{2} + \cdots\right]$$

$$P = Pc\left(1 + \frac{\mu_1^2}{2} + \frac{\mu_2^2}{2} + \cdots\right]$$

$$P_T = Pc\left(1 + \frac{\mu_1^2 + \mu_2^2 + \cdots}{2}\right]$$

$$P_T = Pc\left(1 + \frac{\mu_{CH}^2}{2}\right]$$

Power (P) = $I \cdot V$

$$P = I^2 R$$

$$I_T^2 R = I_c^2 R \left(1 + \frac{\mu^2_{CH}}{2}\right)$$

$$\boxed{I_T = I_C \sqrt{1 + \frac{\mu^2_{CH}}{2}}}$$ multitone

$$\boxed{I_T = I_C \sqrt{1 + \frac{\mu^2}{2}}}$$ – singletone

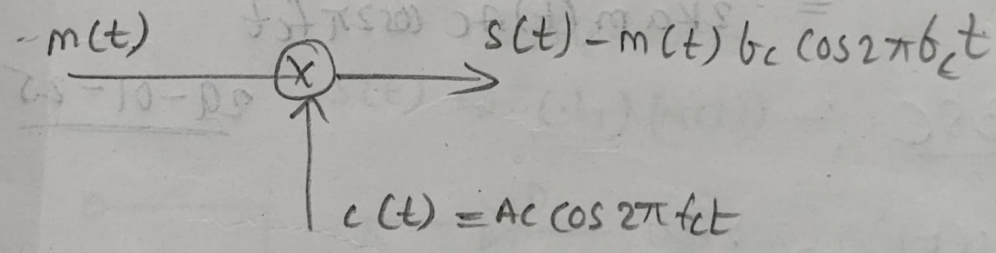
1) An Antenna current of a Sink signal is increased from 8 Amp to 8.93 Amp find % modulation index.

$$8.93 = 8 \sqrt{1 + \frac{\mu^2_{CH}}{2}}$$

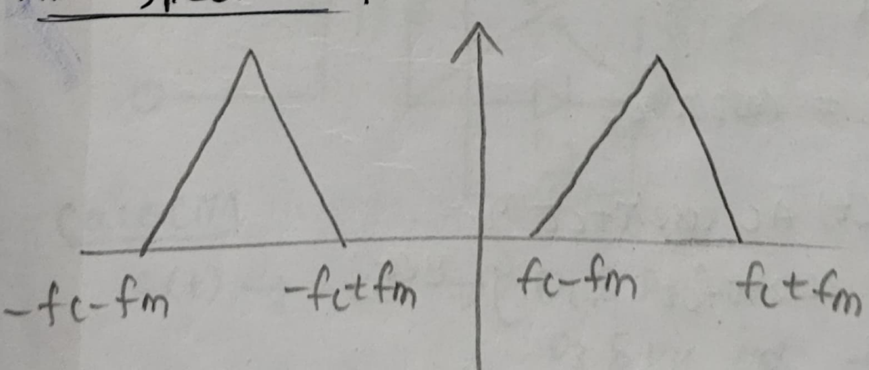
$$8.93 = 8 \sqrt{\frac{2 + \mu^2_{CH}}{2}}$$

$$8.93 = 8 \sqrt{\frac{2 + \mu^2_{CH}}{2}}$$

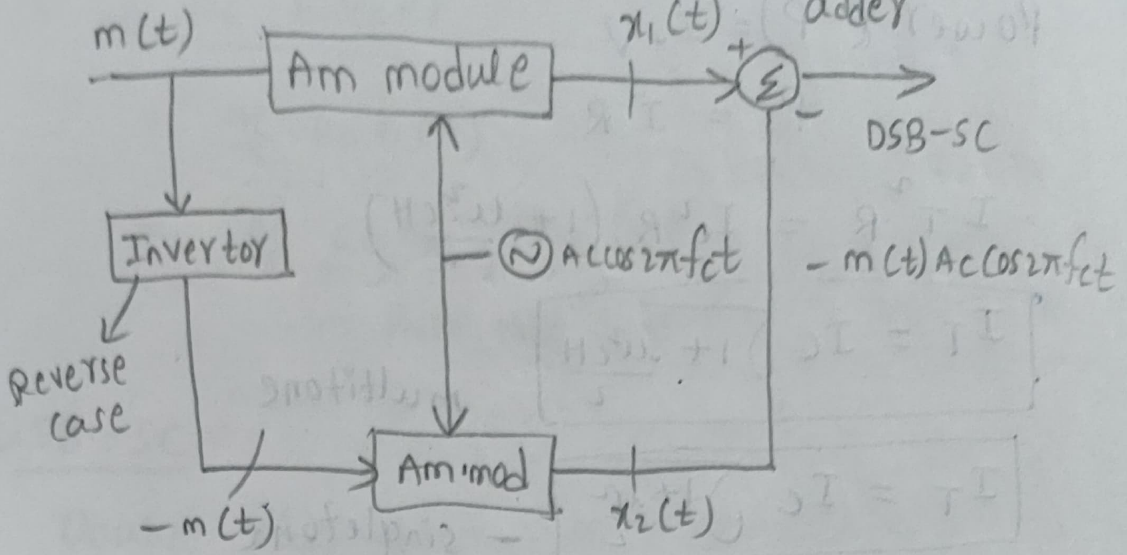
DSB-SC mod^n



Am spectrum :-



BW = 2fm



$x_1(t) - x_2(t)$

$s(t) = A_c\cos 2\pi f_0 + (1 + k_a m(t))$

$x_1(t) = A_c\cos 2\pi f_c t + k_a m(t) A_c\cos 2\pi f_c t$

$x_2(t) = A_c\cos 2\pi f_c t + k_a m(t) A_c\cos 2\pi f_c t$

$x_1(t) - x_2(t)$

DSBSC signal $\rightarrow s(t) = x_1(t) - x_2(t)$

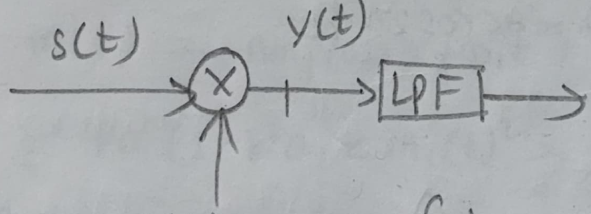
$s(t) = A_c\cos 2\pi f_c\, k_a m(t) A_c\cos 2\pi f_c t -$

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

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

DSBSC :-

29-01-25



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

$$\left.\begin{aligned} s(t) &= m(t) A_c\cos 2\pi f_c t \\ c(t) &= \cos 2\pi f_c t \end{aligned}\right\} y(t)$$

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

$y(t) = m(t)\, A_C \cos 2\pi f_c t \cdot \cos 2\pi f_c t$

$y(t) = m(t)\, A_C \cos^2 2\pi f_c t$

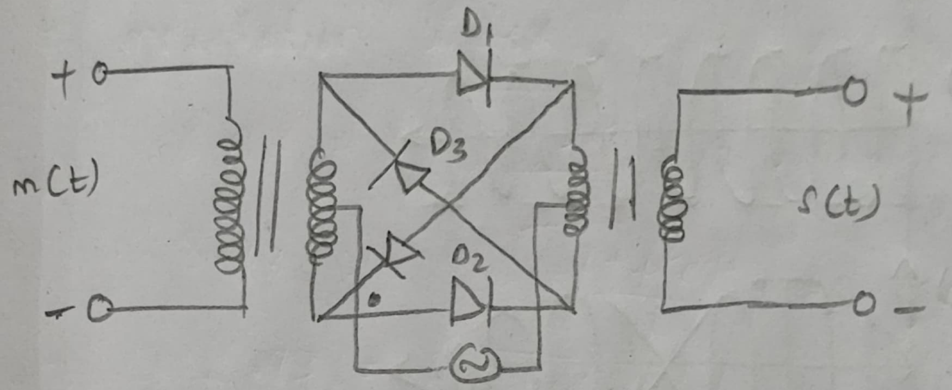
$y(t) = m(t)\, A_C \left(\frac{1 + \cos 2\pi f_c t}{2}\right)$

$y(t) = \underbrace{\frac{m(t) A_C}{2}}_{f_m} + \underbrace{\frac{m(t) A_C \cos 4\pi f_c t}{2}}_{2f_c + f_m \text{ (or) } 2f_c - f_m}$ (High frequency)

(low frequency component)

O/P LPF :- $\frac{A_C}{2} m(t)$

Ring modulator



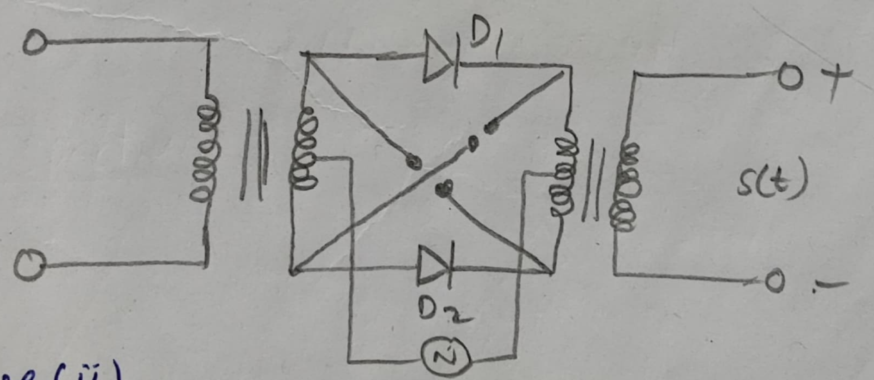
c(t) = +ve

Case (i)

$c(t) \rightarrow +ve \Rightarrow D_1 D_2 \rightarrow ON$

$D_3 D_4 \rightarrow OFF$

$s(t) \Rightarrow (+1)(m(t))$

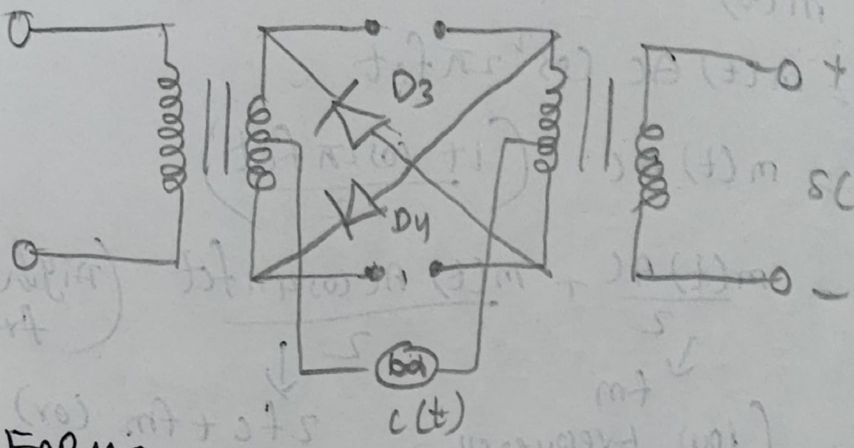


Case (ii)

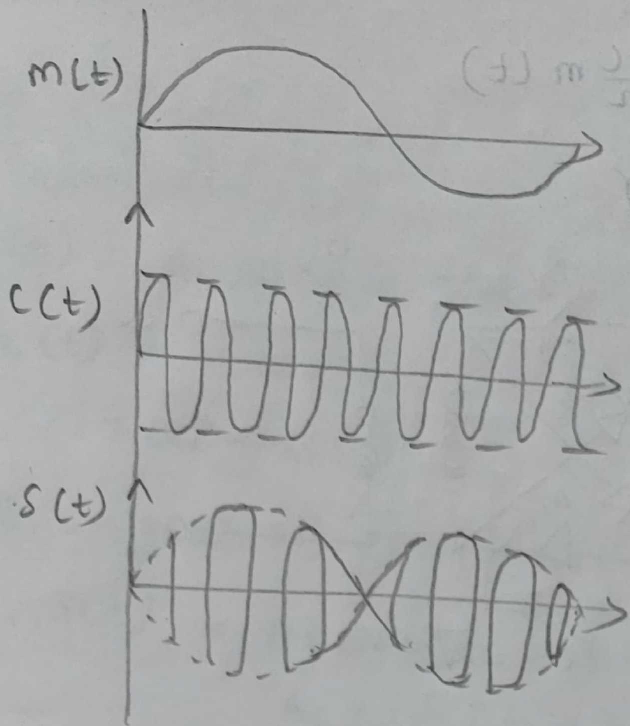
$c(t) \rightarrow -ve \Rightarrow D_1 \,\&\, D_2$ off

$D_3 \,\&\, D_4$ ON

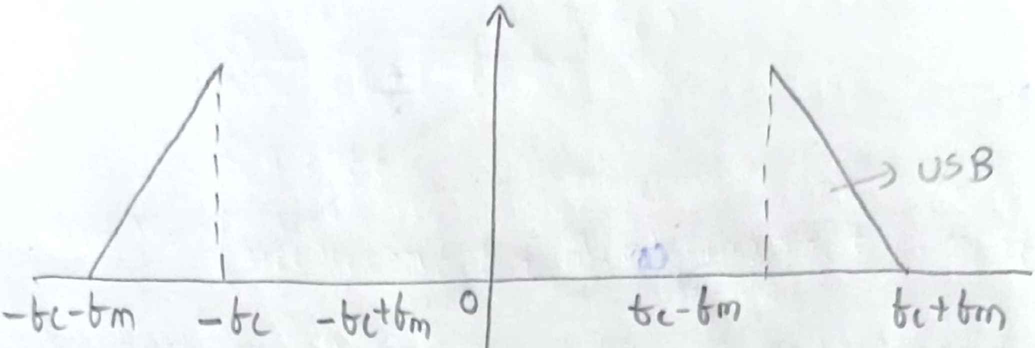
$s(t) \Rightarrow ((-)\, m(t))$



- Wave FORMS



SSB-SC



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

$$\% \eta = \frac{P_{SB}}{P_C + P_{SB}} \times 100$$

$$= \frac{P_{USB}}{P_{USB}} \times 100$$

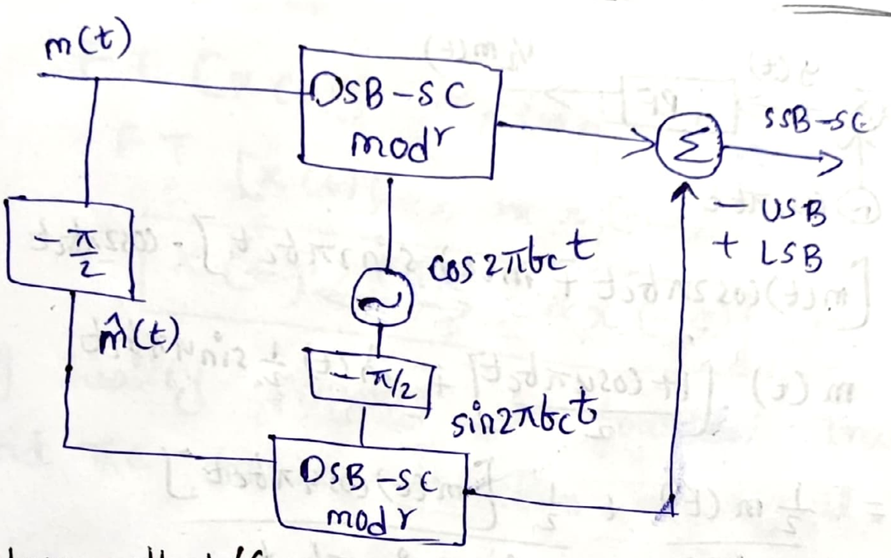
$$= 100\,\%.$$

$$s(t) = m(t)\, A_c \cos 2\pi f_c t$$
$$m(t) = A_m \cos 2\pi f_m t$$
$$s(t)_{DSB\cdot SC} = A_m \cos 2\pi f_m t \cdot A_c \cos 2\pi f_c t$$
$$= \frac{A_m A_c}{2}\Big[\underbrace{\cos 2\pi (f_c+f_m)t}_{USB} + \underbrace{\cos 2\pi (f_c-f_m)t}_{LSB}\Big]$$

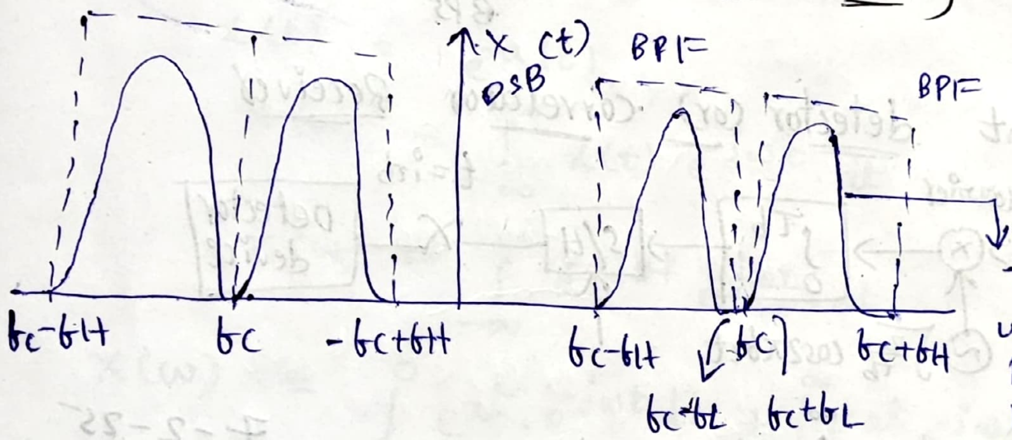
USB :-

$$s(t)_{USB} = \frac{A_c A_m}{2} \cos 2\pi (f_c+f_m)t$$
$$= \frac{A_c A_m}{2}\Big[\cos 2\pi f_c t \cdot \cos 2\pi f_m t - \sin 2\pi f_c t \cdot \sin 2\pi f_m$$
$$s(t)_{USB} = A_c \cos 2\pi f_c t \cdot A_m \cos 2\pi f_m t - A_c \sin 2\pi f_c t \cdot A_m \sin 2\pi$$
$$s(t)_{USB} = m(t).$$

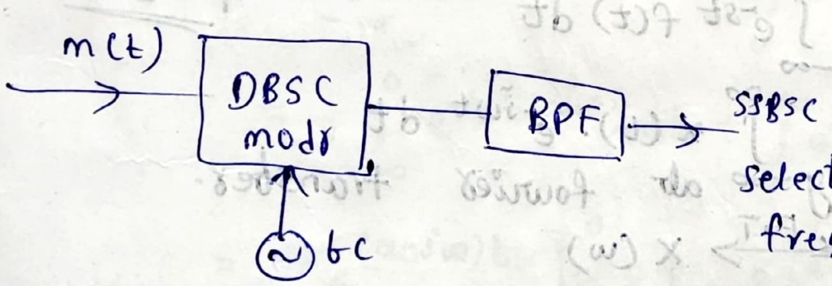
Phase-shift / phase discrimination / Time domain method



filter method / (frequency Discrimination method)



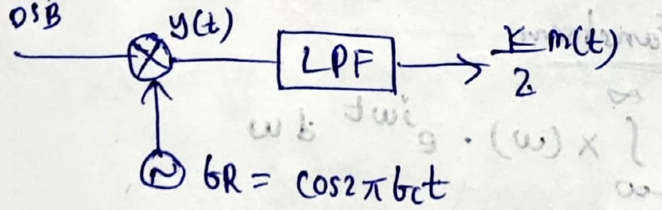
To select upper side band, HPS can be used



Selection BPF freq is Difficult

Coherent Detection of DSBSC

$x(t) = k\,m(t)\cos 2\pi f_c t$ (DSB)

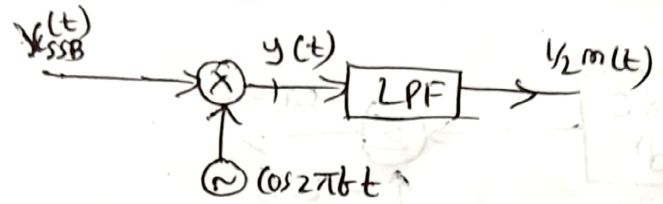


$$y(t) = k\,m(t)\left[\frac{1+\cos 4\pi f_c t}{2}\right]$$

$$= \underbrace{\frac{k}{2} m(t)}_{L.P.S} + \underbrace{\frac{k}{2} m(t) \cos f_c t}_{B.P.S}$$

O/P of LPS $\frac{k}{2} m(t)$

Coherent Detection of SSBSC



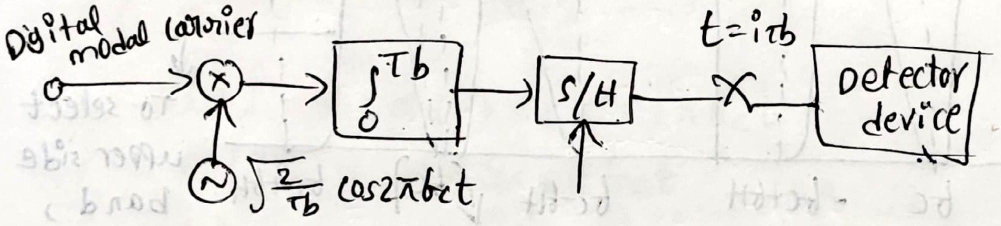
$$y(t) = \left[m(t)\cos 2\pi f_c t \mp \hat{m}(t)\sin 2\pi f_c t\right]\cdot \cos 2\pi f_c t$$

$$= m(t)\left[\frac{1+\cos 4\pi f_c t}{2}\right] \mp \hat{m}(t)\,\frac{1}{2}\sin 4\pi f_c t$$

$$y(t) = \underbrace{\frac{1}{2}m(t)}_{LPS} + \underbrace{\frac{1}{2}\left[m(t)\cos 4\pi f_c t\right]}_{\hat{m}(t)\sin 4\pi f_c t}$$

$\Downarrow$ BPS

Coherent detector (or). correlator Receiver



7-2-25

$$F(t) = \int_{-\infty}^{\infty} e^{-st} f(t)\, dt$$

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

Duality property of fourier transfer.

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

Duality

$$X(t) \xleftrightarrow{F.T} 2\pi\, x(-\omega)$$

Inverse laplace Transform

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

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

interchange t and ω

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

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

$$FT\,[x(t)] = X(\omega)$$

$$FT\,[X(t)] = 2\pi x(-\omega)$$

$$\boxed{X(t) \xleftrightarrow{F.T} 2\pi x(-\omega)}$$

using duality property of fourier Transform.
Find the fourier transform of signal.

$$x(t) = \frac{1}{a^2+t^2}$$

$$x(t) = e^{-a|t|}$$

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

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

$$X(\omega) = \int_{-\infty}^{0} e^{at} . e^{-j\omega t} dt + \int_{0}^{\infty} e^{-at}\, e^{-j\omega t}\, dt$$

$$= \int_{-\infty}^{0} e^{-t(a-j\omega)}\, dt + \int_{0}^{\infty} e^{-(a+j\omega)t}\, dt$$

$$= \left.\frac{e^{(a-j\omega)t}}{a-j\omega}\right]_{-\infty}^{0} + \left.\frac{e^{-(a+j\omega)t}}{-(a+j\omega)}\right]_{0}^{\infty}$$

$$= \frac{e^{(a-2\omega)0} - e^{(a-2\omega)(-\infty)}}{a-2\omega} - \left(\frac{e^{-(a+2\omega)(\infty)} - e^{-(a+2\omega)}}{a+2\omega}\right)$$

$$= \frac{1-0}{a-2\omega} - \left(\frac{0-1}{a+2\omega}\right)$$

$$= \frac{a+J\omega + a-J\omega}{a^2 - J^2\omega^2} = \frac{2a}{a^2-(-1)\omega^2} = \frac{2a}{a^2+\omega^2}$$

$$X(\omega) = \int_{-\infty}^{0} e^{at}\, e^{-J\omega t}\, dt + \cancel{\int_{0}^{\infty} e^{-at}\, e^{-J\omega t}\, dt}$$

$$F.T\left[e^{-a|t|}\right] \longleftrightarrow \frac{2a}{a^2+\omega^2}$$

$$F.T\left[\frac{2a}{a^2+t^2}\right] \longleftrightarrow 2\pi\, e^{-a|-\omega|}$$

$$\frac{1}{a^2+t^2} \longleftrightarrow \frac{2\pi}{2a} e^{-a|-\omega|}$$

$$\frac{1}{a^2+t^2} \longleftrightarrow \frac{\pi}{a} e^{-a|-\omega|}$$

$$\boxed{\frac{1}{a^2+t^2} \xleftrightarrow{FT} \frac{\pi}{a} e^{-a|\omega|}}$$

frequency shifting Property :-

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

$$e^{j\omega_0 t}.x(t) \xleftrightarrow{F.T} X(\omega-\omega_0)$$

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

$$= \int_{-\infty}^{\infty} e^{j\omega_0 t} x(t)\, e^{-j\omega t}\, dt$$

$$X(\omega-\omega_0) = \int_{-\infty}^{\infty} x(t).e^{-j(\omega-\omega_0)t}\, dt$$

Modulation Property :-

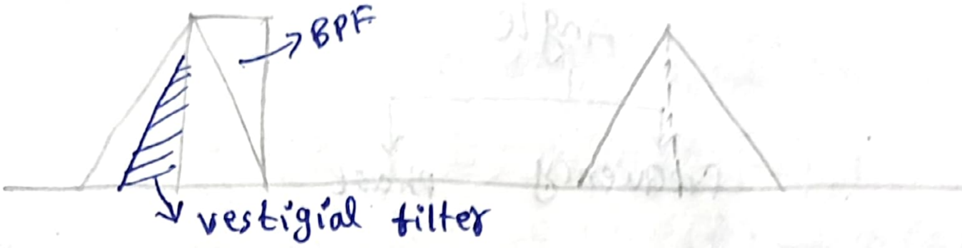
$$m(t)\cos\omega_0 t \xleftrightarrow{F.T} \frac{1}{2}\left[M(\omega-\omega_0)+X(\omega+\omega_0)\right]$$

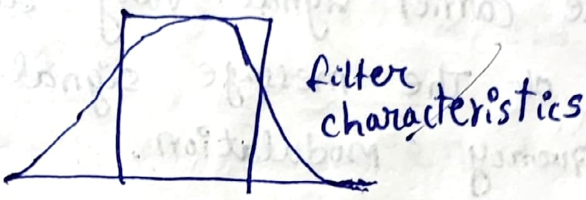
$$\cos\omega_0 t = \frac{e^{j\omega_0 t}+e^{-j\omega_0 t}}{2}$$

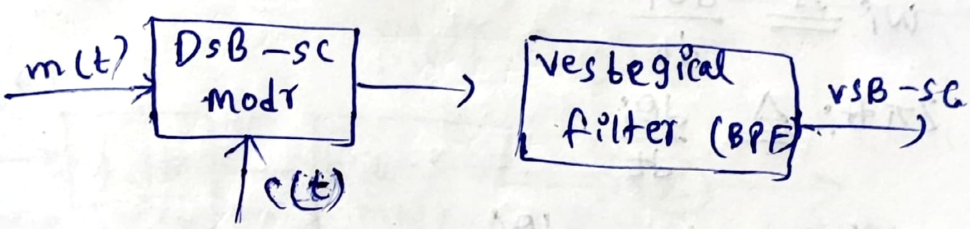
$$m(t)\cos\omega_0 t = \frac{1}{2}m(t)e^{j\omega_0 t} + \frac{1}{2}m(t)e^{-j\omega_0 t}$$

$$= \frac{1}{2}M(\omega-\omega_0) + \frac{1}{2}M(\omega+\omega_0)$$

VSB-SC







$$\underset{\text{VSB-SC}}{s(t)} = m(t)\cos 2\pi f_c t \cdot h_v(t)$$

$$x_{VSB}(t) = x_{DSB}(t)\, h_v(t)$$

$$X_{VSB}(t) = X_{DSB}(f)\, h_v(t)$$

$$y(t) = x_{VSB}(t)\cos 2\pi f_c t$$

$$x(f) = \frac{1}{2}\left[x_{VSB}(f-f_c) + x_{VSB}(f+f_c)\right]$$

$$= \frac{1}{2}\left[x_{DSB}(f-f_c)\, h_v(f-f_c) + x_{DSB}(f+f_c)\, h_v(f+f_c)\right]$$

$$y(t) = \frac{1}{2}\left[\frac{1}{2}m\left(\frac{1}{2}-2f_c\right) + m(f)\right] h_v(f-f_c) + \frac{1}{2}\left[m(f) + m(f+2f_c)\, h_v(f+f_c)\right]$$

$$\Rightarrow \frac{1}{4}\Big[m(f-2f_c)\, h_v(f-f_c) + m(f+2f_c)\, \underbrace{h_v(f+f_c)}_{H.F.S} + \underbrace{\frac{1}{4}m(f)}_{L.F.S}\left[h_v(f-f_c) + h_v(f+f_c)\right]$$

LPF

$$O/P \rightarrow \frac{1}{4}m(f)\underbrace{\left[h_v(f-f_c) + h_v(f+f_c)\right]}_{\text{const}}$$

3. Angle Modulation

Angle
- frequency
- Phase

* frequency of the carrier signal vary according to amplitude of the message signal. is called as frequency Modulation.

$$w_i \triangleq \frac{d\theta_i}{dt}$$

$$2\pi f_i \triangleq \frac{d\theta_i}{dt}$$

$$f_i = \frac{1}{2\pi} \cdot \frac{d\theta_i}{dt}$$

instanteneous frequency

$$\theta_i = 2\pi \int f_i \, dt$$

$$f_i = f_c + K_f m(t)$$

* K_f is frequency sensitive factor among $m(t)$

$$\theta_i = 2\pi \int f_c + K_f m(t) \, dt$$

$$\theta_i = 2\pi f_c t + 2\pi K_f \int m(t) \, dt$$

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

$$s(t)_{FM} = A \cos \left(2\pi f_c t + 2\pi K_f \int m(t) dt\right)$$

$$= A \cos \left(2\pi f_c t + \phi(t)\right)$$

$$\phi(t)_{FM} = 2\pi K_f \int m(t) \, dt$$

Two Types of FM

1) narrow band FM (NBFM) $\phi(t) \ll 1$

2) wide band FM (WBFM) $\phi(t) \gg 1$

narrow band FM :-

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

$$A_c \cos 2\pi f_c t \cdot \cos\phi(t) - A_c \sin 2\pi f_c t \cdot \sin\phi(t)$$

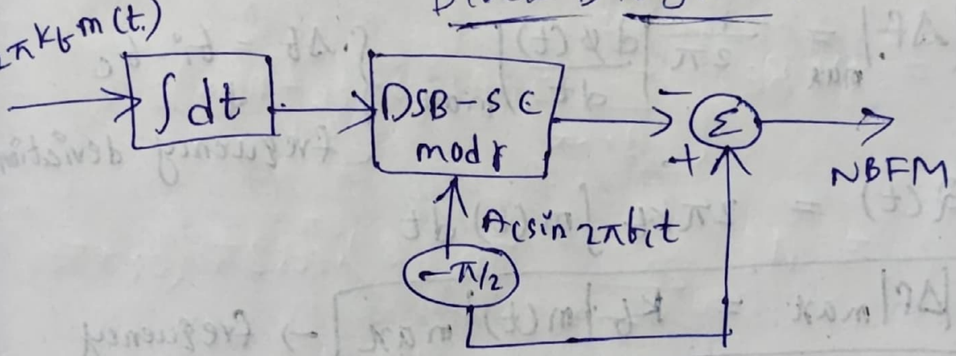
$$\phi(t) << 1 \Rightarrow \cos\phi(t) \Rightarrow 1$$

$$\sin\phi(t) = \phi(t)$$

$$s(t)_{NB\,angle\,M} = A_c \cos 2\pi f_c t - \phi(t) \cdot A_c \sin 2\pi f_c t$$

$$\boxed{s(t)_{NBFM} = A_c \cos 2\pi f_c t - 2\pi k_f \int m(t)\,dt \,]\, A_c \sin 2\pi f_c t}$$

Block Diagram



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

(or)

$$= A_m \sin 2\pi f_m t$$

$$\phi(t) = 2\pi k_f \int m(t)\,dt$$

$$\phi(t) = 2\pi k_f \int A_m \cos 2\pi f_m t \cdot dt$$

$$\phi(t) = \frac{\cancel{2\pi} k_f A_m \cdot \sin 2\pi f_m t}{\cancel{2\pi} f_m}$$

$$\phi(t) = \frac{k_f A_m}{f_m} \cdot \sin 2\pi f_m t$$

$$s(t)_{NBFM} = A_c \cos\left(2\pi f_c t + \frac{k_f A_m}{f_m} \sin 2\pi f t\right)$$

$$\boxed{\beta = \frac{k_f A_m}{f_m}}$$

$$f_i = \frac{1}{2\pi} \cdot \frac{d\theta_i}{dt}$$

$$\theta_i(t) = 2\pi f_c t + \phi(t)$$

$$f_i = \frac{1}{2\pi} \cdot \frac{d}{dt}\left[2\pi f_c t + \phi(t)\right]$$

$$f_i = \frac{1}{2\pi}\left[2\pi f_c + \frac{d}{dt}\phi(t)\right]$$

$$f_i = f_c + \frac{1}{2\pi} \cdot \frac{d\phi(t)}{dt}$$

$$f_i - f_c = \frac{1}{2\pi} \cdot \frac{d}{dt}\phi(t)$$

$$|\Delta f|_{max} = \frac{1}{2\pi}\left|\frac{d\phi(t)}{dt}\right|_{max} \quad \left\{ \Delta f = f_i - f_c \downarrow \text{frequency deviation} \right.$$

$$\phi(t) = 2\pi k_f \int m(t)\, dt$$

$$\boxed{|\Delta f|_{max} = k_f |m(t)|_{max}} \rightarrow \text{frequency deviation for FM}$$

if $m(t)$ sin signal

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

$$|m(t)|_{max} = A_m$$

$$|\Delta f(t)|_{max} = k_f A_m$$

$$\beta = \frac{|\Delta f|_{max}}{f_m}$$

~~Angle~~ ~~modulation~~

Power calculation

$$x(t)_{angle} = A_c \cos(2\pi f_c t + \beta \sin 2\pi f_m t)$$

$$= A_c \, Re\left[e^{j(2\pi f_c t + \beta \sin 2\pi f_m t)}\right]$$

$$= A_c \, Re\left[e^{j2\pi f_c t} \cdot e^{j\beta \sin 2\pi f_m t}\right]$$

$$\cancel{x}_p(t) = \sum_{n=-\infty}^{\infty} C_n e^{j \sin 2\pi f_c t} \leftarrow \text{E.F.S}$$

$$\begin{cases} \phi(t) = \beta \sin 2\pi f_m (t) \\ x(t)_{\text{Angle}} = A_c \cos(2\pi f_c t + \phi(t)) \\ \quad = A_c \cos(2\pi f_c + \beta \sin 2\pi f_m t) \end{cases}$$

$$c_n = \frac{1}{T_0} \int_{-T_0/2}^{T_0/2} x_p(t)\, e^{-jn2\pi f_0 t}$$

fourier series cofficient

Time domain to frequency.

$$e^{j\beta \sin 2\pi f_m t} = \sum_{n=-\infty}^{\infty} c_n\, e^{jn2\pi f_m t}$$

$$c_n = f_m \int_{-1/2 f_m}^{1/2 f_m} e^{j\beta \sin 2\pi f_m t - n 2\pi f_m t}\, dt$$

$$c_n = f_m \int_{-1/2 f_m}^{1/2 f_m} e^{j(\beta \sin 2\pi f_m t - n 2\pi f_m t)}\, dt$$

$$c_n = \frac{1}{2\pi} \int_{-\pi}^{\pi} e^{j\beta} \qquad \boxed{\therefore T_0 = f_m}$$

$$2\pi f_m t = \theta$$

$$dt = \frac{1}{2\pi f_m t}\, d\theta$$

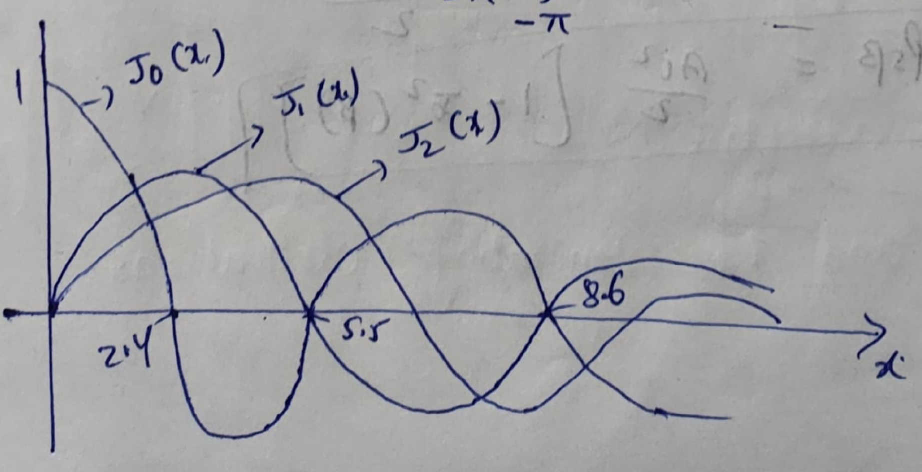
$$t \to \frac{-1}{2f_m}; \quad \theta \to -\pi.$$

$$t \to \frac{1}{2f_m}; \quad \theta \to \pi$$

$$c_n = \frac{1}{2\pi} \int_{-\pi}^{\pi} (e^{j\beta \sin\theta - n\theta})\, d\theta$$

Bessel funtion :- 19-02-25

$$J_n(x) = \frac{1}{2\pi} \int_{-\pi}^{\pi} e^{j(x \sin\theta - n\theta)}\, d\theta$$



$$C_n = \frac{1}{2\pi}\int_{-\pi}^{\pi} e^{j(\beta\sin\theta - n\theta)}\,d\theta$$

$$C_n = J_n(\beta)$$

$$e^{j\beta\sin 2\pi f_m t} = \sum_{n=-\infty}^{\infty} C_n \cdot e^{jn2\pi f_m t}$$

$$e^{j\beta\sin 2\pi f_m t} = \sum_{n=-\infty}^{\infty} J_n(\beta)\cdot e^{jn2\pi f_m t}$$

$$x(t)_{angle} = A_c\, Re\left[e^{j2\pi f_c t}\sum_{n=-\infty}^{\infty} J_n(\beta)\, e^{jn2\pi f_m t}\right]$$

$$= A_c\, Re\left[\sum_{n=-\infty}^{\infty} J_n(\beta)\, e^{j(f_c+nf_m)2\pi t}\right]$$

$$x_{angle}(t) = A_c\sum_{n=-\infty}^{\infty} J_n(\beta)\cdot\cos 2\pi(f_c+nf_m)t$$

$$= \cdots + A_c J_{-1}(\beta)\cos 2\pi(f_c-f_m)t + A_c J_0(\beta)\cdot\cos 2\pi f_c t$$
$$+ A_c J_1(\beta)\cos 2\pi(f_c+f_m)t + \cdots$$

$$P_T = P_{SB} + P_c \qquad \left\{\begin{array}{l} \because P_T = \frac{A_c^2}{2} \\ \because P_c = \frac{A_c^2}{2}\end{array}\right.$$

$$P_{SB} = P_T - P_{CO}$$

$$P_{CO} = \left(\frac{A_c J_0(\beta)}{\sqrt{2}}\right)^2 = \frac{A_c^2 J_0^2(\beta)}{2}$$

$$P_{SB} = \frac{A_c^2}{2} - \frac{A_c^2 J_0^2(\beta)}{2}$$

$$\boxed{P_{SB} = \frac{A_c^2}{2}\left[1 - J_0^2(\beta)\right]}$$

1. Power efficiency :-

$$\%\eta = \frac{P_{SB}}{P_T} \times 100$$

$$= \frac{\frac{A_c^2}{2}\left[1 - J_0^2(\beta)\right]}{\frac{A_c^2}{2}} \times 100$$

$$\boxed{\%\eta = \left[1 - J_0^2(\beta)\right] \times 100}$$

when $\beta = 2.4$ (or) 5.5 (or) 8.6 $\boxed{\therefore J_0(\beta) = 0}$

$\%\eta = 100\%$

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

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

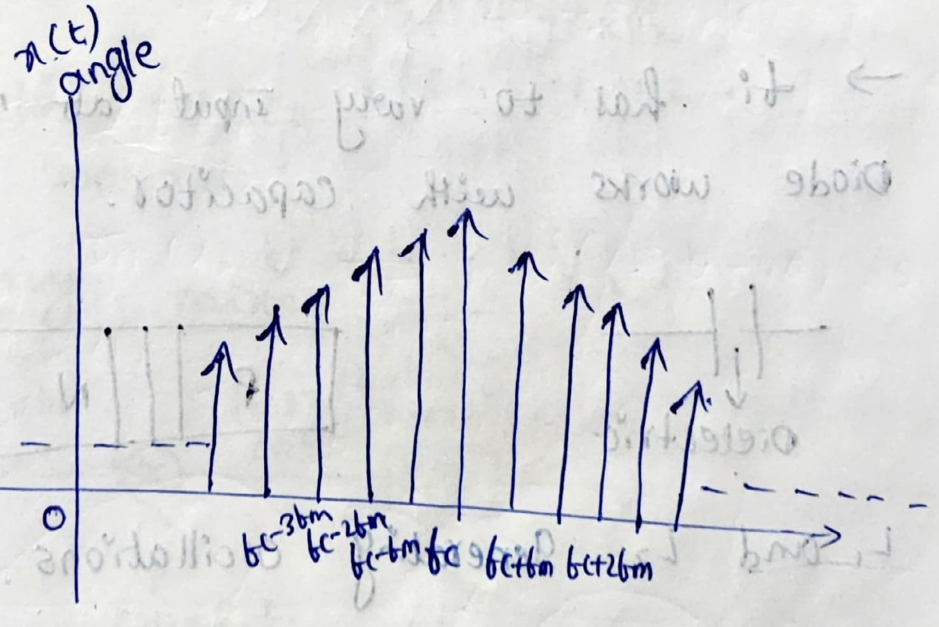
$P_{SB} = \frac{A_c^2}{2}\left[1 - J_0^2(\beta)\right]$

$\%\eta = \left[1 - J_0^2(\beta)\right] \times 100$

* $\beta = \frac{k_f A_m}{f_M}$

* $BW = 2(\beta + 1) f_m$

Band Width :



* Theoretically the bandwidth of FM = ∞ Bandwidth = ∞

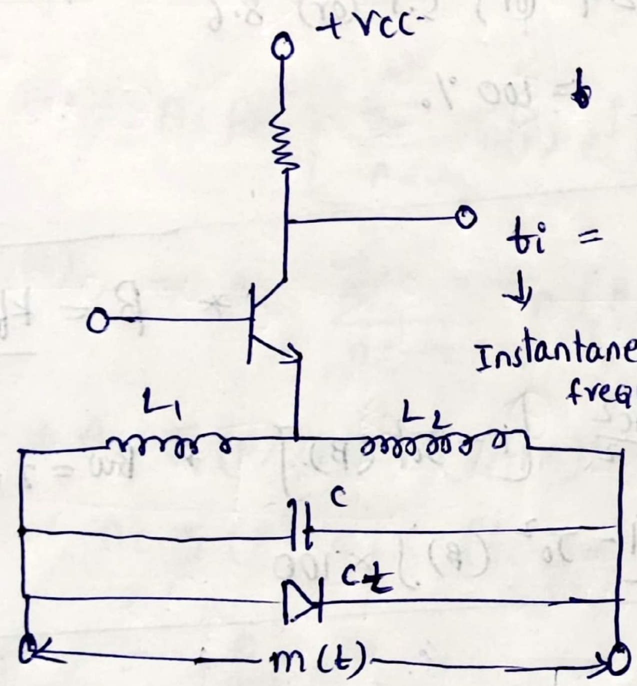
<u>Carson's</u> :- according to Carson's estimation 98% of the Total angle modulated signal Power Presence in the $\beta+1$ sidebands.

<u>Practical Formula</u> :-

$$B.W = 2(\beta+1) f_m$$

5-3-25

<u>Voltage control oscillator</u>.



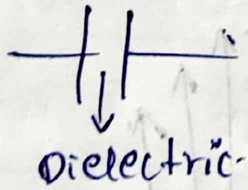
$$f_i = \frac{1}{2\pi\sqrt{(L_1+L_2)(C_1+C_t)}}$$

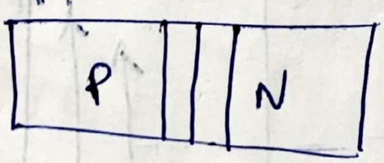
f_i ↓ Instantaneous frequency

* depletion region - stop the current flow.

→ f_i has to vary input at m(t)

* Diode works with capacitor.

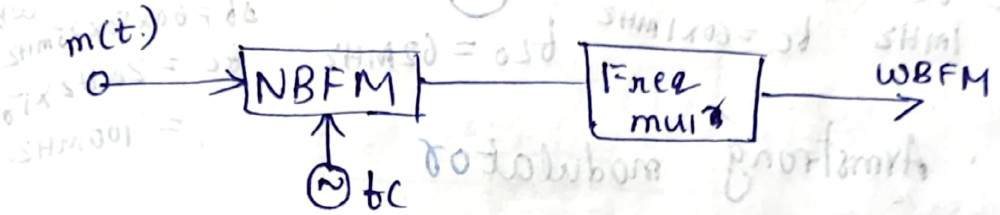


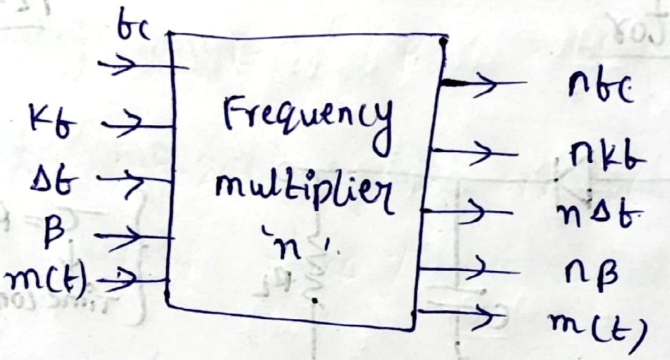


* L_1 and L_2 Generating oscillations.

Armstrong method (Indirect method)

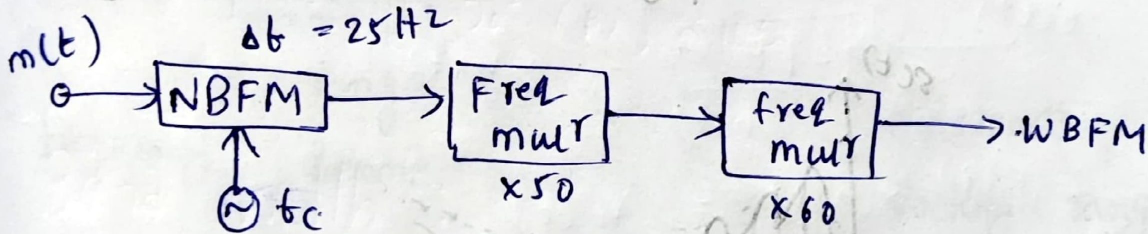
After generating the narrow band FM





*. FM range is $\begin{cases} 88\,MHz \text{ to } 108\,MHz \\ \Delta f = 75\,KHz \end{cases}$

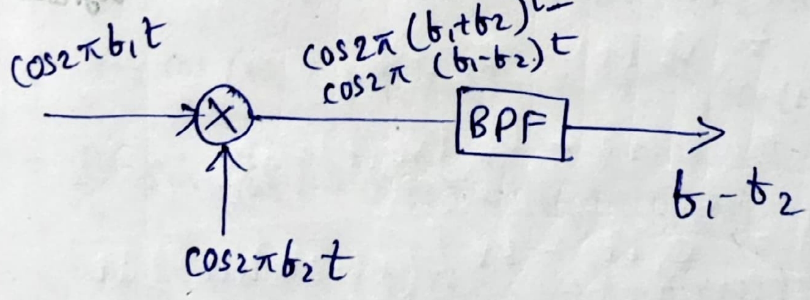
Two - stage frequency multiplier FM

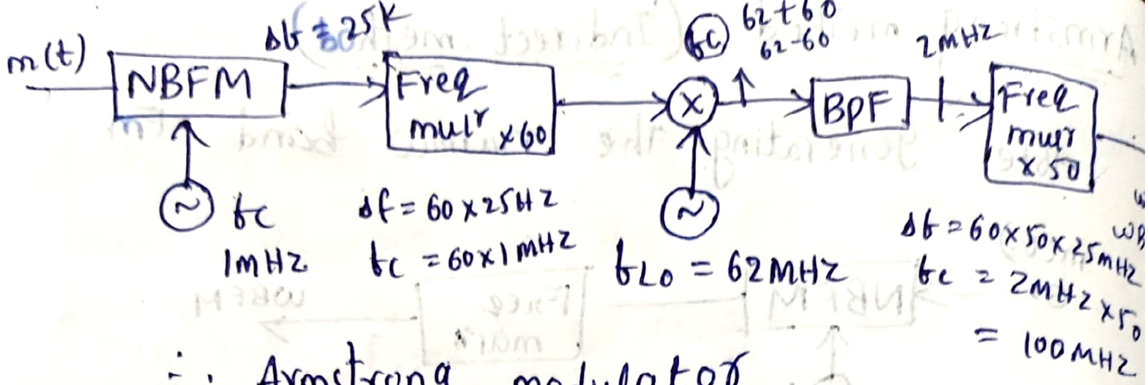


$\begin{cases} \Delta f = 75\,KHz \\ f_c = 1\,MHz. \end{cases}$

$\begin{cases} f_c = 1\,MHz \times 50 \times 60 \\ f_c = 3000\,MHz \end{cases}$

frequency mixer :-

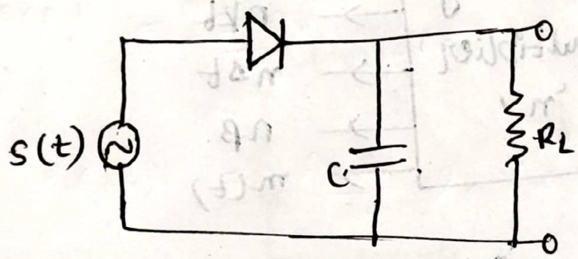




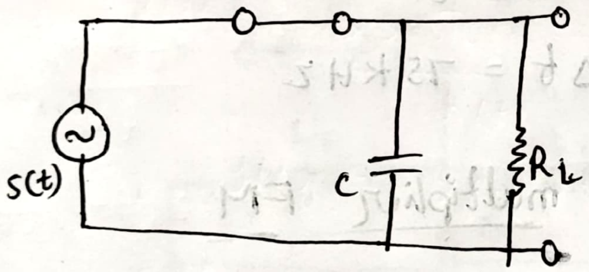
∴ Armstrong modulator

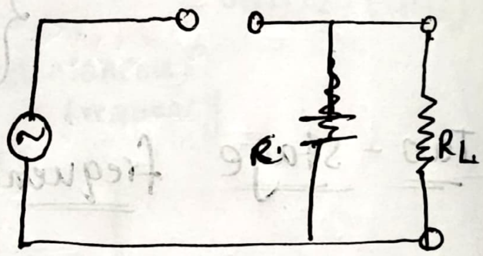
12-3-25

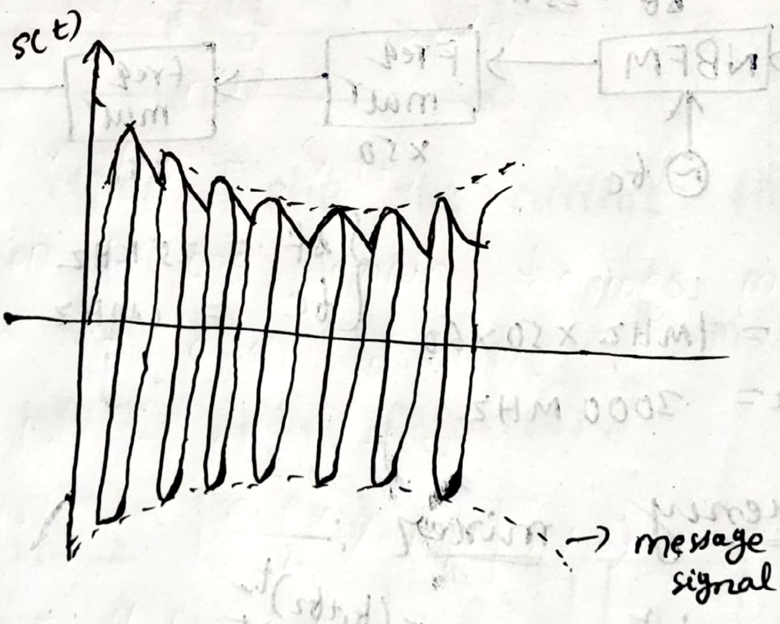
Envelope detector



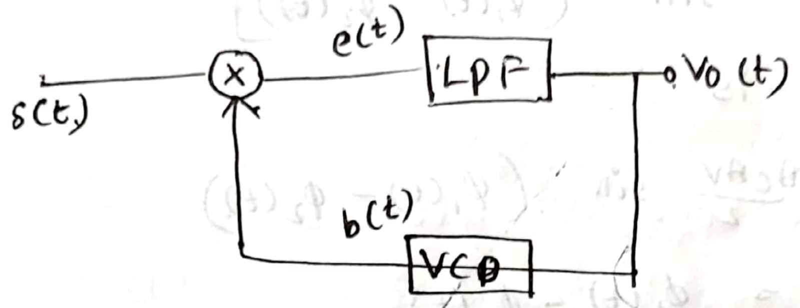
$\tau = RC$
↓
Time constant







PLL - (Phase local loop)



Free running range

The range at which output cann't be Matched with input is called as Free running range.

Capture range :-

The range at which the frequency deference starts reducing is called as capture range.

Locking range :-

The range at which the difference frequency beome zero is called as locking range.

$$s(t) = A_c \cos\left(2\pi f_c t + k_f \int m(t)\, dt\right)$$

$$b(t) = A_c \sin\left(2\pi f_c t + k_v \int v_0(t)\, dt\right)$$

$$e(t) = s(t) \cdot b(t)$$

$$e(t) = A_c \cos\left(2\pi f_c t + k_f \int m(t)\, dt\right) \cdot A_c \sin\left(2\pi f_c t + k_v \int v_0(t)\, dt\right)$$

$$e(t) = A_c \cos(\omega_c t + \phi_1(t)) \cdot A_c \sin(\omega_c (t) + \phi_2(t))$$

$$e(t) = \frac{A_c}{2} \sin\left((\omega_c t + \phi_1(t)) + (\omega_c t + \phi_2(t))\right) - \sin\left((\omega_c t + \phi_1(t)) - (\omega_c t + \phi_2(t))\right)$$

$$e(t) = \frac{A_C A_V}{2} \left[\sin\left(2\omega_c t + \phi_1(t) + \phi_2(t)\right) - \sin\left(\phi_1(t) - \phi_2(t)\right)\right]$$

O/P of LPF is

$$e(t) = \frac{A_C A_V}{2} \sin\left(\phi_1(t) - \phi_2(t)\right)$$

$$\phi_e(t) = \phi_1(t) - \phi_2(t)$$

$$e(t) = \frac{A_C A_V}{2} \sin\left(\phi_e(t)\right)$$

$\phi_e(t) << 1$

$$e(t) = \frac{A_C A_V}{2} \phi_e(t)$$

frequency domain

F.D $\downarrow$

$$e(\omega) = \frac{A_C A_V}{2} \phi_e(\omega)$$

$$x(t) \longrightarrow \underset{h(t)}{\boxed{\text{system}}} \longrightarrow y(t)$$

$$y(t) = x(t) * h(t)$$

$$e(t) \longrightarrow \underset{h(t)}{\boxed{\text{LPF}}} \longrightarrow v_o(t)$$

$$e(t) * h(t) = v_o(t)$$

$\Rightarrow$ Convolution in one domain becomes multiplication in other domain.

$$V_o(\omega) = e(\omega) \cdot H(\omega)$$

$$V_o(\omega) = \left[\frac{A_C A_V}{2} \phi_e(\omega)\right] H(\omega) \longrightarrow (1)$$

$$\phi_e(t) = \phi_1(t) - \phi_2(t)$$

$$= \phi_1(t) - k_v \int v_o(t) \cdot dt$$

$$\boxed{\phi_e(t) = \phi_1(t) - k_v \int \left(e(t) * h(t)\right) dt}$$

$$\phi_e(t) = \phi_1(t) - K_V \int \left[\frac{A_C A_V}{2} \cdot \phi_e(t) * h(t)\right] dt$$

$$\therefore A_C A_V K_V = K_0$$

$$\phi_e(t) = \phi_1(t) - \frac{K_0}{2} \int [\phi_e(t) * h(t)] \cdot dt$$

differentiate both sides

$$\frac{d}{dt}\phi_e(t) = \frac{d}{dt}\phi_1(t) - \frac{K_0}{2}[\phi_e(t) * h(t)]$$

$$\downarrow \text{F·T}$$

$$j\omega\phi_e(\omega) = j\omega\phi_1(\omega) - \frac{K_0}{2}\phi_e(\omega) \cdot H(\omega)$$

$$j\omega\phi_e(\omega) + \frac{K_0}{2}\phi_e(\omega) H(\omega) = j\omega\phi_1(\omega)$$

$$\phi_e(\omega) = \frac{j\omega\phi_1(\omega)}{j\omega + \frac{K_0}{2} \cdot H(\omega)}$$

$$\boxed{\phi_e(\omega) = \frac{\phi_1(\omega)}{1 + \frac{K_0}{2j\omega} \cdot H(\omega)}}$$

$$V_0(\omega) = \frac{A_C A_V}{2} \phi_e(\omega) \cdot H(\omega)$$

$$= \frac{A_C A_V}{2}\left[\frac{\phi_1(\omega)}{1 + \frac{K_0}{2j\omega} H(\omega)}\right] H(\omega)$$

$\phi_e(\omega) \downarrow$ when $H(\omega) \uparrow$

$\phi_e(\omega) = 0$ when $H(\omega) = \infty$

$H(\omega) >> 1$

$$V_0(\omega) = \frac{A_C A_V}{2}\left[\frac{\phi_1(\omega)}{\frac{A_C A_V K_V}{2j\omega} H(\omega)}\right] H(\omega)$$

$$V_0(\omega) = \frac{j\omega\phi_1(\omega)}{K_V}$$

$$\text{T·D} \downarrow \text{I·F·T}$$

$$V_0(t) = \frac{1}{K_V}\frac{d}{dt}[\phi_1(t)]$$

$$V_0(t) = \frac{1}{K_V}\frac{d}{dt}\left[K_f\int m(t)\,dt\right]$$

$$\boxed{V_0(t) = \frac{K_f}{K_V}\, m(t)\, \cancel{dt}}$$

Output of PLL is $m(t)$ ///.

Noise :

19-03-25

The unwanted form of energy which can be interfear with The required Signal.

1) External noise
2) Internal noise

1) **External noise** :- The noise generated external to The Communication system is called as Enternal noise. can't be control but our system can be protected.

Ex :- atmospheric noise
Extra teristrial
Industrial noise

Atmospheric Noise :-

it is the static Noise Produce by lighting discharges in thunderstomes and other Natural electrical disturbances.

These electric impules are random and can Spread over The Complete frequency spectrum used for communications.

These atmospheric Noise is less and frequency above 30MHZ

Extra teristrial Noise

Solar noise
Cosmic noise

Solar Noise :-

The electrical Noise eminated from The sun

Cosmic Noise :-

The Noise from disptants start, these distant stars have high temperature radiant as same manner sun..

Industrial Noise

This are man-made Noise

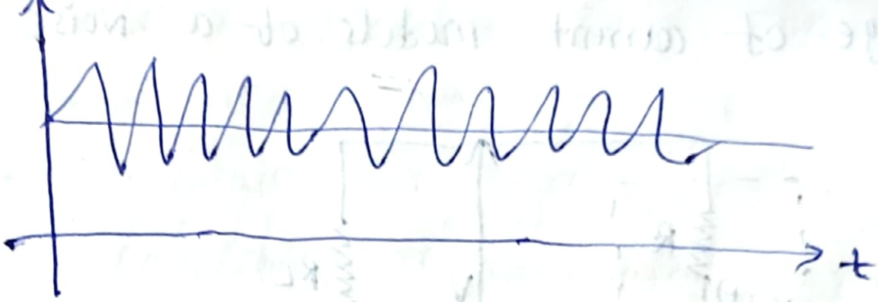
eg :- Automobile
electric motors.

Internal Noise :- The Noise generated within The communication system. This Noise can be reduced by proper system design.

Ex:- short Noise :- it Produced an active devices due to random behaviour of charge carriers.

In electron tubes The short Noise generated due to The random emission of electrons from cathods.

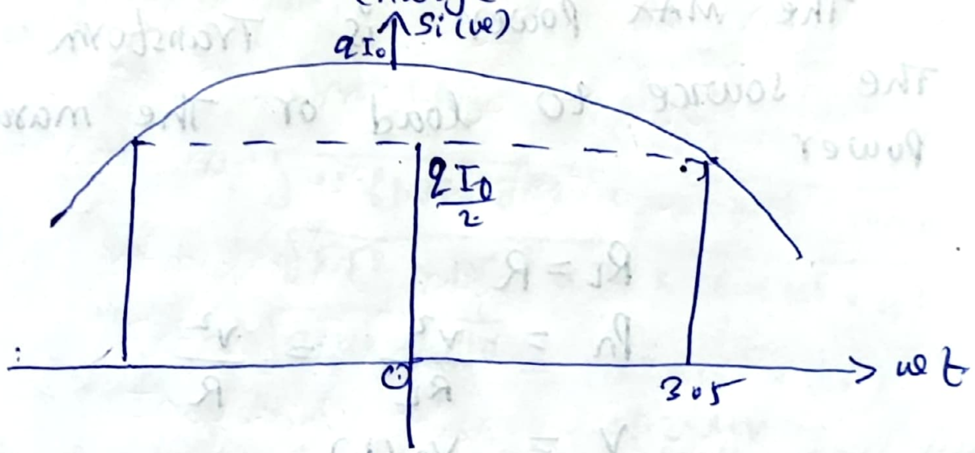
There as in Semiconductor The short Noise is generated due to the random diffusion of minarity carriers.



Power Density Spectrum of short Noise in diodes :-

- $S_i(\omega) = Q \cdot i_0 \rightarrow$ mean value of The current

  $Q \downarrow$ electronic charge



Thermal Noise :-

Thermal Noise also while Noise or Johnson noise

* Random Noise generated in a resistor or The resistive component of a complex Impedence due to The random motion of electrons.

* Temperature Increases Velocity of the electrons in The body Increases (kinetic energy).

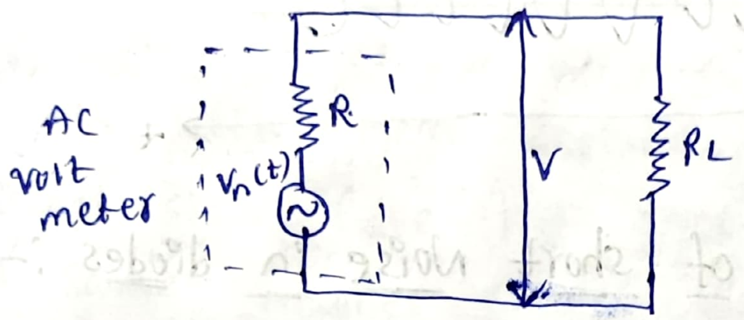
$\therefore$ The Noise Power is Proposnal to the Temperature and bandwidth of our interest.

$$P_n \propto T \cdot B$$

$$P_n = K \cdot T \cdot B \qquad \therefore K = 1.38 \times 10^{-23}\ J/^{\circ}K$$

K = Boltz mans Constanst

Voltage of current models of a Noise resistors.



MAX Power Transform Theorem :-

The MAX power is Transform from The source to load or The maximum power

$$R_L = R$$

$$P_n = \frac{v^2}{R_L} = \frac{v^2}{R}$$

$$V = \frac{V_n(t)}{2}$$

$$P_n = \frac{(V_n(t)/2)^2}{R}$$

$$P_n = \frac{V_n^2}{4R}$$

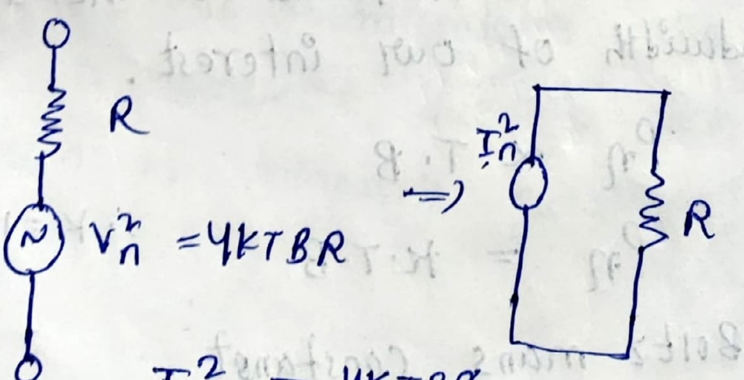
$$V_n^2 = P_n \cdot 4R$$

$$= K \cdot T \cdot B \cdot 4R$$

$$V_n^2 = 4KTBR$$

$$V_n = \sqrt{4KTBR}$$

Thevinen's theorem



$$I_n^2 = \frac{4KTBR}{R^2} = 4KTBG$$

a) An Amplifier operating over the frequency range from 18M to 20MHz as a 10kΩ input resistor calculate the Rms noise voltage at Input to the amplifier. if the root temperature is 27°C

$B = 2\,MHz$

$R = 10\,k\Omega$

$K = 1.38 \times 10^{-23}\ J/°K$

$T = 300\ °K$

$V_n = \sqrt{4KTBR}$

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

$V_n = \sqrt{5.52 \times 10^{-23} \times 300 \times 20 \times 10^{6} \times 10^{3}}$

$V_n = \sqrt{3.312 \times 10^{-10}} = 1.82 \times 10^{-5}\ V$ (or) $18.2\ \mu V$

Q) Additional noises due to several sources in series. (super position of Noise Sources)

Ex:- The sources are R_1, R_2, and R_3 --- Then The Noise Voltages are V_{1n}, V_{2n} & V_{3n} ----.

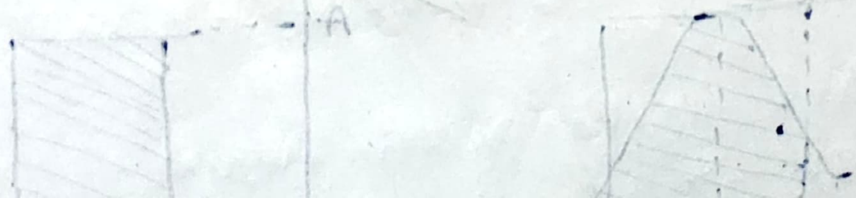
$V_{n1} = \sqrt{4KTBR_1}$, $V_{n2} = \sqrt{4KTBR_2}$, $V_{n3} = \sqrt{4KTBR_3}$

The resultant Noise voltage V_{ns} =

$V_{ns} = V_{n1}^2 + V_{n2}^2 + V_{n3}^2$

$V_{ns} = \sqrt{4KTB[R_1 + R_2 + R_3 + \cdots]}$

$R_s = R_1 + R_2 + R_3 + \cdots$

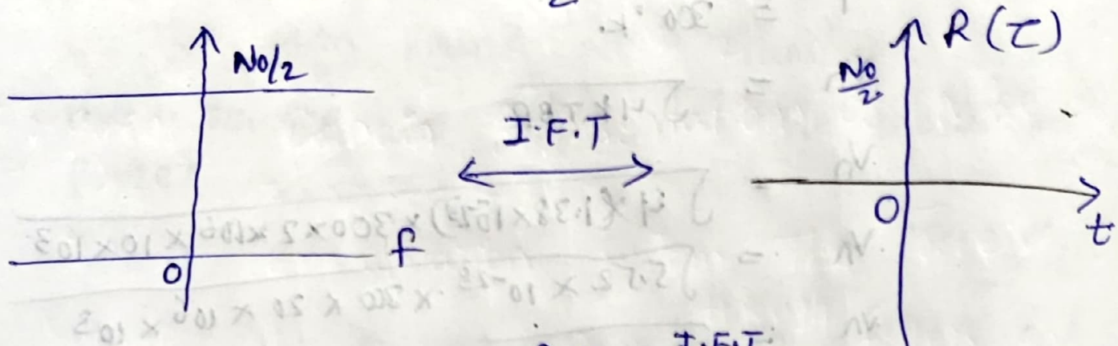


~~Wide~~ white Noise :- 21-03-25

It is a Ideal noise used for analysis white noise consist of all frequency in equal amount.

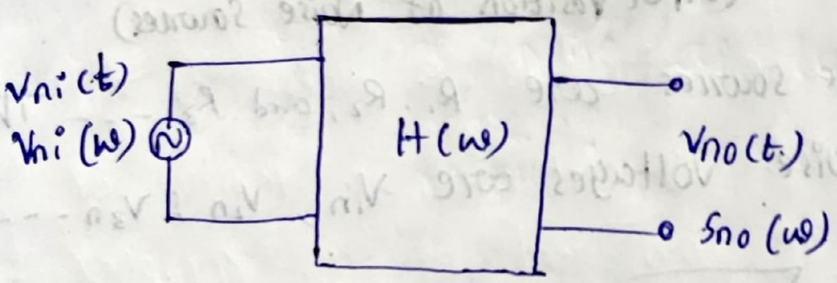
- The Power spectrum density of white Noise is expressed as

$$S(\omega) = \frac{N_0}{2}$$



$$PSD \xleftrightarrow{I.F.T} R(\tau)$$

Equivalent Noise Bandwidth :-



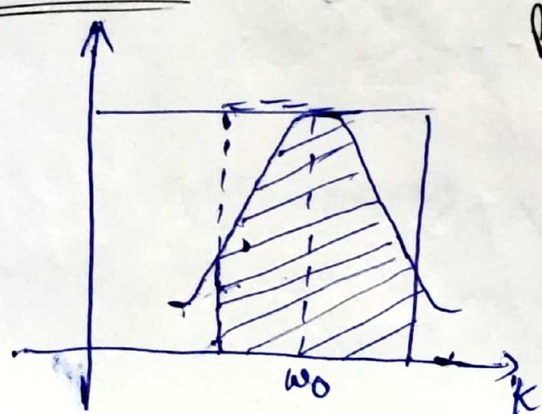
$$V_{no}(t) = V_{ni}(t) * h(t)$$

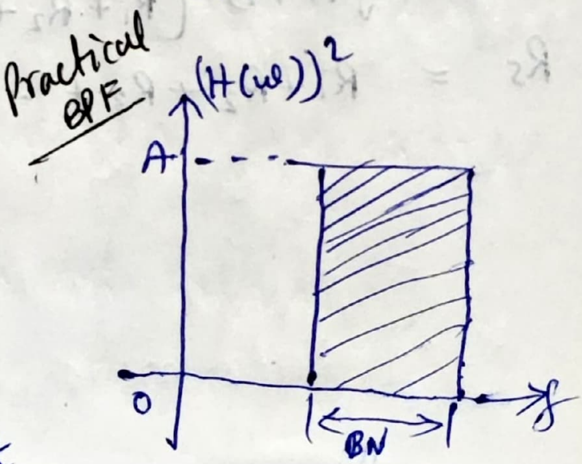
$$V_{no}(\omega) = V_{ni}(\omega) \cdot H(\omega)$$

$$S_{no}(\omega) = S_{ni}(\omega)\,|H(\omega)|^2$$

if That system is BPF

Ideal BPF





output Noise P_o can be evaluate simply by Integrating output Power Spectral density $S_{no}(\omega)$ over The Bandwidth under consideration.

$$\frac{v_n^2}{R=1} = P_o = \frac{1}{2\pi}\int_{-\infty}^{\infty} S_o(\omega)\, d\omega$$

$$= \frac{1}{\pi}\int_{0}^{\infty} S_{ni}(\omega)\,|H(\omega)|^2\, d\omega$$

→ The Input Noise Power spectrum density can be taken as Constant with frequency

$$S_{ni}(\omega) = C$$

$$P_o = \frac{1}{\pi}\int_0^{\infty} C\,|H(\omega)|^2\, d\omega$$

$$\boxed{P_o = \frac{C}{\pi}\int_0^{\infty} |H(\omega)|^2\, d\omega}$$

$P_o = \frac{C}{\pi} \times$ area under The curve of $|H(\omega)|^2$

$$\int_0^{\infty} |H(\omega)|^2\, d\omega = A \times B_N$$

$$\boxed{B_N = \frac{1}{A}\int_0^{\infty} |H(\omega)|^2\, d\omega}$$

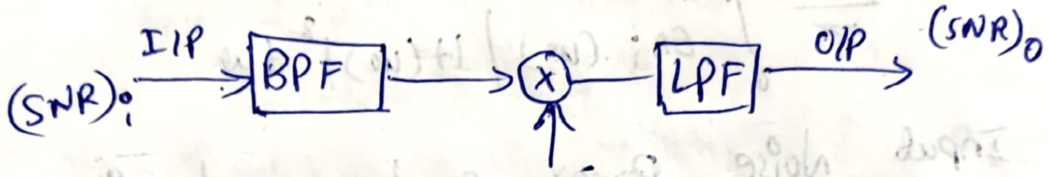
$$P_o = \frac{C}{\pi} \times A \times B_N$$

$$\boxed{v_n^2 = \frac{CAB_N}{\pi}}$$

Noise Figure of Merit (FOM) :-

$$SNR = \frac{\text{signal Power}}{\text{Noise Power}} > 1$$

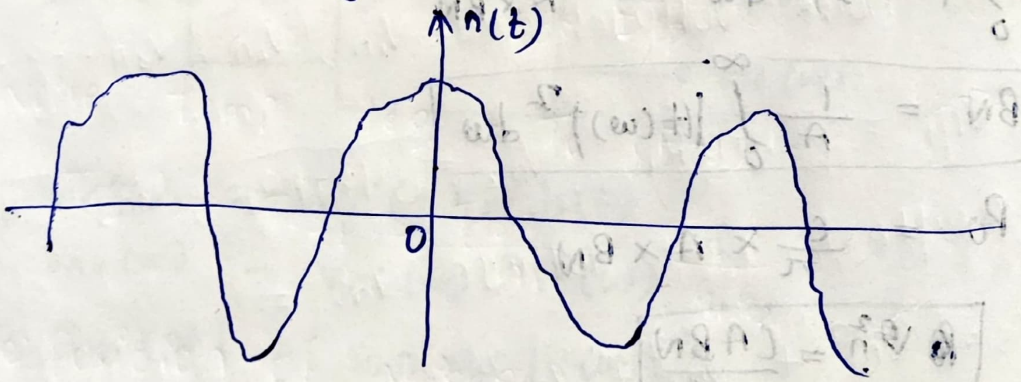
→ The ratio of $(SNR)_i$ to the $(SNR)_o$ of the receiver is called FOM.



Frequency Domain Representation of Noise :-

→ In a Communication system the received signal as to be passed through filters and the filters are characterized frequency domain.

→ to determine the effect of Noise after Passing filter, the Noise as to be converted into frequency domain.



→ The trignometric fourier series freq expaption

$$n_T(k) = \sum_{k=1}^{\infty} A_k \cos 2\pi k \Delta f t + B_k \sin 2\pi k \Delta f t$$

Here, Δf → change in frequency

A_K, B_K → fourier series coefficient and constant.

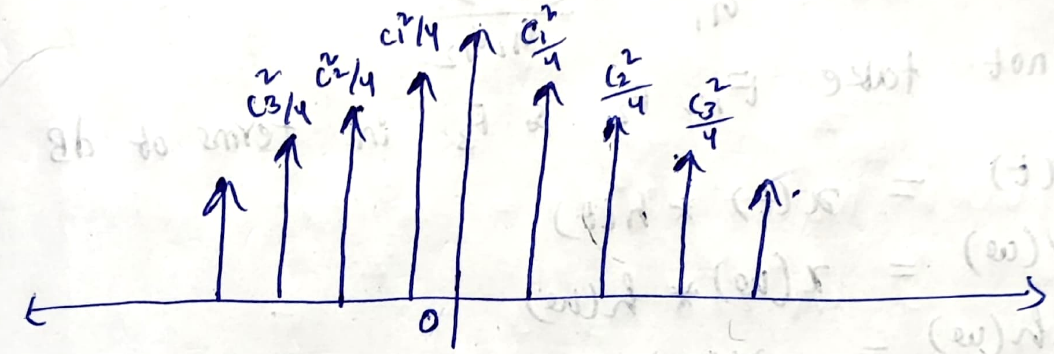
CK = magnitude of both coefficeints

$$C_K = \sqrt{A_K^2 + B_K^2}$$

$$C^2_K = A^2_K + B^2_K \qquad \theta_K = \tan^{-1}\left(\frac{B_K}{A_K}\right)$$

$$P_{noise} = \frac{C_K^2}{2} = \frac{A^2_K + B^2_K}{2}$$

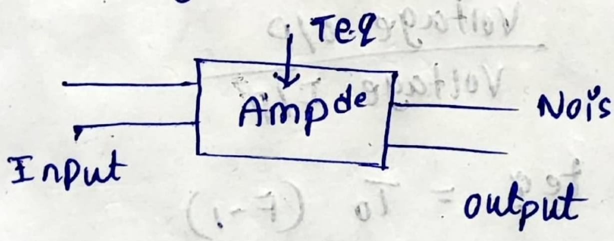
* $$\boxed{P_{noise} = \frac{C_K^2}{4}}$$



Noise Temperature :-

26-3-25

-) It is temperature, which generates Noise Power in system.



Noise by Amp^{de}. P_{Na}

-> Noise Power by compr (T_0) ← Environment temp

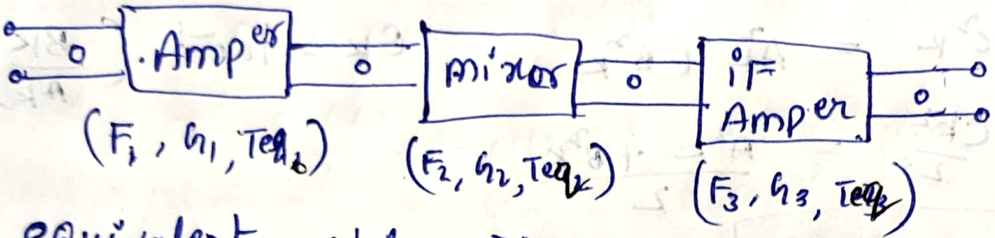
=) $P_{Na} = (F-1)KT_0B$

-) Noise power Power in terms of noise temp Teq.

=) $KT_{eq}B = (F-1)KT \cdot B$

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

Equivalent Noise Temp. and Noise Figure in Casecade communication system.



→ equivalent Noise Figure

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

Do not take F_1, F_2 & F_3 in terms of dB

→ $$y(t) = x(t) * h(t)$$

$$Y(\omega) = X(\omega) * H(\omega)$$

$$H(\omega) = \frac{Y(\omega)}{X(\omega)}$$

→ gain = $\frac{\text{Laplace output}}{\text{Laplace input}}$.

→ voltage gain = $\frac{\text{Voltage o/p}}{\text{Voltage I/p}}$

→ Noise temp. $T_{eq} = T_0 (F-1)$

$$T_{eq} = T_{eq_1} + \frac{T_{eq_2}}{G_1} + \frac{T_{eq_3}}{G_1 G_2}$$

Superposition of Noises

, Total Noise Power =

$$P_T = E[(N_1(t) + N_2(t))^2]$$

$$P_T = E[N_1(t)^2 + N_2(t)^2 + 2N_1(t)N_2(t)]$$

$$P_T = E(N_1^2(t)) + E(N_2^2(t)) + 2E(N_1(t)N_2(t))$$

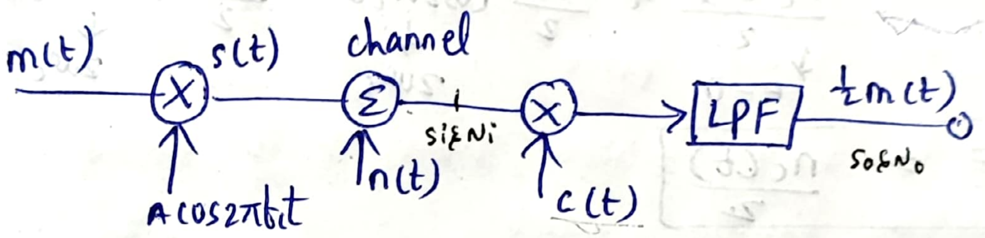
$E(N_i^2(t)) = P_i$, $E[2N_1(t) \cdot N_2(t)] = 0$

$\boxed{P_T = P_1^2 + P_2^2}$

$N_1(t), N_2(t)$ are two different signals.

Noise in DSBSC communication system :

Demodulation Block DSBSC



$$FOM = \frac{(SNR)_i}{(SNR)_o} = \frac{S_i/N_i}{S_o/N_o}$$

$$S(t) = m(t) \cdot \cos 2\pi f_c t$$

$$S_i = \frac{1}{2} \langle m(t)^2 \rangle$$

$$S_o = \frac{1}{4} \langle m(t)^2 \rangle$$

$$\frac{S_i/N_i}{S_o/N_o} = \frac{S_i}{N_i} \times \frac{N_o}{S_o} = \frac{S_i}{S_o} \times \frac{N_o}{N_i}$$

$$\frac{S_i}{S_o} = \frac{\frac{1}{2}\langle m(t)^2 \rangle}{\frac{1}{4}\langle m(t)^2 \rangle} = 2$$

Input Noise Power :-

$$N(t) = \underset{I}{n_c(t)} \cos w_c t - \underset{Q}{n_s(t)} \cdot \sin w_c t$$

$$N_i = \overline{n_c^2(t)} = \overline{n_s^2(t)} = \overline{n_i^2(t)}$$

Output Noise :-

$n(t) \cdot \cos 2\pi f_c t$

$n_c(t) \cos\omega_c t - n_s(t) \sin\omega_c t \cdot \cos 2\pi f_c t$

Mul O/P $= (n_c(t) \cos\omega_c t - n_s(t) \sin\omega_c t) \cos\omega_c t$

$= n_c(t) \cos\omega_c t - n_s(t) \sin\omega_c t \cdot \cos\omega_c t$

$= \frac{n_c(t)}{2}(1+\cos 2\omega_c t) - \frac{n_s(t)}{2} \sin 2\omega_c t$

$= \underbrace{\frac{n_c(t)}{2}}_{F=0} + \frac{n_c(t)}{2} \underbrace{\cos 2\omega_c t}_{2\omega_c} - \frac{n_s(t)}{2} \underbrace{\sin 2\omega_c t}_{2\omega_c}$

$\boxed{\text{O/P of LPF} = \frac{n_c(t)}{2}}$

Noise Power $N_o = \overline{n_o^2(t)} = \frac{\overline{n_c^2(t)}}{4}$

$\frac{N_o}{N_i} = \frac{\overline{n_c^2(t)}/4}{\overline{n_c^2(t)}} = \frac{1}{4}$

FOM :-

$\frac{S_i}{S_o} \times \frac{N_o}{N_i}$

$= 2 \times \frac{1}{4}$

$\boxed{\text{FOM} = \frac{1}{2}}$

Mod-6 **Probability** 2-4-25

→ Probability of an event P(a)

→ P(a) Probability of getting Success.

→ sum of Probability is always "1".

Types of Sample space

1) finite Sample space
2) infinite sample space. → Sample space contain Infinite no. of samples.

Probability of event :-

$$P(A) = \frac{n(A)}{n(S)}$$

function :-

→ 1st condition relation exist

Random variable x :- (x)

x mapping from S to A

Random experiment on trail :-

an experiment which can perform any number of times under the same conditions and the outcomes can't be predicted is called a trail.

Ex :- Tossing a coin
rolling a die

Sample space :-

The set of all Possible outcomes of a trail is called Sample space of a Trail. And it is denoted by 's'.

Types of sample space :-

1) finite sample space

if s is finite Then it is Called finite Sample space.

2) Infinite Sample Space :

if s is Inbinite Them it is called infinite Sample space.

Ex :- In the trail ab TOSS a coin The Possible outcomes are "Head" & "Tail".

∴ Heat = H, T

n(S) = 2

→ The rolling ∴ Sample space S = 1 2 3 4 5 6

n(S) = 6

event :- The subset of The Sample space of a trail is called event

→ If Sample space of a triall is contain n Points then There are 2^n events.

events $= \phi, H, T, (H, T)$

Probability of an event :-

If A is an event of a trial having finite sample Probability of A is denoted by

$$P(A) = \frac{n(A)}{n(S)} = \frac{\text{favourable outcomes}}{\text{Total no. of outcomes}}$$

$P(A)' = 1 - P(A) \rightarrow$ favourite Probability

* $\boxed{P(A) + P(A') = 1}$