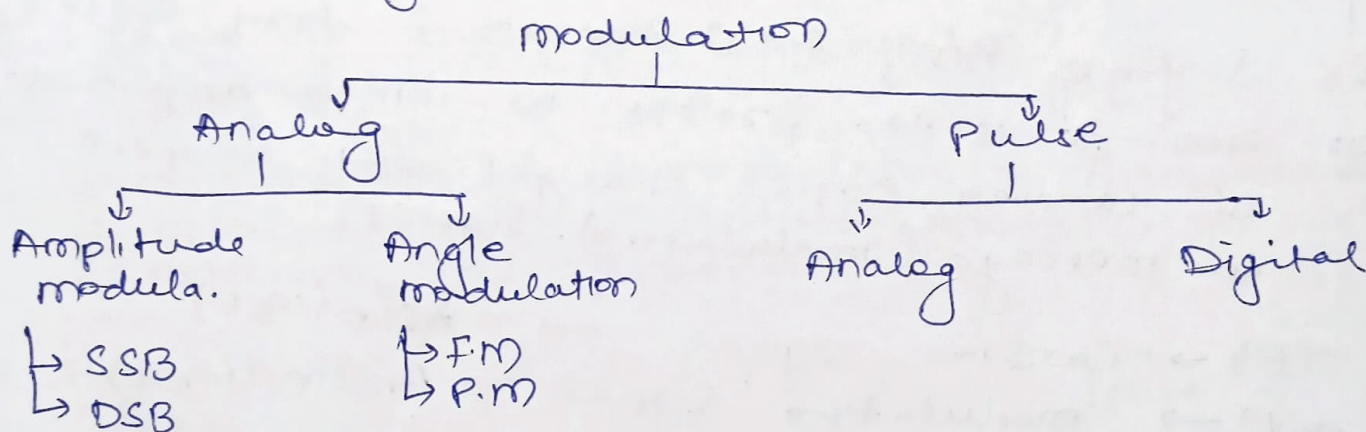NAME : VIPUL GOYAL   DATE: 01-11-2023

BRANCH : IIOT- B1

ENROLL. : 02419011721

Q. what is modulation?

Con: It is defined as a process by which some characteristics of carrier wave is varried according to instantaneous value of modulating signal.

```
                        Modulation
          ┌─────────────────────┴──────────────────────┐
       Analog                                        Pulse
    ┌─────┴─────┐                              ┌────────┴────────┐
Amplitude     Angle                         Analog           Digital
modula.     modulation
  ├ SSB       ├ FM
  └ DSB       └ P.M
```

Q2 various advantages of modulation:

sol: ① Reduce the size of Antenna

② It reduce the cost of wires

③ It easily multiplex the signals

④ allow adjustment of bandwidth

⑤ prohibits mixing of signal.

Q3: modulation Index? Calculation?

soln: modulation index is defined as the ratio of amplitude of message signal to that a carrier signal
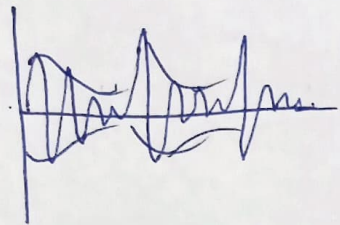
Calculation: $m = \dfrac{A_m}{A_c}$ or $m = \dfrac{A_{max} - A_{min}}{A_{max} + A_{min}}$
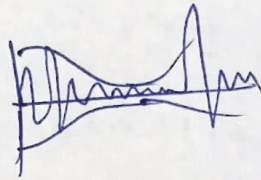
Q4! various degree of modulation in Am ξ

Soln! Degree of modulation are!

① m = 1 → critical modulation
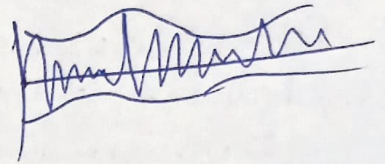
② m > 1 → over modulation

③ m < 1 → under modulation

1 m = 1

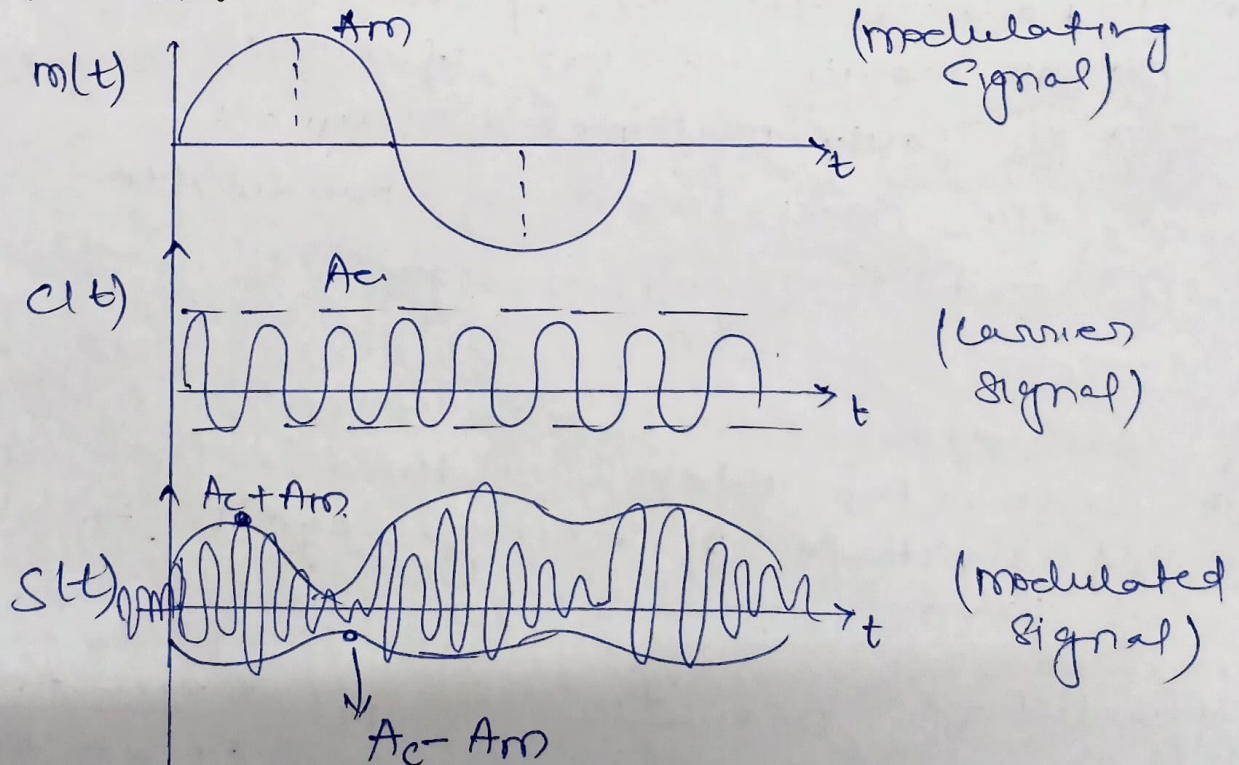
2. m > 1

3. m < 1

Q5. Define Am? time domain & freq spect?

Soln! Am! It is the process in which amplitude of carrier signal changes with respect to message (modulating) signal).
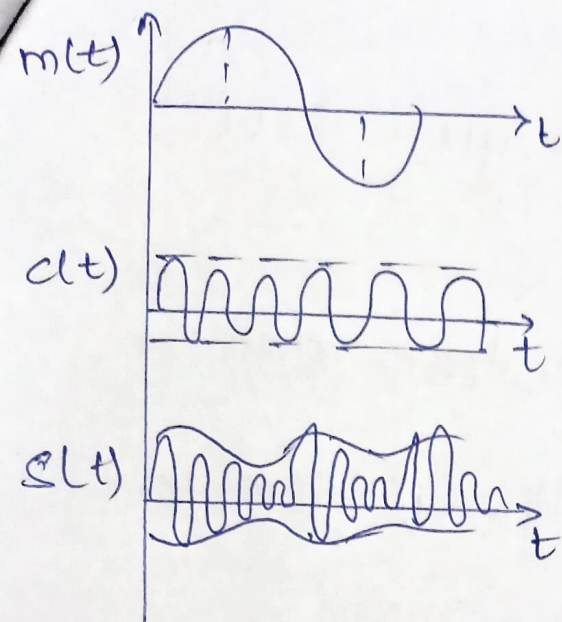
$c(t)$ → carrier signal → $A_c \sin(\omega_c t)$

$m(t)$ → modulating signal → $A_m \sin(\omega_m t)$

$s(t)$ → modulated signal → $[A + m(t)] \sin \omega_c t$

1 time domain :

$m(t)$

A_m

(modulating signal)

$c(t)$

A_c

(carrier signal)

$s(t)$

$A_c + A_m$

$A_c - A_m$

(modulated signal)

freq domain:

$m(t)$ ⟶ F.D ⟶ $m(\omega)$ (triangle spectrum from $-\omega_m$ to ω_m)

$c(t)$ ⟶ F.D ⟶ $c(\omega)$ (impulses at $-\omega_c$ and $+\omega_c$)

$s(t)$ ⟶ F.D ⟶ $s(\omega)$ (triangles at $-\omega_c$ and ω_c)

LSB   USB
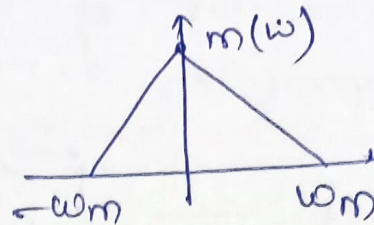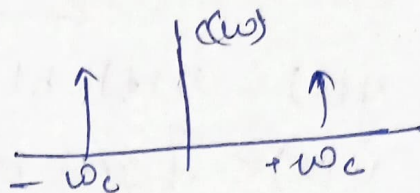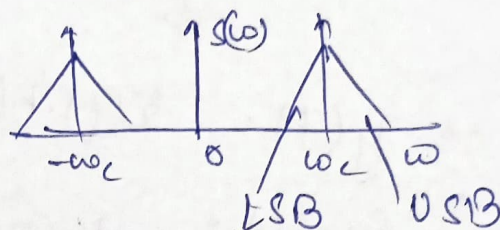
Q6: Comp b/w different AM system?

Soln:

DSB-SC	SSB-SC	VSB-SC
1. demodulation is difficult & expensive	1. demodulation is difficult & expensive	1. Easy demod
2. High Power level	2. less Power level	2. less Power level
3. Point-2-Point Comm.	3. Point-2-Point comm	3. Broadband Service (TV)
4. $B = 2\omega_m$	4. Band = ω_m	4. $B = f_m + f_c$
5. carrier wave are suppressed	5. suppressed carrier wave	5. suppressed carrier wave
6. Receivers are complex & Expensive	6. Receiver are Complex & Expensive	6. Simpler & cheper

Q7: no. of AM broadcast $f_m = 5$ KHz, $B\omega = 100$ kHz AM?

Soln:

$f_m = 5$ KHz, $B\cdot\omega = 100$ KHz

$B\omega = 2 \times f_m = 2 \times 5 = 10$.

Total A.M $= \dfrac{100}{10} = 10$. stations.

Q8: Expression of Hilbert transform & its

Som! Expression!

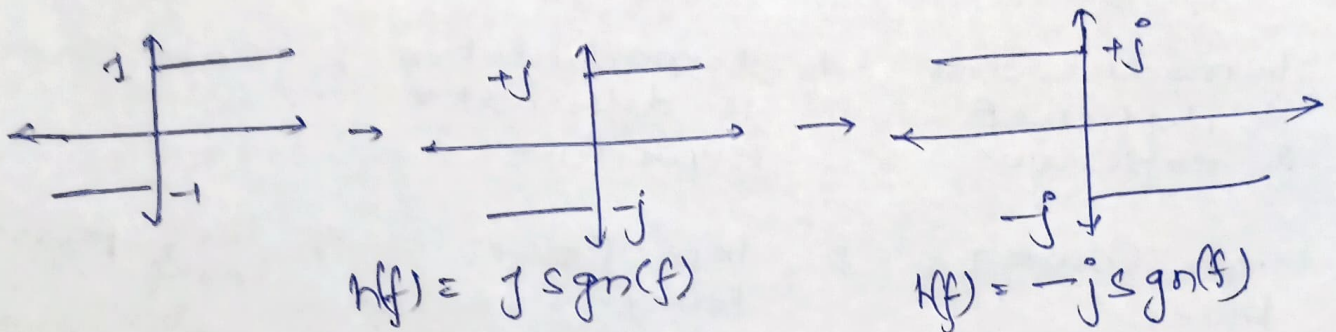$$x(t) \longrightarrow \boxed{\begin{array}{c}\text{Hilbert}\\ \text{Transf}\end{array}} \longrightarrow y(t) = \hat{x}(t).$$

→ $y(t) = x(t) \cdot h(t)$

→ $y(t) = \int_{-\infty}^{\infty} x(\tau) \cdot h(t-\tau) \cdot d\tau$ → time domain

→ $y(f) = x(f) \cdot h(f)$ → freq domain

$$sgn(f) = \begin{cases} 1 & f>0 \\ -1 & f<0 \end{cases}$$

$$h(f) = j \, sgn(f)$$

$$h(f) = -j \, sgn(f)$$

using duality theorem:

$$sgn(t) \xrightarrow{F.T} \frac{2}{j\omega} = \frac{2}{j2\pi f} = \frac{1}{j\pi f}$$

$$\frac{1}{j\pi f} \xrightarrow{F.t} sgn(-f).$$

$$\frac{1}{j\pi t} \xrightarrow{F.T} -sgn(f).$$

multiply j on Both sides

$$\frac{1}{j\pi t} \xrightarrow{f.T} -j \, sgn(f)$$

$$\frac{1}{\pi t} \xrightarrow{F.T} -j \, sgn(f)$$

$$h(f) = -j \, sgn(f)$$

$$h(t) = \frac{1}{\pi t}$$

$$\boxed{\hat{x}(t) = \int_{-\infty}^{\infty} x(\tau) \cdot \frac{1}{\pi(t-\tau)} \, d\tau}$$

Properties of Hilbert transforms

① H.T of odd signal is even & H.T of even signal is odd, $x(t) = A_m \cos \omega_c t$, $\hat{x}(t) = A_m \sin \omega_c t$

② If $\hat{x}(t)$ is H.T of $x(t)$ then H.T of $\hat{x}(t)$ is $\Rightarrow -\hat{x}(t)$

eg: $x(t) = \cos \omega_c t$, $\hat{x}(t) = \sin \omega_c t$, $\hat{\hat{x}}(t) = -\cos \omega_c t$

③ Signal & its H.T are orthogonal to each other.

$$\int_{-\infty}^{\infty} x(t)\, \hat{x}(t)\, dt = zero$$

④ Energy of $x(t)$ is equal to energy of $\hat{x}(t)$.

$$E_x = \int_{-\infty}^{\infty} |x(t)|^2\, dt = \int_{-\infty}^{\infty} |x(f)|^2\, df$$

$$E_{\hat{x}} = \int_{-\infty}^{\infty} |\hat{x}(t)|^2\, dt$$

$$= \int_{-\infty}^{\infty} |fT(\hat{x}(t))|^2\, df$$

$$= \int_{-\infty}^{\infty} x(f) \cdot (-j \operatorname{sgn}(f))|^2\, df$$

⑤ H.T of derivative of any signal is equal to derivative of H.T of that signal.

① $x(t) \xrightarrow{H.T} \hat{x}(t)$

② $x(t) \xrightarrow{d/dt} \dfrac{dx(t)}{dt} \xrightarrow{HT} H.T\left[\dfrac{d(x(t))}{dt}\right]$

③ $x(t) \xrightarrow{HT} \hat{x}(t) \xrightarrow{d/dt} \dfrac{d}{dt}(\hat{x}(t))$

∴ $HT\left[\dfrac{d(x(t))}{dt}\right] = \dfrac{\partial \hat{x}(t)}{\partial t}$

Q9. Total Power in a AM having 100 w Pc
 µ = 0.6 ?

Soln!   Pc = 100w
        µ = 0.6

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

              $= 100 \left(1 + \frac{0.6 \times 0.6}{2}\right)$

              $= 100(1 + 0.18) = 100 \times 1.18$

    $\boxed{T_p = 118 \text{ watt}}$

Q10! Concept of suppressed carrier systems.
     Explain its various types?

Soln! Suppressed carrier system is a system
      in which both power & bandwidth can
      be saved by suppressing carrier
      signal or suppressing carrier signal
      along with sideband (USB/LSB) is called
      suppressed carrier system.

o Carrier signal can be suppressed using
  Band Pass filter or low Pass filter allow
  freq in certain Range or cut off is
  given

* Types of SC!
  ① DSB - SC
  ② SSB - SC
  ③ VSB - SC

Q1. Provide power & current relation Am?

Soln. ① Power.

Total Power = $P_c [1 + \frac{\mu^2}{2}]$.

* we know that;

$$Power = V_{rms} \times I_{rms}$$

$$\boxed{Power = \frac{V_{rms}^2}{R}} \Rightarrow I_{rms}^2 \times R$$

∴ ~~Power~~ = ~~Power × R~~

∴
$$P = P_c [1 + \frac{\mu^2}{2}].$$

$$I_T^2 \times R = I_c^2 \times R [1 + \frac{\mu^2}{2}]$$

$$I_T^2 = I_c^2 [1 + \frac{\mu^2}{2}].$$

$$\boxed{I_T = I_e \sqrt{1 + \frac{\mu^2}{2}}}$$

Q18. Exp. for efficiency of an Am wave?

Soln.
$$\eta = \frac{P_{S.B}}{P_{TOTAL}} \times 100$$

we know,

$$P_{S.B} = \frac{A_c^2 \mu^2}{4R} \qquad (Total \ L.S.B + U.S.B)$$

$$P_{TOTAL} = \frac{A_c^2}{2R} [1 + \frac{\mu^2}{2}].$$

∴
$$\eta = \frac{\frac{A_c^2 \mu^2}{2_4 R}}{\frac{A_c^2}{2R} [1 + \frac{\mu^2}{2}]} = \frac{\mu^2/2}{1 + \frac{\mu^2}{2}} \times 100$$

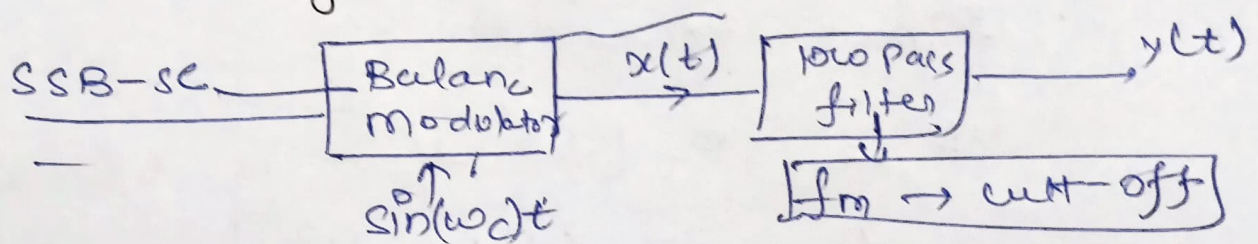$$\boxed{\eta = \frac{\mu^2}{1 + \mu^2} \times 100}$$

Let is take, $\mu = 1$

$$\eta = \frac{(1)^2}{2 + (1)^2} = \frac{1}{3} \times 100\%$$

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

or $\boxed{\eta_{max} = 33.33\%}$

Q13: Coherent detection of SSB-SC? advant &
disadvantages?

Sol^n:

SSB-SC ── [Balance modulator] ──$x(t)$── [low pass filter] ──$y(t)$
                    ↑
                $\sin(\omega_c)t$ f_m → cut-off

• Working:

① $s(t) = m(t) \cdot \sin \omega_c t \pm \hat{m}(t) \cdot \cos \omega_c t$

$s(t) = m(t) \sin \omega_c t \pm \hat{m}(t) \cos \omega_c t$

② $x(t) = s(t) \cdot \sin(\omega_c t)$

$\therefore x(t) = m(t) \sin^2 \omega_c t \pm \hat{m}(t) \cos(\omega_c t) \cdot \sin(\omega_c t)$

By, $\cos 2\theta = 1 - \sin^2 \theta = 1 - 2\sin^2 \theta$

$\boxed{\sin^2 \theta = \frac{1 - \cos 2\theta}{2}}$

$\therefore x(t) = m(t) \frac{[1 - \cos 2\theta]}{2} \pm \hat{m}(t) \cos(\omega_c t) \cdot \sin(\omega_c t)$

Also, $\sin 2\theta = 2 \sin \theta \cdot \cos \theta$

$\therefore x(t) = \frac{m(t)}{2} - \frac{m(t) \cos 2\omega_c t}{2} \pm \frac{\hat{m}(t)}{2} \times 2 \sin \omega_c t \cos \omega_c t$

$\boxed{x(t) = \frac{m(t)}{2} - \frac{m(t) \cos 2\omega_c t}{2} \pm \hat{m}(t) \cdot \sin 2\omega_c t}$

$$x(t) = \frac{m(t)}{2} - \frac{m(t)}{2} \cos 2\omega_c t \pm \hat{m}(t) \cdot \sin 2\omega_c t$$

$$\downarrow \qquad\qquad \downarrow \qquad\qquad\qquad \downarrow$$

$$fm \qquad\qquad \boxed{2\omega_c \pm \omega_m} \qquad\qquad 2\omega_c \pm \omega_m$$

easily $\swarrow$ $\downarrow$ $\downarrow$

easily   can't pass   can't pass
pass by   by low   by low
low pass   pass filter   pass filter
filter

$$\therefore \quad \boxed{x(t) = \frac{m(t)}{2}} \Rightarrow \boxed{y(t) = \frac{m(t)}{2}}$$

$$\downarrow$$
modulating Signal.

* Advantages: of SSB-SC

① Bandwidth is half i.e $B = fm$
② Power is saved
③ noise is reduced

* Disadvantages: SSB-s

① transmission & receiver is complex
② quality get effected if TX & RX are not stable

* Adv & disadv of coherent:

I. Adv:

① Improve signal quality
② Increase Receiver sensitivity
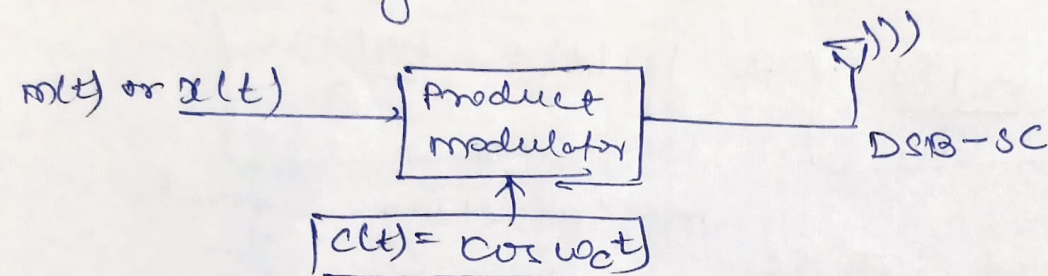③ Enhances data rate capacity
④ Reduce noise

II Disadv:

① Requires complex design
② Higher implementation cost
③ Sensitive to phase noise
④ Need accurate phase info.

Q14. What is DSB-SC AM wave? Gen method?

Soln: Double-Side Band-Suppressed Carrier.

① Carrier wave suppressed.
② Two side band available
③ use to save Power
④ has BW of $2\omega m$ or $2fm$.

* **Block Diagram!**

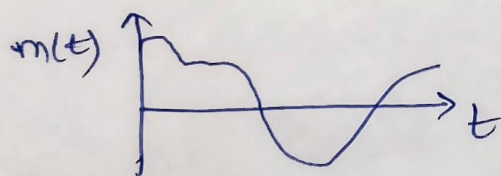$m(t)$ or $x(t)$ → [Product modulator] → DSB-SC))

↑

$c(t) = \cos \omega_c t$

* **Eqn!**

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

$$S(t) = A_c \cos \omega_c t + m(t) \cos \omega_c t$$

↓ carrier wave (neglect)   ↓ DSB-SC

Time-domain

$m(t)$ 〜 t $\xrightarrow{F.T}$ $m(\omega)$ △ ($-\omega m$, 0, ωm)

$c(t)$ 〜〜〜 t $\xrightarrow{F.T}$ $\pi c(\omega)$ ↑↑ ($-\omega c$, 0, ωc)

$S(t) = m(t) \cos \omega_c t$ 〰️〰️ $S(\omega)$ △△ ($-\omega c$, $\omega c - \omega m$, ωc, $\omega c + \omega m$)
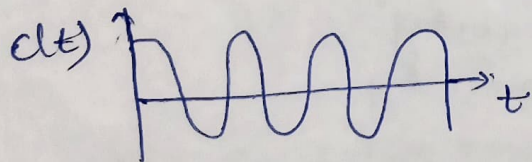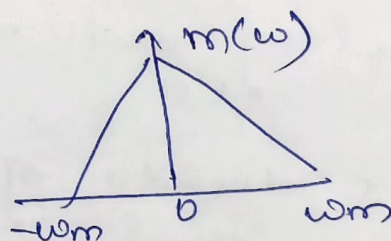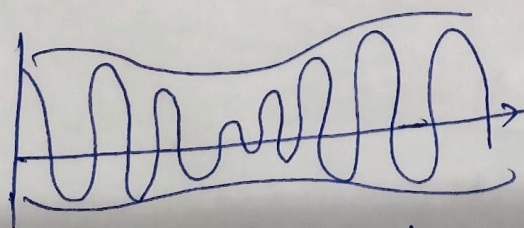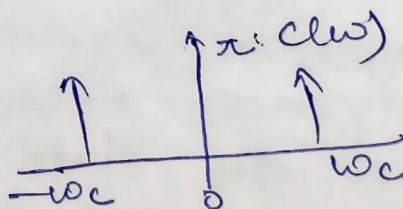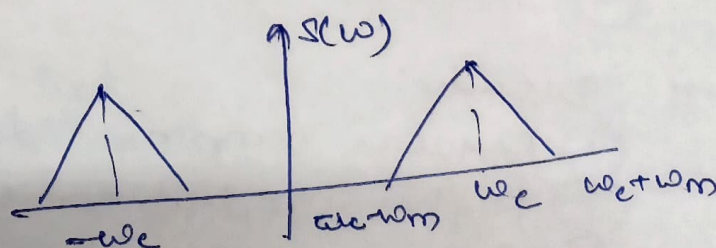
$$S(t) = m(t) \cos \omega_c t$$
$$= A_m \cos \omega_m t \cos \omega_c t = \frac{A_m}{2} [\cos(\omega_c - \omega_m)t + \cos(\omega_c + \omega_m)t] \substack{U.S.B \\ L.S.B}$$
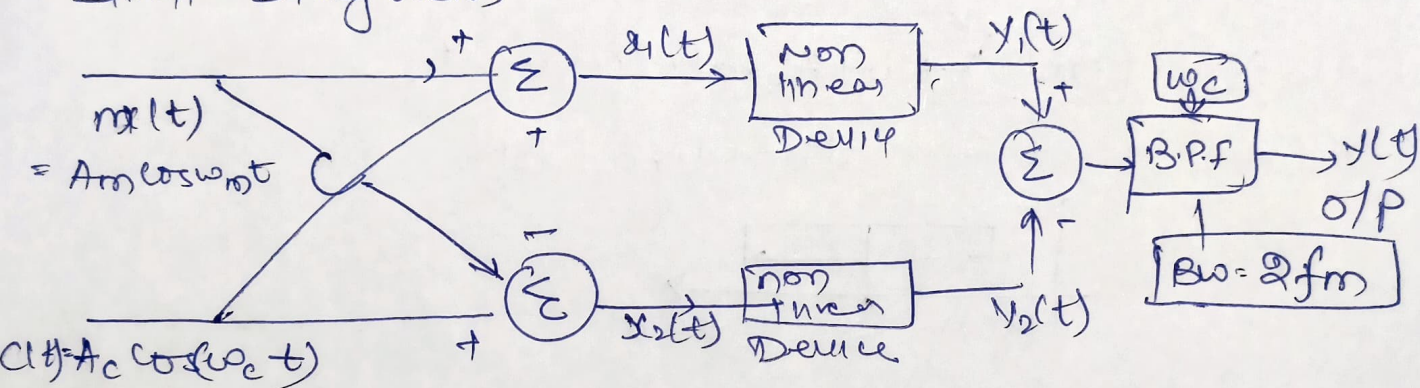
Modulator Types:
① Balanced modulator
② Ring Modulator

1. Balanced modulator:

① Use of 2 non-linear device.
② diode, Transistor
③ 1 non-linear device: carries wave + 2 side Band
④ Using 2 N.Device & carries wave suppressed.

* Block Diagram:

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

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

$x_1(t)$ → Non linear Device → $y_1(t)$

$x_2(t)$ → Non linear Device → $y_2(t)$

→ w_c → B.P.f → $y(t)$ o/p

$Bw = 2f_m$

$- V_{in}$ → Non linear → $V_o = a V_{in} + b V_{in}^2$

∴ $x_1(t) = m(t) + A_c \cos w_c t$

$x_2(t) = - m(t) + A_c \cos w_c t$

$y_1(t) = a x_1(t) + b x_1^2(t)$

$y_2(t) = a x_2(t) + b x_2^2(t)$

∴ $Y_o(t) = y_1(t) - y_2(t)$

∴ $y_1(t) = a(m(t) + A_c \cos w_c t) + b(m(t) + A_c \cos w_c t)^2$

$= a\, m(t) + a A_c \cos w_c t + b[m^2(t) + A_c^2 \cos^2 w_c t + 2 m(t) A_c \cos w_c t]$

$y_1(t) = a\, m(t) + a A_c \cos w_c t + b m^2(t) + b A_c^2 \cos^2 w_c t + 2 m(t) A_c \cos w_c t$

$$\therefore y_2(t) = a\left[-m(t) + A_c \cos \omega_c t\right] + b\left[-m(t) + A_c \cos \omega_c t\right]$$

$$y_2(t) = -am(t) + aA_c \cos \omega_c t + b(m^2(t) + A_c^2 \cos^2 \omega_c t$$
$$\qquad - 2 A_c m(t) \cos \omega_c t$$
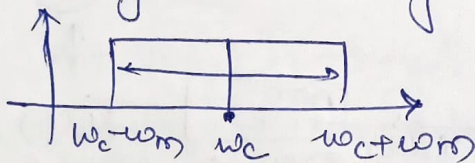
$$\therefore y(t) = y_1(t) - y_2(t)$$

$$= am(t) + aA_c \cos \omega_c t + bm^2(t) + bA_c^2 \cos^2 \omega_c t +$$
$$\quad 2 bA_c m(t) \cos \omega_c t$$

$$+$$
$$am(t) - aA_c \cos \omega_c t - bm^2(t) - bA_c^2 \cos^2 \omega_c t$$
$$+ 2 A_c m(t) \cos \omega_c t$$

$$y(t) = \boxed{am(t)} + b4 A_c m(t) \cos \omega_c t \checkmark$$

After passing through BPf

$$y(t) = 4bA_c \cdot m(t) \cos \omega_c t$$

$$\boxed{y(t) = K A_c m(t) \cos \omega_c t} \rightarrow \text{double side band}$$

$$y(t) = K A_c m(t) \cdot \cos \omega_c t$$

$$y(t) = A_m \cos \omega_m t \cdot A_c \cos \omega_c t$$

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

$$\text{Power} = P_{USB} + P_{LSB} = \frac{A_c^2 A_m^2}{8R} + \frac{A_c^2 A_m^2}{8R}$$

$$= \frac{A_c^2 A_m^2}{4R} = \frac{P_c^2 \cdot A_m^2}{2R}$$

5